世界互联网大会
World Internet Conference

# 科技之魅

CHARM OF SCIENCE AND TECHNOLOGY

## 世界互联网大会
## 领先科技奖收录成果集

Collection of Shortlisted Achievements of World Internet Conference Awards for Pioneering Science and Technology

2026WORLD INTERNET CONFERENCE
乌镇峰会 Wuzhen Summit
世界互联网大会

开源开放 共建共享
—— 携手构建网络空间命运共同体

Open Source and Openness, Joint Contribution and Shared Benefits
— Jointly Building a Community with a Shared Future in Cyberspace


世界互联网大会
World Internet Conference
2026WORLD INTERNET CONFERENCE
乌镇峰会
Wuzhen Summit
世界互联网大会

# 写在《科技之魅》前面

## Preface to *The Charm of Science and Technology*

我们正站在一个技术变革的历史性节点上。纵观人类科技史，真正改变世界的，从来不是工具的渐进改良，而是范式的根本更迭——农耕技术开启了农业文明，机械动力开启了工业时代，电气技术重塑了整个社会，而今天，智能技术正在开启属于它的时代。回望来路，从信息互联到万物互联，互联网以“连接”为本质，深刻改变了人类社会的组织方式；展望前程，智能的浪潮正将这一进程推向全新高度。世界互联网大会领先科技奖，正是为了在纷繁的技术演进中，发现那些真正具有开创性与引领性的成果，让科技之光照见未来之路。

We stand at a historic juncture of technological transformation. Throughout the history of science and technology, the advances that have truly transformed the world have not been mere incremental improvements to existing tools, but fundamental paradigm shifts. Agricultural technologies laid the groundwork for agricultural civilization, mechanical power ushered in the industrial age, and electrical technologies reshaped society as a whole. Today, intelligent technologies are ushering in a new era. Looking back, from information interconnection to the Internet of Everything, the Internet, with connectivity at its core, has profoundly transformed the way human society is organized. Looking ahead, the wave of intelligent technologies is pushing this process to new heights. Amid the rapid evolution of technology, the World Internet Conference Awards for Pioneering Science and Technology (WIC Awards) were established to identify achievements that are truly pioneering and at the forefront of technological progress, allowing the light of science and technology to illuminate the road ahead.

当今互联网发展，呈现三个突出的趋势。其一，连接的范围持续拓展。互联网正从“人与人的连接”走向“万物互联”，并进一步迈向智能与物理世界的深度融合——机器人、智能终端、低空飞行器正在成为网络中新的节点，数字世界与真实世界的边界日益消融。国际权威机构已将“物理 AI”列为 2026 年最具战略意义的技术趋势之一，这正是连接深化最有力的注脚。其二，智能的深度不断跃升。人工智能正在走出实验室、走出演示厅，从令人惊艳的技术体验，沉淀为普惠的技术服务和实实在在的社会价值；单一模型正在让位于多智能体的协同，通用能力正在与行业知识深度融合。智能，正在成为一种新的基础性能力。其三，底座的支撑愈发坚实。从能源到芯片，从算力集群到高速网络，底层基础设施决定着系统的智能程度；融合多种计算范式的超级计算平台快速兴起，量子计算、类脑计算等新型计算路径加速成熟，为连接与智能提供着源源不断的动力。与此同时，以 RISC-V 为代表的开放指令集架构，为处理器设计与芯片创新提供了更加开放、灵活的技术路径，推动软硬件协同创新与产业生态发展。开放架构打破技术创新的固有边界，为全球开发者、科研机构和产业主体参与底层技术创新创造了更多可能，也为构建开放协同的下一代互联网技术体系注入新的活力。三者叠加，共同勾勒出下一代互联网的轮廓：一个万物互联、智能涌现、底座坚实的新世界。

Three prominent trends are shaping the development of the Internet today. First, the scope of connectivity continues to expand. The Internet is evolving from connecting people to the Internet of Everything, and moving further toward the deep integration of intelligence with the physical world. Robots, intelligent terminals, and low-altitude aircraft are emerging as new nodes in the network, while the boundaries between the digital and physical worlds are increasingly blurring. Leading international institutions have listed Physical AI as one of the most strategically significant technology trends for 2026, which underscores this deepening connectivity. Second, AI capabilities are becoming more sophisticated. Artificial intelligence is moving beyond laboratories and product demonstrations, evolving from impressive technological demonstrations into widely accessible technical services and tangible social value. Single models are giving way to multi-agent collaboration, and general capabilities are being deeply integrated with domain-specific expertise. Intelligence is emerging as a new foundational capability. Third, the supporting infrastructure is becoming ever more robust. From energy to chips, from computing clusters to high-speed networks, the underlying infrastructure determines the level of intelligence that systems can achieve. Supercomputing platforms integrating multiple computing paradigms are rapidly emerging, and new computing paradigms such as quantum computing and neuromorphic computing are accelerating toward maturity, providing sustained momentum for connectivity and intelligence. Meanwhile, open instruction-set architectures, such as RISC-V, are offering a more open and flexible technical path for processor design and chip innovation, driving collaborative innovation between hardware and software as well as the

development of industrial ecosystems. Open architectures break down the traditional boundaries of technological innovation, creating more opportunities for developers, research institutions, and industry players worldwide to participate in underlying technology innovation, and injecting new vitality into building an open and collaborative next-generation Internet technology system. Together, these three trends are shaping the next-generation Internet: a new world of ubiquitous connectivity, emergent intelligence, and robust foundations.

作为世界互联网大会领先科技奖评审委员会主席，我深感荣幸地见证了科技奖的国际影响力再上新台阶。本年度，来自全球 43 个国家和地区的申报方积极参与，共征集 400 余项科技成果，涵盖脑机接口、具身智能、量子计算、空间信息传输等前沿领域，恰与上述技术演进的三条脉络遥相呼应，充分彰显了全球科技界对数字化未来的共同关切与积极探索。在来自全球各地的互联网领域权威专家的严格评审与推荐下，一批兼具科学价值与应用前景的优秀成果脱颖而出，收录于本年度《科技之魅》。这些成果跨越了地域与学科的界限，生动诠释了开放合作、协同创新的科学精神。

As Chair of the Review Committee of the WIC Awards, I am deeply honored to witness the growing international influence of the awards. This year, applicants from 43 countries and regions participated enthusiastically, with more than 400 scientific and technological achievements submitted, covering cutting-edge fields such as brain-computer interfaces, embodied intelligence, quantum computing, and spatial information transmission — these correspond precisely to the three threads of technological evolution outlined above, fully demonstrating the common interest and active exploration of the global science and technology community regarding the digital future. Through rigorous review and deliberation by leading Internet experts worldwide, a selection of outstanding achievements that combine scientific value with application prospects has emerged, and been compiled into this year's edition of *The Charm of Science and Technology*. These achievements transcend geographical and disciplinary boundaries, vividly embodying the scientific spirit of open cooperation and collaborative innovation.

科技之魅，在于连接消除了距离，智能释放了想象，而坚实的底座让一切成为可能。环顾当今世界，人类面前展开的技术图景，其广阔程度前所未有。然而，图景越是壮阔，越需要清醒的方向感——技术奔涌向前，而方向始终握在人类自己手中。愿全球科技界同仁以开放包容的胸怀深化合作，让万物互联的网络更加通达，让智能技术更好地赋能千行百业、惠及每一个普通人，让底层创新持续筑牢数字文明的根基。以连接凝聚世界，以智能点亮未来，以责任守护方向——这，正是《科技之魅》所希望传递的信念，也是世界互联网大会始终不渝的追求。

The charm of science and technology lies in how connectivity bridges distances, intelligence sparks the imagination, and a solid foundation makes it all possible. Looking at the world today, the technological landscape unfolding before humanity is unprecedented in its breadth. Yet the grander the vision, the more important it is to maintain a clear sense of direction. Technology surges forward, but the direction it takes remains in human hands. It is my hope that colleagues across the global science and technology community will deepen cooperation with an open and inclusive spirit, making the interconnected network more accessible, enabling intelligent technology to better empower all industries and benefit every individual, and steadily consolidating the foundation of digital civilization. Uniting the world through connection, illuminating the future through intelligence, and keeping our bearings through responsibility — this is the message that *The Charm of Science and Technology* seeks to convey, and the enduring pursuit of the World Internet Conference.



# 01 世界互联网大会领先科技奖获奖成果
Award-winning Achievements of World Internet Conference Awards for Pioneering Science and Technology

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合肥国家实验室 Hefei National Laboratory
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香港中文大学（深圳）　The Chinese University of Hong Kong (Shenzhen)
深圳市人工智能与机器人研究院　Shenzhen Institute of Artificial Intelligence and Robotics for Society (AIRS)
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兴微达有限公司　Nuevida Limited

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**终端安全管理系统研发及应用** **222**
Development and Application of an Endpoint Security Management System

奇安信科技集团股份有限公司　Qi An Xin Technology Group Inc.



# 科技之魅

CHARM OF SCIENCE AND TECHNOLOGY

# 01

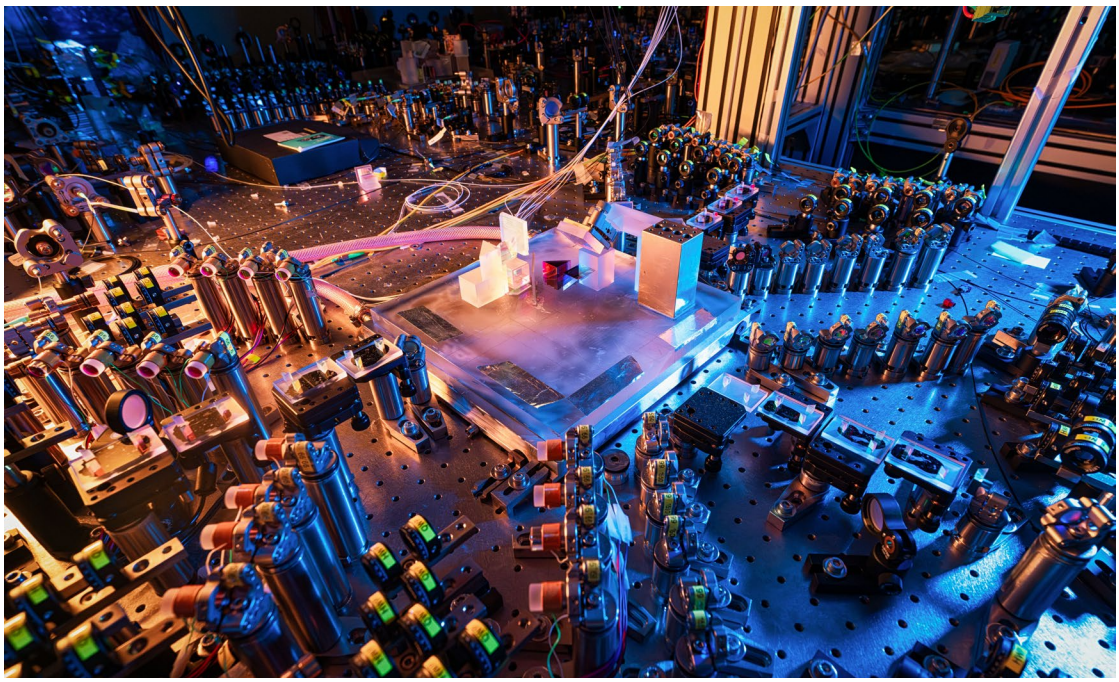
# 世界互联网大会
# 领先科技奖获奖成果

## Award-winning Achievements of World Internet Conference Awards for Pioneering Science and Technology

## 基础研究组
## Basic Research Group

# “九章四号”光量子计算原型机

## Jiuzhang 4.0 Photonic Quantum Computer



“九章四号”可编程光量子计算原型机实验系统
Experimental system of the programmable Jiuzhang 4.0 photonic quantum computing system

中国科学技术大学
University of Science and Technology of China

合肥国家实验室
Hefei National Laboratory

济南量子技术研究院
Jinan Institute of Quantum Technology

九章（济南）量子科技有限公司
Jiuzhang Quantum Technology

## 引言

“九章四号”面向可扩展光量子计算，以空时混合编码、高效率可编程量子光源和主动相位锁定技术，在 8,176 个模式中操纵 1,024 个压缩态，将光量子系统规模和计算复杂度推进至新阶段。

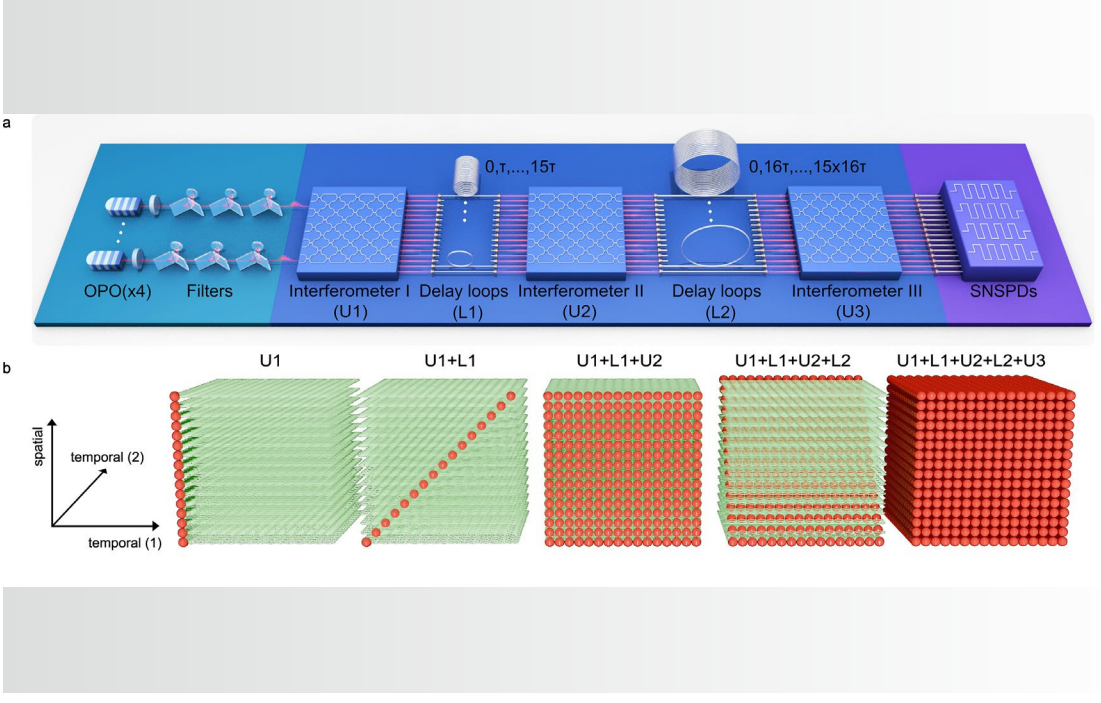
## Introduction

Designed for scalable photonic quantum computing, Jiuzhang 4.0 combines hybrid spatial-temporal encoding, highly efficient programmable quantum light sources and active phase locking. It manipulates 1,024 squeezed states across 8,176 modes, advancing both the scale and computational complexity of photonic quantum systems.

## 空时混合编码突破大规模光量子系统的扩展瓶颈
## Hybrid Spatial-temporal Encoding Overcomes the Scaling Bottleneck of Large Photonic Quantum Systems

传统光量子线路随规模增加会迅速遭遇器件数量、光学损耗和相位漂移的多重制约。“九章四号”提出并实现空时混合编码架构，由多级 16 端口全连通干涉仪与光纤延迟阵列构成，使光子在空间模式跳转的同时跨越 256 个时间窗口发生干涉，以有限物理资源支撑 8,176 个量子模式。团队研制的单模压缩态光源效率达到 92%，全系统效率达到 51%，可独立、快速编程 1,024 路输入态的幅度和相位。三级分布式主动伺服环路将关键光路稳定在纳米量级，保障系统连续运行。实验最大探测到 3,050 个光子事件，较此前同类实验实现数量级跨越；在特定任务上，其处理速度按最优经典模拟估算比全球领先超级计算机快约 $10^{54}$ 倍。

Conventional photonic quantum circuits face multiple constraints with rapidly increasing component counts, optical loss and phase drift as they scale. Jiuzhang 4.0 introduces and demonstrates a hybrid spatial-temporal encoding architecture combining multistage 16-port fully connected interferometers with fiber-delay arrays. Photons interfere across 256 time bins while moving among spatial modes, enabling 8,176 quantum modes with a limited set of physical components. The single-mode squeezed-light sources achieve an efficiency of 92% and the overall system efficiency is 51%. The amplitudes and phases of 1,024 input states can be programmed independently and rapidly. The three-level distributed active servo loop stabilizes critical optical paths at nanometre-level precision for sustained operation. The experiment detected a maximum of 3,050 photons events, an order-of-magnitude over previous comparable experiments. For the designated tasks, the best available classical-simulation estimate indicates that Jiuzhang 4.0 is approximately $10^{54}$ times faster than a world's leading supercomputer.




“九章四号”实验装置及空时混合编码线路中光子分布的演化过程原理
Experimental setup of Jiuzhang 4.0 and the evolution of the photon distribution through the hybrid spatial-temporal encoding circuit

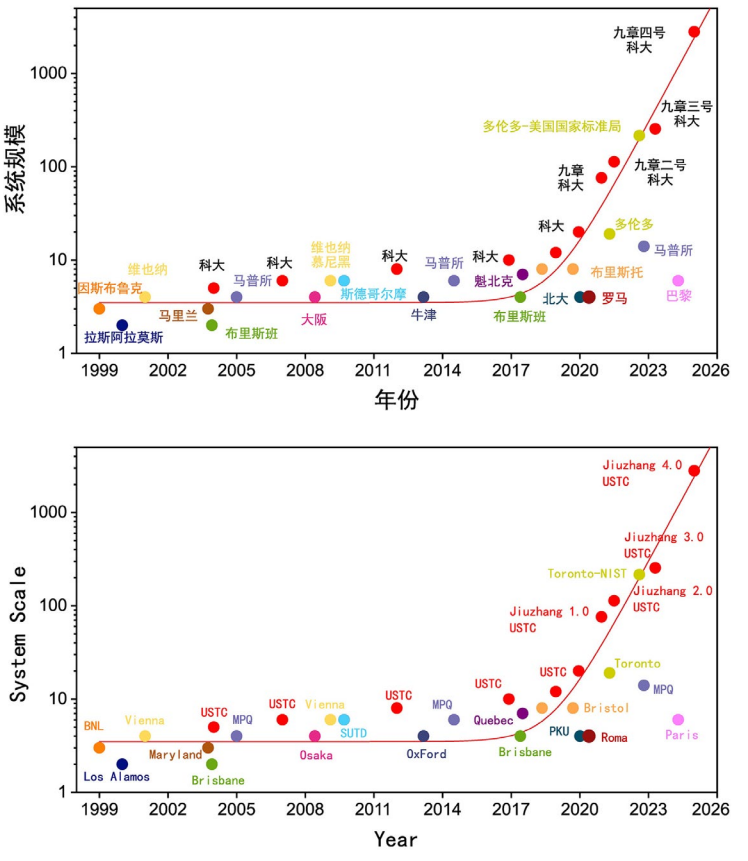


“九章四号”系统中用于实现低损耗大规模光子干涉的 16 模式可编程干涉仪
The 16-mode programmable interferometer used for large-scale, low-loss photonic interference in Jiuzhang 4.0

## 建立可扩展量子计算优越性的新基准
## A New Benchmark for Scalable Quantum Computing Superiority

“九章四号”把量子计算优越性研究从一次性规模展示推进为可扩展、可编程的实验平台。其高连通、低损耗网络把有效压缩光子数提升至约 114，显著超出此前实验仅为约 10 的水平，使矩阵乘积态等已知经典近似算法陷入指数级增长的时间与存储成本。系统探索的希尔伯特空间维度约为 $10^{2461}$，为检验量子力学在超大规模复杂系统中的演化规律提供了实验基础。更重要的是，该平台可进一步用于产生大规模三维簇态和高质量玻色纠错码，为测量型及容错光量子计算研究提供硬件路径；其高效率光源、精密相位控制和单光子探测等方法，也可迁移到量子模拟、图论优化、量子通信与精密测量等方向，推动光量子信息从原理验证走向实用价值探索。

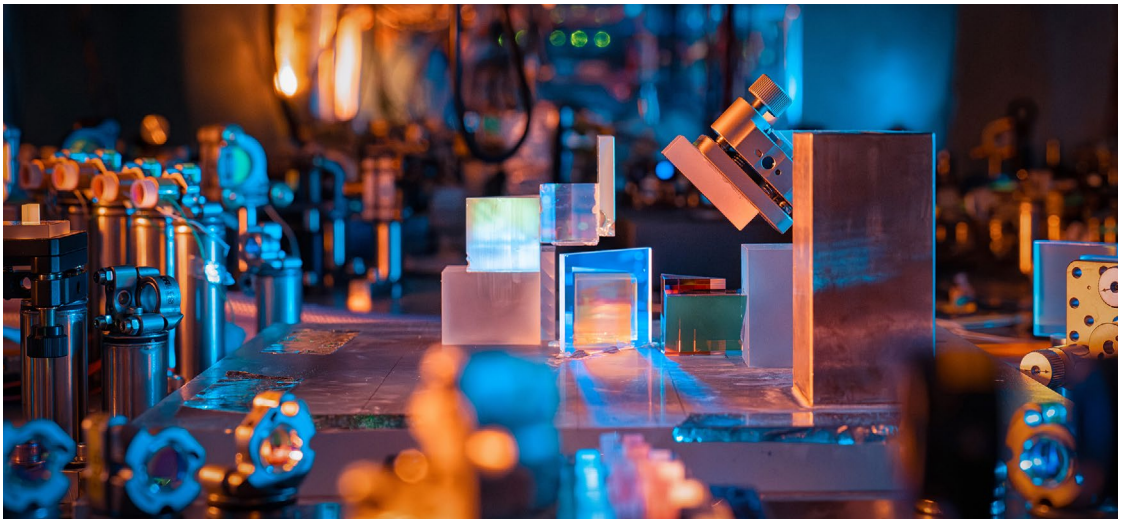
Jiuzhang 4.0 advances quantum computing superiority from a one-off scale demonstration to a scalable and programmable experimental platform. The highly connected, low-loss network raises the number of effective squeezed-photon to about 114, far beyond the level of roughly 10 in previous experiments, forcing known classical approximation methods, including matrix-product-state approaches into exponentially growing time and memory costs. The system explores a Hilbert space of approximately $10^{2461}$ dimensions, providing an experimental basis for probing quantum dynamics evolution in extremely large and complex systems. The platform can also support large three-dimensional cluster states and high-quality bosonic error-correction codes, offering a hardware route towards measurement-based and fault-tolerant photonic quantum computing. The efficient light sources, precision phase control and single-photon detection methods can further be transferred to quantum simulation, graph optimisation, quantum communication and precision measurement, promoting the development of photonic quantum information from proof-of-principle experiments to practical quantum computing applications.




全球代表性光量子计算实验所操纵光子数的演进。“九章四号”最高探测到 3,050 个光子事件，显著提升了光量子计算实验的系统规模

Progress in the number of photons manipulated in representative photonic quantum computing experiments worldwide. Jiuzhang 4.0 detected events involving up to 3,050 photons, substantially extending the experimental scale of photonic quantum computing

2026WORLD INTERNET CONFERENCE



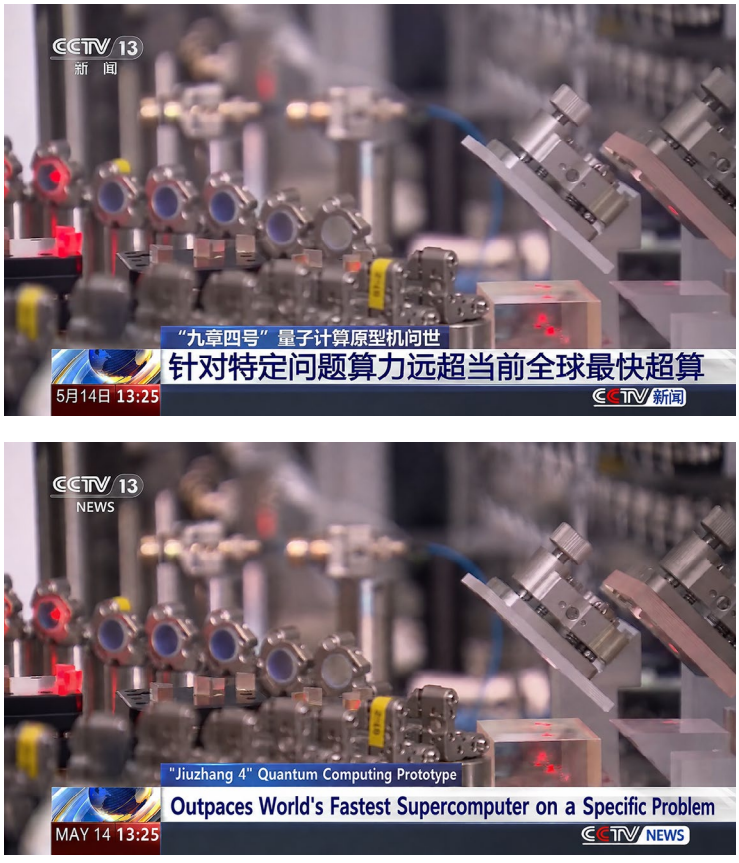
“九章四号”光量子计算原型机中的关键光学模块

A key optical module in the Jiuzhang 4.0 photonic quantum computing prototype

## 顶级论文、国际比较与持续引用彰显全球影响力
## Global Impact Demonstrated by Leading Publications, International Benchmarks and Sustained Citations

“九章”系列已成为国际光量子计算领域具有代表性的标志性成果。首个“九章”成果发表于《Science》后迅速获得国际学术界高度关注，论文发表一周内全文下载量超过 20 万次，相关内容在 Twitter 等国际社交媒体获得超过 600 万次阅读，并入选美国物理学会（APS）“Highlights of the Year”及美国光学学会（OSA，现 Optica）“Optics in 2021”年度重要光学进展。系列代表作《Quantum computational advantage using photons》截至 2026 年 5 月 15 日已被引用 3,522 次，成为线性光量子信息领域引用最高的代表性论文之一。相关成果受到全球超过 100 家科技媒体和新闻机构关注，包括《Nature》《Nature Materials》《Scientific American》《New Scientist》《Physics World》《Science News》《Optics & Photonics News》《Wired》和 Phys.org 等。“九章”还入选联合国教科文组织 Netexplo 全球十大创新，并获德国 Falling Walls 年度十大突破等国际认可。在此基础上，“九章四号”进一步将系统扩展至 1,024 个压缩态、8,176 个模式和最高 3,050 个探测光子事件，核心成果发表于《Nature》，持续推动光量子计算成为全球量子科技竞争的重要技术路线。

Jiuzhang programme has become a landmark achievement in photonic quantum computing worldwide. Following the publication of the first Jiuzhang experiment in Science, the paper has attracted exceptional international attention, receiving more than 200,000 full-text downloads within one week and over 6 million views on international social media platforms including Twitter. Jiuzhang programme has been selected by the American Physical Society (APS) for its “Highlights of the Year” and featured in the Optical Society of America’s (OSA, now Optica) “Optics in 2021”. As of 15 May 2026, the landmark paper named “Quantum computational advantage using photons” has received 3,522 citations, making it one of the most highly cited papers in the field of linear-optical quantum information. This work has been highlighted by more than 100 international news and science-media outlets, including Nature, Nature Materials, Scientific American, New Scientist, Physics World, Science News, Optics & Photonics News, Wired and Phys.org. Jiuzhang has also been selected among UNESCO Netexplo’s Global Top Ten Innovations and recognized by Falling Walls as a Top Ten Breakthrough of the Year. Building on this international impact, Jiuzhang 4.0 scales the system to 1,024 squeezed states, 8,176 modes and events involving up to 3,050 detected photons, with the core result published in Nature, further establishing photonic quantum computing as a major global pathway towards scalable quantum computation.

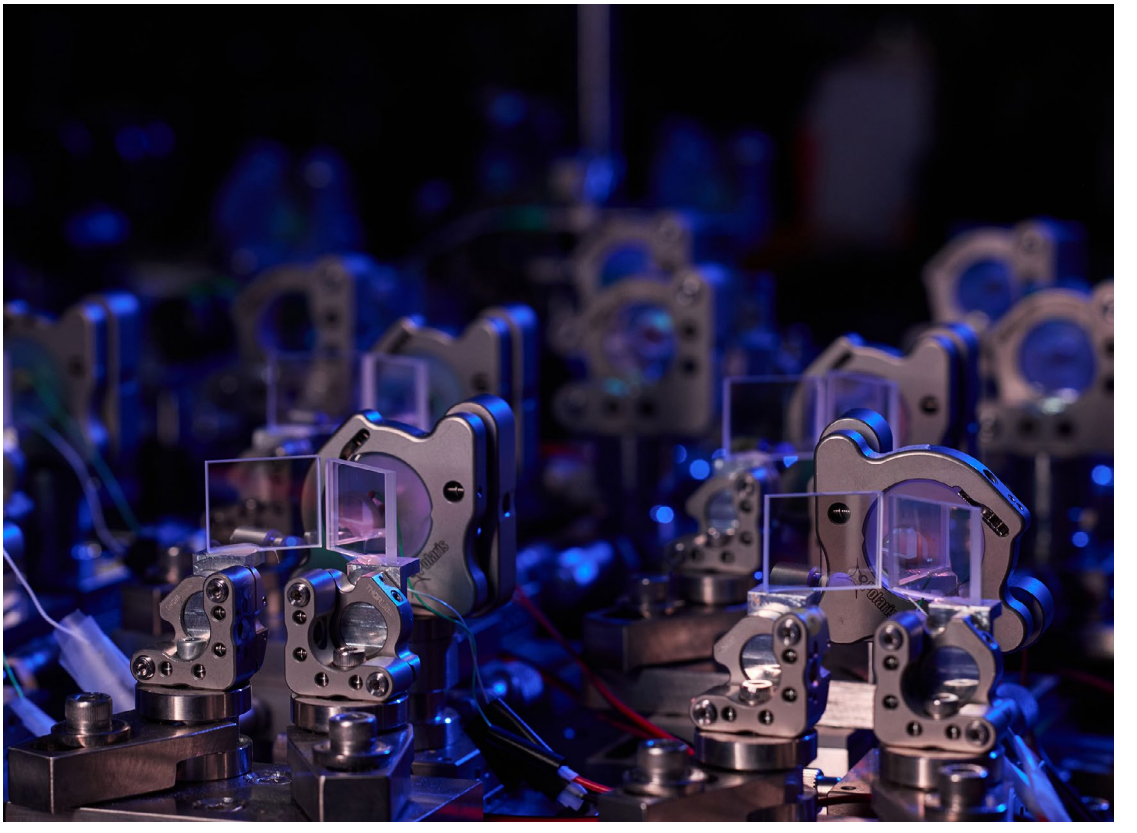



“九章”系列成果获得国际学术机构和科技媒体的广泛关注
Results from the Jiuzhang programme have received extensive attention from international scientific organisations and media outlets

## 关键器件与方法形成可持续的研究基础
## Enabling Key Components and Methods Establish a Durable Research Foundation

围绕九章系列形成的高效率压缩光源、空时混合编码架构、分布式主动相位锁定、与大规模多光子符合计数等技术，已形成多项中国及国际专利申请与授权。它们既支撑“九章”从 76 个光子、100 个模式迭代到 3,050 个光子、8,176 个模式，也为后续可编程、容错光量子计算实验提供可复用的器件和工程方法。

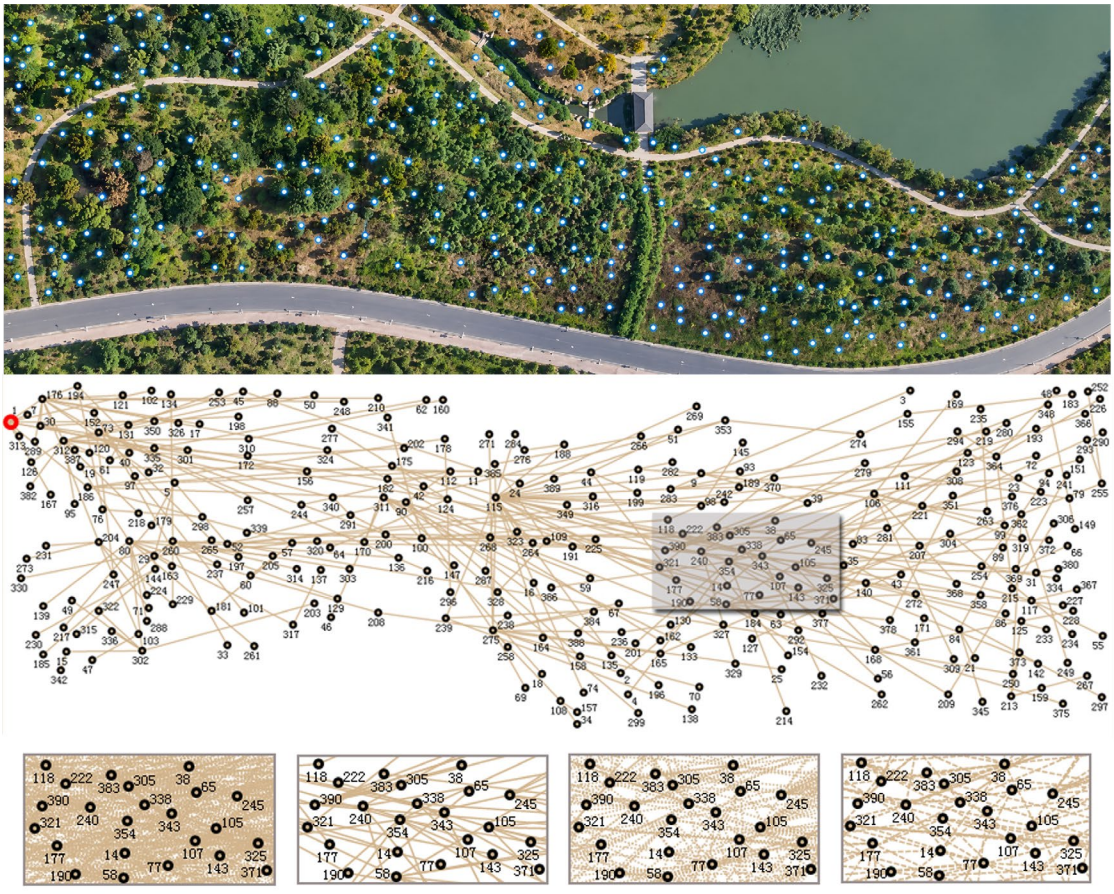
Jiuzhang programme has formed a portfolio of Chinese and international patent applications and grants covering high-efficiency squeezed-light sources, spatial-temporal hybrid encoded photonic circuit, active phase locking for modularity, and large-scale multi-photon coincidence counting. These enabling technologies supported the iteration from 76 photons and 100 modes to 3,050 photons and 8,176 modes, while providing reconfigurable components and engineering methods for future programmable and fault-tolerant photonic quantum computing experiments.



“九章四号”实验系统中的超低损光学滤波阵列及精密相位控制模块
Ultra-low-loss optical filtering array and precision phase-control modules in the Jiuzhang 4.0 experimental system

# 物联网可扩展性理论和方法

## Theory and Methodology for Scalable Internet of Things



无线传感网络的多视角呈现

Multiple Views of a Wireless Sensor Network

清华大学
Tsinghua University

中国科学技术大学
University of Science and Technology of China

南京邮电大学
Nanjing University of Posts and Telecommunications

## 引言

物联网可扩展性理论和方法针对物联网规模扩展难题，提出并构建基于弱状态传感的物联网可扩展性理论，回答物联网能否扩展以及如何扩展两大基础性问题，为实现大规模物联网系统提供了方法支撑。

## Introduction

The Theory and Methods for Scalability of IoT address the challenges of scaling Internet of Things (IoT) systems by proposing and establishing a scalability theory based on reduced dependence on system state information. This theory answers two fundamental questions—whether IoT systems can scale and how scalability can be achieved—providing methodological support for the design and implementation of large-scale IoT systems.

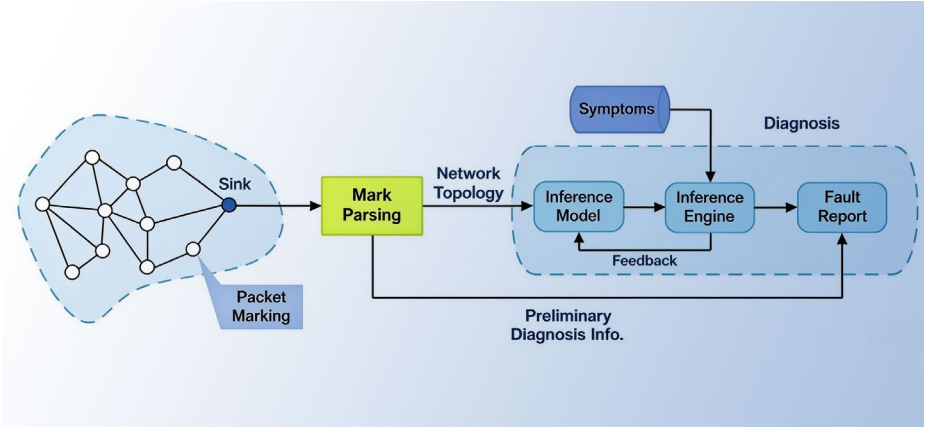
## 构建基于弱状态传感的物联网可扩展性理论
## Developing an IoT Scalability Theory Based on a Weak-State Approach

长期稳定运行的大规模物联网系统是物联网领域的核心难题之一。物联网可扩展性理论与方法提出了物联网可扩展性定义，发现了制约规模扩展的路由 - 感知 - 诊断三元约束关系，揭示了对传感状态的强依赖是物联网扩展的核心瓶颈。

进一步围绕路由稳定、感知扩展和管理效率三个要素，构建能适应大规模人机物互联的物联网系统。针对路由问题，利用局部、不确定的网络状态信息，实现高效可靠传输；针对感知效用边际递减问题，建立感知效用子模一致性模型，提出非专用设备协同的参与式感知机制，提升感知规模扩展能力；针对网络诊断问题，发现局部状态的时空相关性，揭示指标关联模式的故障表征机理，提出基于关联图分析的被动诊断方法，提升故障识别效率与精度。

Developing large-scale IoT systems capable of long-term stable operation remains one of the fundamental challenges in the Internet of Things (IoT) field. The Theory and Methods for Scalability of IoT establish a formal definition of IoT scalability, identify the system among routing, sensing, and diagnosis that limit system scalability, and reveal that strong dependence on three-way constraints state information constitutes a fundamental bottleneck to IoT scalability.

Building on these findings, the research addresses three key aspects—routing stability, sensing scalability, and management efficiency—to enable large-scale IoT systems that seamlessly connect people, machines, and physical objects. For routing, efficient and reliable data transmission is achieved using local and uncertain network state information. To address the diminishing marginal utility of sensing, a submodular consistency model of sensing utility is established, and a participatory sensing mechanism leveraging collaboration among non-dedicated devices is proposed to enhance sensing scalability. For network diagnosis, the research identifies the spatiotemporal correlations of local network states, reveals the mechanisms by which metric correlation patterns characterize network faults, and develops a passive diagnosis method based on correlation graph analysis, improving both the efficiency and accuracy of fault identification.




传感网络故障诊断方法
A Method for Sensor Network Fault Diagnosis



## 物联网可扩展性理论为大规模物联网系统的设计与实现提供了理论依据和方法论支撑

## The Theory of IoT Scalability Provides a Theoretical Foundation and Methodological Support for the Design and Implementation of Large-Scale IoT Systems

物联网可扩展性理论与方法推动了物联网研究从经验性系统设计向可量化、可证明的规模化理论研究转变，应用于能源开采、物流管理、工业制造和城市管理等。研制基于物联网的行李管理系统获中国国际软件博览会金奖。研制了面向工业生产检测数据采集系统，实现了单子网大规模检具节点的并发检测数据采集和管理，在多个工业场景实际应用。研制了基于低功耗广域网的大规模智慧城市物联网系统，支撑城市基础设施数据采集实际应用。

The theory and methods for IoT scalability have advanced IoT research from empirical system design toward quantitative theories of scalability with mathematically proven results, with applications in energy extraction, logistics management, industrial manufacturing, and urban management. An IoT-based baggage management system was developed and received the Gold Award at the China International Software Expo. An industrial inspection data acquisition system was developed to enable concurrent data collection and management from large numbers of inspection devices within a single subnet, and has been deployed in multiple industrial settings. A large-scale smart city IoT system based on Low-Power Wide-Area Networks (LPWANs) was also developed to support data acquisition in real-world urban infrastructure applications.



在油田部署无线传感网络节点
Wireless Sensor Network Deployment in Oilfields

## 物联网可扩展性理论获得国际学术界高度认可
## The Theory of IoT Scalability Has Earned Widespread International Recognition

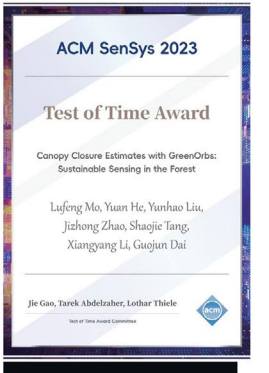
物联网可扩展性理论与方法的多项研究成果发表于国际会议与期刊，包括 ACM SIGCOMM、ACM MOBICOM、IEEE TPDS、IEEE TMC 等。系列研究成果获得罗格斯大学、弗吉尼亚理工大学、普林斯顿大学、加州大学伯克利分校、加州大学戴维斯分校、密歇根大学、帝国理工学院等国际知名机构跟踪引用。相关研究成果撰写了多部教材和专著。

相关成果获得 2009 年国际并行与分布式系统会议 IEEE ICPADS 最佳论文奖、国际移动计算与网络会议 ACM MobiCom 2014 最佳论文奖、2021 年国际感知系统会议 ACM SenSys 唯一最佳论文奖、2021 年国际数据通信旗舰会议 ACM SIGCOMM 最佳学生论文奖。获 ACM SenSys 时间检验奖，实现从原型系统到实用平台的跨越，对物联网产业发展和教育领域产生重大影响。

Our research on the theory and methods for IoT scalability has been published in international conferences and journals, including ACM SIGCOMM, ACM MobiCom, IEEE TPDS, and IEEE TMC. These studies have been widely cited by researchers at internationally renowned institutions, including Rutgers University, Virginia Tech, Princeton University, the University of California, Berkeley, the University of California, Davis, the University of Michigan, and Imperial College London. The research findings have also provided the basis for multiple textbooks and academic monographs.

The research has received numerous prestigious awards, including the Best Paper Award at IEEE ICPADS 2009, the Best Paper Award at ACM MobiCom 2014, the Best Paper Award at ACM SenSys 2021, and the Best Student Paper Award at ACM SIGCOMM 2021. The research also received the ACM SenSys Test of Time Award, These advances enabled the transition from prototype systems to practical platforms and made substantial contributions to the development of the IoT industry and education.

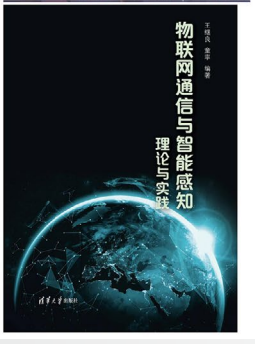


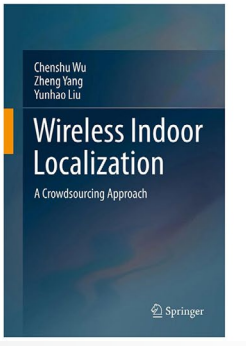











# 科技之魅

CHARM OF SCIENCE AND TECHNOLOGY

# 01

## 世界互联网大会
## 领先科技奖获奖成果

**Award-winning Achievements of World Internet Conference Awards for Pioneering Science and Technology**

# 关键技术组
# Key Technology Group

# AI 赋能感知：面向物理智能的多模态触觉感知关键技术平台

## AI for Sensing: A Multimodal Tactile Perception Platform Enabling Physical AI




AI 赋能感知平台通过智能材料、软件定义传感与嵌入式 AI，为机器赋予可规模化部署的触觉感知能力

The AI for Sensing platform integrates smart materials, software-defined sensing and embedded AI to provide machines with scalable tactile perception

触零科技
TG0

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## 引言

AI 赋能感知技术（AI for Sensing）面向 Physical AI，将智能材料、软件定义传感与嵌入式 AI 深度融合，从有限电信号重建高维触觉信息，使普通材料和结构具备触觉、压力、剪切力和手势感知能力。

## Introduction

AI for Sensing combines smart materials, software-defined sensing and embedded AI to reconstruct high-dimensional tactile information from limited electrical signals, enabling ordinary materials and structures to sense touch, pressure, shear force and gestures for Physical AI.

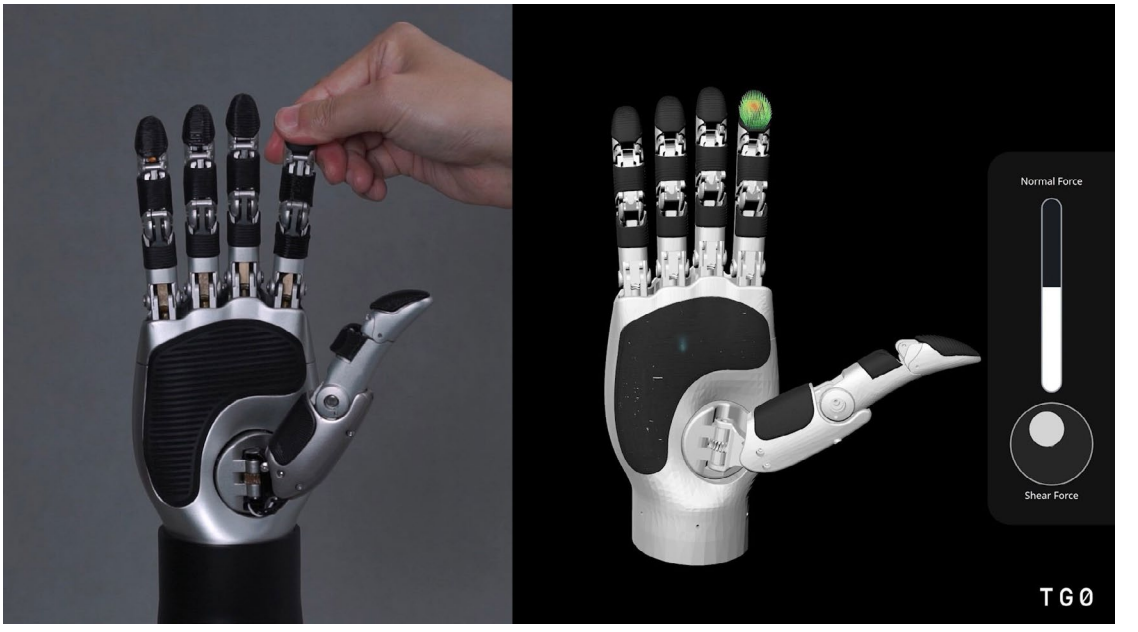
## 以 AI 重构感知：从“堆叠传感器”走向“算法定义感知”
## Innovation & Breakthrough: Reconstructing Perception with AI - from sensor density to Algorithm-Defined Sensing

针对传统触觉系统依赖高密度传感器阵列、成本高、布线复杂、功耗高且难适配复杂曲面的共性难题，成果原创提出“AI 赋能感知（AI for Sensing）”与“算法定义感知（Algorithm-Defined Sensing）”技术框架，以智能材料、软件定义传感、边缘 AI 和嵌入式计算从有限电信号中重建多维触觉信息。在典型应用中可减少 90% 以上传感器数量；统一平台可感知压力、触摸、位置、力方向、剪切力及手势，并通过软件升级扩展功能。轻量化算法可直接运行于低功耗 Cortex-M0 级微控制器，实现毫秒级边缘响应；MultiPad 厚度低至 0.3 毫米，可面向复杂曲面部署。




智能压力感应鞋垫
Smart pressure sensing insoles

Conventional tactile systems rely on dense sensor arrays, resulting in high cost, complex wiring, power consumption and difficult integration on curved surfaces. AI for Sensing introduces an original Algorithm-Defined Sensing framework that combines smart materials, software-defined sensing, edge AI and embedded computing to reconstruct multidimensional tactile information from limited electrical signals. In typical applications, it can reduce sensor count by more than 90%. A unified platform can detect pressure, touch, position, force direction, shear force and gestures, while new capabilities can be added through software. Lightweight models run directly on low-power Cortex-M0-class microcontrollers with millisecond-level edge response. MultiPad is only 0.3 mm thick and can be integrated onto complex surfaces.



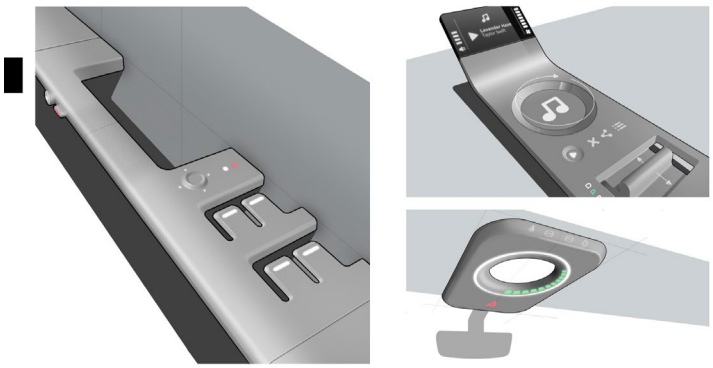

灵巧手指尖触觉三维力传感（含剪切力方向和大小）
Three dimensional force sensing of fingers of dexterous hand (including the direction and magnitude of shear force)

## 从技术平台到全球应用：机器触觉进入机器人、汽车、医疗与智能终端

## Application & Adoption: From a Technology Platform to Global Deployment Across Robotics, Mobility, Healthcare and Intelligent Devices

成果已形成多模态触觉平台、智能表面、智能鞋垫、人机交互系统及 MultiPad 等产品与解决方案，服务全球超过 200 家企业及机构客户，覆盖欧洲、北美和亚洲，并与 Tesla、Airbus、Bentley、Audi、Novares 等国际企业开展合作验证和产品开发。平台通过减少传感器数量、电子元器件及布线，可显著降低硬件复杂度、系统重量、功耗和制造成本，提高可靠性与可制造性。在医疗健康领域，技术已用于步态分析、运动监测、康复训练和压力评估；在机器人领域提升接触感知、人机协作安全和环境适应性；在汽车及消费电子领域支持更自然、直观的交互。相关技术累计获得超过 1500 万美元融资支持。

The platform has developed into a portfolio of multimodal tactile systems, intelligent surfaces, smart insoles, human-machine interfaces and MultiPad solutions. It has served more than 200 organisations and enterprise customers across Europe, North America and Asia, with collaborations involving Tesla, Airbus, Bentley, Audi and Novares. By reducing sensor count, electronic components and wiring, the platform lowers hardware complexity, system weight, power consumption and manufacturing cost while improving reliability and manufacturability. Applications include gait analysis, movement monitoring, rehabilitation and pressure assessment in healthcare; contact perception, safer human-robot collaboration and environmental adaptability in robotics; and more natural interfaces in automotive and consumer electronics. The technology has attracted more than US$15 million in investment.



汽车人机交互应用
The Application of Automobile's HMI



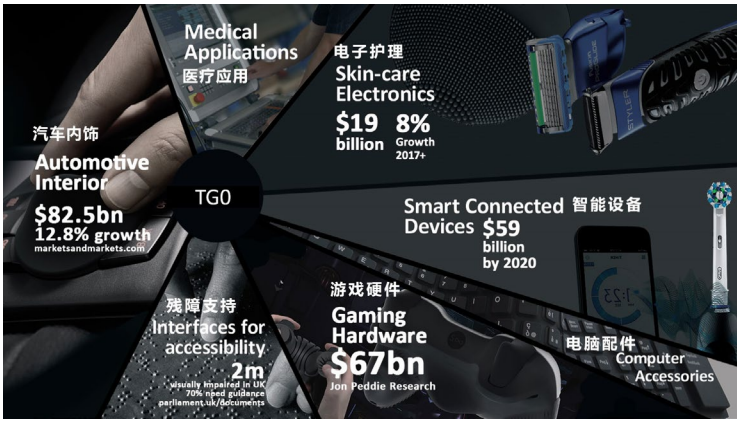

机器人电子皮肤触觉应用
The Application of Robots' electronic skin touch sensing

## 让 AI 从“看见、听见”走向“触摸与交互”，推动 Physical AI 感知基础设施升级

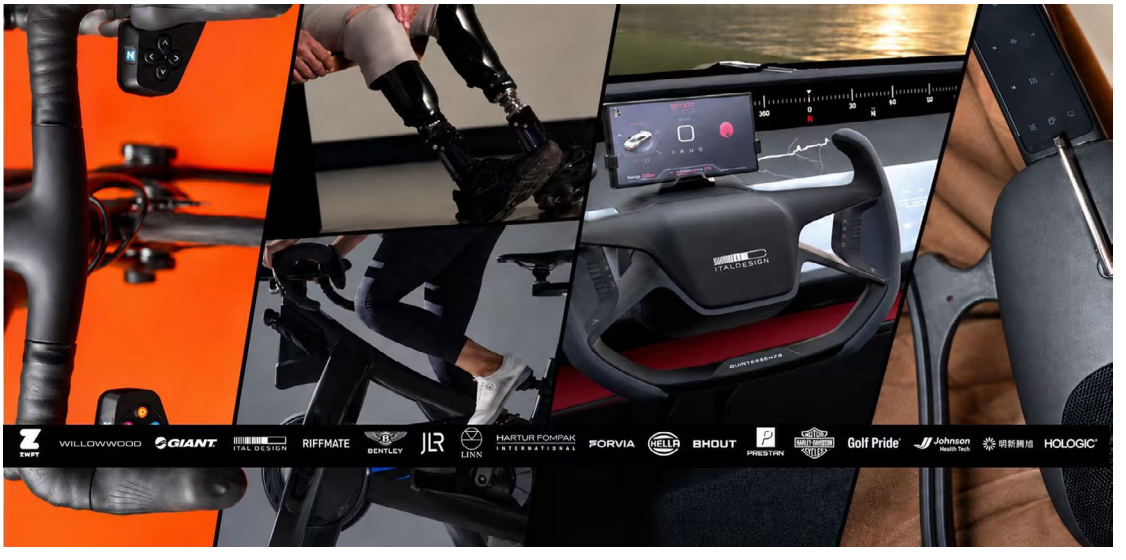
## Impact: Extending AI from Vision and Audio to Touch and Physical Interaction, Driving the Infrastructure Upgrade for Physical AI

成果推动感知系统从硬件主导的“增加传感器”模式，向“材料 + 算法 + 数据”协同驱动的软件定义模式演进，为机器触觉、智能材料、边缘 AI 和具身智能提供新的工程路径。其可规模化触觉能力使机器人实时感知接触、压力、力和交互，为精细操作、安全协作和环境理解提供基础；同时降低触觉感知的部署门槛，促进机器人、智能汽车、医疗设备、消费电子和先进制造的智能化升级。围绕核心技术已形成 10 项国际专利家族、40 项专利成果，知识产权组合估值超过 1 亿美元；并获得 Innovate UK、EIC、Horizon Europe 及英国皇家工程院等机构支持，形成从研究、知识产权到产业应用的国际创新链条。

AI for Sensing advances perception from hardware-intensive sensor architectures toward a software-defined model driven by materials, algorithms and data. It provides a new engineering pathway for machine touch, smart materials, edge AI and embodied intelligence. Scalable tactile perception enables robots to sense contact, pressure, force and interaction in real time, supporting dexterous manipulation, safer collaboration and environmental understanding, while lowering adoption barriers across robotics, intelligent vehicles, healthcare, consumer electronics and advanced manufacturing. The project has established 10 international patent families and 40 patent assets, with an estimated intellectual-property portfolio value exceeding US$100 million. Support from Innovate UK, the European Innovation Council, Horizon Europe and the Royal Academy of Engineering has helped build an international innovation chain from research and IP to commercial deployment.




全球行业应用组合图
Portfolio of Global Industry Applications




已有客户及投资人
Clients and Investors

## 国际创新认可与持续产业化
## International Recognition and Continued Commercialisation

团队获得Tech Nation Future Fifty（2025）、WAIC SAIL Award（2025）、Best in British Tech（2025）等国际项目与奖项认可。AI for Sensing 持续在人工智能、先进传感、智能材料和机器人交叉领域推进技术验证与产业化，为 Physical AI 和下一代人机交互提供可扩展的机器触觉基础能力。

The technology and team have received international recognition including Tech Nation Future Fifty (2025), the WAIC SAIL Award (2025) and Best in British Tech (2025). AI for Sensing continues to advance commercial validation at the intersection of AI, advanced sensing, smart materials and robotics, providing scalable machine-touch capabilities for Physical AI and next-generation human-machine interaction.




国际奖项获奖情况
International Awards and Prizes




2026WORLD
INTERNET
CONFERENCE

# 超大规模通信网络安全弹性防御关键技术及应用

## Key Technologies and Applications for Cybersecurity and Resilient Defense in Ultra-Large-Scale Communications Networks




构建超大规模通信网络安全弹性防御体系

Building a resilient defense system for ultra large scale communication network security

中国移动通信集团有限公司
China Mobile Communications Group Co., Ltd.

中移（杭州）信息技术有限公司
China Mobile (Hangzhou) Information Technology Co., Ltd.

清华大学
Tsinghua University

绿盟科技集团股份有限公司
NSFOCUS Technologies Group Co., Ltd.

卓望数码技术（深圳）有限公司
Zhuowang Digital Technology (Shenzhen) Co., Ltd.

## 引言

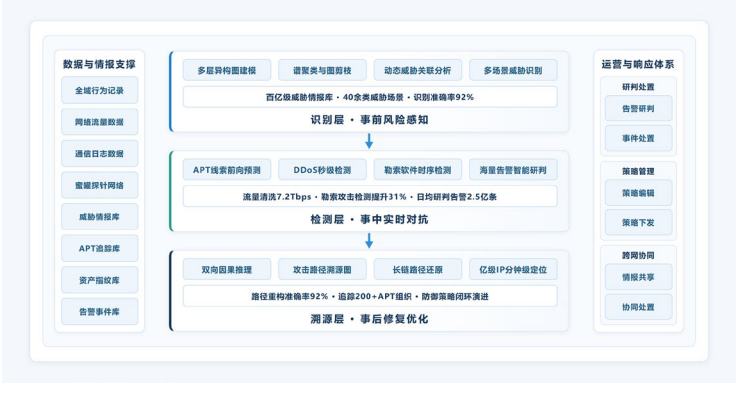
构建业界首个超大规模通信网络安全“事前风险感知、事中实时对抗、事后修复优化”弹性防御体系，突破现有技术在网络攻击识别、检测、溯源等方面的关键瓶颈，引领全球通信网络安全防御技术从被动防御向主动弹性防御转型升级。

## Introduction

This achievement builds the industry’s first elastic defense system for ultra-large-scale communication network security, encompassing “pre-event risk awareness, in-event real-time defense, and post-event remediation and optimization,” breaking through critical bottlenecks in attack identification, detection, and tracing, and leading the transformation of global telecom network security from passive defense to proactive elastic defense.

## 创新构建全球性通信网络安全弹性防御技术体系
## Innovatively Build a Global Resilient Defense Technology System for Communication Network Security

国际网络安全市场以标准化产品为主流，通信网络安全防御面临跨域多点威胁识别覆盖不全、高级复杂攻击检测精度不足、攻击路径与源头无法还原等全球性难题。本成果构建行业首个超大规模通信网络安全“事前风险感知、事中实时对抗、事后修复优化”弹性防御体系，形成三项核心技术突破：一是首创覆盖国际、骨干、城域多层级的动态威胁关联分析技术，利用异构图建模实现全域威胁特征自动提取，威胁识别准确率达 92%；二是突破 DDoS、勒索、APT 等高级攻击检测精度瓶颈，DDoS 检测达毫秒级，流量清洗能力达 7.2Tbps，勒索攻击检测能力较主流引擎精度提升 31%，累计检测发现超 500 起 APT 攻击事件；三是首创全链路攻击溯源定位技术，攻击路径重构准确率达 92%，覆盖全球亿级 IP 地址，实现分钟级定位时效。累计获授权专利 200 余项（含国际专利 8 项），总体达国际领先水平。







超大规模通信网络安全弹性防御技术原理
Principle of elastic defense technology for ultra large scale communication network security

The international cybersecurity market is dominated by standardized products, and communication network security defense faces global challenges such as incomplete cross-domain multi-point threat identification coverage, insufficient detection accuracy for advanced complex attacks, and the inability to reconstruct attack paths and trace origins. This achievement establishes the industry’s first ultra-large-scale communication network security “pre-event risk perception, in-event real-time confrontation, post-event restoration and optimization” resilient defense system, delivering three core technological breakthroughs. First, it pioneers dynamic threat correlation analysis technology covering

multiple tiers including international, backbone, and metropolitan networks, using heterogeneous graph modeling to automatically extract global threat features, achieving a threat identification accuracy rate of 92%. Second, it breaks through the accuracy bottlenecks in detecting advanced attacks such as DDoS, ransomware, and APT: DDoS detection reaches the millisecond level, traffic scrubbing capacity reaches 7.2 Tbps, ransomware detection accuracy improves by 31% over mainstream engines, and over 500 APT attack incidents have been cumulatively detected and discovered. Third, it pioneers full-chain attack source tracing and localization technology, achieving an attack path reconstruction accuracy rate of 92%, covering hundreds of millions of global IP addresses with minute-level localization speed. The achievement has cumulatively obtained more than 200 authorized patents (including 8 international patents), reaching an overall internationally leading level.

## 推动通信网络安全防护与全球产业协同发展
## Promote the Coordinated Development of Communication Network Security Protection and the Global Industry

本成果已在英国、菲律宾、刚果等 60 余个国家交付应用，构建覆盖个人、家庭、政企、车联网、物联网等场景的立体化安全防护体系。在中国 31 个省份的通信网络中实现规模化部署，为 10 亿个人用户、3 亿家庭、3000 万政企客户提供 7×24 小时安全防护，日均处理告警量 2.5 亿条，监测 DDoS 攻击近 300 万次，首发 500 余起 APT 攻击事件。依托成果打造通信网络威胁情报、抗 D、算网安全资源池等多样化安全产品，服务超 5 万家政企客户，在巴西、中东等地与当地头部企业开展深度合作，连续 7 年获 Frost & Sullivan 中国抗 DDoS 市场第一、IDC 中国 IPS 市场占有率第一，安全服务创造营收超 30 亿元。累计发现处置 80 余起以数据窃密为目标攻击事件，避免经济损失超 25 亿元，节约能源费用超 1 亿元。累计承担第 24 届冬奥会、“一带一路”高峰论坛等 30 余次国际重大活动网络安全保障。




构建超大规模通信网络安全弹性防御体系应用
Application of Building a Large Scale Communication Network Security Elastic Defense System

This achievement has been delivered and applied in more than 60 countries including the United Kingdom, the Philippines, and Congo, building a multi-dimensional security protection system covering scenarios such as individuals, households, government and enterprise, Internet of Vehicles (IoV), and Internet of Things (IoT). It has achieved large-scale deployment across communication networks in 31 provinces of China, providing 7×24-hour security protection for 1 billion individual users, 300 million households, and 30 million government and enterprise customers, processing an average of 250 million alerts per day, monitoring nearly 3 million DDoS attacks, and making the first public disclosures of over 500 APT attack incidents. Leveraging this achievement, diversified security products have been developed, including communication network threat intelligence, anti-DDoS solutions, and computing-network security resource pools, serving over 50,000 government and enterprise customers, and establishing in-depth cooperation with leading local enterprises in Brazil, the Middle East, and other regions. The achievement has ranked first in China’s anti-DDoS market by Frost & Sullivan for seven consecutive years and first in China’s IPS market by

IDC, with security services generating revenues exceeding 3 billion yuan. More than 80 attack incidents targeting data theft have been cumulatively discovered and handled, avoiding economic losses exceeding 2.5 billion yuan and saving energy costs exceeding 100 million yuan. The achievement has cumulatively undertaken cybersecurity support for more than 30 major international events, including the 24th Winter Olympics and the Belt and Road Summit Forum.

## 引领全球通信网络安全从被动刚性防御向主动弹性防御转型

## Lead the Global Communication Network Security Shift from Passive Rigid Defense to Proactive Resilient Defense

本成果首创超大规模通信网络弹性防御体系，为全球性安全难题建立典型技术范式，推动全球网络安全技术从被动、静态、刚性防御向主动、动态、弹性防御转型升级。成果累计获授权专利200余项（含国际专利8项），发表SCI收录期刊等论文200余篇，获自动化软件工程国际会议ACM ASE杰出论文奖。深度参与ITU、ISO、GSMA、CCSA等标准化组织工作，主导发布国际首个5G内生安全标准，主导完成国际首个6G安全标准立项，累计参编国际国家标准30余项。国际首发披露“艾登狐”等近10个APT组织及多个僵尸网络，被VirusBulletin等20余家国际媒体转载，获赛门铁克、FireEye等安全公司认可，为100余个受影响国家提供重要防御参考。




部分媒体报道、荣誉奖项、权威认证、知识产权情况
Partial media coverage, honors and awards, authoritative certification, and intellectual property situation

多次入选Gartner欺骗诱捕标杆、全球威胁情报市场指南，构建覆盖全中国的“1+31+N”协同防御体系，为全球网络安全产业从孤岛自治向体系化协同、智能化创新转型提供可复制的运营范式。

This achievement pioneers an ultra-large-scale communication network resilient defense system, establishing a typical technical paradigm for global security challenges and driving the transformation and upgrade of global cybersecurity technology from passive, static, and rigid defense to proactive, dynamic, and resilient defense. The achievement has cumulatively obtained more than 200 authorized patents (including 8 international patents), published over 200 papers including those in SCI-indexed journals, and won the ACM Distinguished Paper Award at the International Conference on Automated Software Engineering (ASE). It has deeply participated in the work of standardization organizations such as ITU, ISO, GSMA, and CCSA, led the release of the world’s first 5G intrinsic security standard, led the establishment of the world’s first 6G security standard project, and cumulatively participated in the compilation of more than 30 international and national standards. It has made the first international public disclosures of nearly 10 APT organizations, including “Aiden Fox”, as well as multiple botnets, which were republished by more than 20 international media outlets such as VirusBulletin, recognized by security companies including Symantec and FireEye, and provided important defense references for over 100 affected countries. It has been repeatedly selected for the Gartner deception technology representative vendors and the global threat intelligence market guide, built a “1+31+N” collaborative defense system covering all of China, and provided a replicable operational paradigm for the transformation of the global cybersecurity industry from isolated autonomy to systematic collaboration and intelligent innovation.

# 高性能分布式存储系统关键技术与应用

## Key Technologies and Applications of High-Performance Distributed Storage Systems




高性能分布式存储系统关键技术与应用
Key Technologies and Applications of High-Performance Distributed Storage Systems

清华大学
Tsinghua University

阿里云计算有限公司
Alibaba Cloud Computing Co., Ltd.

中兴通讯股份有限公司
Zhongxing Telecommunication Equipment Corporation

## 引言

面向云计算与人工智能，提出高性能分布式存储系统，实现数据“存得下”、“取得快”、“用得稳”，获 IO500 全球第一、CCF 技术发明一等奖、FAST 最佳论文奖等，已应用于阿里云、华为、中兴等企业，服务全球超百万家企业。

## Introduction

Designed for cloud computing and artificial intelligence, the High-Performance Distributed Storage System enables data to be stored at scale, accessed rapidly, and used reliably. It has achieved the No. 1 global ranking on IO500, received the CCF Technical Invention First Prize and FAST Best Paper Awards, and has been deployed by Alibaba Cloud, Huawei, ZTE, and other enterprises, serving more than millions of enterprises worldwide.

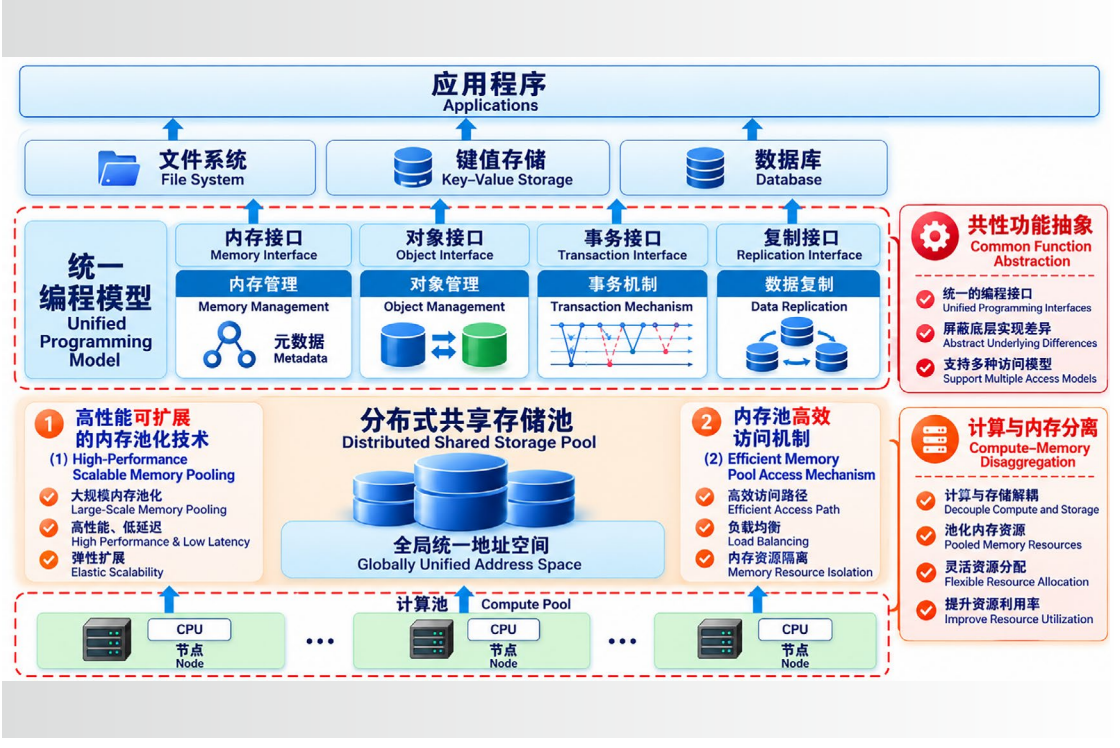
## 突破非易失存储池化、高并行访问与低开销一致性关键技术，构建国际领先的高性能分布式存储系统

## Breakthroughs in Non-Volatile Storage Pooling, Highly Parallel Access, and Low-Overhead Consistency Enable an Internationally Leading High-Performance Distributed Storage System

面向阿里云大规模云存储系统在性能、可靠性和资源效率方面的重大需求，项目组依托阿里云真实业务场景，围绕新型非易失存储器，开展分布式存储系统的全栈自主创新，从架构设计、系统构建、数据可靠性等层面突破了一系列难题，取得以下创新：1. 发明了可扩展非易失存储池化架构与机制，基于计算与内存分离、共性功能抽象的设计思想，实现了非易失内存池的弹性扩展和多种灵活高效的统一接口，具有层次简洁、高可扩展和高性能等特点；2. 发明了高并行存储系统构建方法，在阿里云首次实现了千亿级文件规模下百微秒级的元数据访问性能；3. 发明了低开销存储一致性方法，对比三星等主导研制的 NVMe 协议，提供了操作原子性保障，提升事务处理性能。

To address the major demands of Alibaba Cloud's large-scale cloud storage systems in terms of performance, reliability, and resource efficiency, the project team leveraged real-world Alibaba Cloud production scenarios and carried out full-stack independent innovation in distributed storage systems centered on emerging non-volatile storage technologies. A series of technical challenges were overcome across architecture design, system construction, and data reliability, leading to the following innovations:

1. A scalable non-volatile storage pooling architecture and mechanism was developed. Based on the design principles of compute-memory disaggregation and abstraction of common functions, it enables elastic expansion of non-volatile memory pools and provides multiple flexible, efficient, and unified interfaces, featuring a streamlined architecture, high scalability, and high performance.
2. A method for constructing highly parallel storage systems was developed. On Alibaba Cloud, it achieved, for the first time, hundred-microsecond-level metadata access performance at a scale of hundreds of billions of files.
3. A low-overhead storage consistency method was developed. Compared with the NVMe protocol primarily developed under the leadership of companies such as Samsung, the method provides operation-level atomicity guarantees and improves transaction processing performance.




高性能分布式存储系统总体架构
Overall System Architecture of the High-Performance Distributed Storage Systems

## 成果实现多行业规模化应用，服务全球 500 万 + 企业并创造显著经济社会效益

## The Achievement Has Been Deployed at Scale across Multiple Industries, Serving over Five Million Enterprises Worldwide and Delivering Significant Economic and Social Benefits

项目成果已在阿里云、中兴通讯、华为、鹏城实验室、浪潮、快手实现应用。面向阿里云大规模云存储场景，成果应用于块存储缓存及盘古存储等系统，支撑文件访问规模由百亿级提升至千亿级，系统吞吐率提升 70%，元数据访问延迟较 CephFS 降低 8 倍，实现百微秒级访问性能，服务企业覆盖金融、通信、制造、医疗、能源等重点行业。在中兴通讯，成果形成一体化大数据平台，支撑 PB 级视频数据和亿级业务记录，吞吐率提升 50%，服务百万用户，有效支撑超高清视频、政企视频大数据和数字化办公等业务。成果还应用于华为 Dorado V6、鹏城云脑 II 等系统，提升存储可靠性与计算效率。近些年累计新增销售额 55.77 亿元、新增利润约 9.73 亿元，有力支撑重点行业数字化转型。



项目成果部署于阿里云大规模集群
Deployment of the Project Results in Alibaba Cloud's Large-Scale Clusters




项目成果规模化应用与行业影响
Large-Scale Deployment and Industry Impact of the Project Results

The project results have been deployed in Alibaba Cloud, ZTE, Huawei, Peng Cheng Laboratory, Inspur, and Kuaishou. In Alibaba Cloud's large-scale cloud storage scenarios, the technologies have been applied to block storage caching, Pangu storage, and other systems, supporting an increase in file access scale from tens of billions to hundreds of billions of files, improving system throughput by 70%, and reducing metadata access latency by 8× compared with CephFS, thereby achieving hundred-microsecond-level access performance. The technologies serve enterprises across key sectors including finance, telecommunications, manufacturing, healthcare, and energy.

At ZTE, the project results have been integrated into an all-in-one big data platform, supporting PB-scale video data and hundreds of millions of business records, increasing throughput by 50%, and serving millions of users. The platform effectively supports services such as ultra-high-definition video, government and enterprise video big data, and digital office applications.

The technologies have also been applied to systems including Huawei Dorado V6 and Peng Cheng Cloudbrain II, improving storage reliability and computing efficiency. In recent years, the project has generated cumulative additional sales revenue of RMB 5.577 billion and additional profit of approximately RMB 973 million, providing strong support for the digital transformation of key industries.

## 成果在国际学术界和产业界形成持续影响，推动高性能分布式存储技术演进并支撑云计算与人工智能基础设施升级

## The Project Has Exerted Sustained Influence across Both Academia and Industry, Advancing High-Performance Distributed Storage Technologies and Supporting the Evolution of Cloud Computing and AI Infrastructure

项目成果被 UIUC、ETH Zurich 等高校课程和研讨会列为典型案例，并被 Google 首席工程师、ACM/IEEE Fellow、斯隆奖得主等在多个国际会议 Keynote 中作为典型案例介绍；在工业界，本成果被 Intel、Mellanox、华为等国际公司作为典型范例引发广泛关注讨论，可扩展非易失存储池化架构在全球网络存储工业协会 SNIA 的报告中被列为值得关注的系统、在国际开放联盟 OpenFabrics 作为网络与存储全栈设计的范例报告。成果在 FAST、OSDI、SOSP 等国际顶级会议及期刊发表论文 60 余篇，获华为首届唯一奥林帕斯奖及百万悬红、CCF 技术发明一等奖、FAST 最佳论文奖、FAST 杰出技术成果奖、ACM SIGMOD 研究亮点奖、Communications of the ACM 研究亮点、清华大学年度十大亮点成果等，并于 2023—2025 年 6 次位列国际 IO500 全节点性能全球第一。

The project results have been featured as representative case studies in university courses and workshops at institutions including UIUC and ETH Zurich, and have also been introduced as representative examples in keynote talks at multiple international conferences by Google Principal Engineers, ACM/IEEE Fellows, Sloan Research Fellows, and other leading experts. In industry, the work has attracted broad attention and discussion from international companies such as Intel, Mellanox, and Huawei. The scalable non-volatile storage pooling architecture was listed by the Storage Networking Industry Association (SNIA) as a “Notable Mention” and was presented by the OpenFabrics Alliance as an example of full-stack optimization for networking and storage.

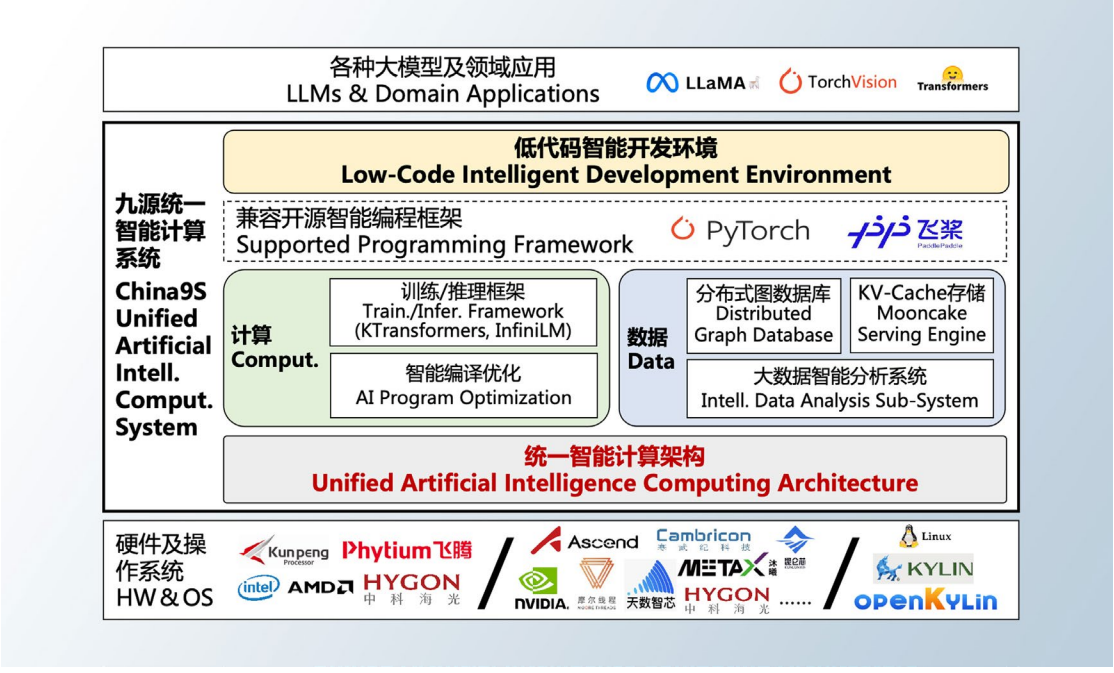
The project has produced more than 60 papers in leading international conferences and journals, including FAST, OSDI, and SOSP. It has received major honors including Huawei’s inaugural and sole OlympusMons Award with a RMB 1 million challenge prize, the CCF Technical Invention First Prize, FAST Best Paper Awards, the FAST Distinguished Artifact Award, the ACM SIGMOD Research Highlights Award, a Research Highlight in Communications of the ACM, and recognition as one of Tsinghua University’s Annual Top Ten Research Highlights. From 2023 to 2025, the project ranked No. 1 globally six times in IO500 full-system performance.




项目成果的国际影响力
International Impact of the Project Results

# 九源统一智能计算系统

## China9S: A Unified Artificial Intelligence Computing System




九源统一智能计算系统的全栈视图
The Full-Stack View of the China9S Unified Artificial Intelligence Computing System

启元实验室
Qiyuan Lab

清华大学
Tsinghua University

## 引言

以大模型为代表的智能负载给计算系统带来了众多挑战，项目对此进行了系统性攻关，研发出九源统一智能计算系统，在算力利用、数据供应、应用开发等方面取得了系列性创新成果并获得了落地应用。

## Introduction

AI workloads, represented by large language models (LLM) training and inference, have imposed numerous challenges to computing systems. To address them, this project conducted systematic research and developed the China9S Unified Artificial Intelligence Computing System, achieving a series of innovative breakthroughs in computing power utilization, data provisioning and application development.

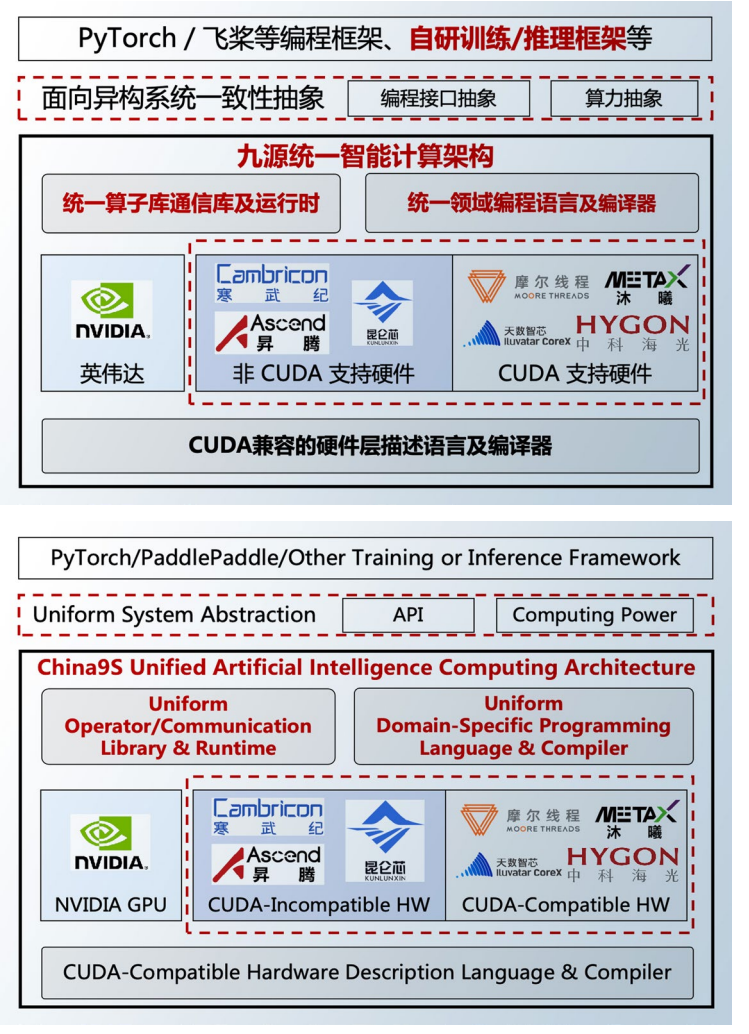
## 从算力架构、数据供应到应用开发全栈创新，多项性能世界领先

## Full Stack Innovation and World-Leading Performance, Spanning Computing Architecture, Data Provisioning and Application Development

1. 算力层面，首创九源统一智能计算架构，破解硬件生态分裂难题，实现了智能模型 / 应用“一次开发、全平台运行”；国际首次提出异构推理加速技术，通过 CPU-GPU 协同使千亿参数大模型可部署于单张消费级显卡，相应的开源框架 KTransformers 星标破 1.9 万，全球影响显著。

2. 数据供应层面，国际首创“以存换算”大模型推理理念，研发的 Mooncake 系统通过分布式 KV-Cache 优化助力万卡集群推理吞吐提升 1 倍以上，获 FAST 2025 最佳论文奖；研发的分布式图数据库基于飞腾处理器，国际率先完成权威 LDBC SNB 基准 SF3000 数据集测试，SF1000 吞吐世界第一。

3. 应用开发层面，研发了支持“拖拽式算法工具箱 +IDE 集成开发”双模式的低代码智能开发环境，其内置的混源代码安全分析工具连续两年蝉联国际程序验证顶级赛事 SV-COMP 并发安全分支冠军。

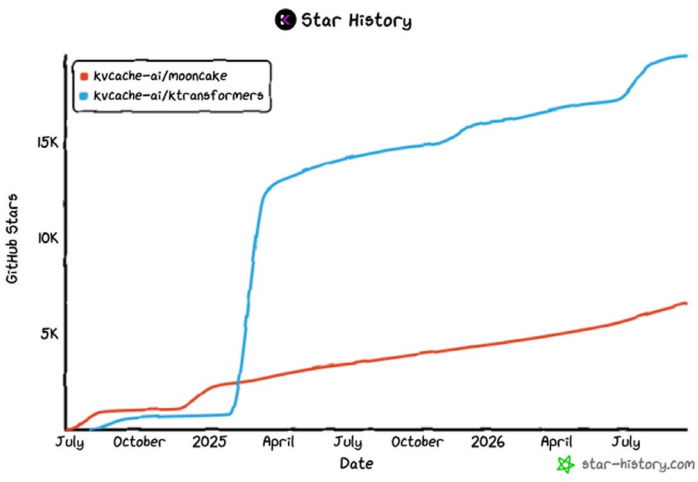



九源统一智能计算架构
The China9S Unified Artificial Intelligence Computing Architecture

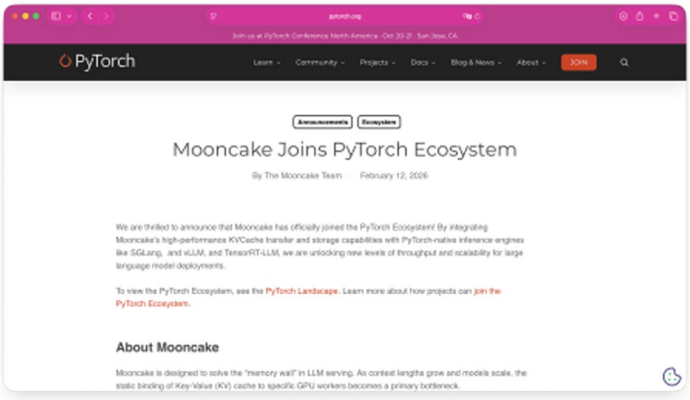
1.At the computing power level, the project pioneered the China9S Unified Intelligent Computing Architecture, resolving the long-standing fragmentation of hardware ecosystems and enabling AI models and applications to be “developed once and run across all platforms.” Furthermore, the project was the first in the world to accelerate LLM inference through heterogeneous CPU-GPU collaboration, making it possible for LLMs with more than 100B parameters to run on a single consumer-grade GPU. As a result, the corresponding open-source inference framework, namely KTransformers has accumulated over 19,000 GitHub stars, achieving significant global impact.

2.At the data provisioning level, the project was the first in the world to present the idea of “trading more storage for less computation” for LLM inference. The resulting Mooncake system has doubled the Kimi inference throughput on a 10,000-GPU cluster via distributed KV-Cache optimization, winning the Best Paper Award at FAST 2025. The China9S distributed graph database was the first in the world to complete the authoritative LDBC SNB SF3000 benchmark, and its throughput on the SF1000 ranks first worldwide.

3.At the application development level, the project developed a low-code intelligent development environment, which vastly improves development efficiency by shipping both a drag-and-drop algorithm toolbox and an integrated development mode. Specifically, the built-in mixed-source code security analysis tool has, for two consecutive years running, won the Concurrency Safety track championship at SV-COMP, the leading international software verification competition.




Mooncake 和 KTransformers 的开源星标增长情况
The Star History of Mooncake and KTransformers







Mooncake 和 KTransformers 并入 PyTorch 生态版图
Mooncake and KTransformers Join PyTorch Ecosystem

## 成果已实现规模化应用，获得用户和开源社区高度认可

## The Results Have Been Deployed at Scale, Earning High Recognition from Users and the Open-Source Community

除英伟达 GPU 外，九源统一智能计算系统已适配昇腾、寒武纪、昆仑芯等中国主流芯片及鲲鹏、飞腾等 CPU，支持 DeepSeek、Qwen 等上百种大小模型，落地 30 余家单位，应用成效显著：百度、华为、寒武纪等用户均认为九源性能表现出色，其推动了飞桨、昇腾的生态建设；图数据库在浪潮应急管理平台中提升 5 倍检索性能、降低 30% 时延，在中电科十五所场景提升数据导入吞吐 100 倍以上；中科院空天信息创新研究院借助九源显著缩短了开发周期，并将程序性能提升 2 倍以上。

项目开源生态效益尤为突出：Mooncake 与 KTransformers 的 GitHub 总星标超 2.6 万，吸引华为、阿里、字节、NVIDIA、Amazon 等共建；Mooncake 已集成至 vLLM、SGLang 框架，承载了 Kimi 近 4000 万月活用户推理，吞吐提升 1 倍以上；KTransformers 成为国际主流 DeepSeek 类 MoE 单机推理框架；二者均已并入 Torch 生态版图，中国唯 3 系统入选。

Beyond NVIDIA GPUs, the China9S Unified Artificial Intelligence Computing System has provided support for mainstream Chinese chips such as Ascend, Cambricon, and Kunlunxin, as well as CPUs such as Kunpeng and Phytium. It can efficiently run over 100 large and small AI models such as DeepSeek and Qwen. With deployment at more than 30 organizations, the system has shown significant impact. For example, Baidu, Huawei, and Cambricon all confirmed China9S' outstanding performance, pointing out that it has advanced the ecosystem development of PaddlePaddle and Ascend. The

application of China9S graph database showed a retrieval performance improvement by 5× and a latency reduction by 30% within the Inspur emergency management platform, and a data import throughput boost by more than 100× in the scenario of the North China Institute of Computing Technology. Leveraging the China9S low-code development environment, the Aerospace Information Research Institute, Chinese Academy of Sciences significantly shortened its development cycles while improving application performance by more than 2×.

The project's impact on the open-source ecosystem is especially notable. Mooncake and KTransformers have accumulated over 26,000 GitHub stars collectively, attracting joint contributions from Huawei, Alibaba, ByteDance, NVIDIA, and Amazon. Mooncake's core function has been integrated into the vLLM and SGLang frameworks, underpinning inference for Kimi's nearly 40 million monthly active users while doubling the inference throughput. KTransformers has become a leading international single-machine inference framework for DeepSeek-like MoE LLMs. They both have been officially incorporated into the PyTorch ecosystem, where only three Chinese systems have ever been selected for inclusion.

## 提供了统一智能计算的“中国方案”，通过技术开源与产业联盟双轮驱动，形成了具有国际影响力的智能计算生态

## Delivering a Chinese Solution for Unified Intelligent Computing, Driven by the Dual Engines of Open-Source Technology and Industry Alliances, and Forming an International Influential Intelligent Computing Ecosystem

1. 有力推动了智能计算技术进步

项目所突破的海量数据快速供应以及“以存换算”、异构协同等推理理念两获华为全球存储“奥林帕斯”奖，并斩获国际顶会 FAST 2025 最佳论文奖；MoonCake 与 KTransformers 开源后并入国际最具影响力的 Torch 生态版图；这些工作充分证明了成果的学术前沿性和产业价值。

2. 实质性推动了中国智能计算产业链的协同与结构升级

MoonCake 与 KTransformers 开源后吸引华为、阿里、字节 NVIDIA、Amazon 等共建生态，服务了月之暗面、阿里、京东、美团、腾讯、百度等企业数十万规模 GPU 环境，并被英伟达采用，实现了从技术突破到产业转化的完整闭环；发起成立九源智能计算系统生态联合体，打通了芯片、整机、操作系统厂商和科研机构全产业链协同攻关的通道，推动软硬件生态从分裂走向统一，获科技日报、中国青年报等媒体密集报道。


usenix
THE ADVANCED COMPUTING SYSTEMS ASSOCIATION

ERIK RIEDEL BEST PAPER AWARD

presented to

Ruoyu Qin, Zheming Li, Weiran He, Jialei Cui, Feng Ren, Mingxing Zhang, Yongwei Wu, Weimin Zheng, and Xinran Xu

for

Mooncake: Trading More Storage for Less Computation — A KVCache-centric Architecture for Serving LLM Chatbot

Presented at the 23rd USENIX Conference on File and Storage Technologies

Amy Rich
President

2/25/2025
Date

以存换算论文获 FAST 2025 最佳论文奖
The Mooncake paper won FAST 2025 Best Paper Award

1.Substantially advanced the progress of intelligent computing technology

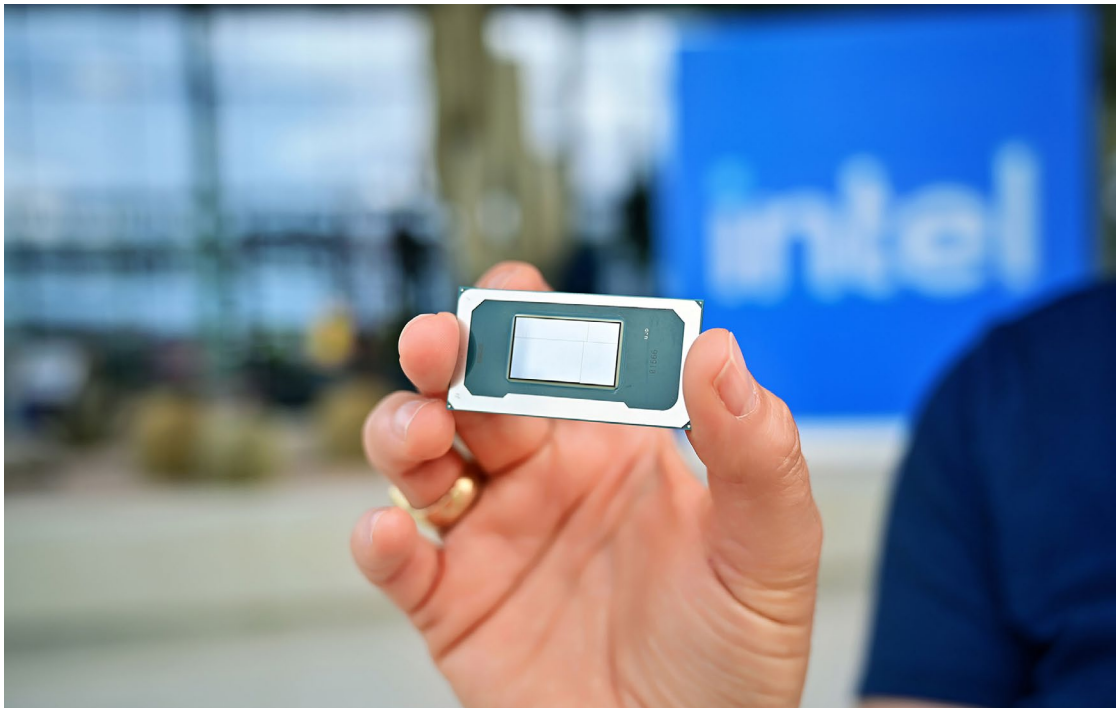
The project's breakthroughs in high-throughput data provisioning, along with ideas such as “Trading More Storage for Less Computation” and heterogeneous collaborative inference, twice won the Huawei OlympusMons Award, a leading global industry honor in data storage. Mooncake was honored with the Best Paper Award at FAST 2025, a premier international conference. After being open-sourced, Mooncake and KTransformers were incorporated into the PyTorch ecosystem, the most influential AI ecosystem in the world. These achievements fully demonstrate the project's academic merits and industrial value.

2.Substantively advanced the collaboration and structural upgrading of China's intelligent computing industry chain

Mooncake and KTransformers have attracted Huawei, Alibaba, ByteDance, NVIDIA, Amazon and so on to jointly build the ecosystem. The technologies have served hundreds of thousands of GPUs across enterprises including Moonshot AI, Alibaba, JD.com, Meituan, Tencent, and Baidu, and were also adopted by global tech titans like NVIDIA, achieving a complete loop from technological breakthrough to industrialization. The project also initiated the China9S Intelligent Computing Ecosystem Alliance, opening a channel for collaborative research and development spanning chip and server manufacturers, operating system vendors, and top-tier research institutions. The alliance's vision and effort — driving the software-hardware ecosystem from fragmentation toward unification — have drawn extensive coverage from media such as Science and Technology Daily and China Youth Daily.

# 基于英特尔 18A 制程技术的第三代酷睿 Ultra 处理器

## Intel Core Ultra Series 3 Processors Based on Intel 18A




第三代英特尔 ® 酷睿™ Ultra 处理器
Intel® Core™ Ultra Series 3 Processors

英特尔（中国）有限公司
Intel China Co., Ltd.

intel

## 引言

第三代英特尔 ® 酷睿™ Ultra 处理器是首款基于 Intel 18A 制程打造的计算平台，首次结合 RibbonFET 全环绕栅极与 PowerVia 背部供电技术，推动计算机迈入 1.8 纳米时代。

## Introduction

The Intel® Core™ Ultra Series 3 processors is the first compute platform built on Intel 18A. It combines RibbonFET Gate-All-Around (GAA) architecture with PowerVia backside power delivery for the first time, ushering personal computing into the 1.8-nanometer era.

## 首款基于 Intel 18A 制程的计算平台，将计算机带入 1.8 纳米时代

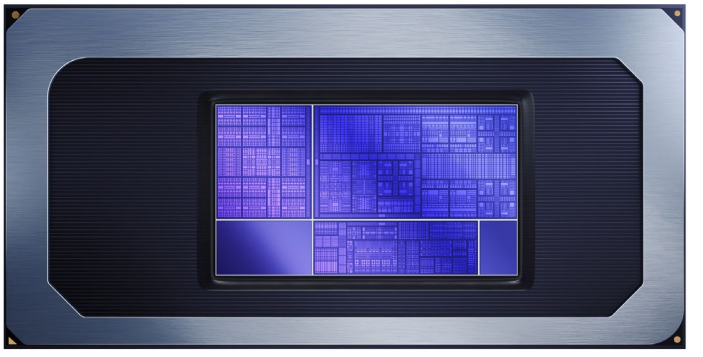
## First Intel 18A Computing Platform, Bringing Personal Computing into the 1.8-nanometer Era

第三代英特尔酷睿 Ultra 处理器从制程、架构与 AI 三个维度带来创新突破。

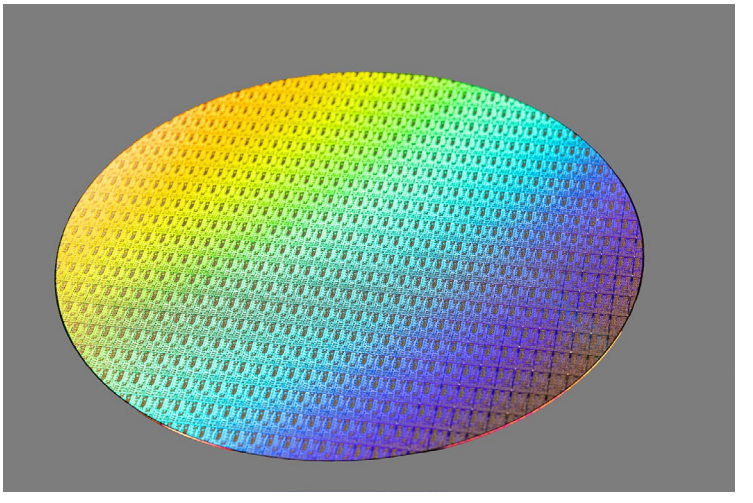
在制程层面，英特尔首次将 RibbonFET 全环绕栅极与 PowerVia 背面供电技术结合，通过优化晶体管微架构和信号走线，相比上一代制程工艺实现芯片密度提升超 30%、能效提升超 15%，奠定新一代晶体管微缩标准。

在架构层面，专为 AI 优化的 XPU 架构，将 12 个 Xe 单元集成于集显之中；三阶异构创新将性能核、能效核与低功耗能效核集成于同一计算芯片，配合全新线程调度器与内存侧缓存，实现从日常办公到重度负载的精准能效调配。游戏性能相比上一代最高提升 77%，续航最高达 27 小时。

在 AI 层面，平台为智能体 AI 提供强大本地算力，NPU 5 提供 50 TOPS 算力，配合 Xe3 GPU 与增强 CPU 带来最高 180 TOPS 平台级 AI 算力。



第三代英特尔 ® 酷睿™ Ultra 处理器
Intel® Core™ Ultra Series 3 processors



第三代英特尔酷睿 Ultra 晶圆
Intel Core Ultra Series 3 Wafer

The Intel Core Ultra Series 3 processors delivers breakthrough innovations across process, architecture, and AI dimensions.

At the process level, Intel pioneers the combination of RibbonFET Gate-All-Around (GAA) transistors and PowerVia backside power delivery for the first time. With innovative transistor architecture and optimized interconnect, it achieves a generational leap on process node with over 30% chip density improvement and over 15% power efficiency gains, establishing the foundation for new-generation transistor scaling.

At the architectural level, the AI-optimized XPU architecture integrates 12 Xe-cores directly into the iGPU. The innovative three-tier heterogeneous design integrates P-cores, E-cores, and LP E-cores within a single chip, complemented by an advanced thread scheduler and memory-side cache, enabling precise power-performance orchestration from everyday productivity to intensive workloads. Core Ultra Series 3 achieves up to a 77% leap in gaming performance compared to the previous-generation, and delivers up to 27 hours of battery life.

In AI, the platform provides robust on-device compute power engineered natively for Agentic AI. The new NPU 5 delivers 50 TOPS of dedicated AI performance, combined with Xe3 GPU and enhanced CPU, it forms an 180 TOPS platform-level AI engine.

## 支持全球 200 余款 PC 设计，拓展 AI PC 多元应用场景
## Enabling Over 200 PC Designs Worldwide and Expanding AI PC across Diverse Scenarios

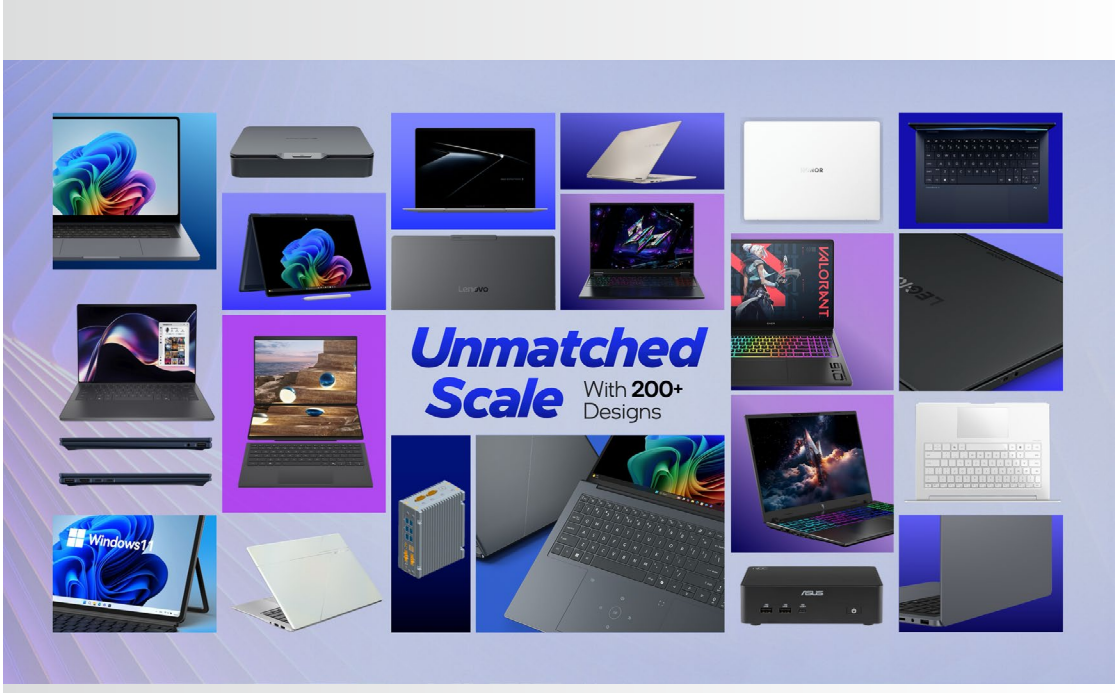
第三代英特尔酷睿 Ultra 处理器已获全球领先合作伙伴采用并支持 200 余款 PC 产品设计，并在中国、美国、欧洲、日本、韩国及东南亚等国家和地区大规模出货。产品涵盖轻薄本、商用本、游戏本和一体机等形态，面向消费、商用及边缘计算等场景，展现出良好的应用拓展基础。

依托 CPU、GPU、NPU 协同及最高 180 TOPS 平台级 AI 算力，该平台支持在本地高效运行各类 AI 模型。同时该平台支持的混合 AI 架构，通过对 AI 任务进行智能化路由与分发，直接针对云端算力成本高昂的行业痛点，确保企业能够以高性价比、高安全性的方式实现 AI 部署的规模化扩展。

这将为用户带来实时、个性化且高度隐私的安全体验，帮助终端用户、开发者和企业提升效率和成本等多维度价值。

Intel Core Ultra Series 3 processors have been adopted by global leading OEMs for more than 200 PC designs and are shipping at scale in countries and regions including China, the United States, Europe, Japan, South Korea and Southeast Asia. The systems span a range of form factors, including thin-and-light laptops, commercial PCs, gaming laptops and all-in-one PCs, serving consumer, commercial, and edge-computing markets, demonstrating a broad potential for further application scalability.

With coordinated CPU, GPU and NPU performance and up to 180 TOPS of AI compute, the platform enables the efficient running of diverse AI models on-device. Furthermore, its native Hybrid AI architecture dynamically routes and dispatches AI workloads. This directly tackles the critical industry pain point of escalating cloud compute costs, empowering enterprises to scale AI cost-effectively and securely.
This translates into a real-time, personalized, and privacy-protected experience that delivers multi-dimensional value in efficiency and cost reduction across end users, developers, and enterprises.




第三代英特尔酷睿 Ultra 处理器支持 200 余产品设计
Intel Core Ultra Series 3 Scaling With 200+ Designs

## 从 PC 到边缘设备，加速 AI 落地生花
## From PC to the Edge, Accelerating AI Scaling across Rich Scenarios

基于最新 Intel 18A 制程工艺以及创新的芯片架构，第三代英特尔酷睿 Ultra 处理器涵盖了多款强大的移动处理器，在一代平台上集中展现了跨代际的性能飞跃，同时，能效也实现大幅提升，推动 AI PC 真正迈入全天候的长效续航时代。

在广泛的生态部署中，第三代英特尔酷睿 Ultra 处理器也在加速 AI 在具身智能、智慧城市、自动化与医疗领域的应用落地，同时以开放的 AI 工具链与边缘计算能力，为中国智能制造、自动驾驶、机器人等本土创新场景提供底层算力支撑，促进跨端技术融合与产业数字化升级。

Powered by the latest Intel 18A process technology and innovative architecture, the Intel Core Ultra Series 3 processors encompass a powerful lineup of mobile processors, delivering leaps in compute power that was previously realized through multi-generation. By pairing outstanding graphics capabilities with massive efficiency gains, it drives AI PCs into an era of uncompromising, all-day battery life.

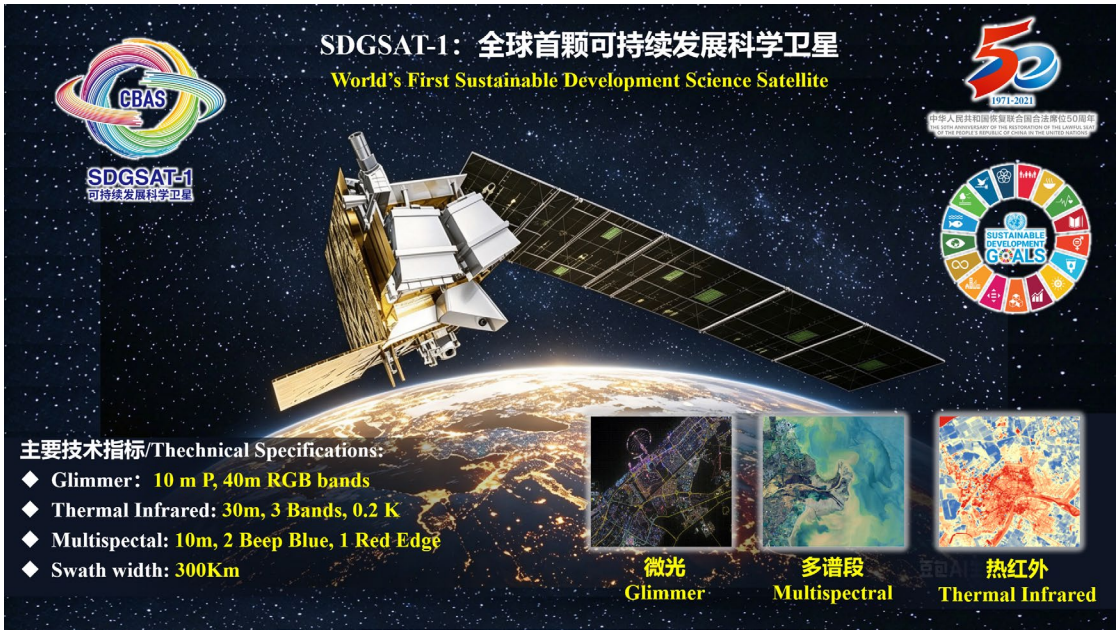
Across broad ecosystem deployments, the platform is also accelerating the real-world adoption of AI across embodied AI, smart cities, industrial automation, and healthcare. Furthermore, its open AI toolchain and edge computing capabilities provide foundational compute support for China's local innovation scenarios in smart manufacturing, autonomous driving, and robotics, fostering cross-terminal technology convergence and industrial digital transformation.




面向边缘的第三代英特尔酷睿 Ultra 处理器
Intel Core Ultra Series 3 at the Edge

# 可持续发展科学卫星 1 号（SDGSAT-1）

## Sustainable Development Goals Science Satellite 1 (SDGSAT-1)




可持续发展科学卫星 1 号（SDGSAT-1）
Sustainable Development Goals Science Satellite 1 (SDGSAT-1)

中国科学院空天信息创新研究院
Aerospace Information Research Institute, Chinese Academy of Sciences

可持续发展大数据国际研究中心
International Research Center of Big Data for Sustainable Development Goals

中国科学院微小卫星创新研究院
Innovation Academy for Microsatellites, Chinese Academy of Sciences

中国科学院上海技术物理研究所
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中国科学院长春光学精密机械与物理研究所
Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences

中国地质大学（北京）
China University of Geosciences (Beijing)

## 引言

从太空评估全球可持续发展目标（SDGs）动态进展是助力联合国 2030 年可持续发展议程实施的创新技术，SDGSAT-1 卫星通过对光 - 热 - 水等要素协同探测，实现人类活动痕迹精细刻画，开创了可持续发展空间观测的新局面。

## Introduction

Assessing the dynamic progress of the global Sustainable Development Goals (SDGs) from space represents an innovative technology to support the implementation of the United Nations 2030 Agenda for Sustainable Development. By conducting synergistic observations of key elements including light, heat and water, the SDGSAT-1 satellite enables the precisely depicting traces of anthropic activities, pioneering a new approach for space-based observation of sustainable development.

## 全球首颗可持续发展科学卫星，综合性能国际领先
## The World's First Sustainable Development Science Satellite with World-Leading Overall Performance

1. 面向全球可持续发展战略需求，提出人类活动空间观测理念，综合“光 - 热 - 谱”等参量，设计了微光、热红外和多谱段协同探测卫星工程系统，构建了人 - 地作用 SDGs 监测评估新方法，开创了人类活动空间探测新途径。

2. 创建了三谱段长波热红外长线列双向摆扫成像体制，突破大口径全光路深低温光机系统等关键技术，研制了 30 米最高 30mK 等效温差热红外成像仪，“核心指标国际领先”。

3. 首创夜间微光与日间多谱段一体化成像体制与大动态共光路昼夜协同探测技术，突破共焦面窗口时序分割与动态卷帘曝光等关键技术，成功研制了国际首台 10 米多谱段与 10 米全色 /40 米彩色微光成像仪，填补宽幅高清彩色微光探测空白。

4. 突破多载荷异化同步精细控制、多模分区精细温控及大扰动非平衡姿轨稳定等关键技术，成功研制全球首颗可持续发展科学卫星，“综合性能国际领先”。

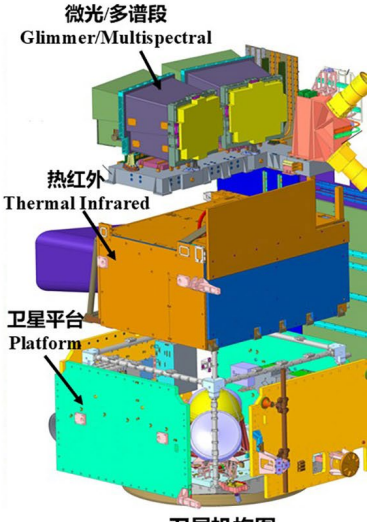
1. To meet the global strategic needs for sustainable development, the concept of space-based observation of anthropic activities was proposed. Integrating parameters of light, heat, and spectrum, the satellite engineering system with coordinated detection by glimmer, thermal infrared, and multispectral payloads was designed. A new method for monitoring and evaluating SDGs related to human-nature interactions was established, opening up a novel approach to space-based detection of human activities.

2. A three-band long-wave thermal infrared long-linear-array bidirectional whisk-broom imaging system was created. Breakthroughs were achieved in key technologies such as large-aperture full-optical-path deep-cryogenic opto-mechanical systems, leading to the development of a Thermal Infrared Spectrometer with a spatial resolution of 30 m and a noise-equivalent temperature difference (NETD) as low as 30 mK, with core specifications being internationally leading.

3. This project pioneered an integrated imaging system for nighttime glimmer and daytime multispectral observation, together with a large-dynamic-range




影像展示
Imagery Display




卫星机构图
Satellite structural diagram

common-optical-path day-night cooperative detection technology. Key technologies including focal-plane window time-division imaging and high-speed dynamic rolling-shutter exposure were conquered, resulting in the world's first Glimmer Imager featuring 10-m multi-spectral, 10-m panchromatic/40-m color nighttime light capabilities, thereby filling the gap in wide-swath high-resolution color glimmer detection.

4. Breakthroughs were made in key technologies such as coordinated fine control of multiple payloads with different operating modes, multi-zone fine temperature control, and high-stability attitude and orbit control under large disturbances and unbalanced structures. These advances led to the successful development of the world's first sustainable development science satellite, with overall performance being internationally leading.

## 支撑 11 个 SDGs 监测评估，服务 119 个国家可持续发展研究与决策

## Supporting the Monitoring and Assessment of 11 SDGs and Sustainable Development , Research and Decision-Making in 119 Countries

截至 2026 年 9 月，全球 119 个国家使用 54 万余景 SDGSAT-1 数据与产品，支持 11 个 SDGs 监测评估，发表 SCI 论文 241 篇并专著 4 部，授权发明专利 77 项，在联合国发布 SDGs 报告 17 份，获联合国教科文组织感谢信等 103 份。生产并发布金砖、非洲国家及欧洲光污染数据产品，联合国优选数据开展 21 个小岛屿国家 SDG 评估。

入选《中非合作论坛 - 北京行动计划（2025-2027）》、全球发展倡议 5 周年 3 大成果、列为“习近平主席提出构建人类命运共同体理念十周年”实际行动。获 2025 中关村论坛重大科技成果奖、2024 上海技术发明一等奖、2023 测绘科技特等奖。第一完成人被授予国际宇航联合会“名人堂”奖、获国际科学理事会“可持续发展科学奖”、被联合国秘书长聘为“联合国可持续发展目标技术促进机制 10 人组”成员。

Through the “SDGSAT-1 Open Science Program,” over 540,000 scenes of global data have been shared with 119 countries, supporting the monitoring and assessment of 11 SDGs. These efforts have contributed to the publication of 241 SCI papers, 4 books, and 77 authorized invention patents, as well as 17 SDG reports released at the United Nations, and over 100 acknowledgment letters from institutions including UNESCO. Data products have been produced and released for BRICS countries, African nations, and European light pollution mapping. The satellite data have been selected by the UN for SDG assessments in 21 Small Island Developing States (SIDS). The achievements have been featured in the Forum on China-Africa Cooperation Beijing Action Plan (2025–2027), recognized as one of the three major outcomes of the fifth anniversary of the Global Development Initiative, and listed as a concrete action for the







构建了人-地作用SDGs监测评估新方法

New method for monitoring the SDGs related to human-environment interaction

tenth anniversary of the vision of building a community with a shared future for mankind proposed by Chinese President XI Jinping. The project has received the 2025 Major Scientific and Technological Achievement Award at the Zhongguancun Forum, the 2024 First Prize of Shanghai Technological Invention Award, and the 2023 Special Prize of Surveying and Mapping Science and Technology. The first completer has been honored with the International Astronautical Federation (IAF) Hall of Fame Award, the International Science Council (ISC) Sustainable Development Science Award, and has been appointed by the UN Secretary-General as a member of the 10-Member Group of the Technology Facilitation Mechanism for the Sustainable Development Goals.

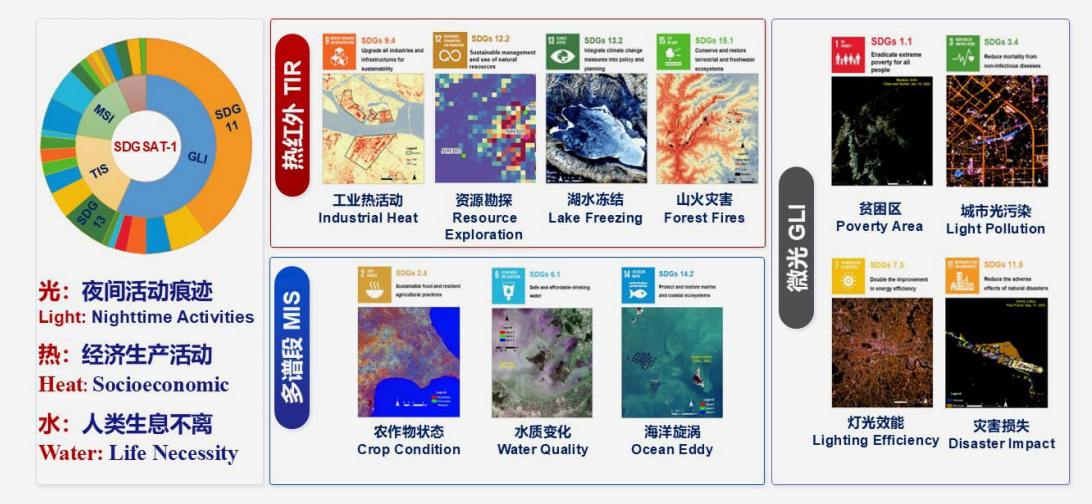
## 开创人类活动空间观测新方向，引领航天产业升级与全球治理服务

## Pioneering a New Direction in Space-Based Observation of Human Activities to Drive Aerospace Industry Upgrading and Serve Global Governance

开创“人类活动空间观测”新方向，构建“光 - 热 - 谱”全天时协同探测体制，确立中国在该领域的开创性领先地位。推动对地观测技术跨越式突破，载荷平台质量比达 1，显著提升微小卫星承载能力与指向精度。微光与热红外性能国际领先，核心组件实现自主供应，产业链韧性显著增强。催生可持续发展监测新业态，形成“数据获取—分析反演—评估服务”全产业链，推动行业从“售卖影像”向“提供解决方案”升级。在联合国、非洲及小岛屿国家实现规模化应用，推动中国空间数据服务全球。

The project pioneers a new direction in space-based observation of human activities and establish an all-time collaborative detection system integrating light, heat, and spectrum, securing China’s pioneering leading position in this field. It drives a leapfrog breakthrough in Earth observation technologies, achieving a payload-to-platform mass ratio of 1, which significantly enhances the carrying capacity and pointing accuracy of small satellites. The performance of the glimmer and thermal infrared sensors is internationally leading; where core components are now independently supplied, markedly strengthening the resilience of the industrial chain.

The project fosters a new industrial format for sustainable development monitoring, forming a full industrial chain covering data acquisition, analytical inversion, and assessment services, and driving the industry to upgrade from selling images to providing solutions. It has promoted large-scale application in the United Nations, Africa, and Small Island Developing States, expanded the global reach of geospatial data services.




SDGSAT-1 开拓了丰富的研究领域和应用场景
SDGSAT-1 has opened up a wide range of research fields and application scenarios

## 有效支撑全球发展倡议等国家战略实施，可持续发展治理

## Effectively Supporting National Strategies Such as the Global Development Initiative and Serving the Vision of Global Sustainable Development

第 77 届联合国大会主席克勒希·乔鲍、联合国常务副秘书长阿明娜·穆罕默德、国际科学理事会主席彼得·格卢克曼分别到访并对卫星成果给高度肯定。克勒希评价为：在空间技术领域取得突破性进展，在支撑全球可持续发展领域发挥了引领作用，为人类共同事业做出卓越贡献。

The President of the 77th United Nations General Assembly, Csaba Kőrösi, the Deputy Secretary-General of the United Nations, Amina J. Mohammed, and the President of the International Science Council, Peter Gluckman, each visited and highly commended the satellite's achievements. Kőrösi commented: "As a remarkablec ontribution to humanity's joint endeavor, SDGSAT-1 makes the breakthrough and takes the leading role in the field of space technology to support the global sustainable development."




**中国将开展可持续发展卫星星座计划，研制并分享可持续发展目标监测数据及信息。**

**Launching a Sustainable Development Satellite Constellation Plan, developing and sharing data and information for Sustainable Development Goals monitoring.**

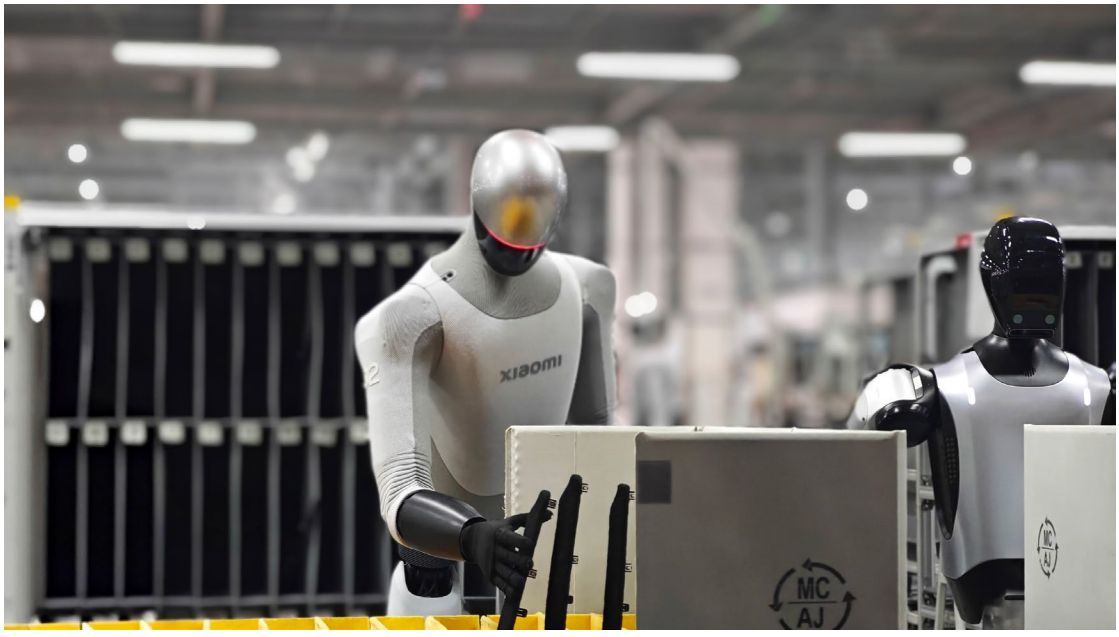
全球发展高层对话会主席声明成果清单任务，2022 年 6 月 24 日
Deliverables of the High-level Dialogue on Global Development, 24 June 2022




2026WORLD
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CONFERENCE

# 面向规模化落地的通用机器人操作基座模型关键技术

## Key Technologies of General-Purpose Robotic Manipulation Foundation Models for Scalable Deployment




小米人形机器人在中控台侧盖板排序连续作业
Xiaomi's humanoid robot performing continuous sorting of center console side covers

小米集团
Xiaomi Corporation

## 引言

小米建立面向通用操作的机器人具身基座模型及在多任务跨场景下规模化应用体系，核心为小米研发的 VLA 基座模型，并对工业制造与生活服务典型场景进行落地探索，构建“技术研发 - 场景应用 - 产业协同”完整生态闭环。

## Introduction

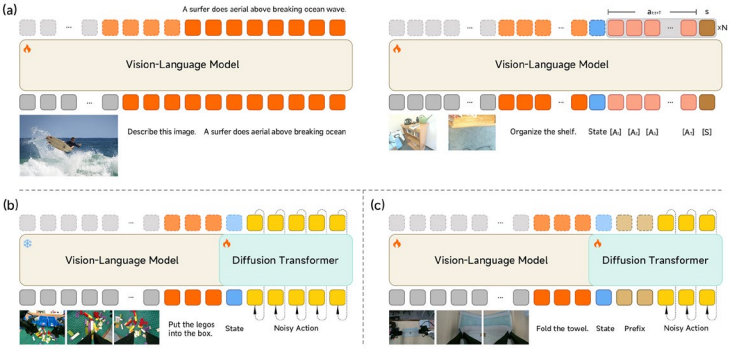
Xiaomi has established a robotic embodied foundation model for general-purpose manipulation and a comprehensive multi-task, cross-scenario large-scale application system. The system is centered on Xiaomi's self-developed VLA foundation models, with exploratory deployments carried out in representative industrial manufacturing and life services scenarios, building an integrated ecosystem that connects technology R&D, real-world deployment, and industry collaboration.

## 面向通用操作的机器人具身基座模型
## An Embodied Foundation Model for General-Purpose Robotic Manipulation

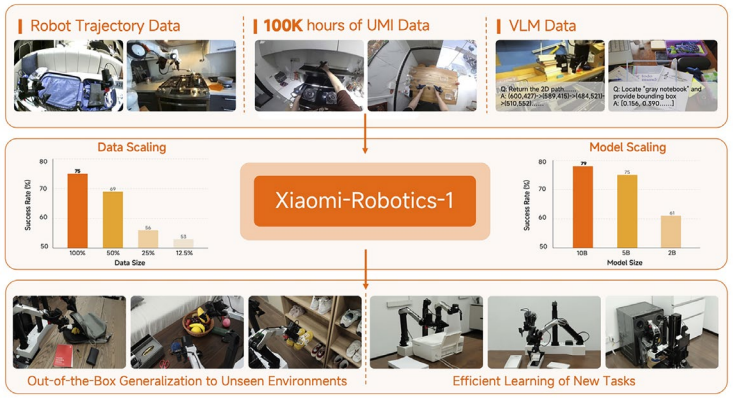
小米研发的 VLA 基座模型，产出 47 亿参数 Xiaomi-Robotics-0(XR0) 与 80 亿参数 Xiaomi-Robotics-1(XR1) 端侧模型。并在工业制造与生活服务典型场景进行落地探索。是全球首批在汽车工站真实环境中，匹配真实产线 76S 节奏，完成 3 小时连续作业的机器人。同时在小米青年公寓开展小范围生活服务试点，构建“技术 - 产品 - 场景 - 数据”闭环。

XR0 基座模型采用“大脑 + 小脑”混合架构，VLM 作“大脑”理解指令与空间关系，DiT 作“小脑”通过流匹配生成高频平滑动作块，在消费级显卡实现 80 毫秒低延迟推理。训练层面，引入 Action Proposal 机制实现特征空间与动作空间对齐，两阶段训练使模型在精通操作的同时完整保留多模态理解能力，消融实验证明该方法首次有效解决 VLA 领域长期存在的 " 能力遗忘 " 问题。推理层面，提出 Λ 形注意力掩码，强制模型关注当下视觉反馈而非照搬历史动作，首次成功应用于 VLA 动作生成，方法简洁可解释。

XR1 在 XR0 基础上进一步拓展数据与训练规模：使用了 10 万小时真实世界操作轨迹进行预训练，并结合跨本体数据完成后训练，在未见环境真实机器人任务中展现稳定的规模化收益、在复杂新任务适配和多个仿真基准中展现出强大的性能。




XR0 模型架构及训练方法：(a) VLM 多模态与动作混合预训练；(b) DiT 专项预训练；(c) 目标任务后训练
XR0 Model Architecture and Training Methodology: (a) VLM multimodal and action hybrid pre-training; (b) DiT specialized pre-training; (c) Downstream task post-training




Xiaomi-Robotics-1

Xiaomi's self-developed VLA foundation models have produced two on-device models: the 4.7-billion-parameter Xiaomi-Robotics-0 (XR0) and the 8-billion-parameter Xiaomi-Robotics-1 (XR1), with exploratory deployments in industrial manufacturing and life services. Xiaomi is among the first globally to achieve continuous 3-hour robotic operation at real automotive workstations, matching a real production-line cycle time of 76 seconds. A small-scale life services pilot has also been launched at Xiaomi's youth apartment complex, establishing a closed-loop process linking technology, products, real-world applications, and data.

XR0 adopts a hybrid “brain + cerebellum” architecture: a VLM serves as the “brain” for instruction understanding and interpreting instructions and spatial relationships, while a DiT serves as the “cerebellum”, generating high-frequency, smooth action chunks via flow matching — all at an inference latency of 80 ms on consumer-grade GPUs. On the training side, an Action Proposal mechanism aligns the feature space with the action space; a two-stage training strategy enables the model to master manipulation tasks while fully preserving its multimodal understanding capability. Ablation studies confirm this method is the first to effectively resolve the long-standing “catastrophic forgetting” problem in the VLA domain. On the inference side, a Λ-shaped attention mask is introduced, forcing the model to attend to current visual feedback rather than replaying historical actions — a technique successfully applied to VLA action generation for the first time, with a clean and interpretable design.

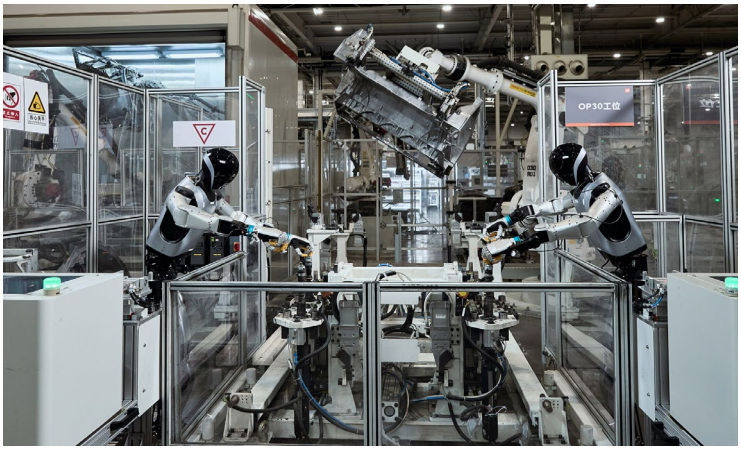
XR1 further scales up data and training on the basis of XR0: pre-training on 100,000 hours of real-world manipulation trajectories, combined with cross-embodiment data for post-training. It demonstrates stable, positive scaling gains on real-robot tasks in previously unseen environments and exhibits strong performance in adapting to complex new tasks and multiple simulation benchmarks.

## 建立多任务跨场景下规模化应用体系
## Building a Scalable Deployment Framework Across Tasks and Scenarios

本成果坚持“开源共享、消费级部署、多场景落地”三位一体推进路径。

XR0 已在主流开源社区 HuggingFace 开源模型权重与完整后训练流程，模型总下载次数超过 8000 次，Github 代码仓库星标数超过 600 次，80 毫秒实时推理运行于单张消费级显卡，无需数据中心级算力，将复现门槛降至单机微调部署级别，惠及高校实验室、中小机器人团队与初创企业。

小米人形机器人已在真实汽车工厂进行多工站规模化验证，从 300 + 工站智能制造场景实地选择：自攻螺母上件工站连续运行 3 小时、双侧安装成功率 98%、满足最快 76 秒产线节拍；中控台侧盖板排序与料箱折叠回收工站均达 90% 成功率；验证了 VLA 基座模型在工业级 “生产节拍 + 合格率” 双重硬约束下的实用价值。拓展生活服务场景，在小米青年公寓启动试点，将 VLA 基座部署于真实居住环境，试点覆盖公共空间整理等任务，验证半结构化生活场景下的泛化能力，按 “无感运维 — 直接服务 — 私密空间进驻” 三阶段稳步推进。




小米人形机器人自攻螺母上件工站连续运行 3 小时、双侧安装成功率 98%

Xiaomi's humanoid robot ran continuously for 3 hours at the self-tapping threaded insert nut loading station, achieving a 98% success rate for installation on both sides




小米人形机器人在料箱折叠回收工站双机协作

Xiaomi's humanoid robots performing collaborative dual-robot operation at the crate folding and recycling station

This achievement follows a three-pillar approach of “open-source sharing, consumer-grade deployment, and multi-scenario implementation.”

XR0 has been open-sourced on the mainstream community platform Hugging Face, releasing model weights and the complete post-training pipeline. The model has accumulated over 8,000 downloads, and its GitHub repository has surpassed 600 stars. Running real-time inference at 80 ms on a single consumer-grade GPU — requiring no data-center-scale compute — it lowers the reproducibility barrier to single-machine fine-tuning and deployment level, benefiting university labs, small-to-medium robotics teams, and startups.

Xiaomi's humanoid robot has undergone large-scale multi-station validation at a real automotive factory, with the deployment scenario selected from over 300 smart manufacturing workstations. At the self-tapping threaded insert nut loading station, it achieved 3 hours of continuous operation with a 98% success rate for installation on both sides, meeting the fastest 76-second production-line cycle time. At the center console side, cover sorting and crate carton folding and collection, it reached a 90% success rate — demonstrated the practical value of the VLA foundation model under industrial-grade dual constraints of production cycle time + pass rate.

In life services scenarios, a pilot program has been launched at Xiaomi's youth apartment complex, deploying the VLA foundation model in a real residential environment. The pilot covers tasks such as public space tidying, validating generalization capability in semi-structured living environments, and will advance steadily through three phases: zero-touch maintenance-direct service-private space entry.

## 借助开源生态实现技术普惠与行业共建
## Broadening Technology Access and Advancing Industry Collaboration Through an Open-Source Ecosystem

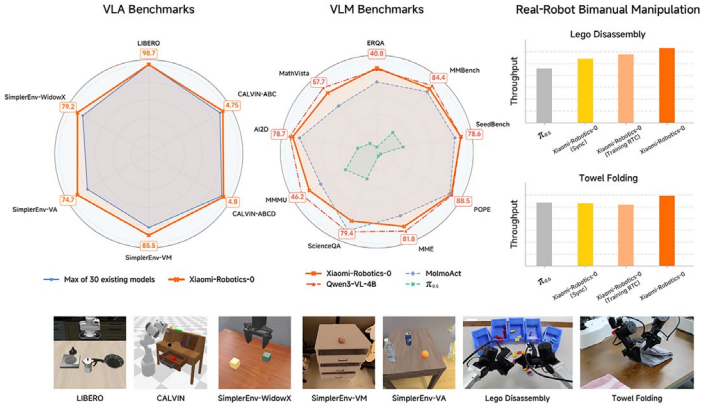
本成果创新构建 “基座模型 + 多任务实地落地” 一体化体系，借助开源生态实现技术普惠与行业共建。

XR0 在实时异步执行与视觉 - 语言能力保留两条正交维度给出可复用方案；XR0 在 LIBERO、CALVIN、SimplerEnv 三大国际主流仿真基准的 30 余种模型对比中全面取得当前最优（截止到 2026-02-12），成为该方向近期研究横向对比的前沿基线。XR1 在 Robocasa365 和 RoboDojo 两大具身智能权威榜单中综合排名第一（截止到 2026-07-16）。坚持开源共享，进行完整后训练体系开源，加速 VLA 技术跨主体、跨领域扩散，带动具身智能产业技术升级与生态共建。

推动产业实现从 “单次高效运行” 到 “实时部署” 的跨越式发展，深耕推理时延、消费级硬件、动作连贯性等工程关键能力，加速具身智能在制造、服务、家庭等场景落地。

通过机器人在生产场景的落地探索及多工站跨场景应用，工站作业成功率均在 90% 及以上，积累真实场景数据，反哺模型迭代优化，形成 “数据积累 — 模型优化 — 成本降低” 的正向循环，助力制造业向智能制造转型。

牵头制定人形机器人数据集、数据格式及评测体系等关键标准，规范行业发展秩序，提升产业整体研发与协同效率。

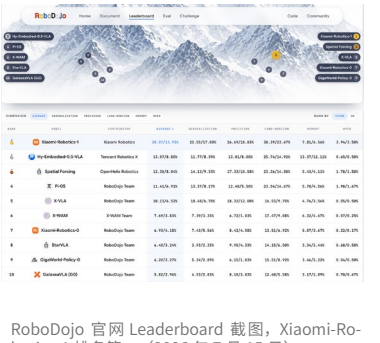



XR0 在 VLA、VLM 的 Benchmark 以及真实机器人的效果指标（截止到 2026-02-12）
XR0 Performance on VLA and VLM Benchmarks and Real-Robot Tasks (as of 2026-02-12)

Leaderboard

| Rank | Policy | Overall | Atomic-Seen | Composite-Seen | Composite-Unseen |
|---|---|---|---|---|---|
| | Xiaomi-Robotics-1 | 57.4 | 80.2% | 57.1% | 32.1% |
| | ABot-M0.6 | 46.6 | 79.4% | 48.3% | 7.9% |
| | ABot-M0.5 | 40.3 | 75.6% | 37.7% | 3.3% |
| #4 | RLDX-1 | 36.0 | 67.6% | 27.9% | 8.5% |
| #5 | WorldDreamer | 35.3 | 66.3% | 26.7% | 9.0% |
| #6 | GR00T N1.5 | 23.9 | 50.7% | 14.8% | 2.7% |
| #7 | GR00T N1.6 | 21.9 | 51.1% | 9.4% | 1.7% |
| #8 | GigaWorld-Policy 0.1 | 20.7 | 44.4% | 11.8% | 2.9% |
| #9 | π0.5 | 16.9 | 39.6% | 7.1% | 1.2% |
| #10 | π0 | 14.8 | 34.6% | 6.1% | 1.1% |
| #11 | Diffusion Policy | 6.1 | 15.7% | 0.2% | 1.3% |

RoboCasa365 官网 Leaderboard 截图，Xiaomi-Robotics-1 排名第一（2026 年 7 月 15 日）
Screenshot of the official RoboCasa365 leaderboard, with Xiaomi-Robotics-1 ranked first (July 15, 2026)



RoboDojo 官网 Leaderboard 截图，Xiaomi-Robotics-1 排名第一（2026 年 7 月 15 日）
Screenshot of the official RoboDojo leaderboard, with Xiaomi-Robotics-1 ranked first (July 15, 2026)

This achievement pioneered an integrated system of foundation model + multi-task real-world deployment, leveraging the open-source ecosystem to achieve technological accessibility and industry-wide co-building.

XR0 delivers reusable solutions along two orthogonal dimensions: real-time asynchronous execution and vision-language capability preservation. In comparisons involving more than 30 models across three leading international simulation benchmarks — LIBERO, CALVIN, and SimplerEnv — XR0 achieves state-of-the-art results across the board (as of 2026-02-12), establishing it as a key baseline in recent research in this area. XR1 ranks first overall on two authoritative embodied intelligence leaderboards — Robocasa365 and RoboDojo (as of 2026-07-16). By open-sourcing the complete post-training pipeline, we accelerate cross-embodiment and cross-domain diffusion of VLA technology, driving technology upgrades and ecosystem co-building across the embodied intelligence industry.

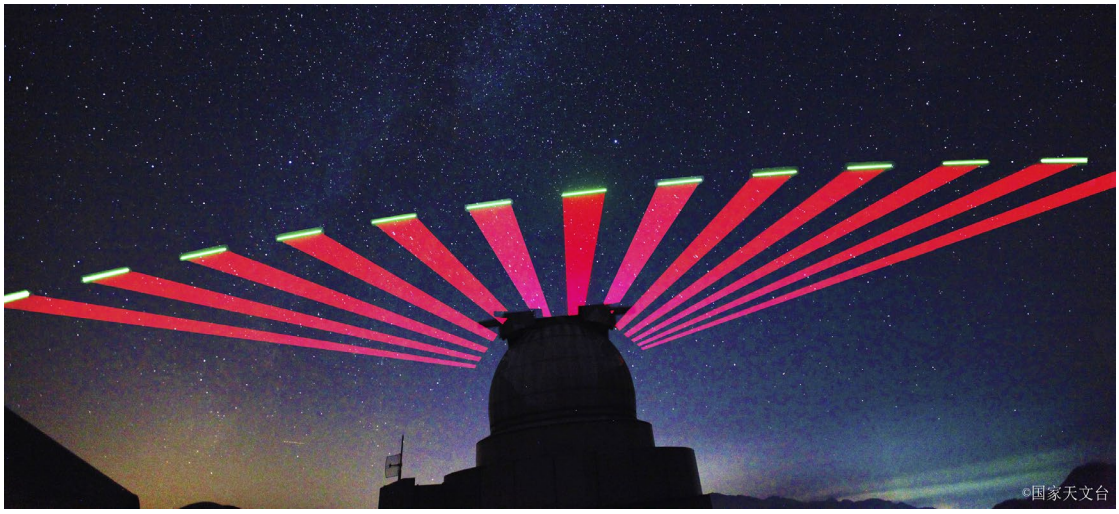
We are pushing the industry toward a leap from “single high-performance” runs to “real-time deployment”,focusing on critical engineering capabilities including inference latency, consumer-grade hardware , and action coherence, accelerating the landing of embodied intelligence in manufacturing, service, and home scenarios.

Through the robot’s exploratory deployment in production scenarios and cross-station, cross-scenario applications — with task success rates of at least 90% across all workstations— we accumulate real-world scenario data to feed back into model iteration and optimization, forming a positive loop of “data accumulation— model optimization— cost reduction,” empowering the transformation of manufacturing toward smart manufacturing.

We take the lead in formulating key standards for humanoid robot datasets, data formats, and evaluation systems, standardizing industry development and enhancing overall R&D and collaboration efficiency across the sector.

# 面向空间量子信息的光传输技术及应用

## Optical Transmission Technologies and Applications for Space Quantum Information




量子科学实验卫星“墨子号”与地面站之间建立千公里级量子光传输链路

A kilometer-scale satellite-to-ground quantum optical transmission link is established between the quantum science satellite Micius and ground stations

中国科学院上海技术物理研究所
Shanghai Institute of Technical Physics, Chinese Academy of Sciences

中国科学技术大学
University of Science and Technology of China

上海国科航星量子科技有限公司
Shanghai Guoke Hangxing Quantum Technology Co., Ltd.

## 引言

面对地面光纤信道衰减与地表曲率带来的距离瓶颈，本成果攻克卫星高速运动下单光子级极弱信号的星地光传输难题，构建天地一体的量子光传输体系，为覆盖全球的广域量子通信网络提供核心技术与工程支撑。

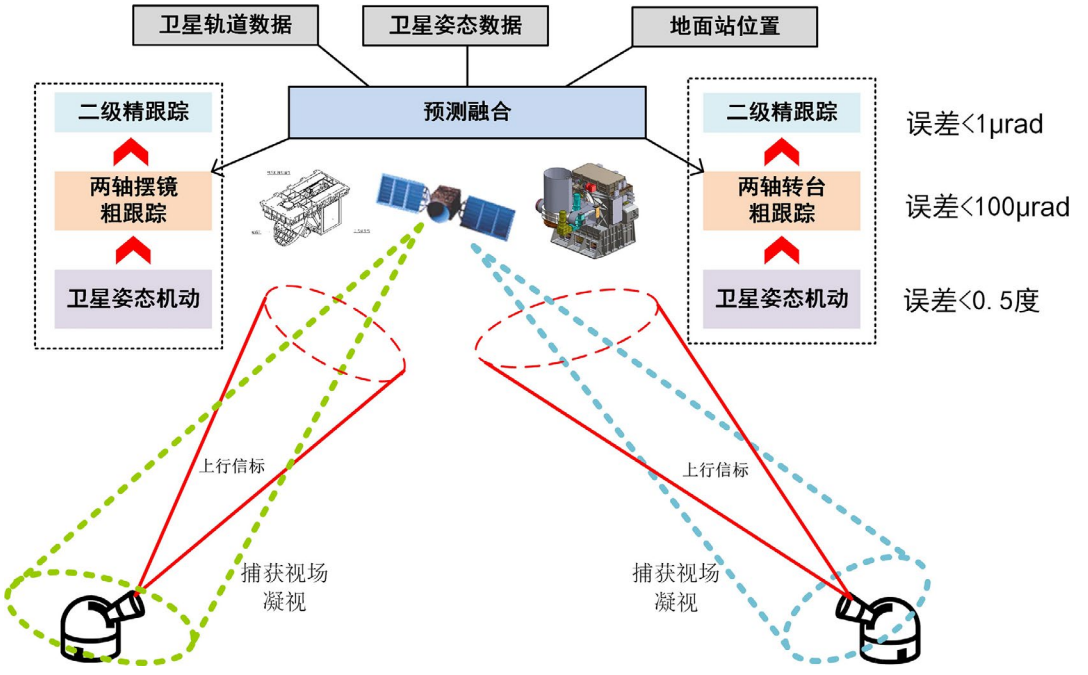
## Introduction

Terrestrial fiber channels suffer from signal attenuation and the curvature of the Earth, which limit quantum communication to a few hundred kilometers. This achievement overcomes the challenge of transmitting extremely weak single-photon signals between fast-moving satellites and ground stations, building an integrated space-to-ground optical transmission system that supports a global wide-area quantum communication network.

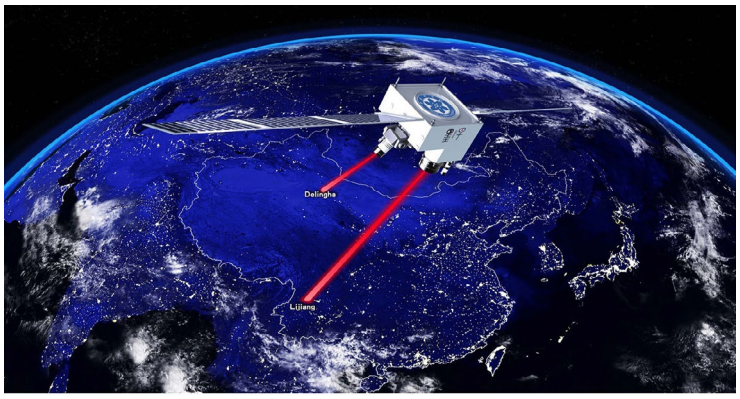
## 亚微弧度级星地量子光链路构建技术
## Sub-microradian-level Satellite-to-Ground Quantum Optical Link Construction Technology

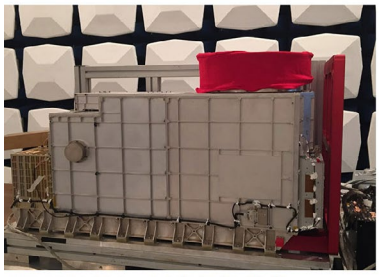
量子通信以单光子为信息载体，但光纤信道衰减与地表曲率使其有效传输距离难以突破千公里级，必须依托卫星平台实现星地传输。本成果历经十余年攻关，突破三大核心技术：其一，发明可变开窗面阵探测器快速鲁棒捕获与高精度复合跟踪技术，国际首次实现千公里级“一星对双站”的稳定捕获与光轴精确指向；其二，提出保偏膜系、偏振调控与天地偏振基矢对准方法，解决单光子偏振态高保真传递难题；其三，构建多源信号一体化复用载荷架构，将光电跟瞄、量子通信与经典激光通信集成于单一卫星载荷，兼容信号强度跨度超 10 个数量级的各类光信号。核心指标达到国际领先水平：链路捕获时间 1.1 秒、跟踪精度 0.5μrad、传输保真度大于 400:1。

Quantum communication encodes information in single photons, yet fiber attenuation and the curvature of the Earth cap its effective range at the thousand-kilometer level, making satellite-to-ground transmission essential for global networks. After more than a decade of effort, this achievement has overcome three core challenges: (1) high-precision acquisition and tracking of space-to-ground optical links, using variable-window area-array detectors for rapid robust acquisition and composite tracking, achieving for the first time internationally stable capture of a high-speed target by one satellite against two ground stations over a thousand-kilometer scale with accurate optical-axis pointing; (2) high-fidelity transmission of space quantum signals, through polarization-maintaining coatings, polarization control, and satellite-ground polarization basis alignment, solving the faithful delivery of single-photon polarization states; (3) a multi-source integrated payload architecture that combines optoelectronic tracking, quantum communication, and classical laser communication in a single payload, accommodating optical signals spanning more than ten orders of magnitude in strength. Key metrics are internationally leading: link acquisition time of 1.1 seconds, tracking precision of 0.5 μrad, and transmission fidelity above 400:1.




一星双站多级跟踪架构
One-satellite dual-station multi-level tracking architecture

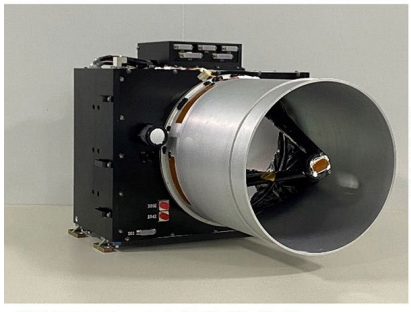


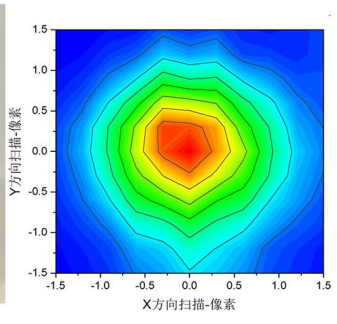





墨子号量子卫星光传输载荷
Optical transmission payload of the Micius quantum satellite








微纳量子卫星光传输载荷
Optical transmission payload of micro-nano quantum satellite

## 从墨子号到卫星互联网星座的规模化应用
## From Micius to the Large-Scale Application of Satellite Internet Constellations

本成果已应用于世界首颗量子科学实验卫星“墨子号”（2016 年）、天宫二号空间实验室（2016 年）与微纳量子卫星“济南一号”（2022 年），实现千公里级星地量子密钥分发、量子纠缠分发与量子隐形传态等里程碑式科学实验，并完成星地量子密钥分发业务化验证，累计建链超千次、成功率近 100%，同时借助星地激光链路完成高速相干激光通信验证。技术成果已实现产业转化，研制多款小型化、低成本星载量子及激光通信终端，服务数十家高校与科研院所。未来可支撑覆盖全球的量子通信网络建设，为金融、能源、电力等行业提供高安全等级通信服务。

The technology has been deployed on the world’s first quantum science satellite Micius (2016), the Tiangong-2 space laboratory (2016), and the micro-nano quantum satellite Jinan-1 (2022), enabling milestone experiments including kilometer-scale satellite-to-ground quantum key distribution, entanglement distribution, and quantum teleportation, along with operational verification of quantum key distribution — more than a thousand links established with a success rate near 100%, as well as a  Gbps high-speed coherent laser communication verification over the satellite-to-ground laser link during the Micius mission. The technology has been transferred to Shanghai Guoke Hangxing Quantum Technology Co., Ltd., producing multiple miniaturized, low-cost satellite-borne quantum and laser communication terminals serving dozens of universities and research institutes, and has been applied in satellite internet constellations such as Xingwang. It is projected that the technology will support a globally covered quantum communication network, delivering high-security communication services to finance, energy, and power industries.

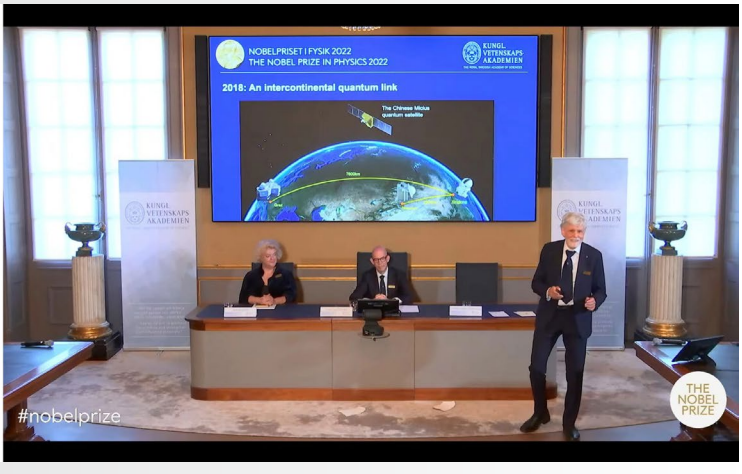
量子光传输载荷及其应用
Quantum optical transmission payload and its applications

## 促进全球量子通信产业变革
## Promote the Transformation of the Global Quantum Communication Industry

本成果构建了空间量子光传输技术体系，形成 23 项授权发明专利、22 篇高水平学术论文，支撑量子信息科学从理论走向实用化。2022 年诺贝尔物理学奖颁奖现场，将“墨子号”星地量子纠缠分发实验作为量子信息科学实用化的核心里程碑专题介绍。成果支撑与奥地利、意大利、俄罗斯等国开展洲际量子通信合作，实现全球首次洲际量子保密通信，获《自然》《科学》等国际顶级期刊正面报道。成果带动低轨卫星互联网星座激光通信终端技术迭代升级，并为全球商业航天打开量子通信应用新赛道。

This work establishes a technical system for space-based quantum optical transmission, yielding 23 granted invention patents and 22 high-level academic papers, which supports the transition of quantum information science from theory to practical application. At the 2022 Nobel Prize in Physics award ceremony, the Micius satellite-to-ground quantum entanglement distribution experiment was featured as a key milestone for the practical deployment of quantum information science. Supported by these achievements, intercontinental quantum communication collaborations have been carried out with Austria, Italy, Russia and other countries, realizing the world's first intercontinental quantum secure communication, which received positive coverage in top international journals including Nature and Science. The results drive the technical iteration and upgrading of laser communication terminals for low-earth-orbit satellite internet constellations and open up a new track for quantum communication applications in global commercial aerospace.




空间量子光传输支撑国际量子信息科学重大进展
Space-based Quantum Optical Transmission Enables Major Advances in International Quantum Information Science

# 昇腾 950 超节点

## Atlas 950 SuperPoD



昇腾 950 超节点
Atlas 950 SuperPoD

华为技术有限公司
Huawei Technologies Co., Ltd.

HUAWEI

## 引言

AI迭代演进加速智能跃迁，大语言模型Scaling Law持续加速，参数从1T走向10T，集群规模从万卡到十万卡。昇腾围绕“超节点+集群”，打造坚实算力底座，持续构建开源开放的昇腾生态，为世界提供新的选择。

## Introduction

AI is advancing at an accelerating pace, unlocking new levels of intelligence. LLM scaling laws continue to drive growth, with model sizes rising from 1T to 10T parameters and clusters scaling from 10,000 to 100,000 accelerators. Ascend centers on “SuperPoDs + SuperClusters” to build a solid computing power foundation, continuously developing an open and accessible Ascend ecosystem, offering a new option for the world.

## Atlas 950 SuperPoD 液冷超节点，业界最大规模商用超节点，万亿模型训推的最佳选择

## Atlas 950 SuperPoD: The industry's largest commercial SuperPoD for trillion-parameter AI training & inference

昇腾 950 超节点基于灵衢高速互联实现 1024 张 NPU 像一台超级计算机一样协同工作，提供 1 EFLOPS FP8 、2 EFLOPS FP4 澎湃算力，拥有 256TB 全局统一内存编址空间，TB 级 NPU 互联超大带宽与 3μs 超低 RTT 时延，从基础器件、协议算法到光电技术，实现系统级创新，突破集群内计算、存储等各类资源的通信瓶颈。

灵衢互联突破物理极限，实现高可靠、高性能的超节点规模扩展。柜内 OD 正交架构，Cable Tray 免背板设计，把传统 3 级互联精简为 2 级。柜间灵衢互联采用 LPO 光模块，通过线性直驱，省去传统光模块的 ODSP，降低时延，4000 多个光模块就减少了 4 万瓦的电力消耗。

昇腾 950 超节点硬件架构原生支持 mxFP8，是国内唯一商用支持 mxFP8 低精训练的超节点。同时基于超节点的 PD 分离叠加大规模专家并行优化，在万亿 MoE 模型上实现 5-10ms 的极致低时延，单卡吞吐比业界风冷集群提升 2.5 倍。

The Atlas 950 SuperPoD, based on the UnifiedBus interconnect, enables 1,024 NPUs to work together like a supercomputer, delivering 1 EFLOPS FP8 and 2 EFLOPS FP4 computing power. It features a unified global memory addressing space of 256 TB, TB-level inter-NPU extra-high bandwidth, and an ultra-low RTT latency of 3 μs. From basic components and protocols to algorithms and optoelectronic technologies, the SuperPoD achieves system-level innovation, breaking through communication bottlenecks for various resources such as computing and storage within the cluster.

The UnifiedBus interconnect pushes beyond physical limits, enabling SuperPoDs to scale to larger configurations with high performance and reliability. The intra-cabinet orthogonal architecture and cable tray design without backplanes reduce the traditional three-tier interconnect to just two tiers. Inter-cabinet UnifiedBus interconnect uses LPO optical modules, which, through linear direct drive, eliminate the ODSP of traditional optical modules, reduce latency, and save 40,000 watts of power consumption with over 4,000 optical modules.

The Atlas 950 SuperPoD hardware architecture natively supports MXFP8, making it the only commercial SuperPoD in China that supports MXFP8 low-precision training. Additionally, based on the prefill-decode disaggregation and MoE expert parallel optimization of the SuperPoD, it achieves an ultra-low latency of 5–10 ms on trillion-parameter MoE models, with a single-NPU throughput that is 2.5 times higher than that of industry-standard air-cooled clusters.



## 昇腾超节点规模商用落地，加速 AI 技术赋能千行万业
## Ascend SuperPoDs are put into large-scale commercial use, accelerating AI technology empowerment for various industries

昇腾超节点已商用落地 1000 多套，规模应用于互联网、运营商、金融、教育、医疗、交通、制造等行业，是国内唯一训练出 SOTA 模型的超节点，已经有 40 多个大模型完成昇腾原生预训练。

昇腾超节点在规模商用的同时，已成为产、学、研在 AI 基础设施领域的共识。

The Ascend SuperPoDs have been commercially deployed in over 1,000 sets and are being widely applied in industries such as the internet, telecommunications, finance, education, healthcare, transportation, and manufacturing. They are the only SuperPoDs in China that have trained State of the Art (SOTA) models, with more than 40 foundation models having completed native pre-training on Ascend.

As Ascend SuperPoDs scale into commercial deployment, they are gaining broad recognition across industry, academia, and research as a key foundation for AI infrastructure.




《超节点定义与实践白皮书》
SuperPoD definition and practice white paper

2026WORLD INTERNET CONFERENCE

## 昇腾 950 超节点引领架构创新，支撑超大规模集群，使全球万亿 MoE 大模型迭代成为可能

## Atlas 950 SuperPoD Leads Architectural Innovation, Supports Hyperscale Clusters, and Enables Iterative Advancement of Global Trillion-Parameter MoE Large Models

超节点已成为建设超大规模 AI 基础设施的必然选择。10 万卡集群已成为训练 10 万亿级 SOTA 模型的标配，在传统计算架构下，集群规模扩大时，资源利用率反而下降，十万卡集群的实际模型算力利用率仅约 20%，大量算力处于等待通信完成的状态。昇腾超节点以灵衢互联为核心，发挥“计算 + 通信”综合优势，重新定义了高效、稳定、可扩展的大规模有效算力新范式。打造集群 + 超节点协同的新计算架构，支持 Agentic AI 时代爆发式增长的计算需求，加速 10 万亿大模型训练和推理。坚持开源开放，全面融入业界主流开源社区，围绕硬件、算子、加速库、模型及应用五大方向，加速原生创新，促进商业共赢，共建繁荣生态，为世界提供新选择。

SuperPoDs have become an inevitable choice for building ultra-large-scale AI infrastructure. Clusters with 100,000 accelerators are becoming the norm for training state-of-the-art models with 10 trillion parameters. Yet under conventional computing architectures, resource utilization declines as cluster size grows. Even in a 100,000-accelerator cluster, model FLOPs utilization (MFU) is only around 20%, with vast amounts of compute sitting idle while waiting for communication to complete.

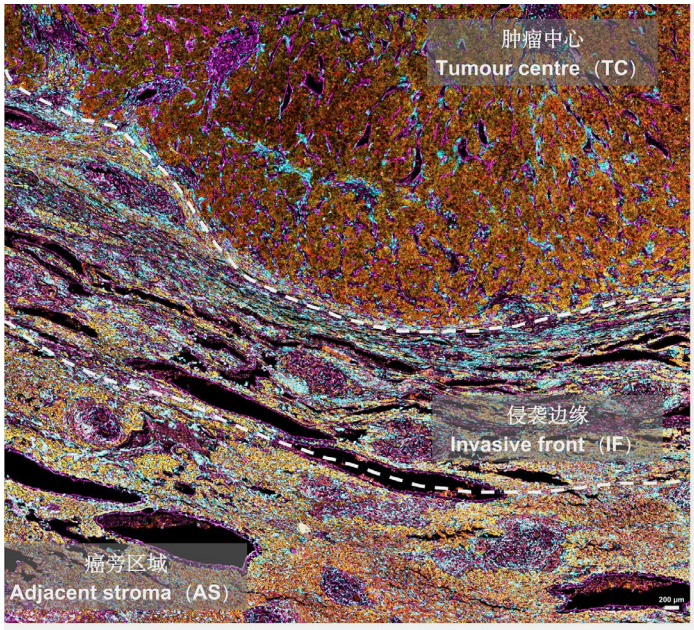
The Ascend SuperPoDs, with its core technology UnifiedBus interconnect, leverages the combined advantages of “compute + communication” to redefine a new paradigm of efficient, stable, and scalable large-scale computing power. It establishes a new computing architecture that synergizes SuperPoDs and SuperClusters, supporting the explosive growth in computing demands of the Agentic AI era and accelerating the training and inference of 10 trillion-parameter models.

Ascend remains committed to open-source and open systems, actively engaging with leading open-source communities worldwide. Across five key areas—hardware, operators, acceleration libraries, models, and applications—Ascend is accelerating native innovation, fostering win-win partnerships, and building a thriving ecosystem to offer the world a new option.



# TIMES：面向精准肿瘤学的空间免疫评分系统

## TIMES: Spatial Immune Scoring for Precision Oncology




**01**
**复发风险**
**Recurrence Risk**

**02**
**患者分层**
**Patient Stratification**

**03**
**靶点发现**
**Target Discovery**

空间免疫景观与平台价值总览
空间免疫智能平台将病理图像中的免疫空间信息转化为疾病风险、患者分层和靶点发现结果

Spatial immune landscape and platform outputs
The Spatial Immune Intelligence Platform converts immune spatial information in pathology images into disease risk, patient stratification and target-discovery outputs

中国科学技术大学
University of Science and Technology of China

## 引言

免疫治疗研发的关键难题，不只是发现靶点，还要判断哪些靶点应联合干预、哪些患者可能获益。平台从患者组织出发，将病理图像中的空间免疫关系转化为复发风险、患者分层和可成药靶点，连接靶点发现、药物开发与伴随诊断。

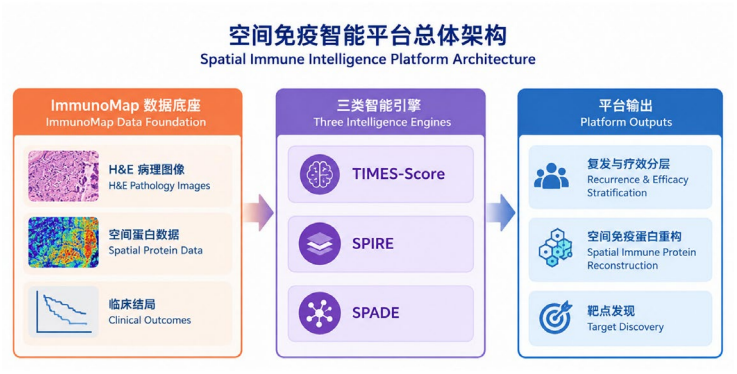
## Introduction

A central challenge in immunotherapy development is not only identifying targets, but also determining which targets should be co-targeted and which patients are likely to benefit. Starting from patient tissues, the platform converts spatial immune relationships in pathology images into recurrence risk, patient stratification and druggable targets, connecting target discovery, drug development and companion diagnostics.

## 从数细胞到读空间 人工智能把肿瘤免疫组织转化为可验证的临床评分

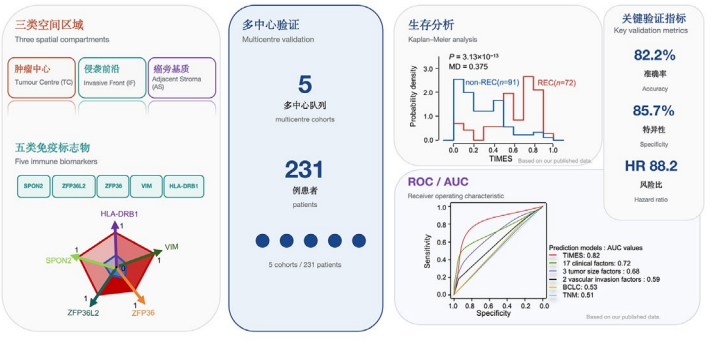
## AI Converts Spatial Immune Architecture into a Clinically Validated Score

传统病理和多数病理人工智能主要识别细胞形态或统计细胞数量，难以解释同一种免疫细胞为何因所处位置不同而呈现相反功能。平台提出“位置决定免疫功能”的可计算框架，将带临床结局的 H&E、空间蛋白和多重免疫荧光数据整合为 ImmunoMap 数据底座，并形成 TIMES-Score 临床预测、SPIRE 空间免疫蛋白重构和 SPADE 空间靶点发现等引擎。核心成果 TIMES 从肿瘤中心、侵袭边缘及癌旁区域提取五类免疫标志物的空间关系。在 5 个多中心队列 231 例患者中，模型预测肝细胞癌术后复发的 AUC 为 0.82，准确率 82.2%，特异性 85.7%，高低风险组风险比为 88.2，优于 118 项临床指标。研究同时鉴定出侵袭边缘 SPON2 阳性 NK 细胞及其抗复发机制，形成从空间模式、临床预测到生物学因果验证的闭环。




空间免疫智能平台总体架构
ImmunoMap 整合病理图像、空间蛋白和临床结局，为 TIMES-Score、SPIRE 和 SPADE 三类引擎提供统一的数据底座

Architecture of the Spatial Immune Intelligence Platform
ImmunoMap integrates pathology images, spatial proteins and clinical outcomes as a shared data foundation for the TIMES-Score, SPIRE and SPADE engines




TIMES 多中心临床验证
TIMES 量化三类组织区域中五类免疫标志物的空间关系，并在 5 个多中心队列 231 例患者中验证肝细胞癌术后复发预测能力

Multicentre clinical validation of TIMES
TIMES quantifies the spatial relationships of five immune markers across three tissue regions and was validated for postoperative HCC recurrence prediction in 231 patients from five multicentre cohorts

Conventional pathology and most pathology AI systems focus on cell morphology or cell counts. They rarely explain why the same immune-cell type can behave differently according to its position in tissue. The platform establishes a computable framework in which position helps determine immune function. It integrates outcome-linked H&E images, spatial protein measurements and multiplex immunofluorescence into the ImmunoMap data foundation, which supports the TIMES-Score clinical prediction engine, the SPIRE spatial immune-proteome reconstruction engine and the SPADE spatial target-discovery engine. Its lead achievement, the Tumour Immune Microenvironment Spatial score (TIMES), measures the spatial relationships of five immune markers across the tumour centre, invasive front and peritumoural tissue. In 231 patients from five multicentre cohorts, TIMES predicted postoperative hepatocellular carcinoma recurrence with an AUC of 0.82, 82.2% accuracy and 85.7% specificity. The hazard ratio between the high- and low-risk groups was 88.2, and the model outperformed 118 clinical variables. The same programme identified SPON2-positive NK cells at the invasive front and established their antirecurrence mechanism, linking spatial patterns, clinical prediction and causal biology.

## 以常规病理切片为入口 构建可推广的复发预测与免疫治疗分层工具

## A Scalable Route from Routine Pathology Slides to Recurrence Prediction and Immunotherapy Stratification

平台以临床常规切片和数字病理流程为入口，不要求医院新增空间组学仪器，适合在现有病理基础设施上部署。TIMES 学术平台已累计服务 20,000 余名用户，覆盖 45 个国家；肝癌模型正在开展多中心临床验证，并支持两项已注册前瞻性试验。平台正在由肝癌术后复发分层拓展至肺癌复发和泛癌种免疫治疗响应评估。在探索性回顾性队列中，TIMES 筛选使免疫治疗客观缓解率富集约 1.94 至 2.08 倍，提示其可用于临床试验入组优化和阴性或弱阳性试验的生物标志物重分析。其潜在价值是帮助临床识别真正需要强化随访或辅助治疗的高风险人群，同时减少低风险患者的过度治疗；对药企，则可减少非应答者入组，提升试验统计效能和研发决策效率。相关患者富集分析仍处于回顾性探索阶段，后续将通过前瞻性研究和规范化流程继续验证。

The platform enters clinical workflows through routine pathology slides and digital whole-slide imaging, without requiring hospitals to install spatial-omics instruments. This makes it compatible with existing pathology infrastructure. The academic TIMES platform has served more than 20,000 users across 45 countries. Multicentre clinical validation is under way, and the system supports two registered prospective trials. Development is extending from postoperative HCC recurrence to lung-cancer recurrence and pan-cancer assessment of immunotherapy response. In exploratory retrospective cohorts, TIMES-based selection enriched objective response rates by approximately 1.94- to 2.08-fold. These findings suggest potential applications in trial-enrolment optimisation and biomarker reanalysis of negative or marginal immunotherapy programmes. For clinicians, the platform could help identify patients who require more intensive surveillance or adjuvant intervention while reducing unnecessary treatment for lower-risk patients. For pharmaceutical developers, it could reduce the enrolment of likely non-responders and improve statistical power and development decisions. The patient-enrichment analyses remain retrospective and exploratory and will require prospective validation and standardised operating procedures before regulatory use.




从常规病理切片到风险评分报告
平台适配现有数字病理流程，将标准切片转化为空间免疫分析和可解释的风险评分报告

From routine pathology slide to risk report
The platform fits existing digital-pathology workflows and converts standard slides into spatial immune analyses and interpretable risk reports



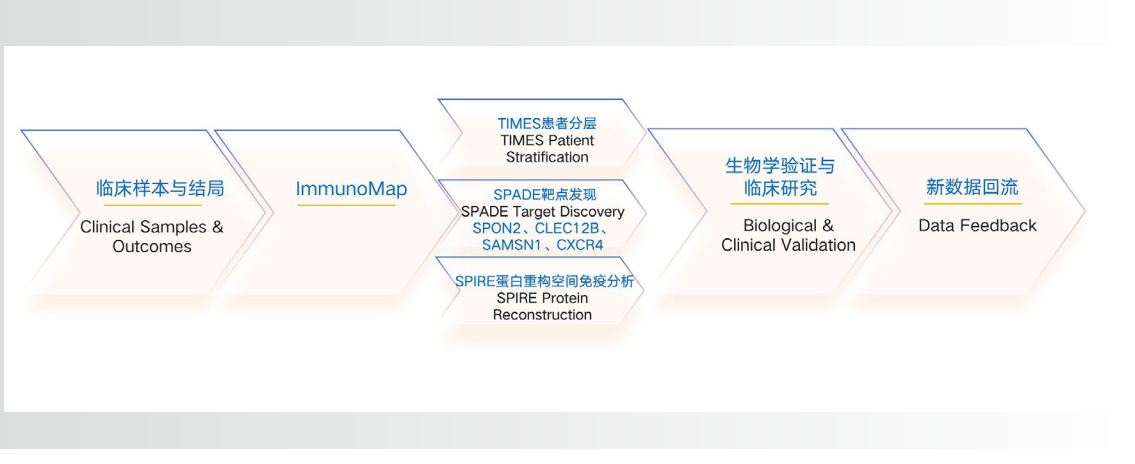

推广规模与前瞻性验证路径
TIMES 学术平台已服务 20,000 余名用户、覆盖 45 个国家，并由已发表验证进入多中心和前瞻性临床验证阶段

Adoption and prospective validation pathway
The academic TIMES platform has served more than 20,000 users across 45 countries and is progressing from published validation to multicentre and prospective clinical studies

## 空间免疫智能正在连接疾病预测 靶点发现与新药研发
## Spatial Immune Intelligence Connects Disease Prediction Target Discovery and Drug Development

该成果把肿瘤免疫评估从“有多少免疫细胞”推进到“免疫细胞在哪里、与谁相邻以及如何影响结局”，为病理人工智能增加了可解释的空间免疫维度。TIMES 研究以封面论文发表于 Nature，并入选 2025 年度中国十大科学进展；其全球用户基础表明空间免疫分析已经从单项研究转化为可复用的科研基础设施。在此基础上，平台进一步将患者分层与药物研发连接起来：SPADE 从临床样本的空间差异和结局关联中识别 SPON2、CLEC12B、SAMSN1、CXCR4 等空间免疫节点，并推动其中部分进入候选抗体验证；TIMES-Score 服务于复发和疗效分层，为药物特异性伴随诊断提供路径；SPIRE 则探索由常规 H&E 重构空间免疫蛋白信息。该体系有望为医院提供可扩展的风险评估工具，为药企提供生物标志物、患者富集和耐药机制分析能力，并推动空间多组学、数字病理、人工智能和免疫药物研发形成相互验证的转化链条。平台正面向医院、药企和转化研究机构开展三类合作：多中心前瞻性验证；临床试验患者富集及药物特异性伴随诊断开发；围绕已验证空间靶点开展候选抗体共同开发与许可合作。

This work advances tumour-immune assessment from asking how many immune cells are present to asking where they are, which cells they neighbour and how those relationships influence outcome. It therefore adds an interpretable spatial-immune layer to pathology AI. The TIMES study was published as a Nature cover article and selected as one of China’s Top 10 Scientific Advances of 2025. Its international user base shows that spatial immune analysis can develop from a single research project into reusable scientific infrastructure. The platform now connects patient stratification with target discovery: SPADE uses spatial differences and outcome associations in clinical samples to identify candidate targets including SPON2, CLEC12B, SAMSN1 and CXCR4; SPIRE explores the reconstruction of spatial immune-protein information from routine H&E images; and TIMES-Score supports recurrence and treatment-response stratification. This integrated system could provide hospitals with scalable risk assessment and pharmaceutical developers with capabilities for biomarker discovery, patient enrichment and resistance-mechanism analysis. More broadly, it creates a translational chain in which spatial multi-omics, digital pathology, AI and immunotherapeutic development can test and strengthen one another. The platform is open to three forms of collaboration with hospitals, pharmaceutical companies and translational research institutions: multicentre prospective validation; clinical-trial patient enrichment and drug-specific companion diagnostic development; and co-development or licensing of therapeutic antibodies against validated spatial immune targets.




空间免疫智能转化闭环
平台把临床样本、空间免疫计算、患者分层、靶点发现和生物学验证连接为可持续迭代的转化闭环

Translational loop for spatial immune intelligence
The platform links clinical samples, spatial immune computation, patient stratification, target discovery and biological validation in an iterative translational loop



# 科技之魅

CHARM OF SCIENCE AND TECHNOLOGY

# 01

## 世界互联网大会
## 领先科技奖获奖成果

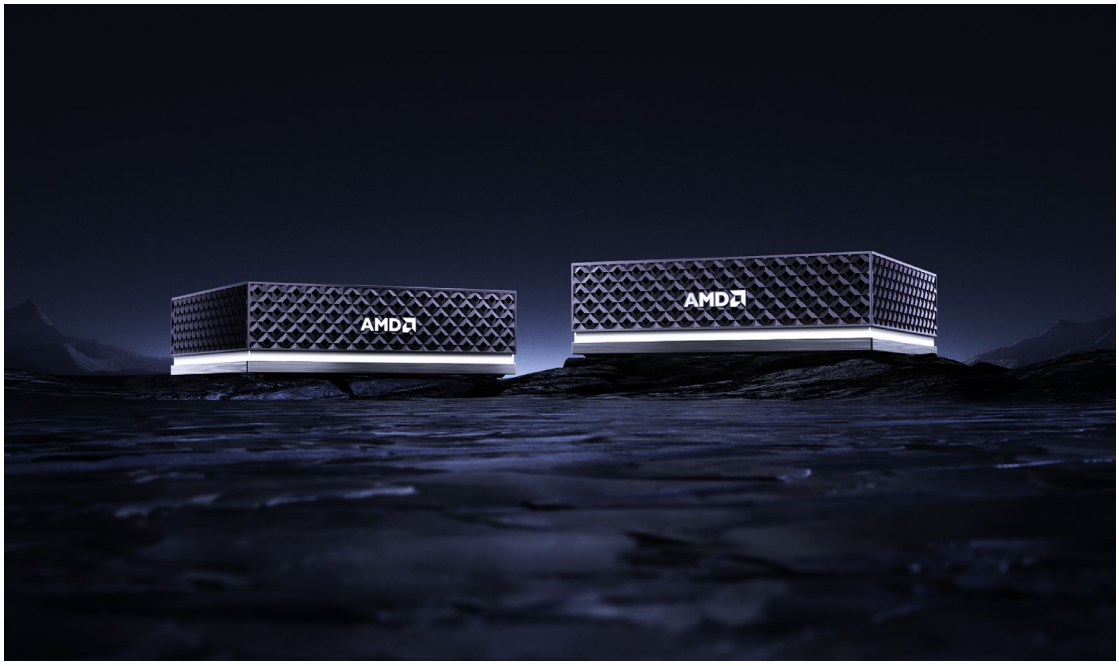
**Award-winning Achievements of World Internet Conference Awards for Pioneering Science and Technology**

# 工程研发组

# Engineering Research and Development Group

# AMD 锐龙 AI Max+ 智能体主机处理器

## AMD Ryzen AI Max+ Agent Computer Processors




AMD 锐龙 AI Halo
AMD Ryzen AI Halo

超威半导体（中国）有限公司
AMD

## 引言

AMD 锐龙 AI Max+ 智能体主机处理器是面向智能体 AI 时代的新一代端侧 AI 计算平台。通过 CPU、GPU、NPU 融合架构和大容量统一内存设计，为本地大模型部署、多智能体协同和行业 AI 应用提供算力基础，支持医疗、教育、金融、招投标等场景部署。

## Introduction

AMD Ryzen AI Max+ Agent Computer Processors are a new generation of end point AI computing platforms designed for the era of agentic AI. Combining CPU, GPU and NPU computing with large, unified memory, they provide a foundation for local large-model deployment, multi-agent collaboration and industry AI applications across healthcare, education, finance and other sectors.

## 以异构计算，大容量统一内存架构和动态显存分配技术，突破端侧超大模型部署与多智能体协同的硬件瓶颈

## Breaking Hardware Bottlenecks in On-Device Large Model Deployment and Multi-Agent Collaboration Through Heterogeneous Computing, Large Unified Memory, and Dynamic VRAM Allocation

AMD 锐龙 AI Max+ 智能体主机处理器面向智能体 AI 以完成任务为目标的多样化计算需求，通过 CPU、GPU 与 NPU 融合，大容量统一内存及动态可调显存设计，突破传统终端设备在模型规模、显存容量和本地运行时编排效率方面的限制。基于 AMD 锐龙 AI Max+ PRO 495 处理器，智能体主机可提供最高 160GB 显存，用于大语言模型承载及 AI 工作负载，支持最高 3000 亿参数模型在本地高效运行，并可支持多个 AI 智能体协同工作。依托成熟的 x86 软硬件生态，该成果将过去主要依赖云端或大型服务器的 AI 能力带到终端，为本地大模型、AI 员工及行业智能体应用提供新的计算平台，降低超大模型和智能体 AI 在企业与个人场景中的部署门槛。







The AMD Ryzen AI MAX+ Agent computer processor is designed for the diverse computing needs of agentic AI that aim to complete task. By combining CPU, GPU, and NPU computing with large unified memory, and the Dynamic adjustable VRAM solution. The platform helps overcome the limitations of conventional endpoint devices in model scale, graphics memory capacity, and local processing and orchestration efficiency. Powered by the AMD Ryzen AI Max+ PRO 495 processor, an Agent Computer can provide up to 160GB of VRAM for large language model hosting and AI workloads, enabling models with up to 300 billion parameters to run efficiently and locally while supporting collaboration among multiple AI agents. Built on the mature x86 hardware and software ecosystem, the platform brings AI capabilities traditionally associated with cloud infrastructure or large servers to endpoint devices, providing a new computing foundation for local large models, AI employees, and industry-specific agentic AI applications.

## 基于超大参数模型让 AI 智能体在本地高效运行，推动人工智能真正融入行业生产力场景

## Enabling Efficient Local Execution of AI Agents with Ultra-Large Parameter Models, Driving AI Adoption in Real-World Industrial Productivity Scenarios

AMD 锐龙 AI Max+ 智能体主机处理器已完成整机、模型与应用的适配，进入多行业应用验证和实施阶段，目前已面向医疗、教育、金融、招投标、法律服务等专业场景开展应用实践，可为办公辅助、知识检索、文档分

析和多智能体协作提供本地计算基础。将相关工作负载部署在端侧，有助于减少对高成本云端算力和持续 Token 调用的依赖，并更好地满足企业对合规、安全、隐私、知识产权保护、即时响应和数据主权的需求。相关研究显示，将企业日常 AI 智能体应用，包括办公辅助和 AI 员工等，放在端侧设备运行，可使企业 AI Token 消耗降低 80% 以上。通过大容量统一内存与成熟 x86 生态，该平台降低了本地大模型及智能体应用的部署门槛，为企业构建成本可控、数据本地化且响应及时的 AI 基础设施提供了新的选择。

AMD Ryzen AI Max+ Agent Computer Processors have completed the adoption phase and entered the stage of multi-industry application implementation which have been applied in professional scenarios including healthcare, education, finance, public tendering, and legal services. The platform provides a local computing foundation for office assistance, knowledge retrieval, document analysis, and multi-agent collaboration. Deploying these workloads on endpoint devices can reduce reliance on cloud computing resources and continuous token consumption, while helping address enterprise requirements for compliance, security, privacy, intellectual property protection, instant responsiveness, and data sovereignty. Related research cited in the confirmed material indicates that moving everyday enterprise AI agent workloads, including office assistance and AI employees, to endpoint AI devices can reduce enterprise AI token consumption by more than 80 percent. Large unified memory and the mature x86 ecosystem further reduce deployment barriers, offering enterprises a practical option for building cost-manageable, locally operated, and responsive AI infrastructure.







## 开创智能体主机新型计算设备形态，为 AI 规模化进入千行百业提供实践路径

## Pioneering a New Computing Device Category for AI Agents, Providing a Practical Path for Large-Scale AI Adoption Across Industries

人工智能正在从“会回答问题”的聊天机器人向“会完成工作”的 AI 智能体演进，计算需求也由单次问答转向持续规划、工具调用和多任务协作。附件引用的行业数据表明，智能体应用的 Token 消耗可达到聊天机器人的 5 至 30 倍；到 2027 年，全球 2000 强企业的 AI Token 消耗量可能较当前增长 1000 倍。AMD 锐龙 AI Max+ 智能体主机处理器针对这一趋势，将超大模型、本地数据和多智能体工作流集中到端侧计算平台，减少敏感数据上传及持续云端调用，降低企业部署和使用 AI 的综合成本。智能体主机演进为可真正承载 AI 员工和行业智能体的生产力平台，为人工智能从模型创新走向产业应用提供了可实践、可扩展的新路径。

AI is evolving from chatbots that answer questions to AI agents capable of planning, using tools, coordinating tasks, and completing real work. Industry data cited in the confirmed material indicates that agentic AI applications can consume five to thirty times more tokens than chatbots. By 2027, AI token consumption among Global 2000 companies could increase by one thousand times compared with current levels. AMD Ryzen AI Max+ Agent Computer Processors respond to this shift by bringing large models, local data, and multiple AI agents together on an endpoint computing platform. By reducing dependence on cloud infrastructure and supporting local processing, the platform provides a new deployment approach for data-sensitive and professional applications. Agent computer is a productivity platform capable of supporting AI employees and industry-specific agents, offering a practical and scalable path from model innovation to real-world AI adoption.




## 依托开放的 x86 和 ROCm 生态，构建连接模型、应用与行业创新的端侧 AI 基础设施平台

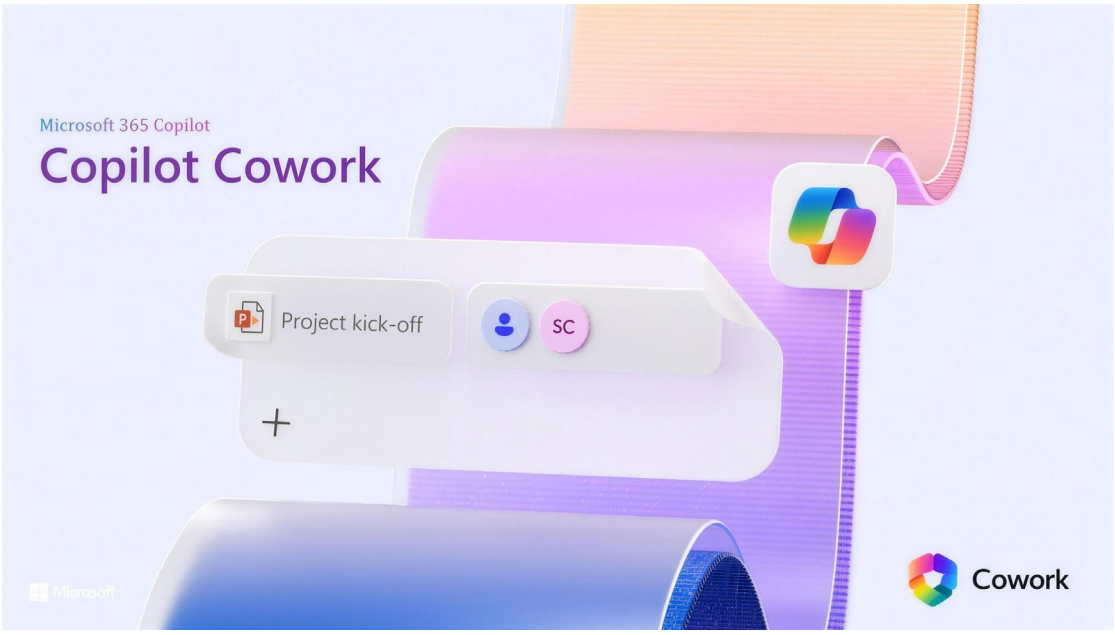
## Building an Edge AI Infrastructure Platform Connecting Models, Applications, and Industry Innovation Through the Open x86 and ROCm Ecosystems

AMD 锐龙 AI Max+ 智能体主机处理器不仅提升端侧 AI 算力，也充分利用成熟的 x86 软件生态和开源开放的 ROCm 生态，支持开发者在熟悉的计算环境中部署本地大模型和开发面向专业场景的定制化智能体应用。随着中国创新企业开源模型能力不断提升，端侧模型已经足够优秀承载更多智能体应用，结合智能体主机平台大容量统一内存和本地化部署能力，行业从业者和开发者可以更便捷地探索智能体 AI 的行业场景创新与融合。

AMD Ryzen™ AI Max+ processors for agent computers not only enhance on-device AI performance, but also leverage the mature x86 software ecosystem and the open-source ROCm™ ecosystem. This enables developers to deploy local large language models and build customized agentic applications for specialized use cases within familiar computing environments.
As Chinese innovators continue to advance the capabilities of open-source models, on-device models are becoming powerful enough to support a broader range of agentic applications. Combined with the large unified memory and local deployment capabilities of agent computer platforms, industry professionals and developers can more easily explore innovative industry use cases and accelerate the adoption and integration of agentic AI.

# Copilot Cowork：面向真实任务场景的下一代生产力引擎

## Copilot Cowork:
## A Next-Generation Productivity Engine Built for Real-World Tasks




Copilot Cowork：面向真实任务场景的下一代生产力引擎
Copilot Cowork: A Next-Generation Productivity Engine Built for Real-World Tasks

微软（中国）有限公司
Microsoft China Co., Ltd.

Microsoft

## 引言

Copilot Cowork 是微软于 2026 年 3 月发布的新一代企业级智能体系统，推动企业级 AI 从问答与内容生成向任务执行与成果交付演进，实现从 AI 辅助到 AI 执行的跨越。

## Introduction

Released by Microsoft in March 2026, Copilot Cowork is a next-generation enterprise agentic AI system that advances enterprise AI from question answering and content generation to task execution and outcome delivery. By enabling users to delegate meaningful work while staying in control, it establishes a new model for enterprise agentic work.

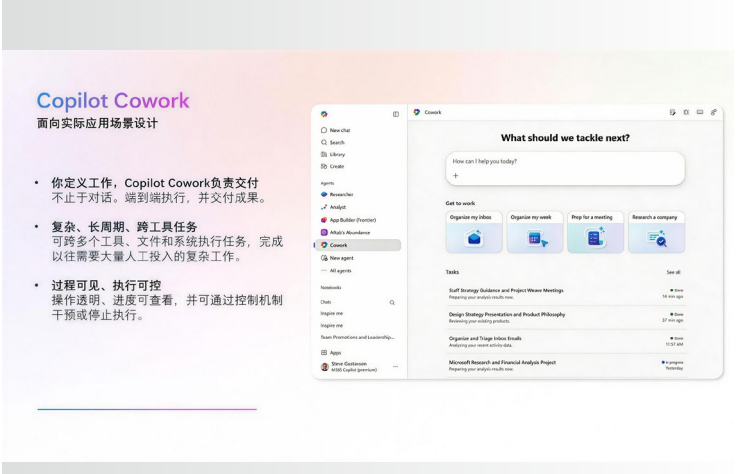
## 从对话生成到执行交付，创建企业级智能体新范式
## From Conversation to Execution, A New Paradigm for Enterprise Agentic AI

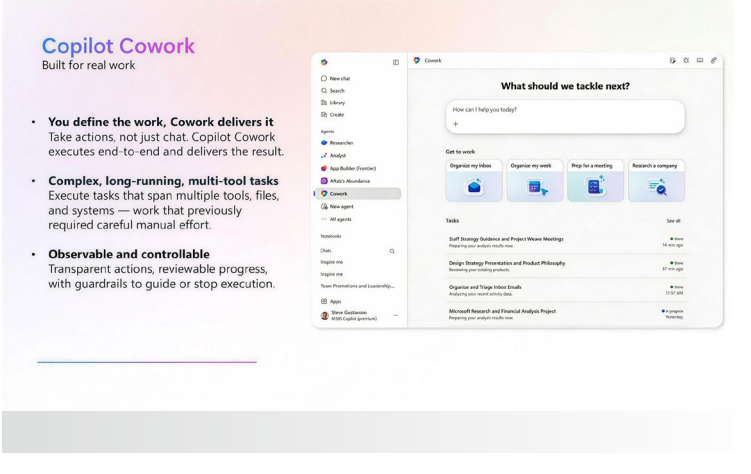
Copilot Cowork 融合企业上下文、推理与执行能力，将 AI 从问答与内容生成扩展到任务执行与成果交付，帮助用户将工作目标转化为可执行行动，并跨应用持续推进，同时保持用户全程可控。

应用范式创新。Copilot Cowork 将用户目标转化为结构化执行计划，将复杂工作拆解为可管理步骤，并在多个应用之间持续推进任务。不同于一次性生成响应，它能够规划、执行和协调多步骤工作，同时提供过程可见、审批节点和人工干预机制，推动 AI 从单次交互工具向成果导向的工作执行系统演进。

技术原理创新。基于 Work IQ 智能层，Copilot Cowork 构建统一企业工作上下文，融合邮件、会议、文档、沟通记录、人员关系及业务系统信息。通过语义理解、跨应用推理、任务编排和多模型协同能力，将企业上下文转化为 Microsoft 365 及相关系统的协同行动。

技术方法创新。Copilot Cowork 引入可复用的 Skills 技能机制，将高频业务流程封装为参数化工作流，实现组织知识的沉淀与规模化复用。




分级执行模型将自主执行与人工控制相结合，在授权范围内自动完成常规任务，同时保留高风险操作的人工审批。依托 Microsoft 365 身份、权限、安全、合规和治理体系，实现过程可观察、行动可审计、执行可干预，为企业级智能体的部署提供了实践路径。

Copilot Cowork introduces a new way of working with AI. By combining enterprise context, reasoning, and action, it extends AI beyond question answering and content generation to task execution and outcome delivery. Copilot Cowork enables users to delegate meaningful work, turning goals into executable plans and carrying work forward across applications while keeping users in control.

Application Paradigm Innovation. Copilot Cowork transforms user goals into structured execution plans, breaking complex work into manageable steps and advancing tasks across applications over time. Instead of generating a single response, it can plan, execute, and coordinate work while providing visibility, approval checkpoints, and opportunities to steer progress.

Technical Foundation Innovation. Built on the Work IQ intelligence layer, Copilot Cowork brings together organizational context from emails, meetings, documents, communications, people, and business systems. Through semantic understanding, cross-application reasoning, task orchestration, and a multi-model architecture, it translates enterprise context into coordinated actions across Microsoft 365 and connected systems.

Execution Model Innovation. Copilot Cowork introduces reusable Skills that package recurring business processes into parameterized workflows, enabling organizational knowledge capture and reuse at scale. A tiered execution model combines autonomous execution with human control, allowing routine actions to proceed under delegated authority while preserving approval for higher-risk operations. Built on Microsoft 365 identity, security, compliance, and governance controls, Copilot Cowork provides a practical path to secure and governable enterprise agent deployment.

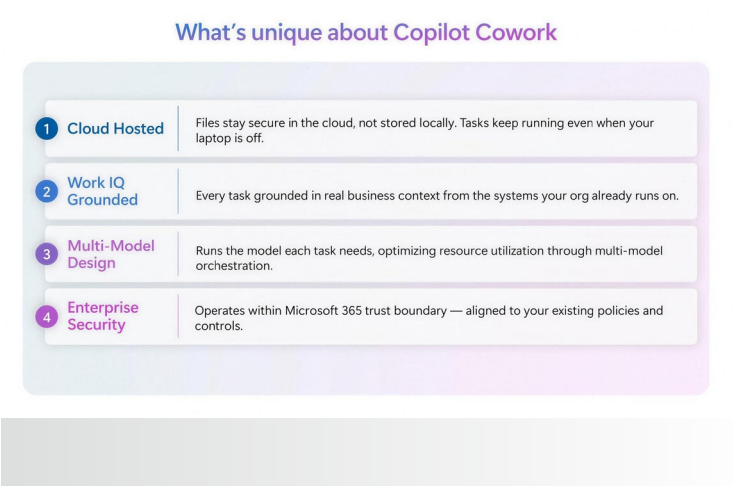
## 释放生产力，构建企业级智能体
## Unlocking Productivity at Enterprise Scale

Copilot Cowork 将 AI 从辅助交互扩展到任务执行与成果交付，使用户能够委托跨应用、跨文件和业务系统的复杂长周期工作，减少协调成本和重复操作，将更多时间投入判断、创造与协作等高价值活动。

Skills 技能机制将重复性业务流程转化为可复用的组织能力，帮助企业沉淀和复用知识资产，降低复杂工作流的使用门槛，促进能力复用、流程标准化和组织学习。

基于云原生执行架构，Copilot Cowork 支持跨应用的长周期任务持续运行，通过集中调度和多模型协同提升资源利用效率。身份、权限、安全、合规和审计能力贯穿任务执行全过程，实现安全、可控、可审计的企业级部署。




Copilot Cowork extends AI beyond assisted interaction to task execution and outcome delivery. By enabling users to delegate complex, long-running work that spans applications, files, and business systems, it reduces coordination overhead and repetitive operational tasks, allowing people to focus on higher-value work such as judgment, creativity, and collaboration.

Reusable Skills transform recurring business processes into repeatable capabilities, enabling organizations to capture and reuse knowledge at scale. This lowers the barrier to complex workflows while promoting capability reuse, process standardization, and organizational learning.

Built on a cloud-native execution model, Copilot Cowork supports long-running work across applications while optimizing resource utilization through centralized orchestration and multi-model execution.

Identity, permissions, security, compliance, and auditing controls are embedded throughout the execution lifecycle, enabling secure, controllable, and enterprise-ready deployment.



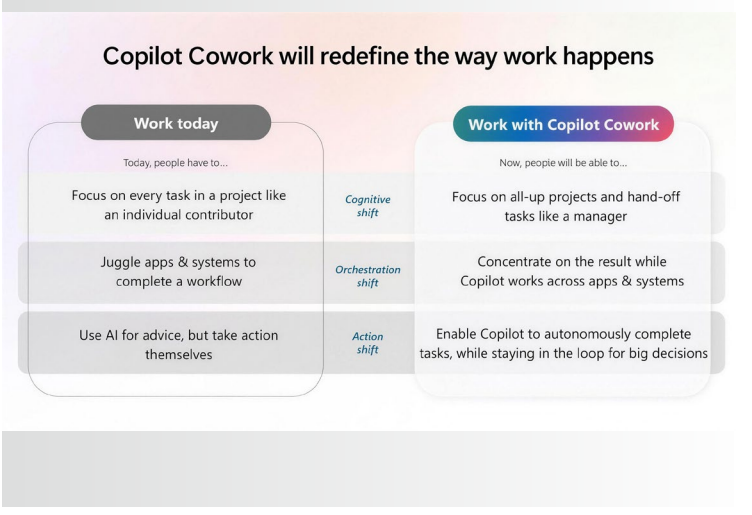
## 重塑工作方式，推动企业级 AI 迈向组织级能力建设
## Reshaping How Organizations Work

Copilot Cowork 推动企业级 AI 从单点效率工具向组织级能力建设演进，在经济价值、人机协同、产业生态和全球应用层面产生广泛影响。根据用户反馈，可减少约 75% 的协调与执行类工作时间；《财富》世界 500 强企业试点显示，代码审查周期可缩短约 40%，显著提升工程效率并加速产品上市速度。

除生产力提升外，Copilot Cowork 正帮助用户将 AI 能力转化为可规模化运营的组织能力。Work IQ 支持跨应用任务执行，减少系统间的信息传递与人工衔接；Skills 技能机制将任务流程、输出规范和沟通实践沉淀为可复用的企业数字资产，推动知识复用、流程标准化和组织能力建设。

Copilot Cowork 已覆盖全球 170 多个国家和地区，超过半数《财富》500 强企业正在使用，为企业智能体的治理、部署和运营提供了实践参考，展现了从技术创新向企业级应用的发展方向。



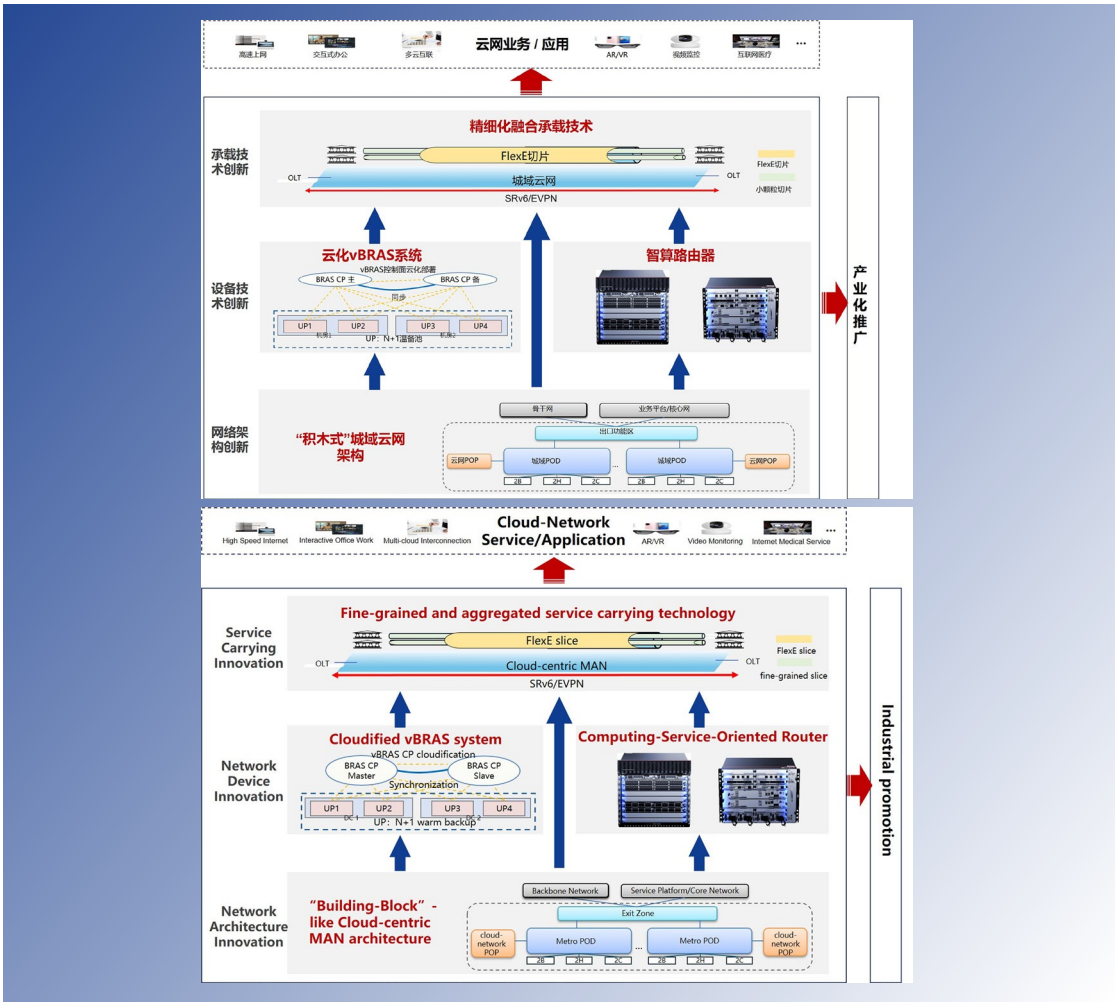

Copilot Cowork is accelerating the evolution of enterprise AI from isolated productivity tools to organization-wide capability building, creating impact across economic value, human-AI collaboration, industry development, and global adoption. Customer deployments have demonstrated up to a 75% reduction in coordination and execution effort, while Fortune 500 pilots reported 40% shorter code-review cycles, improving engineering productivity and accelerating time-to-market.

Beyond productivity gains, Copilot Cowork helps organizations turn AI into scalable, operational capabilities across the enterprise. Work IQ enables cross-application execution that reduces manual handoffs across systems, while reusable Skills transform task procedures, output standards, and communication practices into enterprise digital assets that can be shared, refined, and reused across teams. This promotes knowledge reuse, process standardization, and organizational capability building.

Available across more than 170 countries and regions, and adopted by over half of participating Fortune 500 companies, Copilot Cowork provides a practical reference for enterprise agent governance, deployment, and operational adoption at scale,demonstrating the trajectory from technological innovation to enterprise-level application.

# 城域云网关键技术研发及应用

## Key Technology R&D and Application of Cloud-Centric Metropolitan Area Network




城域云网技术创新体系

Technology Innovation System of Cloud-Centric MAN

中国电信集团有限公司
China Telecommunications Group Co., Ltd.

沙特电信公司
Saudi Telecom Company (STC)

清华大学
Tsinghua University

华为技术有限公司
Huawei Technologies Co., Ltd.

## 引言

城域云网是赋能数字经济发展的新型云网基础设施，以固移融合、云网一体、高效智能、绿色低碳为目标，通过组网架构、网元与协议技术创新，实现“连接、算力、应用”一体化供给，助力打造城市毫秒级时延圈。

## Introduction

The Cloud-centric MAN is a key cloud-network infrastructure for empowering the digital economy development. Targeted to fixed-mobile convergence, cloud-network convergence, high efficiency, intelligence and environmental sustainability, it has achieved innovative breakthroughs in network architecture, network elements, and protocol technologies. The Cloud-centric MAN enables integrated provision of connectivity, computing power and applications, laying a solid foundation for building a city-wide millisecond-level latency circle.

## 构建了云网一体新型基础设施底座，关键技术达到国际领先水平
## Established a New Cloud-Network Convergence Infrastructure Base with Global-Leading Key Technologies

中国电信牵头联合产业伙伴，提出城域云网架构与关键技术创新体系，打造了云网一体、敏捷智能的新型云网创新底座。

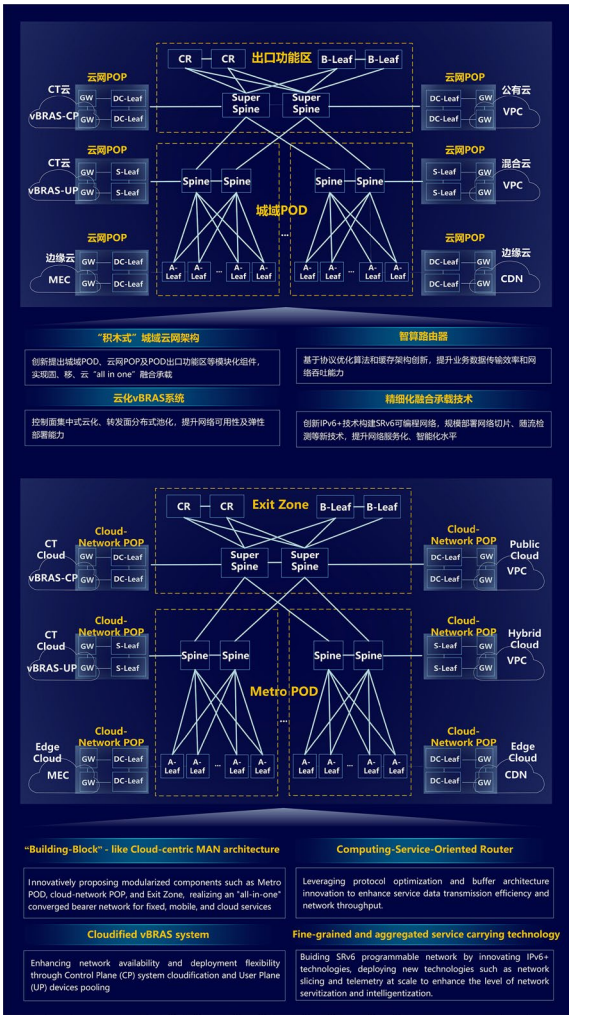
组网架构方面，提出基于转发图的混合链路保护等技术，构建城域“积木式”弹性可扩展架构，实现“南北 + 东西”向流量高效疏导和毫秒级云网业务访问时延。

网元技术方面，提出了控制面微服务化集群、转发面池化温备高可靠技术，研发了转控分离、虚实结合的云化 vBRAS 系统，业务承载效率提升 70%；推出了支持无损传输及全域负载均衡的智算路由器，满足分布式训练及推理全场景业务承载需求，赋能算力普惠化发展。

承载协议方面，提出了 FlexE+VTN+VPN 的层次化网络切片等技术，打造了骨干 + 城域端到端 SRv6 可编程广域网络，实现固、移、云全业务融合承载。

China Telecom proposed the Cloud-centric MAN architecture and key technology innovation system jointly with industrial partners, and established new cloud-network innovation base featuring cloud-network convergence, agility and intelligence.

In terms of network architecture, China Telecom proposed the forwarding graph-based hybrid link protection technology and built metropolitan “Building-Block”-like architecture featuring elasticity and scalability, realizing effective steering of east-west and north-south traffic and millisecond-level cloud-network access latency.




云网融合、敏捷高效的城域云网组网架构
Network Architecture of Cloud-centric MAN Featuring Cloud-Network Convergence, Agility and High Efficiency

As for network elements, China Telecom proposed technologies including control-plane microservice clustering and pooled forwarding-plane warm standby with high reliability, and developed cloudified vBRAS system in a Control Plane and User Plane Separation (CUPS) manner, delivering a 70% improvement in service carrying efficiency. Additionally, we have developed Computing-Service-Oriented Routers supporting lossless transmission and global load balancing to meet service carrying requirements across all scenarios of distributed training and inference, and empower inclusive development of computing power.
Regarding service carrying protocols, China Telecom proposed technologies including “FlexE+VTN+VPN” hierarchical network slicing and built “backbone + metropolitan E2E” SRv6 programmable network, realizing unified carrying of fixed, mobile, and cloud services.

## 赋能业务创新与绿色发展，推动全球城域网络演进
## Enabling Service Innovation and Sustainable Development, Driving the Global Evolution of Metropolitan Networks

城域云网在提质增效、云网业务创新方面成效显著，引领产业发展，经济效益和社会效益明显。

城域云网已覆盖全球超 3 亿用户，带动新型云网业务规模发展。云宽带等融合边缘新业务发展近 500 万户，融云、融 AI、融安全的视联网业务发展超 500 万户，网络切片及智算路由器赋能教育、电力、工业等 20 余行业算网应用创新及数字化转型。城域云网实现了城域内 IP 设备数减少 40%，承载效率提升 50%，助力全球减少碳排放超 10 万吨，实现绿色发展。

城域云网推动全球网络基础设施演进升级，赋能数字经济全球化发展。在沙特 STC 和马来西亚 Telekom Malaysia（TM）等 30 多家运营商实现了规模部署，为 2022 年杭州亚运会和 2023 年成都大运会等重大社会活动提供稳定、可靠的网络支持。




城域云网覆盖全球超 3 亿用户
The Cloud-centric MAN Serves over 300 Million Users Worldwide

The Cloud-centric MAN has accomplished remarkable achievements in quality and efficiency improvements as well as cloud-network convergence innovation. We have taken the lead in driving industry development and generated significant economic and social benefits.
Over 300 million subscribers have accessed the Cloud-centric MAN, driving the large-scale development of new cloud-network services. Converged edge services such as cloud broadband have gained nearly 5 million subscribers, and more than 5 million subscribers have subscribed vision networking services with AI and security features. In addition, dedicated network slicing and Computing-Service-Oriented Routers have accelerated service innovations and digital transformation across more than 20 sectors, including education, energy and manufacturing. The construction of the Cloud-centric MAN has reduced the number of devices by 40%, enhanced carrying efficiency by 50%, reduced global carbon emissions by more than 100,000 tons, contributing to green development.
The Cloud-centric MAN has driven the evolution of global network infrastructure, and empowered the global development of digital economy. It has been massively deployed in over 30 operators such as Saudi Arabia and Malaysia etc., and provided stable and reliable network support to many major social events, such as the Hangzhou 2022 Asian Games and Chengdu 2023 FISU World University Games.

## 引领 IP 网络产业发展，构建云网融合、算网融合新生态
## Leading the Development of the IP Network Industry, Building a New Ecosystem for Cloud-Network and Computing-Network Convergence

五年来，中国电信城域云网实现跨越式发展，为大规模云网融合实践提供了坚实的网络底座，并通过规模化部署应用，极大推动了 IP 网络产业发展。以城域云网为底座，孵化了融合边缘、视联网、Token 服务等创新应用，为企业带来新的业务增长点，树立全行业云网融合、算网融合实践典范。

城域云网成为中国电信创新平台，在 vBRAS、智算路由器、SRv6、层次化切片、随流检测等技术方面形成了一系列知识产权体系，输出授权专利 222 项、标准 73 项、专著 2 部及论文 39 篇；并联合华为和沙特电信（STC）等产业伙伴积极推进国际落地，目前已在沙特阿拉伯、马来西亚等 30 多个国家规模推广，覆盖全球用户超 3 亿，为全球信息基础设施数字化升级提供解决方案。

Over the past five years, China Telecom's Cloud-centric MAN has achieved a leapfrog development, building a solid network foundation for large-scale cloud-network convergence services. Via large-scale deployment, it has greatly promoted the development of the IP network industry. China Telecom fosters innovative applications, including the converged edge, vision networking, and token-based service based on Cloud-centric MAN, bringing new service revenue growth for enterprises, and setting an excellent example for cloud-network convergence and computing-network convergence practices across the entire industry.

China Telecom has set the Cloud-centric MAN as a comprehensive innovation platform, and formed a series of intellectual properties in vBRAS, Computing Service oriented Routers, SRv6, hierarchical slicing, and telemetry, including 222 authorized patents, 73 standards, 2 monographs and 39 papers. We further promote the overseas implementation of the related solutions in cooperation with industry partners such as Huawei and Saudi Telecom Company (STC). These solutions have been widely deployed in more than 30 countries such as Saudi Arabia and Malaysia etc., covering over 300 million global subscribers, which provided solutions for the digitalization of global information infrastructure.




**中国通信学会科学技术奖一等奖**
**First Prize of Science and Technology Award of China Institute of Communications**




**WBBA Innovation Excellence Award**



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Published Papers and Authorized Patents




**UBBF Best Practice of Net5.5G**

# 大模型驱动的全流程数智健康服务平台

## Large Model-Powered Full-Lifecycle Digital & AI Health Service Platform




蚂蚁阿福
AQ

蚂蚁科技集团股份有限公司
Ant Group Co., Ltd.

蚂蚁集团 ANT GROUP

## 引言

蚂蚁阿福是由蚂蚁集团依托自研的大模型能力，研发的连接用户、医生与医疗机构三端的 AI 医疗健康服务平台，实现了从健康问答、报告解读、AI 挂号和陪诊、在线问诊到康复管理的全生命周期健康服务。

## Introduction

AQ is an AI-powered healthcare service platform developed by Ant Group, leveraging its proprietary large language model capabilities to connect the three ends—users, doctors, and medical institutions. It delivers full-lifecycle health services, ranging from health Q&A and medical report interpretation to AI-assisted appointment booking, medical escort, online consultations, and rehabilitation management.

# “用户 - 医生 - 机构”三端联动的全生命周期服务平台

## A Full-Lifecycle Healthcare Service Platform Connecting Users, Doctors, and Healthcare Institutions




蚂蚁阿福聚焦优质医疗资源普惠可及这一核心命题，构建了“用户 - 医生 - 机构”三端联动的 AI 数智健康服务平台，解决了 AI 医疗技术应用面临的专业知识质量不高、服务链条割裂等核心痛点，实现了从健康问答、在线问诊、AI 挂号陪诊到康复管理的全生命周期健康服务闭环。主要技术创新包括：基于隐私脱敏与分层循证校验的多模异构医疗语料融合构建技术，基于尺度缩放定律与医学准则约束的大模型全流程可控训练技术，基于知识可溯源与高风险干预的医疗智能体构建技术，以及从方法论到数据再到基准三位一体的医疗 AI 测评与应用标准体系。截至目前，项目已获授权发明专利 40 余项，在 CVPR、KDD 等顶会上发表论文 20 余篇，主持和参与国际 / 国家 / 行业 / 团体标准十余项。

AQ addresses the core challenge of making high-quality medical resources universally accessible. It has built an AI-powered digital health service platform that connects users, doctors, and healthcare institutions across three endpoints, resolving key pain points in AI healthcare applications—including suboptimal professional knowledge quality and fragmented service chains—and achieving a closed loop of full-lifecycle health services spanning health Q&A, online consultations, AI-assisted appointment booking and medical escort, and rehabilitation management. Its key technological innovations include: multi-modal heterogeneous medical corpus fusion and construction technology based on privacy de-identification and hierarchical evidence-based validation; full-process controllable large-model training technology governed by scaling laws and medical guideline constraints; medical intelligent agent construction technology featuring traceable knowledge and high-risk intervention mechanisms; and a medical AI evaluation and application standards system integrating methodology, data, and benchmarks. To date, the project has been granted over 40 invention patents, published more than 20 papers at top-tier conferences including CVPR and KDD, and led or participated in the development of over ten international, national, industry, and group standards.

项目已获多项授权发明专利
The project has been granted multiple invention patents.




在 CVPR、KDD、ACL 等国际顶会议/期刊上发表多篇论文
The project has published multiple research papers at leading international conferences and in journals, including CVPR, KDD, and ACL



## 助力医疗资源下沉、促进普惠医疗服务
## Driving Healthcare Resources to the Grassroots Level and Advancing Inclusive Healthcare

蚂蚁阿福已支持健康咨询、就医陪诊、报告解读等多元化服务，让专业的医疗健康服务变得更普惠、更可及。构建的“用户 - 医生 - 机构”三端联动的医疗健康服务体系，在助力医疗资源下沉、促进普惠医疗方面发挥了积极作用。截至目前，蚂蚁阿福已覆盖中国省市县乡村五级医疗机构 5000 余家，App 最新用户数已达 1.5 亿，单



日咨询量近2000万人次，其中老年群体约占25%，三线及以下城市用户超55%，已经发展成为中国用户规模最大、覆盖范围最广、技术最先进的 AI 医疗健康服务平台，社会价值显著。

AQ supports a diverse range of services, including health consultations, medical escort, and medical report interpretation, making professional healthcare services more inclusive and accessible. The three-end healthcare service system connecting users, doctors, and institutions has played a positive role in channeling medical resources to lower-tier regions and promoting inclusive healthcare. To date, in China, AQ has been connected with over 5,000 medical institutions across all five administrative levels—province, city, county, township, and village. Its user base has reached 150 million, with nearly 20 million consultations per day. Approximately 25% of its users are elderly, and over 55% are from third-tier and smaller cities. AQ has thus become China's largest AI-powered healthcare service platform in terms of user scale, coverage, and technological sophistication, delivering remarkable social value.

## 全球普惠医疗健康服务的“中国方案”
## The Chinese Solution for Advancing Global Inclusive Healthcare Services

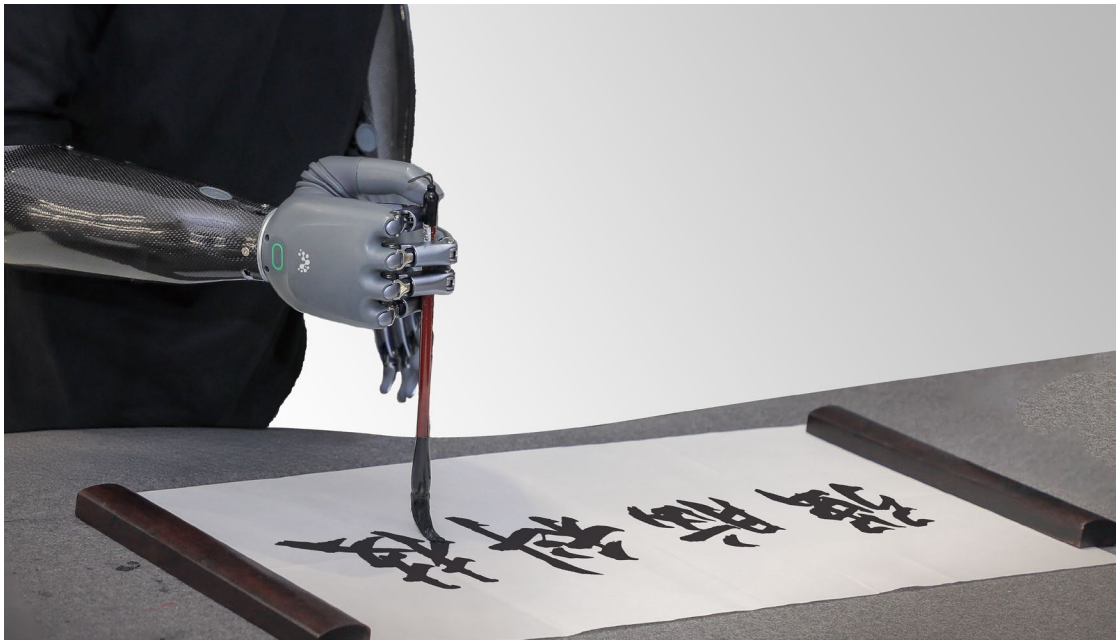
技术层面，蚂蚁阿福的核心模型在 HealthBench 等医疗权威评测榜单中名列前茅，医疗知识问答准确率超95%。生态层面，蚂蚁阿福已与中国 8 省市卫健委、18 省市医保局展开合作，与多家机构开展 AI 医疗研究，支持超 400 家医院上线就医智能体，并与苹果、华为、荣耀、小米、VIVO、欧姆龙、鱼跃等 18 家头部智能硬件厂商建立深度合作。蚂蚁阿福入选 WHO、ITU 等多个权威机构奖项和案例，打造了普惠健康服务的中国样板；获 2025 联合国国际电信联盟 AI for Good 全球峰会创新影响案例奖，并在 2026 年世界卫生大会上被称为“向全球健康事业贡献了可复制、可推广的‘中国方案’与中国经验”。

On the technical front, AQ's core model ranks among the top on authoritative medical evaluation benchmarks such as HealthBench, achieving over 95% accuracy in medical knowledge question answering. On the ecosystem front, AQ has partnered with health commissions in 8 provinces and municipalities and medical insurance bureaus in 18 provinces and municipalities, collaborated with multiple institutions on AI healthcare research, and supported over 400 hospitals in deploying medical intelligent agents. It has also established in-depth partnerships with 18 leading smart hardware manufacturers, including Apple, Huawei, Honor, Xiaomi, Vivo, Omron, and Yuwell. AQ has been selected for awards and case studies by multiple authoritative organizations including the WHO and the ITU, setting a Chinese benchmark for inclusive health services. It received the Innovative Impact Case Award at the 2025 ITU AI for Good Global Summit, and was commended at the 2026 World Health Assembly for “contributing replicable and scalable ‘Chinese solutions’ and ‘Chinese experiences’ to global health” .



# BrainCo 智能仿生手关键技术体系研发及规模化助残应用

## BrainCo Intelligent Bionic Hand: Core Technology Development and Large-Scale Assistive Applications



基于脑机接口技术的 BrainCo 智能仿生手，助力上肢截肢用户重获精细操作能力
The BrainCo Intelligent Bionic Hand, powered by brain-computer interface technology, helps people with upper-limb amputations regain fine motor control

浙江强脑科技有限公司
Zhejiang Qiangnao Technology Co., Ltd.

BrainCo

## 引言

BrainCo 智能仿生手基于脑机接口技术，采集并解析残肢末端的肌肉电与神经电信号，识别使用者的运动意图，驱动仿生手完成相应动作。产品自 2020 年量产以来持续迭代，帮助更多上肢截肢用户重获手部功能，提升生活自主能力。

## Introduction

The BrainCo Intelligent Bionic Hand is built on brain-computer interface technology. It captures and interprets muscle and neural electrical signals from the residual limb to identify the user's movement intentions and drive the bionic hand to perform the corresponding movements. Since entering mass production in 2020, the product has undergone continuous iteration, helping more users with upper-limb amputations regain hand function and achieve greater independence in everyday life.

## 精准识别运动意图，实现手随心动
## Accurately Identify Motor Intentions to Achieve Mind-Controlled Hand Movement

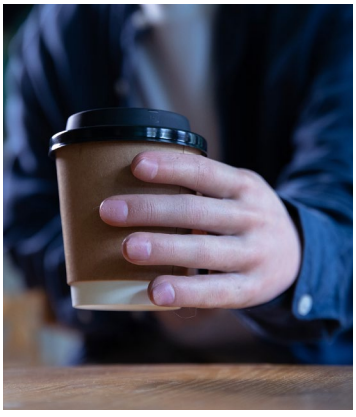
从复杂且存在个体差异的神经信号中准确识别运动意图，并将其稳定转化为自然、精细的手部动作，是智能仿生手实现灵巧控制的关键。基于脑机接口技术，BrainCo 智能仿生手通过采集残肢末端的神经电和肌肉电信号，结合人工智能算法进行实时解析，并通过运动控制系统驱动仿生手，实现五指独立运动及多指协同。新一代产品手体重量仅 383 克，控制精度达到 0.1°，五指握力达到 50N，整手承载能力达到 20kg，在轻量化、力量输出与精细控制之间实现良好平衡。产品还可搭配高仿真仿生手皮，通过对皮肤纹理、触感及外观细节的模拟，使仿生手在具备灵巧运动能力的同时，进一步接近自然手部的外观与触感。

Accurately identifying movement intentions from complex neural signals that vary across individuals, and reliably translating them into natural and precise hand movements, is key to achieving dexterous control of intelligent bionic hands. Built on brain-computer interface technology, the BrainCo Intelligent Bionic Hand captures neural and muscle electrical signals from the residual limb and uses artificial intelligence algorithms to interpret them in real time. Its motion control system then drives the bionic hand, enabling independent movement of all five fingers as well as coordinated multi-finger movements.

The latest-generation product weighs only 383 grams, achieves a control precision of 0.1°, delivers a five-finger grip force of 50 N, and supports a whole-hand load capacity of 20 kg, while balancing lightweight design, force output, and precise control. The product can also be fitted with highly realistic bionic skin that replicates the texture, feel, and visual details of human skin, bringing the appearance and tactile experience of the bionic hand closer to those of a natural hand while maintaining dexterous movement capabilities.



用户穿戴 BrainCo 智能仿生手进行电脑操作
A user operates a computer while wearing the BrainCo Intelligent Bionic Hand



用户穿戴搭配高仿真仿生手皮的
BrainCo 智能仿生手完成日常抓握动作
A user performs an everyday grasping task with the BrainCo Intelligent Bionic Hand fitted with highly realistic bionic skin



用户穿戴 BrainCo 智能仿生手进行攀岩运动
A user engages in rock climbing while wearing the BrainCo Intelligent Bionic Hand

## 推动脑机接口技术走向规模应用，让智能仿生手服务更多真实需求
## Bringing Brain-Computer Interface Technology to Large-Scale Application: Addressing a Broader Range of Real-World Needs with Intelligent Bionic Hands

BrainCo 智能仿生手于 2020 年实现量产，2022 年获得美国 FDA 上市批准，产品持续从技术研发走向实际应用。用户只需产生运动意图，系统即可通过残肢末端的神经电和肌肉电信号识别其意图，并驱动仿生手完成相应动作，实现“意念控制”的自然交互体验。通过技术迭代、规模化制造与供应链协同，产品在保持性能的同时不断提升可及性，为更多肢体残障人士提供智能假肢选择。在实际使用中，智能仿生手能够帮助使用者重新获得抓握、捏取等手部功能，更加自主地完成工作和日常生活任务，减少对他人照护的依赖，提升生活独立性与社会参与度，推动智能仿生技术进一步走进真实生活。

The BrainCo Intelligent Bionic Hand entered mass production in 2020 and received U.S. FDA clearance in 2022, with the product continuing to advance from technological development toward real-world applications. When users form an intention to move, the system identifies that intention through neural and muscle electrical signals from the residual limb and translates it into corresponding movements of the bionic hand, enabling intuitive, intention-driven control. Through continuous technological iteration, scaled manufacturing, and supply-chain collaboration, the product has become increasingly accessible while maintaining its performance, providing intelligent prosthetic options for a broader population of people with limb disabilities. In everyday use, the intelligent bionic hand helps users regain essential hand functions such as gripping and pinching, enabling them to perform work and daily activities with greater independence, reduce reliance on assistance from others, and participate more fully in social life.

## 以脑机接口技术助力肢残人士提升生活自主性，拓展社会参与的更多可能

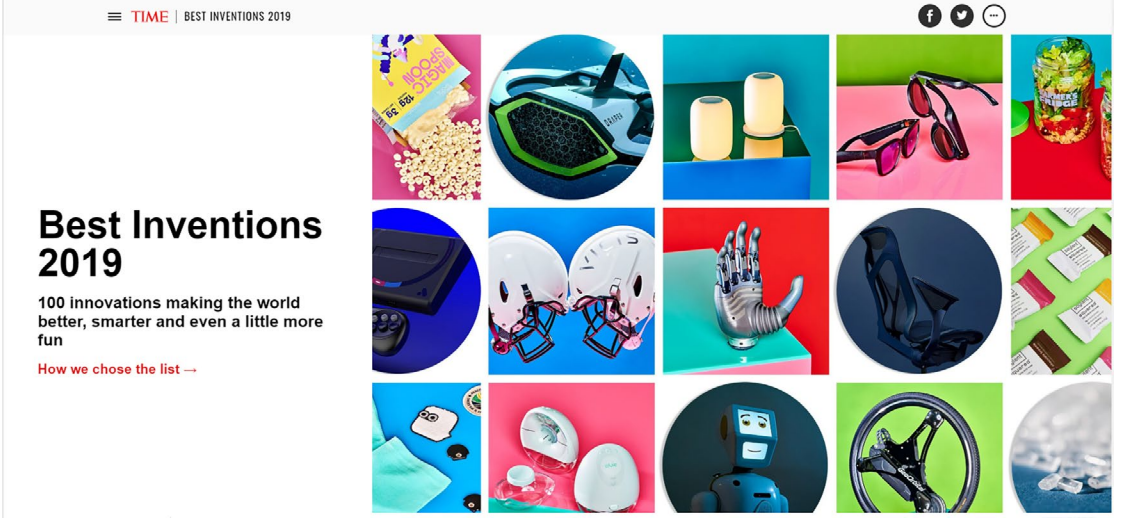
## Empowering People with Limb Disabilities to Achieve Greater Independence and Expand Opportunities for Social Participation through Brain-Computer Interface Technology

BrainCo 智能仿生手将脑机接口技术应用于肢残人士的功能恢复与生活辅助，其应用价值进一步延伸至生活自主与社会参与。2018 年，因意外失去右手的女孩借助 BrainCo 智能仿生手与钢琴家郎朗完成四手联弹；2022 年北京冬残奥会火炬传递中，残疾人运动员穿戴智能仿生手完成圣火传递；2023 年杭州第 4 届亚残运会开幕式上，残疾人运动员穿戴智能仿生手点燃主火炬。智能仿生手也先后获得 CES 创新大奖、德国红点最佳设计奖，并入选美国《时代》杂志 2019 年度百大最佳发明。随着产品持续走向更广泛的实际应用，脑机接口技术正在帮助更多肢体残障人士提升生活自主性，为他们参与工作、运动及社会生活提供更多可能，持续拓展技术应用的社会价值。



用户穿戴搭配高仿真仿生手皮的 BrainCo 智能仿生手完成日常精细动作
A user performs everyday fine-motor tasks with the BrainCo Intelligent Bionic Hand fitted with highly realistic bionic skin

The BrainCo Intelligent Bionic Hand applies brain-computer interface technology to support functional restoration and everyday living for people with limb disabilities, with its impact extending further to greater independence and social participation. In 2018, a young woman who had lost her right hand in an accident performed on stage with renowned pianist Lang Lang while wearing the BrainCo Intelligent Bionic Hand. In 2022, an athlete with a disability used the bionic hand to carry the flame during the Beijing Winter Paralympic torch relay. In 2023, an athlete wearing the BrainCo Intelligent Bionic Hand lit the main cauldron at the opening ceremony of the 4th Asian Para Games in Hangzhou. The product has also received international recognition, including a CES Innovation Award and the Red Dot: Best of the Best, and was named one of TIME's Best Inventions of 2019. As the product reaches broader real-world applications, brain-computer interface technology is helping more people with limb disabilities achieve greater independence and opening up more possibilities for participation in work, sports, and social life, further expanding the social value of its applications.




BrainCo 智能仿生手入选美国《时代》杂志 2019 年度百大最佳发明
The BrainCo Intelligent Bionic Hand was named one of TIME's Best Inventions of 2019

# 面向物理 AI 的整车智能体技术平台

## Vehicle Agent Technology Platform for Physical AI




地平线：整车智能全品类技术赋能者
Horizon Robotics: A Full-Range Technology Provider for Vehicle Agent

地平线
Horizon Robotics

## 引言

汽车是物理 AI 最先规模化落地的场景，正从出行工具演进为整车智能体。地平线为此构建了面向物理 AI 的整车智能体技术平台，包含智驾芯片征程 ®、舱驾融合整车智能体芯片星空™、整车智能体操作系统咖咖虾™、全场景辅助驾驶系统 HSD。

## Introduction

The automotive industry is the first to bring Physical AI to scale, as vehicles evolve from modes of transportation into intelligent agents. Horizon Robotics has built a technology platform for the physical-AI vehicle agent, integrating the Journey® intelligent driving SoC, the Starry™ AD-cockpit fusion SoC, the KKClaw™ vehicle intelligence agent operating system, and the Horizon SuperDrive™ (HSD) full-scenario assisted driving system.

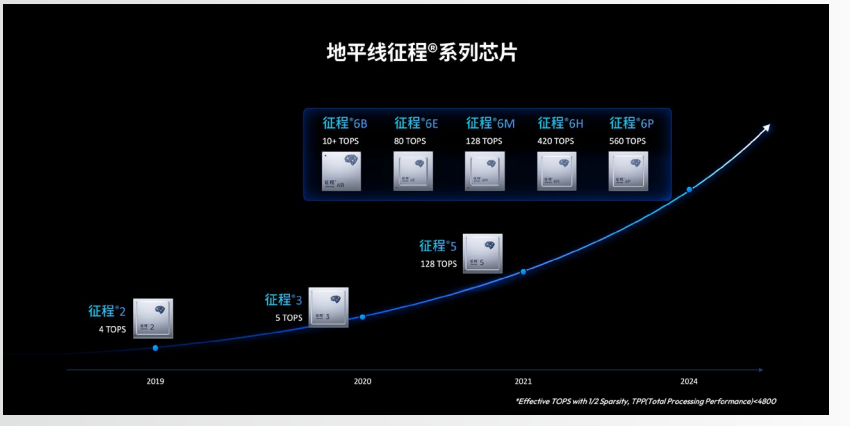
## 面向整车智能体时代，实现算力底座、智能交互中枢、行动中枢三重创新
## Three Layers of Innovation for the Vehicle Agent: Compute, Interaction, Action

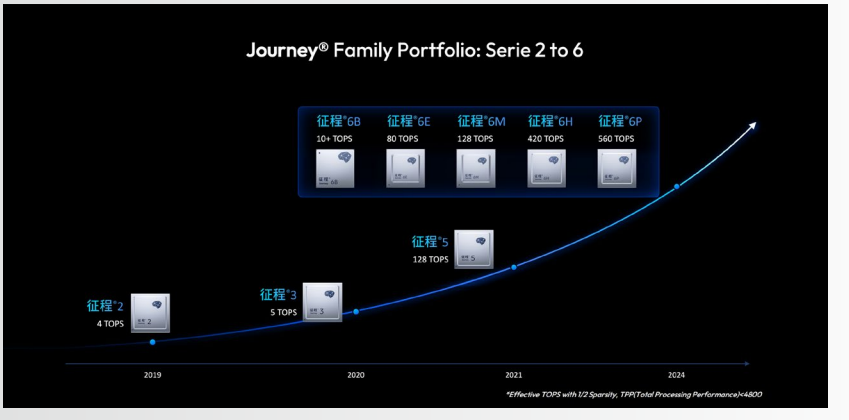
整车智能体依赖强大的算力底座。征程 ® 系列车规级芯片基于自研 BPU® 架构，通过算法、编译器与硬件深度协同，持续提升计算效率。在此基础上，推出舱驾融合整车智能体芯片星空 ®，以单颗芯片实现智驾、座舱、仪表、车控四域融合，提供中央计算基座。

算力底座之上，操作系统决定汽车能否具备智能体特质。咖咖虾是面向整车智能体的原生操作系统，提出“任务即服务”的智能交互范式，使其成为真正理解用户的智能伴侣。

整车智能体不仅要懂用户，更要安全地行动。地平线全场景辅助驾驶系统 HSD（Horizon SuperDrive ™）将生成式大模型能力与端到端架构深度整合，率先突破了“感知—规划—控制”模块化串联架构误差逐级累积、规则代码难以覆盖长尾场景的行业瓶颈，构成行动中枢。

A whole-vehicle agent runs on compute. Journey™ is powered by Horizon’s self-developed BPU™ intelligent acceleration engine. Starry® takes that further: on a single piece of silicon, it unifies four domains into one central computing base.
Compute alone does not make a car an Agent - the operating system does. KKClaw is an operating system built for the vehicle agent, on one simple shift: the unit of service is the task, not the function. The car works out what you are trying to do, instead of waiting for you to find the right button.
Understanding the user is not enough. The agent has to act, and act safely. Horizon SuperDrive™ (HSD) is a full-scenario assisted driving system. It brings generative large-model capability into an end-to-end architecture, replacing the modular perception–planning–control pipeline, in which errors compound from stage to stage and hand-written rules cannot cover the long tail.




地平线征程 ® 系列芯片
Horizon JourneyTM Series




地平线 HSD（Horizon SuperDrive ™）全场景辅助驾驶系统
HSD: Horizon SuperDrive™

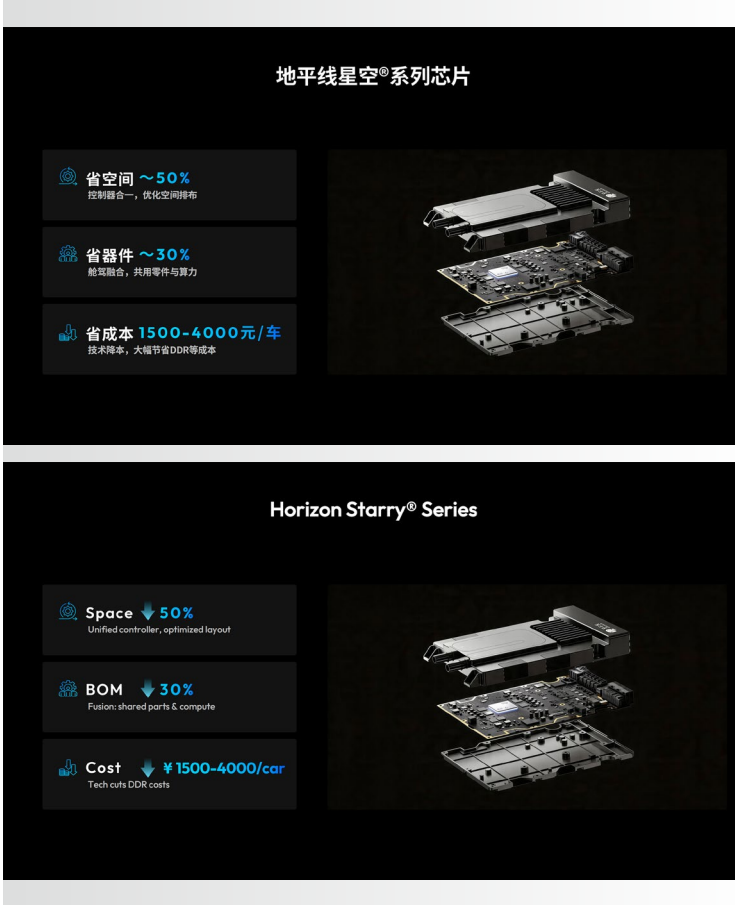
## 技术平台规模化应用，推动整车智能体时代加速到来
## Scaled Deployment of the Technology Platform, Accelerating the Arrival of the Vehicle Agent Era

算力底座征程 ® 系列车规级芯片累计出货突破 1,500 万套，中国每三台智能网联汽车就有一台搭载地平线方案。星空 ® 芯片已完成实车验证，即将量产首发。

经济效益层面，星空舱驾融合方案通过技术创新实现单车 1,500 至 4,000 元综合硬件成本下降，舱驾一体软硬件整体交付时间缩短 56%。此外，技术平台推出 HSD Together 算法服务模式，允许合作伙伴聚焦系统集成、车型适配等功能开发，可将产品开发人力投入、算力消耗与上市周期降低 90%。

社会效益层面，技术平台持续推动智驾普惠。在中国境内，将城区 NOA 带入 15 万元级主流市场。技术平台的规模化应用，不仅推动整车智能体从概念走向产业现实，更为全球汽车产业向物理 AI 时代的整体跃迁提供了可复制、可验证的技术路径与产业范本。

Cumulative shipments of Journey™ series have surpassed 15 million units, and one in every three intelligent connected vehicles in China is equipped with Horizon's solution. Starry® has completed on-vehicle validation and will enter mass production soon.
In economic terms, the Starry® AD-cockpit fusion solution reduces total per-vehicle hardware cost by RMB 1,500 to 4,000 through technological innovation, and shortens overall delivery time for integrated cockpit-and-driving hardware and software by 56%. The technology platform also introduces HSD Together, an algorithm service model that allows partners to concentrate on system integration, vehicle adaptation and related feature development, reducing product development manpower, computing resource consumption and time-to-market by 90%.
In social terms, this platform continues to bring assisted driving within reach of the mass market. Within China, it has brought urban navigation-assisted driving into the RMB 150,000 mainstream segment. The scaled deployment not only takes the vehicle agent from concept to reality, but also provides the global industry with a replicable, verifiable technology path and model for its transition to the Physical AI era.




地平线星空 ® 系列芯片
Horizon Starry® Series




持续构建覆盖功能安全、网络安全、预期功能安全与 AI 安全的全维度保障体系
One Safety Framework: Functional Safety, Cybersecurity, SOTIF and AI Safety

## 构建安全体系、服务客户需求，赢得行业广泛认可
## Building a Safety System, Serving Customer Needs, Earning Broad Industry Recognition

客户选择是对技术最直接认可。大众、比亚迪、奇瑞、长安等全球主流车企，以及博世、电装等国际 Tier-1 均已达成合作，赋能超 40 家整车企业及品牌。2026 年上半年，在中国自主品牌乘用车智驾芯片（全阶）市场，地平线以 31.94% 的市场份额，继续保持行业第一。

国际标准认证是对技术平台的权威背书。2025 年，地平线获得全球首个 ISO/PAS 8800 道路车辆 AI 安全认证，率先成为将 AI 安全、预期功能安全与功能安全融合为统一开发体系的智驾科技企业，累计取得 10 项国际权威体系认证。

行业奖项是对技术创新的持续肯定。核心成果先后获得世界互联网大会领先科技成果、全球新能源汽车创新技术奖、中国汽车工程学会科学技术奖一等奖等，涵盖芯片、智驾、整车智能多维度，印证了从技术研发到规模化产业落地的完整创新链条。

Customers vote with their orders. Leading global automakers including Volkswagen, BYD, Chery and Changan, together with international Tier-1 suppliers such as Bosch and Denso, have established partnerships with the platform, which now supports more than 40 automakers and brands. In the first half of 2026, Horizon held a 31.94% share of the assisted driving computing solution market for Chinese domestic-brand passenger vehicles across all tiers, retaining its position as the market leader.

International standards put the platform to an independent test. In 2025, Horizon obtained the world's first ISO/PAS 8800 certification for AI safety in road vehicles, becoming the first assisted driving technology company to bring AI safety, safety of the intended functionality and functional safety together into a single unified development system. It now holds 10 international system certifications in total.

Industry awards reflect sustained recognition of technological innovation. Core achievements have received the World Internet Conference Leading Technology Achievement Award, the World New Energy Vehicle Innovative Technology Award and the First Prize of the China Society of Automotive Engineers Science and Technology Award, among others. These span computing solutions, assisted driving and vehicle intelligence, evidence of a complete innovation chain running from R&D through to large-scale industrial deployment.

## 物理世界与数字世界融合，奔赴整车智能体
## Where the Physical and Digital Worlds Converge: Toward the Vehicle Agent Era

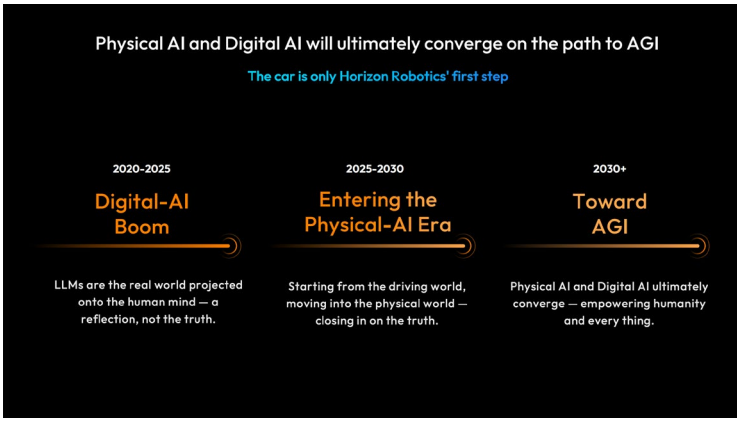
人类社会正经历从数字 AI 到物理 AI、再到二者全面融合的历史性跨越。

地平线以智能汽车为切入点，致力于成为物理 AI 时代的超级平台。整车智能体技术平台是这一路径上经千万量级量产验证的物理世界 AI 完整技术栈。其积累的软硬协同经验、大规模数据闭环能力与开放生态体系，将随技术演进向具身智能、工业自动化等更广泛的物理 AI 应用场景延伸，为人类迈向物理 AI 与数字 AI 融合的新时代奠定坚实基础。

Human society is making a historic leap — from digital AI to Physical AI, and on to the convergence of the two.

Horizon is entering Physical AI through the intelligent vehicle, with the ambition of becoming the platform that era is built on. Its whole-vehicle agent technology platform is a complete AI stack for the physical world, proven at ten-million-unit production scale. What that platform has accumulated, hardware and software designed together, a data loop that closes at scale, an open ecosystem, will extend as the technology matures into embodied AI, industrial automation and other physical-world applications, laying the groundwork for an era in which Physical AI and digital AI become one.



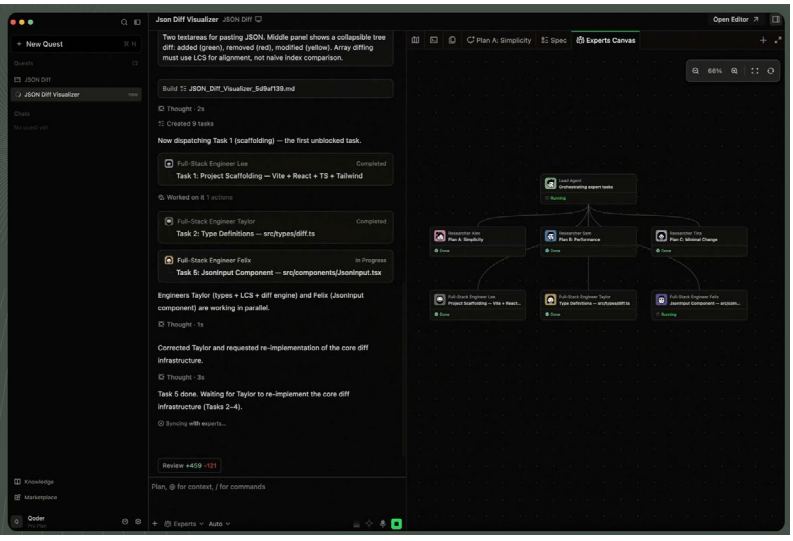

地平线：从国民智驾，到通用智能
Horizon: From Assisted Driving for Everyone to Intelligence for Everything

# Qoder：AI 时代的智能体生产力平台

## Qoder: An Agentic Productivity Platform for the AI Era

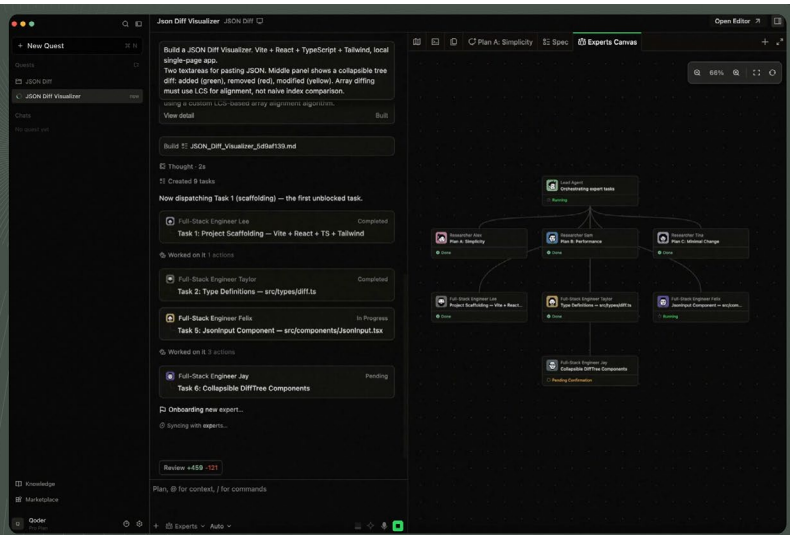
### 自主编程新范式

Qoder 通过多智能体协同、长时委派执行、记忆与知识引擎机制，与代码库和工具链的深度连接，让 AI 围绕真实任务持续完成理解、规划、执行、验证与迭代，直至交付。让每个开发成为超级个体。




### A New Paradigm of Agentic Coding

Qoder enables AI to understand, plan, execute, and iterate on real-world tasks through multi-agent collaboration, long-horizon execution, memory, and deep codebase integration—until delivery is complete.




Qoder 智能体生产力平台概览
Qoder Agentic Productivity Platform at a Glance

## 引言

Qoder 是面向真实工作的智能体生产力平台，以特训模型、多智能体编排、工程知识引擎为核心，推动 AI 从对话助手进化为可自主理解、规划、执行、验证与迭代的工程智能体，已服务全球超 600 万用户与超十万家企业。

## Introduction

Qoder is an agentic productivity platform for real-world work. Through specially trained models, multi-agent orchestration, and an engineering knowledge engine, it advances AI from conversational assistant to an autonomous engineering agent capable of understanding, planning, executing, verifying, and iterating until delivery. It now serves over 6 million users and over 100,000 enterprises worldwide.

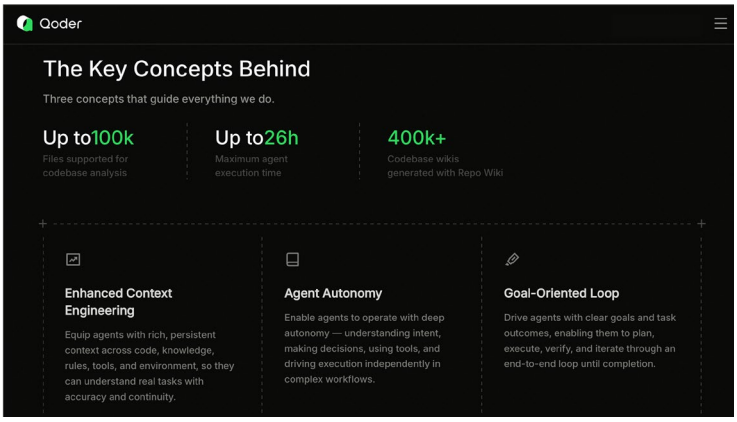
## 基于 Harness Engineering 方法论，以增强上下文工程、智能体自主性与目标导向闭环系统性突破智能体自主执行完整研发任务的瓶颈

## Built on Harness Engineering, Qoder systematically breaks the barriers of autonomous agentic execution through Enhanced Context Engineering, Agent Autonomy, and a Goal-Oriented Loop

智能体自主执行完整研发任务面临模型认知、多智能体协作与工程上下文三大核心挑战。Qoder 基于 Harness Engineering 方法论，实现系统性突破：在模型层，首创过程感知训练方法 SWE-GPT，将仓库理解、缺陷定位与补丁生成的认知过程纳入训练信号，72B 模型在 SWE-bench Verified 达 30.20% 问题解决率，获 ISSTA 2025 杰出论文奖；自研 Qoder NEXT 智能编辑预测模型，代码生成率提升超 53%，用户接受率提升 65%。在上下文工程层，工程知识引擎通过 Code Graph 语义建模、Agentic Search 检索解耦与 Repo Wiki 长期记忆，为智能体提供覆盖代码、知识、规则、工具与环境的持续上下文；知识按用户、团队、仓库和任务四维索引，检索 token 下降 21%，任务完成度提升 12%，记忆使不满意率下降 27%，95% 新仓库一分钟内完成索引。在智能体自主性层，率先将服务网格理念引入智能体编排，Experts Mode 由 Leader Agent 调度 Coding、QA、Review 等专家并行协作，质量评分超越单智能体 67%，已获授权发明专利。目标导向闭环（Goal-Oriented Loop）以目标和结果驱动，规划、执行、验证与迭代直至任务完成，交付可审查、可提交。

Autonomous execution of complete development tasks faces three core challenges: limited domain-specific model cognition, inefficient multi-agent collaboration, and constrained engineering context understanding. Built on the Harness Engineering methodology, Qoder achieves systematic breakthroughs. At the model layer, it pioneers SWE-GPT, a process-centric training method that incorporates repository comprehension, defect localization, and patch generation into training signals; the 72B model achieves a 30.20% resolution rate on SWE-bench Verified and received the ISSTA 2025 Distinguished Paper Award. The proprietary Qoder NEXT edit-prediction model improves code generation rate by over 53% and user acceptance by 65%. At the Enhanced Context Engineering layer, the engineering knowledge engine delivers semantic-level understanding through Code Graph modeling, Agentic Search decoupling, and Repo Wiki long-term memory, providing agents with persistent context across code, knowledge, rules, tools, and environment. Knowledge is indexed across four dimensions (user, team, repository, task), reducing retrieval tokens by 21%, improving task-completion scores by 12%, cutting dissatisfaction by 27% through memory, and indexing 95% of new repositories within one minute. At the Agent Autonomy layer, Qoder is the first to apply service-mesh concepts to agent orchestration; the Experts Mode Leader-Expert architecture coordinates Coding, QA, and Review specialists in parallel, outperforming single-agent approaches by 67% in quality scores, with a granted invention patent. The Goal-Oriented Loop drives planning, execution, verification, and iteration until the task is complete; delivery can be reviewed and submitted.




Qoder 三大核心理念：增强上下文工程、智能体自主性与目标导向闭环

Qoder's Three Key Concepts: Enhanced Context Engineering, Agent Autonomy, and Goal-Oriented Loop

## 服务全球超 600 万用户与超十万家企业，实现从辅助编程到自主编程的规模化落地

## Serving Over 6 Million Users and Over 100,000 Enterprises Worldwide, Achieving Large-Scale Deployment from Assisted to Autonomous Programming

Qoder 于 2025 年 8 月上线，仅 5 天即突破 10 万注册用户，目前已服务全球超 600 万用户与超十万家企业，覆盖 200 多个国家和地区，中国以外的用户约占四成。平台带来阶梯式效率提升：辅助编程阶段研发效率提升约 30%，协同编程阶段提升 30% 至 100%，自主编程阶段将完整研发任务委派给智能体团队，效率提升超 100%；长时委派最长可达 26 小时，交付可审查、可提交。QoderCLI 使人工操作步骤减少 60%，代码修复交付速度提升 2 倍；成本上综合场景 token 下降 15% 至 30%，其中 10 万以上文件仓库检索 token 下降 30.46%。在行业落地方面，上汽通用汽车累计节省编码时间超 45,000 分钟，人均每月节省约 5.3 小时；海信推动研发范式从辅助编程向自主编程转变；上海三菱电梯一期部署超 1,000 席位，将技术生产力释放至产品经理等非开发者角色。

Launched in August 2025, Qoder reached 100,000 registered users within 5 days. It now serves over 6 million users and over 100,000 enterprises across more than 200 countries and regions, with about 40% of users outside China. The platform delivers tiered productivity gains: in the assisted programming stage, R&D efficiency improves by about 30%; in collaborative programming, gains reach 30% to 100%; in autonomous programming, complete R&D tasks are delegated to agent teams, delivering over 100% improvement. Long-horizon execution can run up to 26 hours, with delivery reviewable and submittable. Qoder CLI reduces manual operation steps by 60% and doubles code-fix delivery speed. Token consumption falls 15% to 30% in mixed scenarios; in repositories with more than 100,000 files, retrieval tokens fall 30.46%. In industry deployments, SAIC General Motors saved over 45,000 minutes of coding time with each developer saving about 5.3 hours per month; Hisense is shifting its R&D paradigm from assisted to autonomous programming; Shanghai Mitsubishi Elevator deployed over 1,000 seats in Phase One, extending technical productivity to non-developer roles such as product managers.

## 核心成果获国际顶级学术认可，开源共享与标准共建推动全球 AI 编程生态演进

## Core Results Earn Top International Academic Recognition; Open Sharing and Standards Co-Development Advance the Global AI Coding Ecosystem

Qoder 核心技术先后被 ISSTA、ICSE、ICLR、AAAI 等国际顶级学术会议收录，代表性成果 SWE-GPT 获 ACMSIGSOFT 杰出论文奖，为该届唯一授予企业的论文。累计发表论文 30 余篇，获授权发明专利 18 项，代表性专利 CN120653405B 保护基于服务网格的多智能体编排方法。SWE-GPT 推理代码与模型权重已向全球开发者开放，配套技术文档与评测基准公开共享；团队作为智能化软件工程工作组首批成员单位，联合发起代码大模型行业标准。在全球 AI 编程赛道，Qoder 是少数拥有面向编程场景特训模型的平台之一，中国以外的用户超四成。Qoder 推动编程从专业技能转变为通用工具：自然语言和自主编程降低工程门槛，开发者从写代码转为指挥智能体；QoderWork 让非技术人员通过自然语言完成完整工作流，QoderWake 以记忆和技能自进化支持 7×24 执行，开创 AI 原生数字员工新品类。2024 年，前身通义灵码入选 WAIC 镇馆之宝。模型、智能体与产品按周共进化，推动软件开发从辅助工具走向可委派的智能体协作。



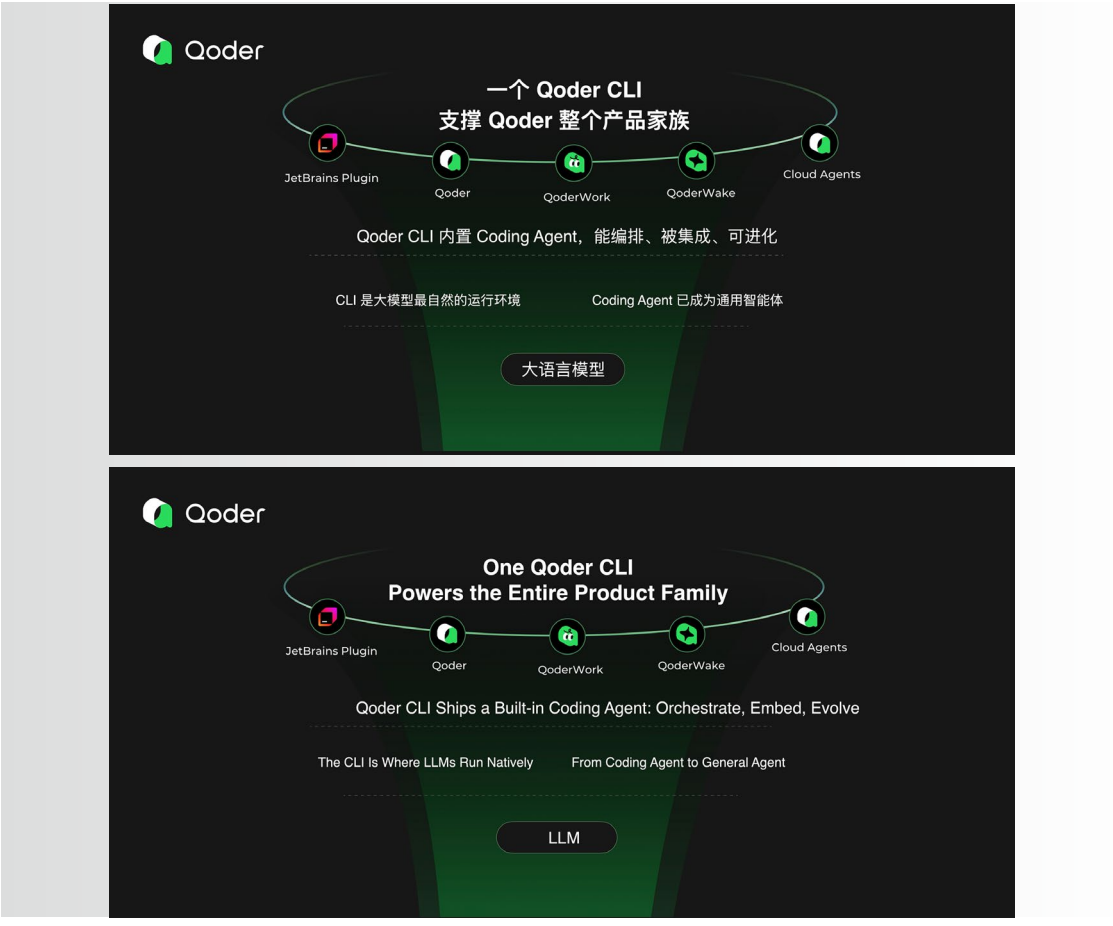

QoderWake 数字员工：有工号、有技能，与人组建协同办公网络
Your First AI Employee: Digital Workers with Identities and Expanding Skills, Collaborating with Humans

Qoder's core technologies have been published at premier international conferences including ISSTA, ICSE, ICLR, and AAAI. The representative work SWE-GPT received the ACM SIGSOFT Distinguished Paper Award, the only enterprise paper so honored in its edition. Over 30 papers have been published and 18 invention patents granted; the representative patent CN120653405B covers service-mesh multi-agent orchestration. SWE-GPT inference code and model weights are open to global developers, with technical documentation and evaluation benchmarks publicly shared. As a founding member of the Intelligent Software Engineering Working Group, the team co-initiated a code large model industry standard. In the global AI coding arena, Qoder is one of the few platforms with a specially trained model for programming scenarios; overseas users account for over 40%. Qoder is transforming programming from a specialized skill into a general tool: natural language and agentic coding lower the barrier to engineering work, and developers move from writing code to delegating work to agents. QoderWork enables non-technical personnel to complete full workflows through natural language; QoderWake uses self-evolving memory and skills for 7x24 execution, pioneering the category of AI-native digital employees. In 2024, the predecessor Tongyi Lingma was selected as a WAIC "Treasure of the Exhibition" exhibit. Models, agents, and the product co-evolve weekly, advancing software development from assistance tools toward delegated agent collaboration.

## 从编码辅助到自主智能体平台，五大主力产品构建智能体生产力矩阵
## From Coding Assistance to Autonomous Agentic Platform: Five Flagship Products Forming an Agentic Productivity Matrix

Qoder 完成从编码辅助到智能体平台的跃迁，形成五大主力产品矩阵。Qoder IDE 定位自主开发 IDE，深度融合 Quest Mode 自主编程、Experts Mode 多智能体协作与工程知识引擎，面向真实软件开发；Qoder CLI 将智能体能力延伸至终端与 CI/CD 场景，既是编程伙伴，也是可构建的智能体引擎；QoderWork 进一步将 AI 生产力延伸至知识工作者；QoderWake 为企业提供安全可投产、持续进化的 7×24 AI 员工，为组织提供可扩展人力；Cloud Agents 作为全托管云端智能体平台，支撑企业将智能体快速集成至多元业务场景。平台具备周级别快速演进能力。

Qoder has completed a full leap from coding assistance to an agentic platform, now built around five flagship products. Qoder IDE, the autonomous development IDE, deeply integrates Quest Mode, Experts Mode multi-agent collaboration, and the engineering knowledge engine for real-world software development. Qoder CLI extends agent capabilities to terminals and CI/CD, serving as both a coding partner and a buildable agent engine. QoderWork further extends AI productivity to knowledge workers. QoderWake delivers secure, production-ready, continuously evolving 7×24 AI employees, giving organizations scalable workforce. Cloud Agents, a fully managed cloud-based agent platform, helps enterprises rapidly integrate agents into diverse business scenarios. The platform sustains weekly-level rapid evolution.

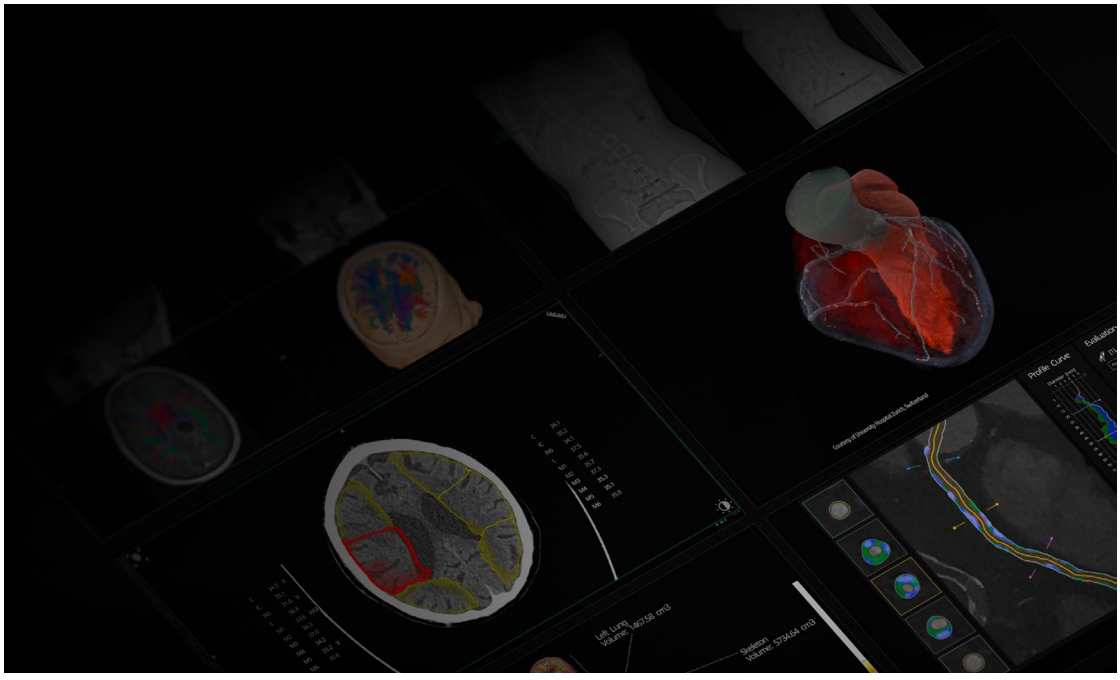



Qoder 产品家族
The Qoder Product Family


2026WORLD
INTERNET
CONFERENCE

# syngo.via 飞云智慧影像平台

## syngo.via Medical Image Post-processing Platform




syngo.via 飞云智慧影像平台
syngo.via Medical Image Post-processing Platform

西门子医疗系统有限公司
Siemens Healthineers Ltd.

SIEMENS Healthineers

## 引言

syngo.via 飞云智慧影像平台已在全球 20,000 余家医疗机构部署，获 20 余国权威认证。平台建成开放式多厂商统一架构，在中国落地多项独创智能应用，构建 AI 开放平台，推动影像能力下沉基层。

## Introduction

syngo.via, Siemens Healthineers' medical image post-processing platform, has been deployed at more than 20,000 medical institutions worldwide and has obtained regulatory clearances or certifications in more than 20 countries. Featuring an open multi-vendor architecture, China-pioneered AI applications, and an open AI platform, it extends advanced imaging capabilities to primary care.

## 开放式 AI 影像平台，普惠全球基层医疗
## An Open AI Imaging Platform Bringing Accessible Healthcare to Grassroots Communities Worldwide

syngo.via 飞云智慧影像平台攻克了多品牌医疗设备异构数据整合、传统影像模态壁垒及 AI 临床转化“最后一公里”等长期工程瓶颈。平台首创开放式多厂商兼容架构，实现 CT、MR、PET 等异构数据统一接入与处理，打破数据孤岛；率先将 AI 推理引擎与多模态 3D 重建引擎深度原生融合，构建从影像加载、智能分析到结构化报告生成的全链路自动化工作流，而非简单外挂式集成。

平台原创“一次胸部 CT 平扫、多病种同步评估”技术，单次检查即可完成肺癌、肺气肿等五种疾病联合筛查，颠覆传统“一病一查”模式。首创 cVRT 技术，较传统体积渲染呈现更逼真空间解剖关系。已获全球 20,000 余家机构采用及 20 余国权威认证，技术先进性达国际领先水平。

syngo.via has overcome long-standing engineering bottlenecks in heterogeneous data integration across multi-brand medical devices, traditional imaging modality barriers, and the “last mile” of AI clinical translation. The platform pioneered an open, multi-vendor compatible architecture that enables unified ingestion and processing of heterogeneous CT, MR, and PET data, eliminating data silos. It was the first to achieve deep native integration of the AI inference engine with the multimodality 3D reconstruction engine, establishing an end-to-end automated workflow spanning image loading, intelligent analysis, and structured report generation—rather than superficial plug-in integration.

The platform originally developed the “single chest CT scan, multi-disease synchronous assessment” technology, enabling simultaneous screening for five diseases including lung cancer and emphysema within one examination, overturning the traditional “one-disease-one-scan” paradigm. It pioneered cVRT (cinematic volume rendering technology), delivering substantially more realistic spatial anatomy than conventional volume rendering. Adopted by over 20,000 institutions worldwide and certified by authoritative bodies in more than 20 countries, the platform has attained an internationally leading level of technological sophistication.



## 全球两万余机构装机，降本增效普惠基层
## Over 20,000 Institutions Worldwide, Improving Efficiency and Expanding Access to Healthcare

syngo.via 已在全球 20,000 余家医疗机构成熟部署，覆盖北美、欧洲及亚太主要市场，获美国 FDA、欧盟 CE、中国 NMPA 等权威认证。“一次 CT 多病种评估”减少重复检查，降低就医成本；AI 辅助缩短阅片时间 21%，提升设备周转与人力效率，基层医院无需购置高端设备即可获高级后处理功能。社会效益上，平台推动均质医疗，AI 诊断能力下沉基层，提高诊断质量；智能分诊优先推送急性脑卒中、创伤出血等危急病例，缩短急诊响应时间；肿瘤精准评估提升患者生存率。syngo.via 以其开放式 AI 模型平台构建起覆盖算法研发、临床验证到商业落地的完整产业生态，不仅创造可观市场价值，更通过提升全球诊断水平、优化医疗资源配置，成为推动医疗数字化转型的关键基础设施。

syngo.via has been maturely deployed across over 20,000 medical institutions worldwide, covering major markets in North America, Europe, and Asia-Pacific, with authoritative certifications including U.S. FDA, EU CE, and China NMPA. Its “single CT scan, multi-disease assessment” reduces redundant examinations and lowers healthcare costs; AI assistance cuts reading time by 21%, improving equipment turnover and human resource efficiency, while grassroots hospitals gain advanced post-processing capabilities without purchasing high-end equipment. Socially, the platform advances homogeneous healthcare by extending AI diagnostic capabilities to primary-care settings and improving diagnostic quality; intelligent triage prioritizes emergency cases such as acute stroke and trauma hemorrhage, shortening emergency response times; precise tumor assessment improves patient survival rates. With its open AI model platform, syngo.via has built a complete industrial ecosystem spanning algorithm development, clinical validation, and commercial deployment, generating considerable market value while elevating global diagnostic standards and optimizing medical resource allocation, establishing itself as critical infrastructure for healthcare digital transformation.



## 全球核心市场领先，引领医学影像智能化变革
## Leading in Core Global Markets, Driving the Intelligent Transformation of Medical Imaging

syngo.via 的规模化应用正在重塑全球医疗影像服务的供给模式。经济上，平台通过 AI 辅助诊断与多病种同步评估，显著降低医疗机构运营成本与患者就医负担，基层医院无需重资产投入即可获得高水平影像处理能力，实现优质医疗资源的“轻资产化”下沉。社会层面，智能分诊系统重构了急诊影像响应机制，为脑卒中、创伤等危急重症赢得黄金救治时间；同时，MR 智能应用将前列腺、脑血管等复杂疾病的诊断同质化水平提升至国际领先，有效缓解因医生经验差异导致的诊疗质量参差。产业层面，开放式 AI 模型平台打破了传统医疗软件封闭生态，赋能全球开发者与医疗机构协同创新，加速 AI 算法从实验室到临床的转化闭环，构建起覆盖研发、验证、落地的完整产业生态。长远来看，syngo.via 不仅创造了可观的市场价值，更通过推动医疗均质化、降低体系运行成本、减少不必要的辐射暴露与碳排放，为全球医疗数字化转型提供了可持续的基础设施支撑。

The large-scale adoption of syngo.via is transforming the global medical imaging service delivery model. Economically, the platform significantly reduces operational costs for healthcare institutions and patient care expenses through AI-assisted diagnosis and multi-disease synchronous assessment. Grassroots hospitals gain advanced capabilities without heavy capital investment, enabling asset-light delivery of premium diagnostic resources to underserved areas.

Socially, the intelligent triage system restructures emergency imaging response mechanisms, securing golden treatment windows for critical conditions such as stroke and trauma. Meanwhile, MR intelligent applications elevate diagnostic homogeneity for complex diseases including prostate and cerebrovascular disorders to internationally leading standards, effectively mitigating quality disparities caused by variations in physician experience.

Industrially, the open AI model platform disrupts the closed ecosystem of traditional medical software, empowering global developers and healthcare institutions to collaborate on innovation. This accelerates the closed-loop translation of AI algorithms from laboratory to clinical practice, establishing a complete industrial ecosystem spanning research, validation, and deployment.

In the long term, syngo.via generates considerable market value while advancing healthcare homogenization, reducing system operating costs, and minimizing unnecessary radiation exposure and carbon emissions. It provides sustainable infrastructure support for global healthcare digital transformation.





# 科技之魅

CHARM OF SCIENCE AND TECHNOLOGY

# 02

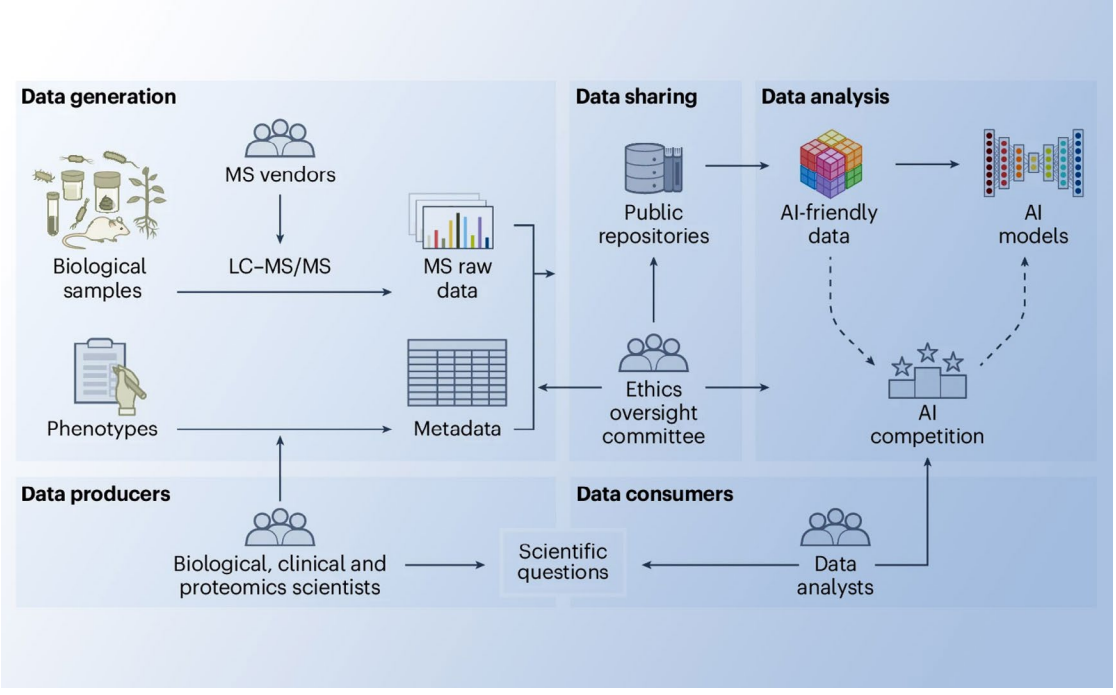
# 世界互联网大会
# 领先科技奖收录成果

Collection of World Internet Conference
Awards for Pioneering Science and Technology

# 基础研究组
# Basic Research Group

# AI 驱动的蛋白质组大数据研究

## AI-Driven Proteomics Big Data Research




构建面向人工智能的质谱蛋白质组生态系统
Building an AI-friendly ecosystem for MS-based proteomics

西湖实验室（生命科学和生物医学浙江省实验室）
Westlake Laboratory

西湖大学
Westlake University

## 引言

蛋白质组大数据研究长期受限于检测深度不足、通量有限及 AI 可用数据匮乏。团队构建了覆盖高通量数据生成、标准化数据体系、深度学习解析与疾病应用的全链条技术框架，推动蛋白质组学向数据驱动型科学转型。

## Introduction

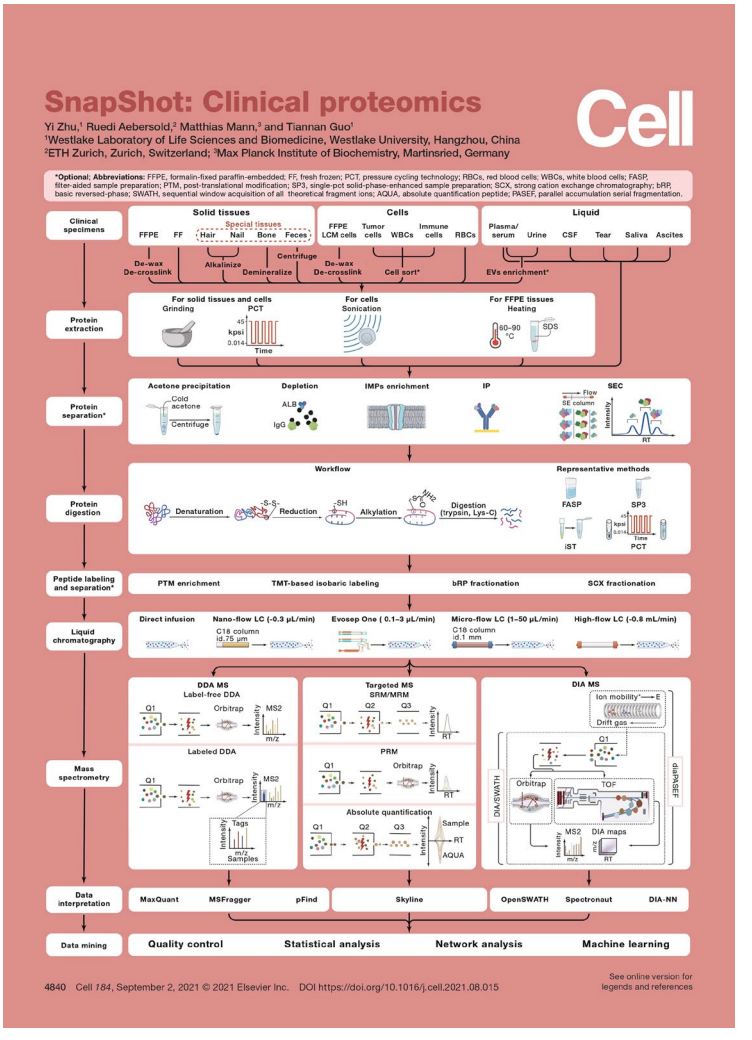
Proteomics big data research has long been constrained by limited detection depth, low throughput, and insufficient AI-ready data. This project established a end-to-end technological framework spanning high-throughput data generation, standardized data infrastructure, deep-learning interpretation, and disease applications, driving the transformation of proteomics toward data-driven scientific research.

## 原创开发蛋白质组大数据核心技术体系，系统性突破 AI 训练数据瓶颈

## Development of an Original Core Technology System for Proteomic Big Data, Systematically Breaking Through Bottlenecks in Data Acquisition for AI Modeling

团队原创开发 PCT-DIA-MS、ProteomEx、FAXP 系列核心技术，解决了蛋白质组数据获取中微量样本检测深度不足、空间分辨率低及 FFPE 样本兼容性差等关键难题，实现从微量临床样本到亚细胞尺度的高精度时空蛋白质组解析。其中 PCT-DIA-MS 实现了微量临床样本的高深度、高重复、高通量检测；ProteomEx 与 FAXP 突破空间组学对抗体依赖的传统局限，实现亚细胞尺度空间蛋白质解析。针对 AI 训练数据匮乏，建立国际领先的蛋白质组 AI 语料库 MassNet，覆盖数千物种、数百亿级谱图数据，实现跨平台、跨物种与跨实验室的数据标准化组织。在此基础上开发 DIA-BERT、DDA-BERT 及 XuanjiNovo 等 AI 模型，在蛋白质鉴定、谱图解析及从头测序任务中显著提升性能，蛋白鉴定数量提升 50%-100%，推动蛋白质组学由规则驱动分析向深度学习范式转变。相关技术被 Nature 以 Technology Feature 专题报道，并被 Trends in Biochemical Sciences 评为“Method of the Month”。

The team developed PCT-DIA-MS, ProteomEx, and FAXP as a original core technology series, overcoming critical bottlenecks in proteomic data acquisition, including insufficient detection depth from trace samples, limited spatial resolution, and poor compatibility with FFPE samples, enabling high-precision spatiotemporal proteomic profiling from minute clinical samples to subcellular scale. PCT-DIA-MS enables high-depth, high-reproducibility, and high-throughput detection from trace clinical samples; ProteomEx and FAXP overcome the traditional antibody dependence of spatial omics, achieving subcellular-resolution spatial proteomics analysis. To address the scarcity of AI-ready data, the team established MassNet, an internationally leading proteomics AI corpus covering thousands of species with hundreds of billions of spectral data, and enabling standardized data organization across platforms, species, and laboratories. Based on this, AI models including DIA-BERT, DDA-BERT, and XuanjiNovo were developed, significantly improving performance in protein identification, spectral interpretation, and de novo sequencing, with protein identification coverage increased by 50%-100%, driving proteomics analysis from rule-based workflows toward deep learning-driven paradigms. These technologies were featured by Nature as a Technology Feature and recognized as “Method of the Month” by Trends in Biochemical Sciences.

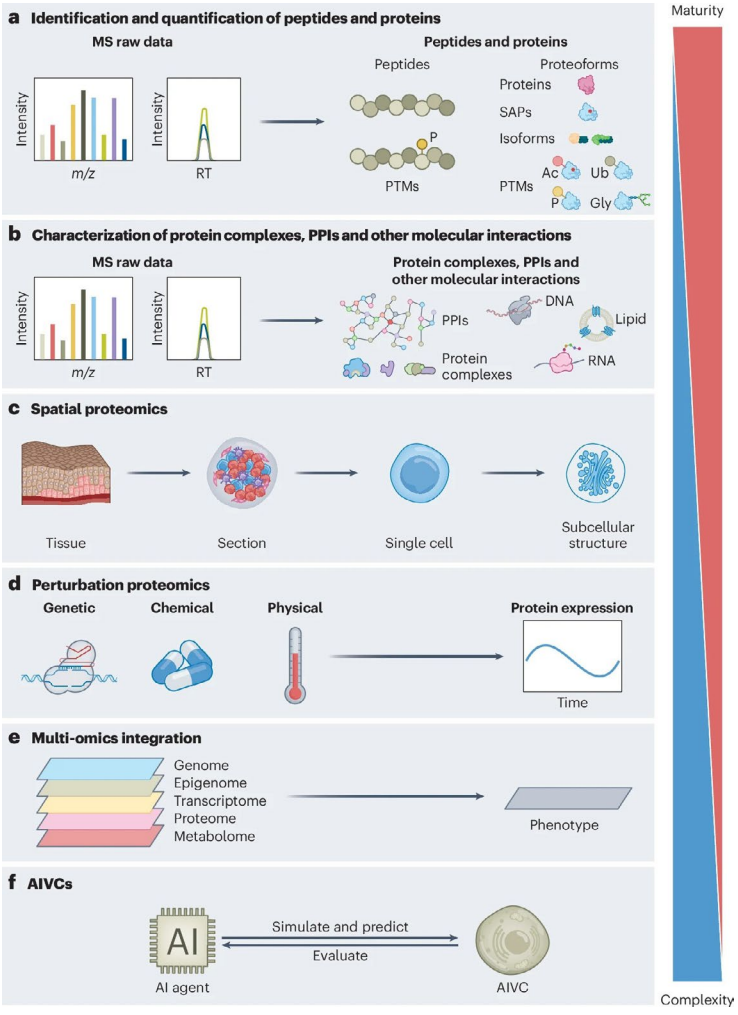



临床蛋白质组学
Clinical proteomics

## 原创蛋白质组大数据技术体系，驱动精准医学发现

## A Novel Big-Data Technological Framework for Proteomics, Enabling Discoveries in Precision Medicine

本成果在蛋白质组大数据技术体系上实现原创性突破。技术方法层面，首创基于压力循环技术（PCT）的微量组织前处理方法，利用循环高压实现毫克级乃至 0.1 毫克级微量组织裂解与酶解，建立国际首个适用于微量临床样本的蛋白质组分析方案；在此基础上，突破性开发基于水凝胶的膨胀蛋白质组技术（ProteomEx 与 FAXP），将样本需求量降低五个数量级（达 1 纳克级），首次实现单细胞乃至亚细胞尺度的空间蛋白质组解析，从根本上解决了微量样本检测深度不足和空间分辨率低等长期瓶颈。同时，建立蛋白质组 AI 语料库 MassNet 与深度学习模型体系（DIA-BERT、XuanjiNovo 等），蛋白鉴定数量提升 50%-100%，开创了深度学习驱动的蛋白质组数据分析新方法。应用层面，基于上述技术体系，构建了覆盖肿瘤、衰老及代谢疾病的大规模蛋白质组研究框架，在前列腺癌、弥漫性大 B 细胞淋巴瘤、结直肠癌、甲状腺结节及卵巢癌等疾病中实现 AI 辅助诊断与生物标志物发现，并在阿尔茨海默病模型中揭示了与突触损伤相关的分子线索。该成果形成了“技术突破—数据生成—AI 解析—精准应用”的完整链条，推动了蛋白质组学、人工智能与精准医学的深度融合。




This work achieves original breakthroughs in the proteomics big data technology system. At the methodological level, the team pioneered a pressure cycling technology (PCT)-based sample preparation method, utilizing cyclic high pressure to achieve lysis and digestion of milligram-scale, and even sub-milligram-scale (down to 0.1 mg) tissue samples, establishing the first international proteomic analysis protocol applicable to minute clinical samples. Building on this, the team developed hydrogel-based expansion proteomics technologies (ProteomEx and FAXP), reducing sample requirements by five orders of magnitude (down to the nanogram level) and achieving, for the first time, spatial proteomic analysis at single-cell and even subcellular resolution, fundamentally overcoming the long-standing bottlenecks of insufficient detection depth from trace samples and limited spatial resolution. Concurrently, the team established MassNet, an internationally leading proteomics AI corpus, and a suite of deep-learning models (including DIA-BERT and XuanjiNovo), improving protein identification coverage by 50%-100% and pioneering a deep-learning-driven approach for proteomics data analysis. At the application level, leveraging the above technological framework, large-scale proteomic research infrastructures covering cancer, aging, and metabolic diseases were constructed, enabling AI-assisted diagnosis and biomarker discovery in prostate cancer, diffuse large B-cell lymphoma, colorectal cancer, thyroid nodules, and ovarian cancer, while also revealing molecular clues associated with synaptic damage in Alzheimer’s disease models. This work forms a complete chain of “technological breakthrough - data generation - AI interpretation - precision application,” driving forward the deep integration of proteomics, artificial intelligence, and precision medicine.

临床蛋白质组学
Clinical proteomics

## 蛋白质组大数据技术体系获国际广泛认可，引领 AI 蛋白质组学新方向

## Proteomic Big Data Technology System Gaining Broad International Recognition, Leading a New Direction in AI Proteomics

本成果获得国际学术界与产业界广泛认可，相关成果发表于 Cell、Nature 等国际权威期刊，多篇代表性论文发表两年以上，在国际同行中形成持续引用与方法学应用。PCT-DIA-MS 技术已成为临床蛋白质组学的重要技术路线之一，被澳大利亚 ProCan 等国际大型研究计划采用，在临床蛋白质组高通量检测体系中形成代表性技术方案。团队建立的人类蛋白质组谱图库 DPHL 被国际广泛引用。空间蛋白质组技术 FAXP 被 Nature 报道为亮点技术，并入选 Trends in Biochemical Sciences 的“Method of the Month”专栏。相关方法已被多个国际研究团队采用，推动空间蛋白质组分析技术路线的扩展与标准化发展。团队联合 60 余位国际专家在 Nature Methods 上共同定义 AI 蛋白质组学关键研究方向，促进形成跨机构国际协同研究框架与方法学共识，并主导建立西湖虚拟酵母联盟及西湖甲状腺联盟等国际协同研究网络。整体技术体系在临床蛋白质组学、空间蛋白质组学及 AI 驱动质谱分析等方向被广泛关注与采用，具有一定的国际影响力。

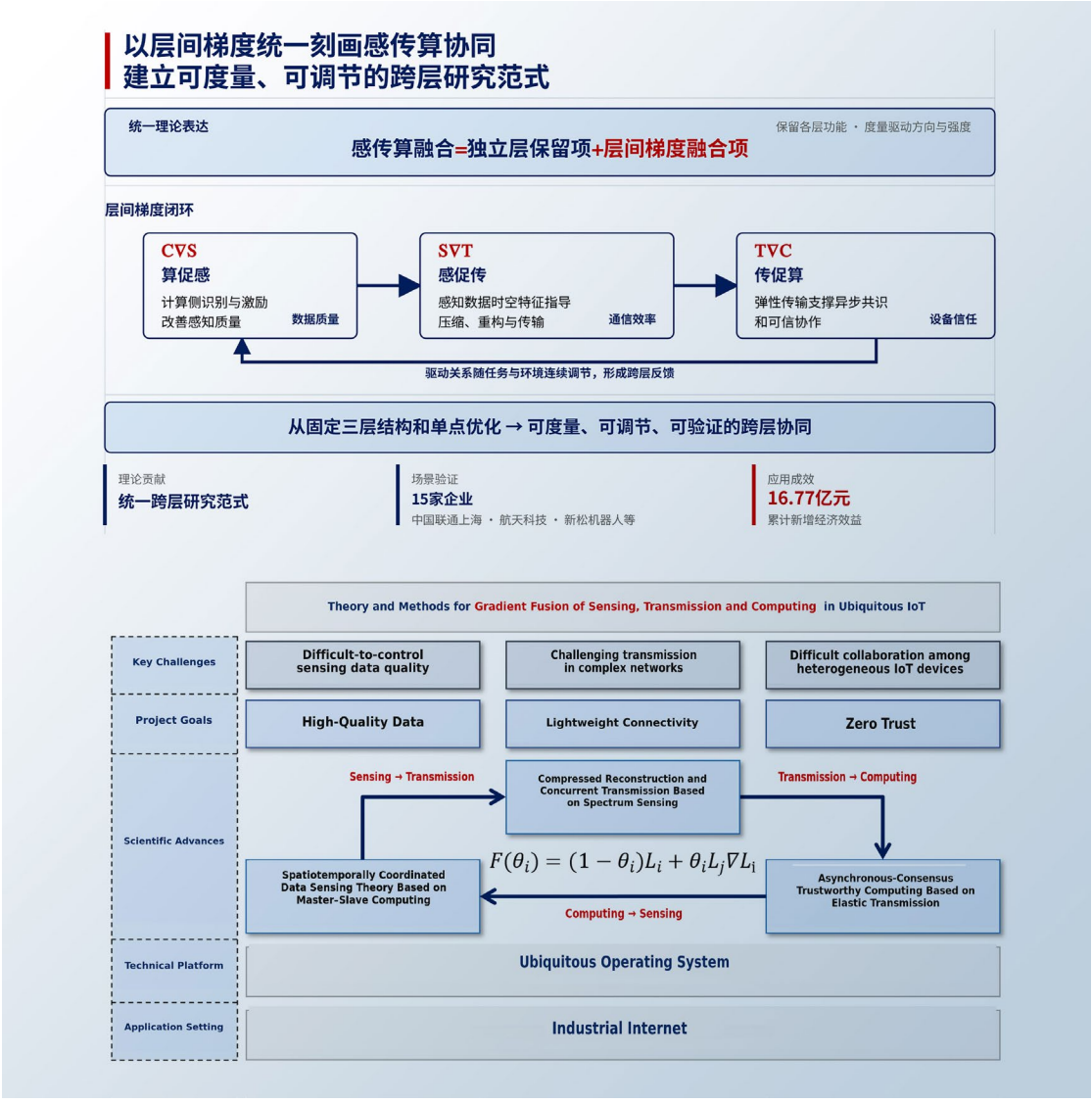
This work has received wide recognition from the international academic and industrial communities. Findings have been published in leading journals including Cell and Nature, with multiple representative papers published for more than two years and continuing to receive sustained citations and methodological adoption. PCT-DIA-MS has become one of the important methodological frameworks in clinical proteomics and has been adopted by major international initiatives such as ProCan in Australia, forming a representative technical solution in high-throughput clinical proteomics workflows. The DPHL spectral library established by the team has been widely cited internationally. The spatial proteomics technology FAXP was featured as a Technology Feature by Nature and recognized as “Method of the Month” by Trends in Biochemical Sciences, with adoption by multiple international research groups, contributing to the expansion and standardization of spatial proteomics methodologies. The team coordinated over 60 international experts to define key research priorities in AI proteomics in Nature Methods, contributing to the formation of cross-institutional collaborative research frameworks and methodological consensus, and established international collaborative networks including the Westlake Virtual Yeast Alliance and Westlake Thyroid Alliance. Overall, the technological framework has been widely recognized and adopted in clinical proteomics, spatial proteomics, and AI-driven mass spectrometry analysis, and has gained notable international influence.




蛋白质组大数据技术体系的国际学术影响力
International academic impact of the proteomics big data technology system

# 泛在物联网感传算梯度融合理论与方法

## Theory and Methods of Gradient Fusion for Sensing, Transmission and Computing in the Ubiquitous Internet of Things




感传算梯度融合框架

Framework for gradient fusion of sensing, transmission and computing

上海交通大学
Shanghai Jiao Tong University

香港科技大学
Hong Kong University of Science and Technology

## 引言

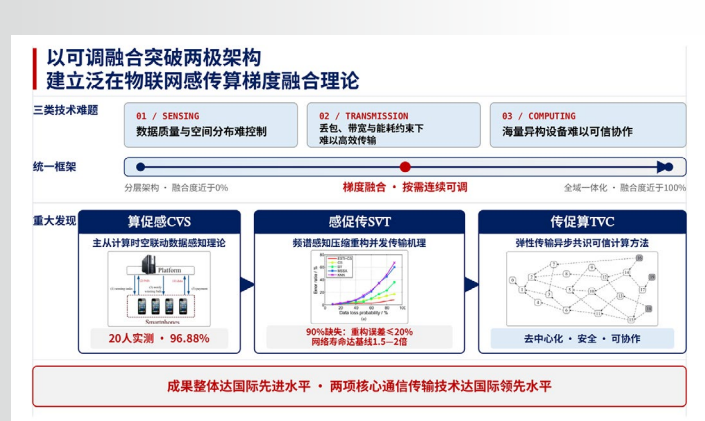
泛在物联网连接异构设备，不同场景对感知质量、传输效率和计算可信性提出差异化需求。成果提出感传算梯度融合理论，通过调节层间融合程度，协调数据获取、信息传输与可信计算，为高效运行提供理论与方法。

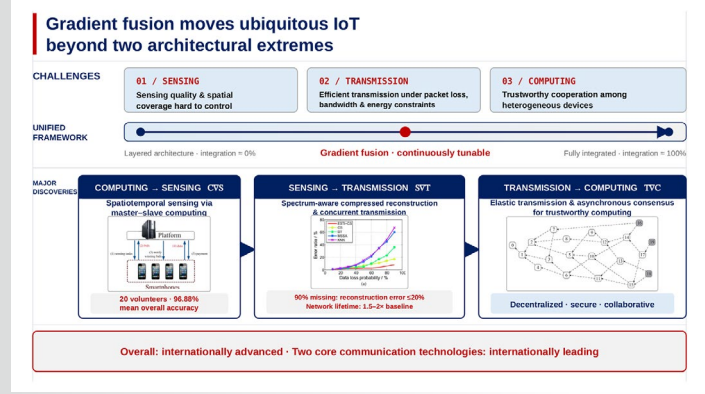
## Introduction

Ubiquitous IoT systems connect heterogeneous devices, with application-specific requirements for sensing quality, transmission efficiency and trustworthy computing. This work introduces a gradient-fusion theory that adjusts inter-layer integration to coordinate data acquisition, information transmission and trustworthy computing, providing a theoretical and methodological foundation for efficient operation.

## 以可调融合突破两极架构，建立泛在物联网感传算梯度融合理论

## A Gradient-Fusion Theory for Sensing, Transmission and Computing in Ubiquitous IoT: Moving Beyond Two Architectural Extremes Through Adjustable Integration




针对感知数据质量与空间分布难以兼顾、低功耗终端受丢包、带宽和能耗约束而难以高效传输、异构设备难以可信协作等问题，本成果形成三项科学发现。提出主从计算时空联动感知理论，将神经网络识别与位置感知反向拍卖相结合，从数据识别和采集激励两方面改善感知效果，平均总体识别准确率达96.88%。揭示频谱感知压缩重构并发传输机理，利用数据时空相关性支撑缺失数据重构与高效传输，在90% 数据缺失时将重构误差控制在20% 以内，在估计误差为 5%-20% 时使网络寿命达到基线方案的 1.5-2 倍。提出弹性传输异步共识可信计算方法，利用信用分级 DAG 区块链支持资源受限终端安全协作。经中国电子学会组织鉴定，成果整体达到国际先进水平，两项核心通信传输技术达到国际领先水平。

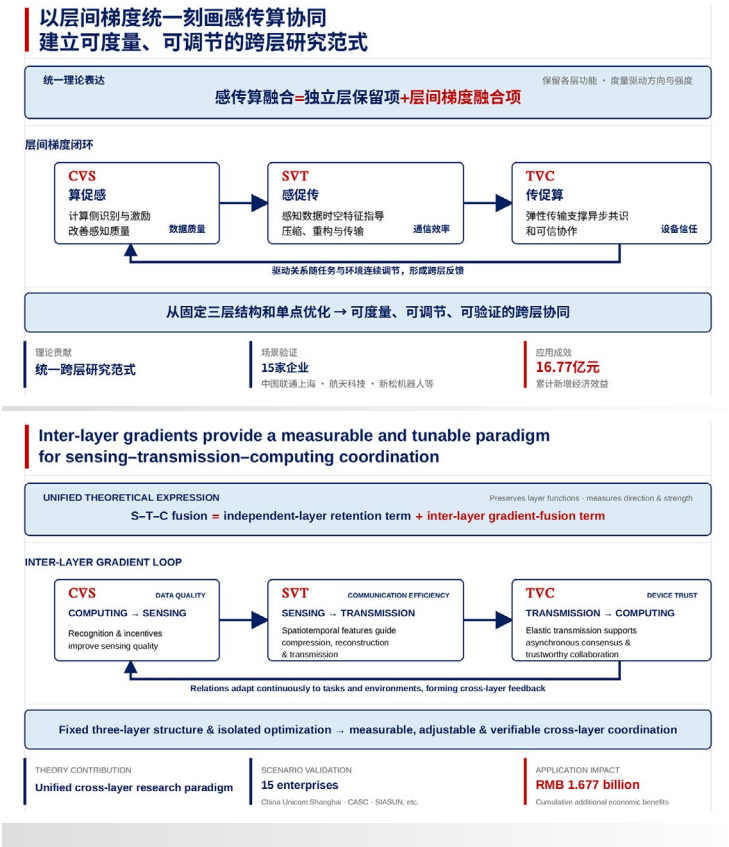
The work addresses challenges in balancing sensing quality and spatial coverage, transmitting data efficiently from low-power devices under packet loss, bandwidth and energy constraints, and enabling trustworthy cooperation among heterogeneous devices. It establishes three advances. First, a spatiotemporal sensing theory based on master-slave computing combines neural-network recognition with a location-aware reverse auction to improve sensing through data recognition

and collection incentives, achieving an average overall recognition accuracy of 96.88%. Second, a spectrum-aware mechanism for compressed reconstruction and concurrent transmission uses spatiotemporal data correlations to support missing-data reconstruction and efficient transmission. It keeps reconstruction error below 20% with 90% missing data and extends network lifetime to 1.5-2 times that of baseline methods at estimation errors of 5%-20%. Third, a trustworthy computing method combines elastic transmission with asynchronous consensus, using a credit-graded directed acyclic graph (DAG) blockchain to support secure cooperation among resource-constrained devices. An appraisal organized by the Chinese Institute of Electronics rated the work as internationally advanced and two core communication and transmission technologies as internationally leading.

## 以层间梯度统一刻画感传算协同，建立可度量、可调节的跨层研究范式

## Inter-Layer Gradients Provide a Unified Description of Sensing-Transmission-Computing Coordination and Establish a Measurable, Tunable Paradigm for Cross-Layer Research

本成果将感传算融合表述为“独立层保留项＋层间梯度融合项”：前者维持各层功能，后者以梯度方向和强度描述层间作用，将分层、部分融合与一体化纳入统一框架。其原创性在于将融合程度作为研究变量，使层间关系能够随具体应用场景的需求调节，为研究不同架构下的感传算协同提供共同理论基础。在研究方法上，计算侧识别与激励用于改善感知质量，感知数据的时空特征用于指导压缩、重构与传输，弹性传输用于支撑异步共识和可信协作，由此将数据质量、通信效率与设备信任联系起来。这一框架为分析层间依赖和性能权衡提供统一视角，使物联网系统设计能够同时考虑各层功能及其相互作用，并将场景需求转化为层间协同关系的设计依据，拓展跨层协同机制的建模与分析方法。




The work represents sensing–transmission–computing fusion as the sum of an independent-layer retention term and an inter-layer gradient-fusion term. The former preserves layer functions; the latter describes inter-layer interactions through gradient direction and magnitude, unifying layered, partially integrated and fully integrated architectures. Its contribution is to treat the degree of integration as a research variable, allowing inter-layer relationships to be adjusted to application requirements and providing a theoretical basis for coordination across architectures. Methodologically, computation-side recognition and incentives improve sensing quality; spatiotemporal data characteristics guide compression, reconstruction and transmission; and elastic transmission supports asynchronous consensus and trustworthy cooperation. These relationships connect data quality, communication efficiency and device trust. The framework offers a unified perspective on inter-layer dependencies and performance trade-offs. It allows system design to account for individual layer functions and their interactions, using application requirements to guide inter-layer coordination and extending methods for modeling and analyzing such mechanisms.

## 持续获得国际同行引用、权威期刊关注与多层次学术评价

## Sustained Citations by International Peers, Attention from Leading Journals, and Academic Evaluation at Multiple Levels

10 篇代表性论文获 Google Scholar 引用 2769 次，相关研究获 40 余位全球同行引用。中国科学院院士钱德沛与 IEEE Fellow Sajal K. Das 教授引用位置感知反向拍卖研究；IEEE Fellow Jie Lu 教授肯定细粒度行为识别方法区分正常与异常行为的能力。欧洲科学院外籍院士、IEEE Fellow 张大庆教授采用相关物理距离相关性模型与压缩感知参数设置，印度信息技术学院阿拉哈巴德分校 Shekhar Verma 教授以 ESTICS 时空压缩感知框架为研究基础。加拿大皇家学会及加拿大工程院院士、IEEE Fellow 沈学民教授，美国国家工程院院士、IEEE Fellow William H. Sanders 教授及 IEEE Fellow Mohsen Guizani 教授，分别讨论 DAG 区块链与信用分级共识在吞吐性能、安全性、交易效率及资源受限终端适配方面的价值。代表性论文获 ESI 高被引认定及 IEEE Xplore Innovation Spotlight 展示，衍生成果获 IWQoS、ICPADS、ISPA 等国际会议最佳论文奖 16 项。




The ten representative papers have received 2,769 Google Scholar citations, with related work cited by over forty scholars worldwide. Chinese Academy of Sciences Member Depei Qian and IEEE Fellow Professor Sajal K. Das cited the location-aware reverse-auction study. IEEE Fellow Professor Jie Lu highlighted the fine-grained behavior-recognition method's ability to distinguish normal from anomalous behavior. Professor Daqing Zhang, a Foreign Member of Academia Europaea and an IEEE Fellow, adopted the physical-distance correlation model and compressed-sensing parameter settings. Professor Shekhar Verma of the Indian Institute of Information Technology Allahabad built on the ESTICS spatiotemporal compressed-sensing framework. Professor Xuemin Shen, a Fellow of the Royal Society of Canada, the Canadian Academy of Engineering and IEEE; Professor William H. Sanders, a Member of the U.S. National Academy of Engineering and an IEEE Fellow; and IEEE Fellow Professor Mohsen Guizani discussed the value of DAG blockchain and credit-graded consensus for throughput, security, transaction efficiency and suitability for resource-constrained devices. Representative papers have received ESI Highly Cited Paper recognition and been featured in IEEE Xplore Innovation Spotlight. Derivative work has received sixteen best-paper awards at international conferences including IWQoS, ICPADS and ISPA.



获国际会议最佳论文 16 项（CCF B 类 2 项）




2024年度上海市计算机学会自然科学一等奖



16 International Conference Best-Paper Awards, Including 2 at CCF-B venues




First Prize
Natural Science Award
Shanghai Computer Society
(2024)

## 从理论方法到产业验证，服务多类泛在物联场景

## From Theoretical Methods to Industrial Validation: Supporting Diverse Ubiquitous IoT Applications

相关方法已在中国联通上海分公司、航天科技、新松机器人等 15 家企业应用，覆盖工业互联网、算力网络、机器人制造和预测性维护等场景，累计新增经济效益 16.77 亿元。成果将感知、传输与可信计算方法转化为可部署的算法和系统，服务异构设备接入、数据交互及协同运行，为企业兼顾能耗、可靠性和安全性提供技术支撑。

多类产业场景涵盖数据采集、网络连接与设备协作等环节，拓展了研究成果的应用范围，推动理论研究与企业生产管理、运维需求衔接。

The methods have been applied at fifteen enterprises, including China Unicom Shanghai, China Aerospace Science and Technology Corporation, and SIASUN Robot. Applications span industrial internet, computing-power networks, robot manufacturing and predictive maintenance, generating cumulative additional economic benefits of RMB 1.677 billion. The work translates sensing, transmission and trustworthy computing methods into deployable algorithms and systems for heterogeneous device connectivity, data exchange and coordinated operation, helping enterprises balance energy consumption, reliability and security. These applications cover data collection, network connectivity and device cooperation, extending research applications and connecting theory with enterprises' production management and operational needs.





# 科技之魅

CHARM OF SCIENCE AND TECHNOLOGY

# 02

## 世界互联网大会
## 领先科技奖收录成果

Collection of World Internet Conference
Awards for Pioneering Science and Technology

# 关键技术组
# Key Technology Group

# 阿里云百炼：企业级大模型服务平台

## Alibaba Cloud Model Studio: Enterprise-Grade Large Model Service Platform




阿里云百炼平台概览
Alibaba Cloud Model Studio at a Glance

阿里云计算有限公司
Alibaba Cloud Computing Co., Ltd.

阿里云

## 引言

阿里云百炼是面向智能体时代的一站式大模型服务平台，以推理调度、Agent 训练和多模态应用三大核心技术创新，服务全球超 500 万用户与 80 万企业客户，推动大模型从实验室走向规模化生产环境。

## Introduction

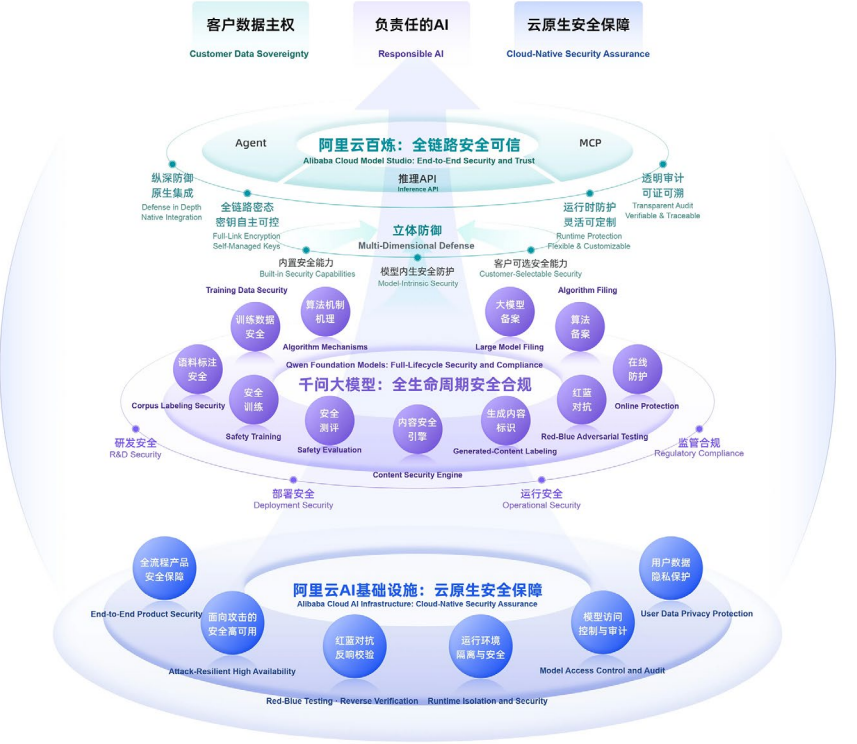
Alibaba Cloud Model Studio is a one-stop large model service platform for the Agent era. Through core innovations in inference scheduling, Agent training, and multi-modal applications, it serves over 5 million users and 800,000 enterprise customers globally, advancing large models from research to production-scale deployment.

## 首创 Token 级推理调度与 Agent 强化学习训练体系，系统性突破大模型规模化服务瓶颈

## Pioneering Token-Level Inference Scheduling and Agentic Reinforcement Learning to Overcome Large Model Scalability Barriers

大模型规模化服务面临推理效率瓶颈、Agent 训练缺乏闭环、多模态应用能力不足三大核心挑战。阿里云百炼实现系统性突破：在推理服务层，首创 Token 级模型自动扩缩容机制，将调度粒度细化至单个 Token 生成步骤，资源利用率提升 82%，承载能力提升 2.5 倍；提出乘法融合双目标调度框架，首响应延迟降低 92%；构建全链路追踪诊断系统，追踪开销较主流方案降低 97.8%。在训练层，首创面向 Agent 的强化学习框架 AgentTaskPilot，实现 Agent 系统零代码接入与异步训练流水线，首次将 Agentic RL 推进至生产级闭环。在应用层，提出 OminiRAG 全模态检索增强生成框架与多模态记忆图机制，效果超越当前最优方案 15%。核心成果发表于 SOSP、OSDI、NSDI 等国际顶级学术会议。

Large-scale model deployment faces three core challenges: inference inefficiency, absence of closed-loop Agent training, and insufficient multi-modal capabilities. Alibaba Cloud Model Studio achieves systematic breakthroughs across all dimensions. At the inference layer, it pioneers a token-level auto-scaling mechanism that refines scheduling granularity to individual token generation steps, improving resource utilization by 82% and serving capacity by 2.5x. A multiplicative dual-objective scheduling framework reduces first-token latency by 92%, while a full-link tracing system lowers observability overhead by 97.8%. At the training layer, AgentTaskPilot enables zero-code Agent system integration with asynchronous training pipelines, advancing Agentic RL to production-grade closed-loop deployment for the first time. At the application layer, the OminiRAG omni-modal retrieval-augmented generation framework and multi-modal memory graph surpass state-of-the-art approaches by 15%. Core results are published at SOSP, OSDI, and NSDI.




阿里云百炼核心安全理念
Core Security Philosophy of Alibaba Cloud Model Studio

## 服务 500 万用户与 80 万企业，支撑从消费级应用到全球化政企部署的规模化落地

## Serving 5 Million Users and 800,000 Enterprises from Consumer Applications to Global Enterprise Deployments

阿里云百炼已形成成熟的规模化应用体系，注册用户超 500 万，企业客户超 80 万，年化经常性收入突破 80 亿元，覆盖互联网、制造、金融、政务、教育等行业。在消费级应用领域，高德推出 AI 原生出行智能体，融合语音交互与多模态理解服务亿级用户；Rokid 眼镜依托千问模型实现多语言翻译与 AI 问答。在行业应用领域，超星集团构建高校 AI 能力中心，知识库准确率近 90%，开发效率提升 85%，人力成本降低 70%；零跑汽车打造智能座舱体验；猎聘优化 JD 生成、人岗匹配与面试摘要全链路智能决策。在全球化部署方面，平台推出百炼专属版，覆盖亚太、北美、欧洲市场，支持阿斯利康等全球企业构建药物智能报告系统，流程效率提升 300%，以工程创新显著降低大模型应用门槛。

Alibaba Cloud Model Studio has built a mature large-scale application ecosystem with over 5 million registered users, 800,000 enterprise customers, and annualized recurring revenue exceeding RMB 8 billion, spanning internet, manufacturing, finance, public services, and education. In consumer applications, Amap launched an AI-native travel agent integrating voice interaction and multi-modal understanding to serve hundreds of millions of users; Rokid glasses leverage the Qwen model for multilingual translation and AI-powered question answering. In industry applications, Chaoxing Group built university AI capability centers achieving nearly 90% knowledge base accuracy, 85% development efficiency improvement, and 70% labor cost reduction; Leapmotor developed intelligent cockpit experiences; and Liepin optimized end-to-end recruitment decision-making across job description generation, candidate matching, and interview summarization.

For global deployment, the platform's Exclusive Edition covers Asia-Pacific, North America, and Europe, supporting AstraZeneca in building intelligent pharmaceutical reporting systems with 300% efficiency gains, substantially lowering barriers to large model adoption through engineering innovation.

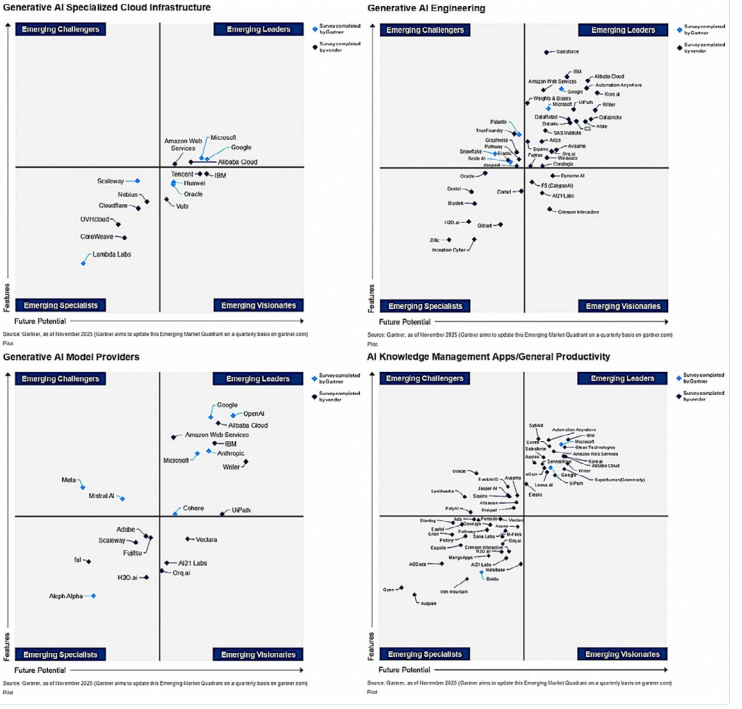



阿里云百炼服务千行百业客户
Alibaba Cloud Model Studio Serves Customers across All Industries

## 学术成果引领全球推理系统前沿研究，权威市场评估获评全球领导者

## Leading Global Inference System Research with Recognition as a Global Industry Leader by Authoritative Analysts

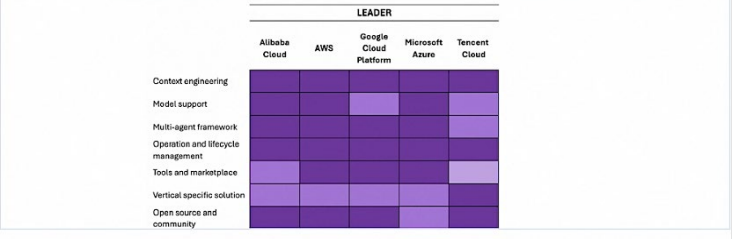
阿里云百炼核心技术先后被 SOSP、OSDI、NSDI、USENIX ATC、EMNLP、NeurIPS、ICML 等国际顶级学术会议收录，配套数据集与评测代码已开源，被多个国际研究团队引用采用。团队深度参与开源推理引擎 vLLM 核心架构演进，主导 Model Runner V2 的设计与实现，高负载场景下吞吐提升 56.2%。平台通过 SOC 2 审计并获 ISO 42001 人工智能管理体系认证。在 Gartner 2025 生成式 AI 技术创新指南中，入选云基础设施、AI 工程、模型供应商、知识管理应用四大领域新兴领导者；在 Omdia 2025 全球企业级 MaaS 市场分析报告中获评全球领导者，五大维度均获最高评级；在 Omdia 2026 亚太 Agentic AI 开发平台评估中摘得领导者桂冠，五项核心能力获 Advanced 最高评级，与 AWS、谷歌、微软同处最高梯队。据 Omdia 报告，阿里云 AI 云市场份额达 38.1%，稳居第一。




在 Gartner 2025 生成式 AI 技术创新指南中，阿里云入选生成式 AI 云基础设施、生成式 AI 工程、生成式 AI 模型供应商、AI 知识管理应用 / 通用生产力 4 大领域的新兴领导者

In the Gartner 2025 Innovation Guide for Generative AI Technologies, Alibaba Cloud was named an Emerging Leader across four key domains: Generative AI Cloud Infrastructure, Generative AI Engineering, Generative AI Model Providers, and AI Knowledge Management Applications/General Productivity

**Figure 1: Omdia heatmap for agentic AI development platform in Asia and Oceania**




Source: Omdia

在 Omdia2026 年亚太 Agentic AI 开发平台市场评估报告中，阿里云凭借卓越的技术深度和全栈 AI 布局摘得“领导者”桂冠，5 项核心能力获得最高评级（Advanced），是中国厂商最优，与 AWS、谷歌、微软等全球科技巨头同处最高评级梯队

In the Omdia 2026 Market Radar: Agentic AI Development Platforms in Asia & Oceania, Alibaba Cloud was recognized as a “Leader” for its technical depth and full-stack AI layout. It achieved the highest “Advanced” rating in five core capabilities—the best among vendors in China—and joined global tech giants like AWS, Google, and Microsoft in the top tier

Core technologies have been accepted at premier international conferences including SOSP, OSDI, NSDI, USENIX ATC, EMNLP, NeurIPS, and ICML, with companion datasets and evaluation code open-sourced and adopted by multiple international research teams. The team deeply contributes to the open-source inference engine vLLM, leading the design and implementation of Model Runner V2 with 56.2% throughput improvement under high-load scenarios. The platform passed SOC 2 audit and obtained ISO 42001 AI management system certification. In Gartner’s 2025 Generative AI Innovation Guide, it was named an emerging leader across four domains: cloud infrastructure, AI engineering, model providers, and knowledge management applications. Omdia’s 2025 Global Enterprise MaaS Market Analysis rated it a global leader with top scores across all five dimensions, and Omdia’s 2026 Asia-Pacific Agentic AI Development Platform assessment awarded it Leader status, with all five core capabilities receiving the highest “Advanced” rating alongside AWS, Google, and Microsoft. Per Omdia, Alibaba Cloud holds a leading 38.1% AI cloud market share.

# 从模型到生产力 - 真实世界规模化部署的具身智能在线进化系统

## From Model to Productivity: Embodied AI Online Evolution System for Real-World Scalable Deployment



智元精灵 G2 人形机器人以产线“正式员工”的身份，深度融入真实 3C 作业产线
AGIBOT G2 serving as a “full-time employee” on the production line, is deeply integrated into real 3C manufacturing operations

智元创新（上海）科技股份有限公司
AGIBOT

## 引言

过去数年，人工智能的核心突破长期囿于数字世界。机器人领域尤为典型，长期依赖“离线训练—部署执行”的传统范式，导致系统在面对真实环境的动态变化时，适应性差、部署成本高昂、规模化落地困难，成为制约具身智能从“技术概念”走向“产业应用”的核心瓶颈。

## Introduction

For years, the core breakthroughs in artificial intelligence have long been confined to the digital world. The robotics field is a prime example — it has long relied on the traditional paradigm of “offline training followed by deployment and execution,” resulting in poor adaptability, high deployment costs, and difficulties in large-scale implementation when systems face the dynamic changes of real-world environments. This has become the core bottleneck constraining embodied intelligence from a “technical concept” to “industrial application.”

## 突破传统范式，构建真实生产场景规模化部署的具身智能在线进化系统

## Breaking Through the Traditional Paradigm to Build an Embodied Intelligence Online Evolution System Deployed at Scale in Real Production Scenarios

本项目突破传统范式，提出并落地“部署即学习”的全新理念，构建全球首个在真实生产场景中规模化部署的具身智能在线进化系统，实现从“模型能力”到“真实生产力”的关键跨越。系统通过“具身基础模型 + 世界模型推演 + 分布式在线强化学习 + 端云协同基础设施”的四位一体架构，打通“认知 - 决策 - 执行 - 进化”的全链路闭环：构建具身基础模型（GO-2），攻克“语义 - 动作鸿沟”行业难题，首创“动作思维链 + 异步双系统”机制，让机器人从“能说对任务”升级为“能做准动作”，实现认知与执行的精准对齐；世界模型（GE 2.0），作为机器人的“脑内模拟器”，支持执行前的策略推演与轨迹评估，在虚拟空间中完成数据生成与决策优化，大幅降低真实场景试错成本；分布式在线强化学习，突破“离线训练”局限，让机器人在真实工作中“边干边学”，通过实时数据回流持续优化策略，实现能力的动态进化；端云协同基础设施，支持百台级机器人并行学习、经验共享与策略同步，形成“群体智能”，加速整体能力的迭代升级。实现“虚实双驱 + 多机协同 + 在线进化 + 真实部署”的统一闭环，让机器人从“固定功能设备”进化为“持续学习的智能体系统”。

This project breaks through the traditional paradigm by pioneering and implementing the groundbreaking concept of “learning upon deployment”. It establishes the world’s first embodied intelligence online evolution system deployed at scale in real production scenarios, achieving the critical leap from “model capability” to “real-world productivity”.

Powered by a four-in-one architecture—embodied foundation model + world model inference + distributed online reinforcement learning + end-cloud collaborative infrastructure—the system closes the full loop of “cognition-decision-execution-evolution”:

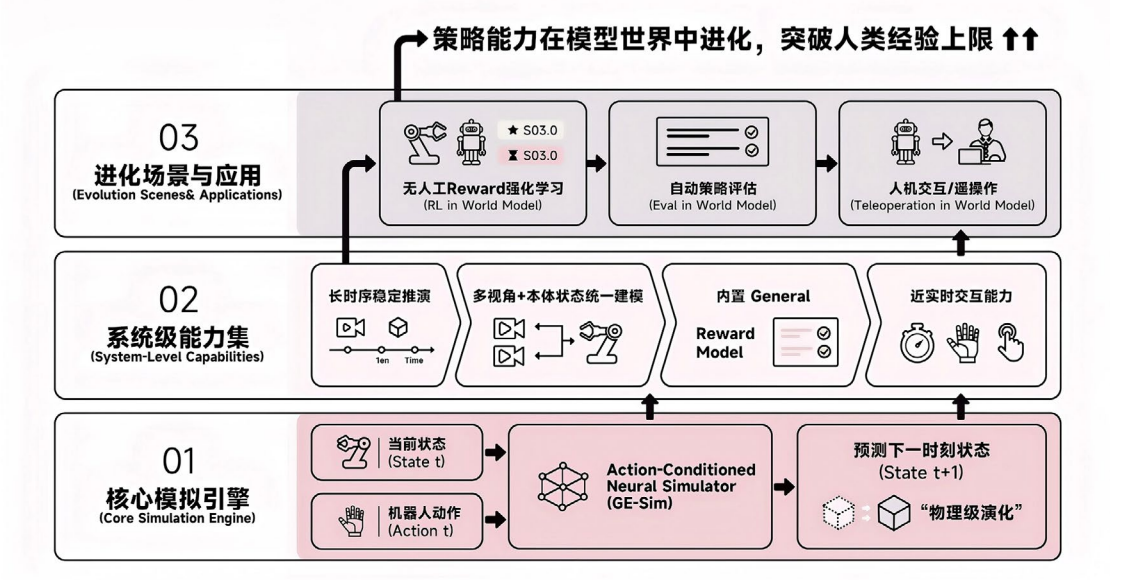
Embodied Foundation Model (GO-2) addresses the industry-wide “semantic-action gap” with its pioneering “chain of action thought + asynchronous dual-system” mechanism, upgrading robots from “correctly understanding tasks” to “precisely executing actions” and achieving precise alignment between cognition and execution.

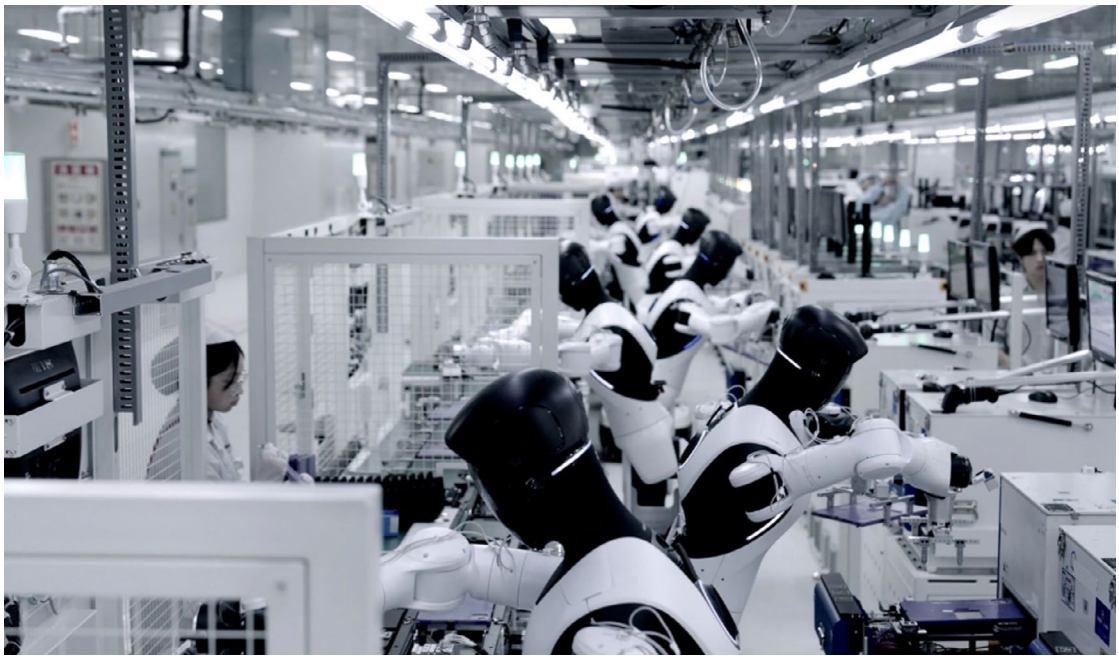
World Model (GE 2.0), serving as the robot’s “mental simulator,” supports strategy inference and trajectory evaluation before execution, generating data and optimizing decisions in virtual space to dramatically reduce trial-and-error costs in real scenarios.

Distributed Online Reinforcement Learning transcends the limitations of “offline training”, enabling robots to “learn while working” in real operations. Through real-time data feedback, strategies are continuously refined for dynamic capability evolution.

End-Cloud Collaborative Infrastructure supports parallel learning, experience sharing, and strategy synchronization across hundreds of robots, forming “swarm intelligence” that accelerates overall capability iteration.

This unified closed loop of “virtual-real dual-drive + multi-robot collaboration + online evolution + real deployment” transforms robots from “fixed-function devices” into “continuously learning intelligent agent systems”.





## 智元与龙旗科技联合创新项目将智元精灵 G2 部署于真实工业产线

## The Joint Innovation Project Between AGIBOT and Longcheer Technology Deploys the AGIBOT Genie G2 on Real Industrial Production Lines

在消费电子精密制造领域，长期面临着一个难以调和的矛盾：产品迭代极快与产线响应极慢。传统的自动化产线就像是一台精密的“专用机器”，虽然效率高，但极其“娇气”且“死板”。导致大量工序至今仍依赖人工，难以实现真正的无人化。智元与龙旗科技的联合创新项目，成功将智元精灵 G2 部署于真实工业产线，交出了一份可量化的“工业级”答卷。我们不再仅仅是用机器替代简单的体力劳动，而是实现了对复杂工序的完全接管。机器人实现了 12 小时无间断自主作业，单小时产出达到 310，单作业流程压缩至 18-20 秒，不仅达到了人工节拍，更在稳定性上远超人类。端到端作业成功率突破 99.9%，模型层实现 100% 零误差，平均故障间隔时间已达 12 小时并持续优化，真正做到了“无人化”前提下的稳定运行。预计 2 年内即可实现成本回本，证明了具身智能不再是昂贵的“展示品”，而是具备清晰投资回报率的生产力工具。

In the precision manufacturing of consumer electronics (3C), a long-standing and seemingly irreconcilable contradiction persists: extremely fast product iteration versus painfully slow production line response. Traditional automated production lines are like sophisticated “special-purpose machines” — efficient yet fragile and rigid. As a result, numerous processes still rely on human labor, making true unmanned operations elusive.

The joint innovation project between AGIBOT and Longcheer Technology has successfully deployed the AGIBOT Genie G2 on real industrial production lines, delivering a quantifiable, industrial-grade solution. We are no longer merely replacing simple physical labor with machines — we are achieving full takeover of complex processes. The robot operates autonomously for 12 consecutive hours, with a units-per-hour (UPH) output of 310 and a single workflow cycle compressed to 18–20 seconds. It not only matches human takt time but also far surpasses human performance in stability. The end-to-end operation success rate exceeds 99.9%, with zero error at the model level, and the mean time between failures (MTBF) has reached 12 hours and continues to improve — truly achieving stable operation under unmanned conditions.

With an expected return on investment within 2 years, this proves that embodied intelligence is no longer an expensive “showpiece” but a productivity tool with a clear return on investment (ROI).

## 推动全球制造业向柔性智能生产转型，重塑产业模式、人才分工与安全生产体系

## Driving the Global Manufacturing Industry Toward Flexible Intelligent Production, Transforming Industrial Models, Workforce Roles, and Workplace Safety Systems

本项目掀起全球制造领域技术范式与产业模式双重变革，具备跨行业、跨地域的深远社会价值与普惠性全球影响力。

在全球制造业赛道，项目推动传统刚性自动化体系全面转向柔性智能生产新体系，大幅提升全球各地生产线适配多品种、小批量定制订单的灵活响应能力，赋能全球制造企业落地按需定制化生产模式，全域降低全产业链原材料、生产能耗的无效损耗。

在全球劳动力发展层面，工业机器人承接重复、重载、高危流水线作业，释放全球人力转向研发、设计、创意等高附加值创造性岗位，驱动全球制造业从业者职业迭代、专业技能持续升级，重塑全球制造行业人才分工体系。

在全球职业安全生产领域，智能机器人可替代人类深入高温、高压、有毒、高风险作业场景，从底层大幅降低全球工业生产工伤事故发生率，建立全球通用的制造业安全作业新标准，全方位守护全球一线劳动者健康与生命安全。

在全球科研与人才培育领域，整套技术平台可作为全球高校、科研院所通用的具身智能实训、前沿科研载体，打通全球 AI 与机器人交叉学科人才培养链路，加速全球智能技术创新人才供给。

This project triggers dual transformations of technical paradigms and industrial models across global manufacturing, delivering far-reaching cross-industry and cross-regional social value as well as inclusive worldwide influence.

Within the global manufacturing sector, the project drives a comprehensive shift from rigid traditional automation systems to novel flexible intelligent production frameworks. It drastically enhances the agility of production lines worldwide to respond to customized orders featuring diverse product ranges and small batch sizes, empowers manufacturers globally to adopt on-demand custom production models, and cuts redundant consumption of raw materials and production energy across entire industrial chains.

From the perspective of global workforce development, industrial robots take over repetitive, heavy-duty and high-risk assembly line tasks. This frees up human labor globally to shift toward high-value creative roles such as R&D, design and innovation, facilitates career advancement and continuous skill upgrading for manufacturing practitioners worldwide, and reshapes the talent division system of the global manufacturing industry.

In the field of global occupational safety and health, intelligent robots can replace humans to operate in harsh environments with extreme heat, high pressure, toxic substances and other severe hazards. They substantially reduce the incidence of industrial workplace injuries worldwide at the source, establish universal new safety operation standards for manufacturing industries globally, and fully safeguard the health and lives of frontline workers across the globe.

In terms of global scientific research and talent cultivation, the complete technical platform serves as a universal carrier for embodied intelligence training and cutting-edge research for universities and research institutions worldwide. It streamlines the training pipeline for interdisciplinary talents specializing in AI and robotics globally and accelerates the supply of innovative professionals for intelligent technologies worldwide.



# Dilium：空间计算数字孪生套件

## Dilium - Spatial Computing Company




Dilium 借助协同式空间计算生态系统，将物理世界、智能数字孪生与人融为一体
Dilium connects physical reality, intelligent digital twins and people through one collaborative Spatial Computing ecosystem

Dilium srl

>_dilium
Technologies for Ideas

## 引言

Dilium 的空间计算生态系统将物理对象、环境及专业知识转化为协同式数字孪生。该生态系统以 3DtoMe 为核心，并通过 Spatial Plan（空间规划）、Spatial Drawing（空间标注）、Spatial Companion（空间伴行）和 PortalGate（门户通道）进行扩展，统一整合了三维采集、AI 辅助优化与识别、空间批注、实时协同、沉浸式可视化及 Web 端共享。借助原生应用、浏览器访问、标准三维数据交换、SDK 及企业级集成，连接不同设备上的各类用户。该生态系统通过可互操作的、以人为本的空间工作流，服务于制造业、检测、维护、文化遗产、旅游、教育和商业等领域。

## Introduction

Dilium's Spatial Computing ecosystem transforms physical objects, environments and expertise into collaborative digital twins. Centered on 3DtoMe and extended by Spatial Plan, Spatial Drawing, Spatial Companion and PortalGate, it unifies 3D capture, AI-assisted optimization and recognition, spatial annotation, real-time collaboration, immersive visualization and web sharing. Native applications, browser access, standard 3D exchange, SDKs and enterprise integration connect users across different devices. The ecosystem supports manufacturing, inspection, maintenance, cultural heritage, tourism, education and commerce through interoperable, human-centred spatial workflows.

## 通过统一的可互操作空间工作流，将物理实体与现场环境转化为协同式数字孪生

## From Physical Reality to Collaborative Digital Twins Through One Interoperable Spatial Workflow

企业空间计算目前仍呈碎片化状态：捕获、优化、设备、审查和协作分别在各自独立的工具中进行；专业人员和不同硬件将利益相关者排除在外；而上下文信息在传统报告中丢失。Dilium 通过模块化、连续的数据之旅来解决这一问题。

3DtoMe 将摄影测量捕获和现有资产与 AI 减面、标注和分发功能相结合，支持 iOS、macOS、visionOS、Pico、Meta、Web 及其他沉浸式设备。Spatial Drawing SDK 可将徒手标注和测量标注锚定于 3D 对象之上。





覆盖从数据采集和人工智能处理，到空间标注、协同合作、Web 端访问及企业级复用的全流程
From capture and AI processing to spatial annotation, collaboration, web access, and enterprise reuse

Spatial Plan 利用 Apple Vision Pro 扫描环境，将几何数据与测量值、注释、语音笔记和 AI 对象识别相结合；记录结果以 3D 格式导出，供跨设备审查。Spatial Companion 引导沉浸式会话，而 PortalGate 则将 3D 和 360 度媒体内容转化为可探索的环境。

其突破性在于构建了一条从物理现实到数字孪生、协同决策和现场行动的工作流。原生开发支持响应式交互；Web 交付、SDK、API 和标准格式提升了互操作性。2023 年参与位于伦敦和库比蒂诺的 Apple Vision Pro 开发者实验室，有助于将新硬件能力转化为企业工作流。

Enterprise Spatial Computing remains fragmented: capture, optimization, devices, review and collaboration occur in separate tools; specialist and different hardware excludes stakeholders; and context is lost in conventional reports. Dilium addresses this through a modular, continuous data journey.

3DtoMe connects photogrammetric capture and existing assets with AI decimation, annotation and distribution across iOS, macOS, visionOS, Pico, Meta, web and others immersive devices. The Spatial Drawing SDK anchors freehand and measured annotations to 3D objects. Spatial Plan uses Apple Vision Pro to scan environments and combine geometry with measurements, annotations, voice notes and AI object recognition; records export in 3D for cross-device review. Spatial Companion guides immersive sessions, while PortalGate turns 3D and 360-degree media into explorable environments.

The breakthrough is a workflow from physical reality to digital twin, collaborative decision and field action. Native development supports responsive interaction; web delivery, SDKs, APIs and standard formats improve interoperability. Participation in Apple Vision Pro Developer Labs in London and Cupertino in 2023 helped translate new hardware capabilities into enterprise workflows.

## 该生态系统部署于工业、文化和商业领域，将空间数据转化为共享的运营价值

## Deployed Across Industry, Culture and Commerce, the Ecosystem Turns Spatial Data into Shared Operational Value

生态系统已从原型阶段推进至公开产品、企业分发和现场演示。Spatial Plan 通过热那亚市 CTE（数字文化工坊，Opificio Digitale per la Cultura）开发，于 2025 年发布，并于 2026 年通过 Apple Store 分发。它支持基础设施、保险和现场服务领域的检查、维护和文档记录。

Deetekt 与米兰理工大学和 Focchi 集团合作开发，运用 AI 视觉检测幕墙缺陷，并将标注与远程数字孪生审查相连接。在 2025 年 Ecomondo 展会上，C&G Depurazione Industriale 展示了交互式 3DtoMe 模型，无需运输大型机械。PortalGate 为数百名 TTG Travel Experience 访客展示了沉浸式目的地访问体验。

推广活动包括 Apple Developer Labs、戛纳 WAICF 和巴塞罗那 MWC，并伴有意大利贸易署代表团参与。目前拥有 3,000 多家客户、30 多个项目、6 次成功中标以及超过 200 万次浏览和使用。其收益包括：减少运输和差旅、文档互联互通、远程专业知识和支持、可复用资产，以及通过互操作性解决方案实现更清晰的技术沟通与协作。




交互式数字孪生能够展示复杂工业设备，无需运输实体机械

Interactive digital twins communicate complex industrial equipment without transporting the physical machinery



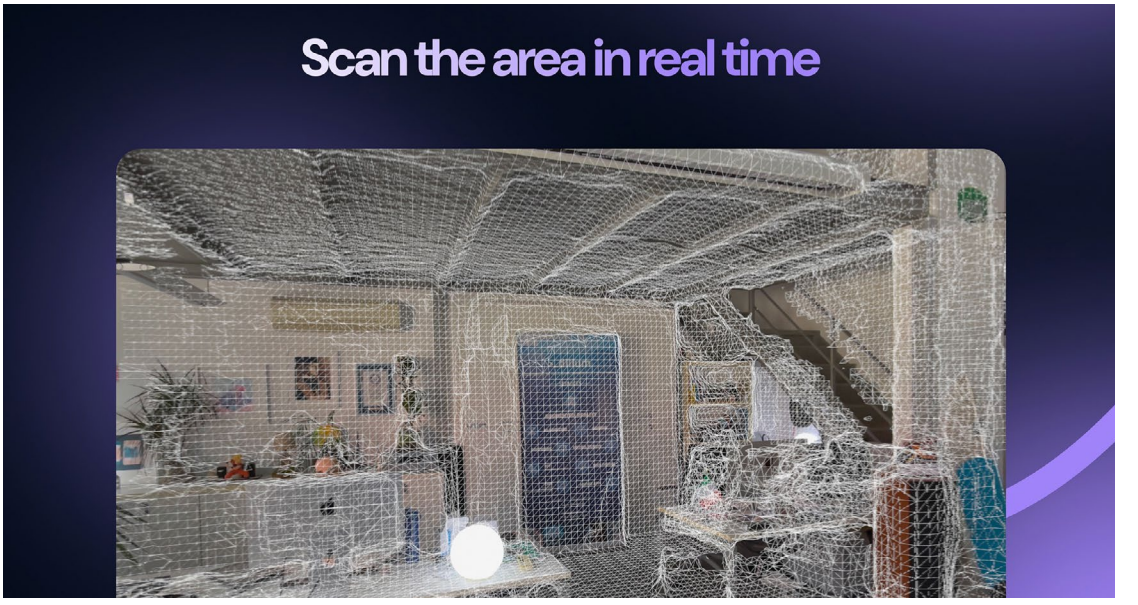
在 2026 年戛纳 WAICF 上，Dilium 将推出 Spatial Companion 及其以人为本的引导式空间计算方案

At WAICF Cannes 2026, Dilium introduces Spatial Companion and its human-centred approach to guided Spatial Computing

The ecosystem has progressed from prototypes to public products, enterprise distribution and field demonstrations. Spatial Plan was developed through CTE Comune of Genova - Opificio Digitale per la Cultura, launched in 2025 and distributed through Apple Store in 2026. It supports inspection, maintenance, documentation for infrastructure, insurance and field service.

Deetekt, developed with Politecnico di Milano and Focchi Group, applies AI vision to detect curtain-wall defects and connects annotations with remote digital-twin review. At Ecomondo 2025, C&G Depurazione Industriale presented interactive 3DtoMe models without transporting large machinery. PortalGate demonstrated immersive destination access to hundreds of TTG Travel Experience visitors.

Promotion has included Apple Developer Labs, WAICF Cannes and MWC Barcelona with Italian Trade Agency delegations. With 3,000+ customers, 30+ projects, 6+ successful tenders and 2+ million views and uses. Benefits include: fewer shipments and trips, connected documentation, remote expertise and support, reusable assets and clearer technical communication and collaboration with an interoperability solutions.




## 空间计算正成为更安全、更高效、更具包容性的数字化转型的共享基础设施

## Spatial Computing Becomes Shared Infrastructure for Safer, More Efficient and Inclusive Digital Transformation

这一成就将空间计算从孤立的体验提升为可重用的操作层。物理资产转化为持久的信息空间，人们可以在其中捕捉证据、理解上下文并开展远程协作。

其产业影响体现在三个方面：产品和场地成为覆盖检查、培训、维护、销售及文化解读的全生命周期资产；AI 和计算机视觉始终与人的判断相结合；沉浸式用户能够与传统设备和浏览器上的同事协同工作。

标准 3D 导出、浏览器交付、SDK 和 API 使其能够在现有流程中复用，并可由国际合作伙伴进行扩展。模块化设计为小型组织提供了切实可行的采纳路径。文化领域用户可扩大访问范围并改进文档记录；工业用户则能保存知识、增强可追溯性，并减少不必要的差旅、重复现场访问及物料密集型演示。空间数据是对专业知识的增强，而非替代。




The achievement advances Spatial Computing from isolated experiences to a reusable operational layer. Physical assets become persistent information spaces where people capture evidence, understand context and collaborate remotely.

Its industrial impact is threefold: products and sites become lifecycle assets for inspection, training, maintenance, sales and cultural interpretation; AI and computer vision remain connected to human judgement; and immersive users collaborate with colleagues on conventional devices and browsers.

Standard 3D export, browser delivery, SDKs and APIs enable reuse in existing processes and extension by international partners. Modularity gives smaller organizations a practical adoption path. Cultural users can widen access while improving documentation; industrial users can preserve knowledge, strengthen traceability and reduce avoidable travel, repeat visits and material-intensive demonstrations. Spatial data augments expertise rather than replacing it.

## 从研究到落地：Dilium 在米兰理工大学展示企业级空间计算实践

## From Research to Reality: Dilium's Enterprise Spatial Computing Journey at Politecnico di Milano

自 2017 年以来，Dilium 已构建了涵盖空间计算、计算机视觉、人工智能和原生工程的多学科能力。在米兰理工大学的“意大利之路”框架下，Dilium 与学术及产业合作伙伴共同展示了企业级应用，将研究需求与运营实践相连接。其国际曝光包括参与伦敦和库比蒂诺的苹果开发者实验室，以及东京、首尔、戛纳和巴塞罗那的技术展会。在戛纳 WAICF 和 Ecomondo 展会上，Dilium 向全球观众展示了其空间计算与空间协作生态系统。其发展路线图持续朝向更广泛的互操作性以及负责任、人工监督的 AI 方向推进。

Since 2017, Dilium has built multidisciplinary capabilities across Spatial Computing, computer vision, AI and native engineering. At Politecnico di Milano's for the Italian way, Dilium presented enterprise applications alongside academic and industrial partners, connecting research with operational needs. International exposure has included Apple Developer Labs in London and Cupertino and technology events in Tokyo, Seoul, Cannes and Barcelona. At WAICF Cannes and Ecomondo, Dilium demonstrated its Spatial Computing and Spatial Collaboration ecosystem to global audiences. Its roadmap continues toward broader interoperability and responsible, human-supervised AI.




Dilium 在米兰理工大学的 XR 技术研讨会上展示企业级空间计算应用案例
Dilium presents enterprise Spatial Computing use cases at Politecnico di Milano's XR Technologies Workshop


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CONFERENCE

# 多模态高可信数字专家关键技术及产业应用

## Key Technologies and Industrial Applications of Multimodal Trustworthy Digital Experts




多模态高可信数字专家
Multimodal Trustworthy Digital Experts

中国科学技术大学
University of Science and Technology of China

云知声智能科技股份有限公司
Unisound AI Technology Co., Ltd.

中国科学技术大学第一附属医院 ( 安徽省立医院 )
The First Affiliated Hospital of the University of Science and Technology of China (Anhui Provincial Hospital)

## 引言

项目构建了“云端芯 - 人机交互 - 垂域认知 - 智能体”多层递进且协同的系统架构，形成了通专跨层深融合的有机技术体系与软硬一体化的系统性解决方案，实现了从基础计算支撑到智能应用落地的全流程覆盖。

## Introduction

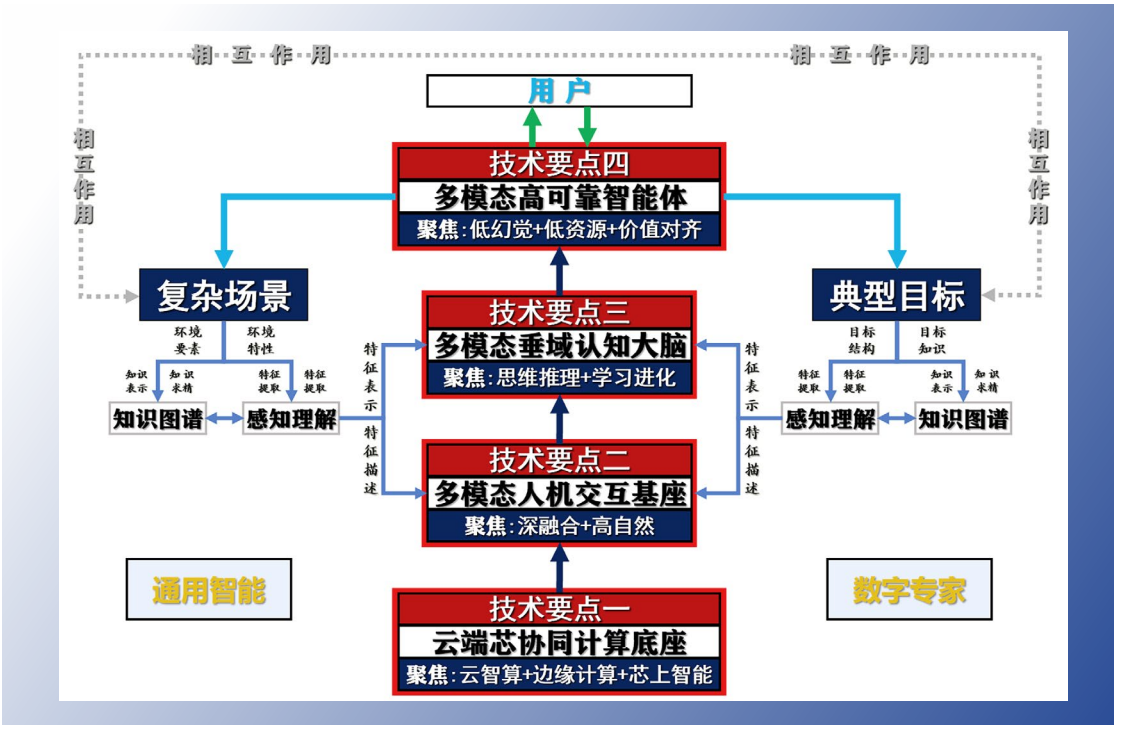
The project establishes a multi-layered, progressive, and synergistic system architecture integrating “cloud-edge-chip collaboration, human-machine interaction, specialized cognition, and intelligent agents”, forming an organic technical framework with cross-layer/general-specific deep integration and a comprehensive hardware-software solution that covers the entire process from basic computing to intelligent application.

## 构建多模态数字专家四大技术基座，实现云端芯协同与高可信认知突破

## Building Four Major Technological Pillars for Multimodal Digital Experts, Achieving Breakthroughs in Cloud-Edge-Chip Collaboration and Highly Trustworthy Cognition

项目考量基础能力、专业深度和资源代价层面，以构建多模态数字专家为目标，瞄准“1. 打造高可信垂域模型，提高严肃场景应用水准；2. 对标人类专家知识水平，实现极低成本人机协同；3. 发展通用 > 专业 > 端侧路线，快速适配各类行业应用”问题，开展云端芯协同计算底座（支撑数字专家训练、演进和规模化的算力中枢）、多模态人机交互基座（提升数字专家易用性和自然度的关键要素）、多模态垂域认知大脑（赋予数字专家强大思维推理和学习进化能力的重要载体）、多模态高可靠智能体（达成数字专家真正行业可用的根本因素）研究，从云端芯协同计算底座、多模态人机交互基座、多模态垂域认知大脑、多模态高可靠智能体四大方面探索关键技术，取得了系统性研究成果，并在技术创新矩阵“芯上端侧小模型精炼化、端到端大模型融合交互、多模态情智兼备数字人、知识增强高可信大模型”上得到了多个国际院士专家组的充分肯定，技术鉴定获得国际领先认定 6 项 / 先进认定 2 项。

The project focuses on foundational capabilities, professional depth, and resource cost, aiming to build multimodal digital experts. It addresses three core questions: 1.To develop highly trustworthy domain-specific models and elevate the application standards in serious scenarios; 2.To match human expert knowledge levels and achieve ultra-low-cost human-machine collaboration; 3.To follow a path from general to specialized to edge-side deployment, enabling rapid adaptation across diverse industry applications. The research covers four key components: a cloud-chip collaborative computing infrastructure (a computational hub supporting training, evolution, and scaling of digital experts), a multimodal human-machine interaction foundation (a critical element enhancing usability and naturalness), a multimodal domain-specific cognitive brain (a vital carrier enabling strong reasoning, learning, and evolutionary capabilities), and a high-reliability multimodal intelligent agent (the fundamental factor ensuring real-world industrial applicability). By exploring cutting-edge technologies across these four dimensions, the project has achieved systematic research outcomes. Its innovations-summarized in the technology matrix as “miniaturized model refinement on chip for edge devices, end-to-end integration of large models with interaction, multimodal digital humans combining emotion and intelligence, and knowledge-enhanced, highly trustworthy large models”-have received strong endorsement from international academicians and expert panels. The technology evaluation has earned six international-leading and two advanced-level recognitions.



## 项目成果多领域规模化落地，创效 32 亿并深度融入华为生态

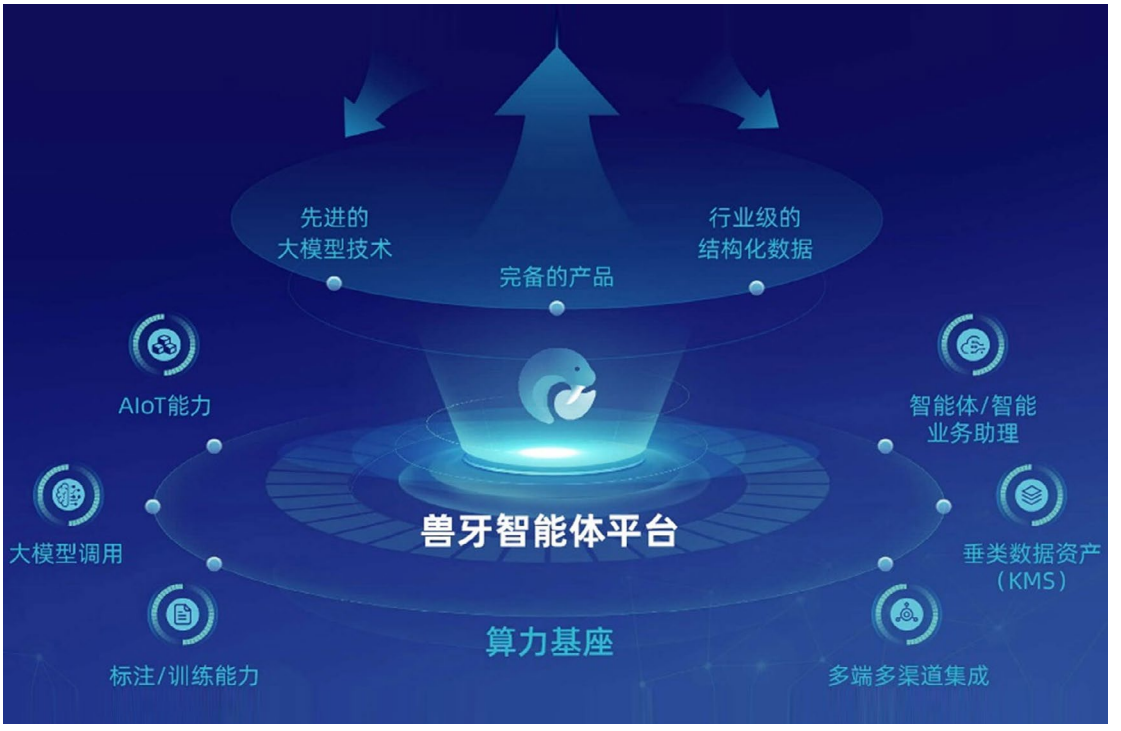
## Project Outcomes Feature Large-Scale Multi-Domain Deployment, Generating 3.2 Billion Yuan in Value and Integration into the Huawei Ecosystem

项目算法、工具、资源应用于家居、医疗、座舱、交通、政务、金融、教育、城市综合治理等多领域的 AI 交互芯片、决策支持工具、数字人客服、教育平板、政务问答平台等软硬件产品，服务超 2.62 亿用户，平台月调用峰值超 10 亿次，芯片出货近 1 亿颗，赋能设备超 10 万种，合作伙伴超 5.1 万家，创造经济效益 32.01 亿元 ( 直接 31.26 亿元 + 间接 0.75 亿元 )；负责人主导形成系列模型套件进入华为计算产品线，获华为最具价值教师称号 ( 全球仅 18 名 )、教育部 - 华为栋梁之师奖，主编 2 部端芯教材获华为 ICT 优秀教材奖 ( 全球仅 20 本 )；核心技术应用于医疗和教育体系改革、政务服务效率优化、基层社区治理和应急管理，取得了良好社会效益。

The project's algorithms, tools, and resources have been applied to AI interaction chips, decision-support tools, digital human customer service, educational tablets, government Q&A platforms, and other software and hardware products across multiple domains including home, healthcare, cabin, transportation, public administration, finance, education, and urban comprehensive governance. These solutions serve over 262 million users, with the platform reaching a monthly peak of over 1 billion calls. The chips have shipped nearly 100 million units, enabling more than 100,000 types of devices and collaborating with over 51,000 partners, generating economic benefits of 3.201 billion yuan (3.126 billion directly and 0.75 billion indirectly). The project leader led the development of a series of model kits integrated into Huawei's computing product line, earning recognition as one of Huawei's Most Valuable Teachers (only 18 globally) and receiving the Ministry of Education-Huawei Pillar Teacher Award. As chief editor of two textbooks for edge-chip education, he won the Huawei ICT Outstanding Textbook Award (only 20 textbooks worldwide). Core technologies have been applied to reform in healthcare and education systems, optimization of government service efficiency, grassroots community governance, and emergency management, achieving significant social benefits.






## 打通 AI 工业级落地路径，获 6 项国际领先认定与百余项国际大奖

## Paved the Way for Industrial-Grade AI Deployment, Earning 6 Internationally Leading Recognitions and Over 100 International Awards

项目成功验证了“通用底座 + 专业智能体 + 端侧芯片优化 + 基础设施”的闭环技术架构和路径在产业级应用中的优越性，推动了 AI 从“技术原型”向“工业级产品”演进，为 AI 模型在高风险场景中的落地提供了可复用的方法论，为可信 AI 领域发展贡献了关键实践案例，在技术创新和产业、社会效益方面取得了重大进展与影响力。项目形成了 895T 高质量数据；授权专利 18 项、软著 4 项；制定国标 3 项、团标 1 项；发表论文 37 篇 ( 含 TPAMI 4 篇 + IJCV 1 篇 )，一作 / 通讯获 IEEE 顶会最佳论文奖 7 项；主编 2 部华为优秀教材；序 1、序 2 获省部科技一、二等奖 8 项；牵头获工信部创新奖、AWE 艾普兰·核芯奖、全国智慧医保大赛一等奖、世界机器人大赛双冠、国际权威评测冠军 (100+ 项 )，获央视焦点访谈深度报道；技术获国际领先认定 6 项、先进认定 2 项。

The project successfully validated the superiority of the closed-loop technical architecture and pathway, comprising a general-purpose foundation, specialized intelligent agents, edge-chip optimization, and infrastructure, in industrial-scale applications. This advancement has driven AI's evolution from “technological prototypes” to “industrial-grade products,” providing reusable methodologies for deploying AI models in high-risk scenarios and contributing key practical case studies to the development of trustworthy AI. It has obtained significant progress and impact in technological innovation and industrial/social benefits. The project generated 895TB of high-quality data; obtained 18 authorized patents and 4 software copyrights; developed 3 national standards and 1 group standard; published 37 papers (including 4 in TPAMI and 1 in IJCV), with first authors/corresponding authors receiving 7 best paper awards at top IEEE conferences; edited 2 outstanding Huawei textbooks; received 8 provincial/ministerial science and technology first/second prizes for Foreword 1/Foreword 2; led the team to win the Ministry of Industry and Information Technology Innovation Award, AWE Applan-Core Award, first prize in the National Smart Medical Insurance Competition, double crown in the World Robot Competition, and international authoritative evaluation champion (100 items), and received in-depth coverage by CCTV Focus Interview; technology recognized as internationally leading in 6 items and advanced in 2 items.

# 大型航空公司运营计划智能决策引擎关键技术与应用

## Intelligent Decision Engine for Large-Scale Airline Planning: Key Technologies and Applications




“天策”航空求解器
“Tiance” Airline Solver

南航数智科技（广东）有限公司
CSN Digital Intelligence Technology Co., Ltd.

南航数科 CHINA SOUTHERN DIT

## 引言

航空运营计划是航司降本增效与安全运行的核心环节，本项目研发了具有自主知识产权的“天策”航空求解器，综合性能达到国际先进水平，推动民航运行控制从经验驱动向算法驱动的智能化转型，打造航空运营决策新范式。

## Introduction

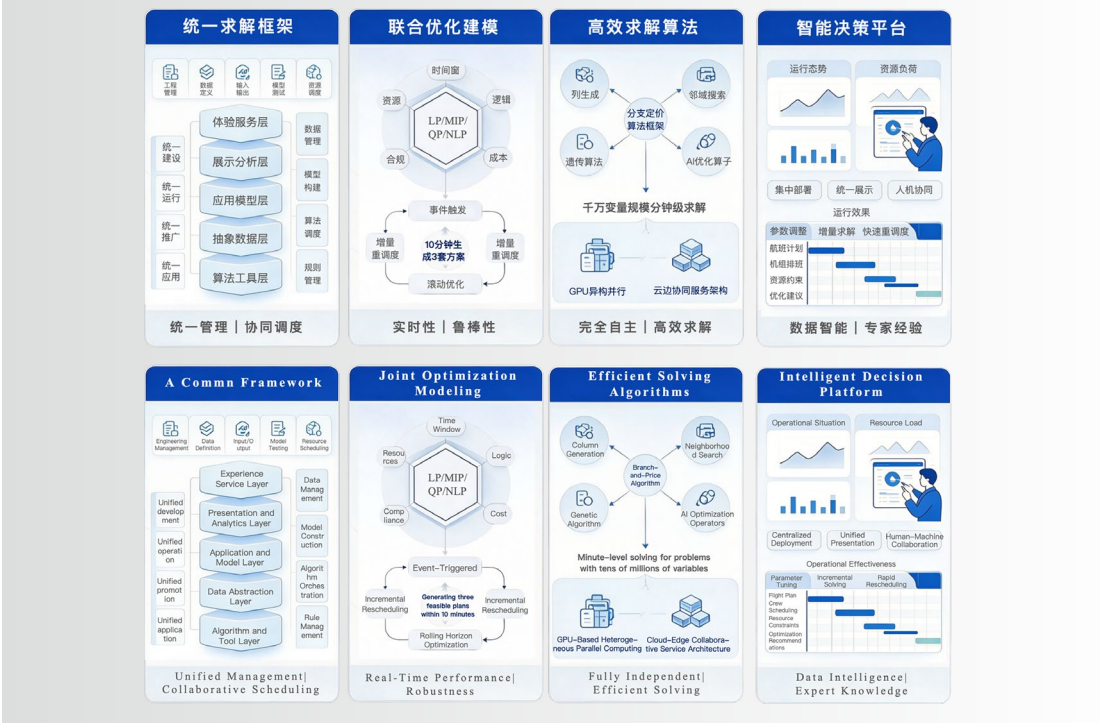
Airline Operational planning is the core component for airlines to reduce costs, improve efficiency, and ensure safe operations. This project has developed “Tiance” Airline Solver with fully independent intellectual property rights, achieving internationally advanced comprehensive performance. It drives the intelligent transformation of civil aviation operations control from experience-driven to algorithm-driven, establishing a new paradigm for aviation operational decision-making.

## “天策”在航空业务模型、核心算法与工程架构三维度实现系统性突破，攻克超大规模航空运营场景求解难题

## “Tiance” Has Achieved Systematic Breakthroughs in Three Dimensions: Airline Business Models, Algorithms, and Engineering Architecture, Overcoming the Challenges of Solving Ultra-Large-Scale Airline Operations Scenarios

航空运营计划智能决策引擎“天策”攻克了核心技术长期依赖国际商用解决方案、自主决策产品缺失的难题，解决了中国通用求解器在超大规模、多变量、强约束场景下求解效率不足的瓶颈，综合性能达国际先进水平，在业务模型、核心算法、工程架构三大维度具有完全自主知识产权。参数化自动建模实现多维度时空强耦合约束的轻量化建模，事件触发机制支持增量式重调度与滚动时域优化，保障决策引擎的实时性与鲁棒性。分布式并行混合算法使核心场景运算从小时级压缩至分钟级，综合性能较国际主流商用求解器提升 1.5 倍。通用求解框架实现模型、数据、规则、算法、求解器的统一管理与协同调度，统一智能决策平台支持方案调整与人工干预，实现算法自动生成与人工精调优化的决策闭环。

“Tiance” intelligent decision engine for airline planning has overcome the long-standing reliance on international commercial solutions for core technologies and the lack of domestically developed decision products. It has broken through the bottleneck of insufficient solving efficiency of China’s general-purpose solvers in ultra-large-scale, multi-variable, strongly constrained scenarios. Its overall performance has reached the internationally advanced level, with complete independent intellectual property rights across three dimensions: airline business models, algorithms, and engineering architecture. Parameterized automatic modeling enables lightweight modeling of multi-dimensional spatiotemporally strongly coupled constraints, while the event-triggered mechanism supports incremental rescheduling and rolling horizon optimization, ensuring the real-time responsiveness and robustness. The distributed parallel hybrid algorithm compresses computational time for core scenarios from the hour scale to the minute scale, with overall performance surpassing that of leading international commercial solvers by a factor of 1.5. The common framework realizes unified management and coordinated scheduling of models, data, rules, algorithms, and solvers. The unified intelligent decision platform supports plan adjustment and human intervention, forming a closed-loop decision process that seamlessly integrates algorithm-generated solutions with manual refinement and optimization.




航空运营计划智能决策引擎体系框架
Framework of the Intelligent Decision Engine for Airline Planning

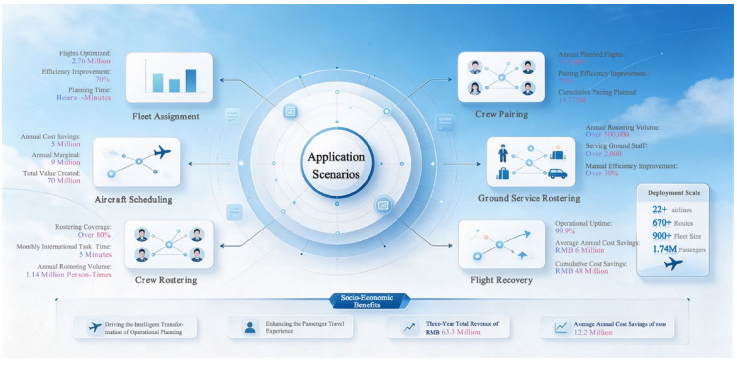
## 赋能航空公司运营计划全流程智能化升级
## Enabling End-To-End Intelligent Upgrading of Airline Planning

项目成果在南航集团 22 家分子公司及青岛航空实现规模化应用，覆盖机型优化、飞机排班、机组搭班、机组排班、地服排班、航班恢复六大核心运行场景。周航班计划编排时间由人工 4 小时缩短至 1 至 5 分钟，整体运营计划编制效率提升 30% 至 70%，有效降低了航司计划人员的工作负荷与人力成本投入。机组调度场景中年支撑超 200 万航班的衔接方案，运算耗时由小时级降至分钟级，减少机组执勤时间超标风险，提升一线人员排班满意度；地服排班场景中年完成超 50 万人次排班，成功率达 97.57%，降低地服人员冗余配置与培训成本；航班恢复场景下大面积延误可在 10 分钟内生成多套可行调整方案，有效减少航班延误对旅客出行的影响。项目投产三年以来合计收益 6360 万元，投资回报率达 3.65，年均节约成本 1220 万元，年均边际贡献 900 万元。




大型航空公司运营计划核心业务场景
Core Scenarios for Large-Scale Airline Planning




航空运营计划智能决策引擎应用情况
Application of the Intelligent Decision Engine for Airline Planning

The project has been implemented on a large scale across 22 subsidiaries of China Southern Airlines Group and airlines such as Qingdao Airlines, covering six core operational scenarios: fleet assignment, aircraft scheduling, crew pairing, crew rostering, ground service rostering and flight recovery. In terms of operational efficiency, the time required for weekly flight plan scheduling has been reduced from 4 hours of manual work to 1-5 minutes, achieving an overall improvement of 30%-70% in operational plan formulation efficiency, reducing the workload and labor costs of airline planning personnel. In the crew scheduling scenario, the system supports connection plans for over 2 million flight segments annually, with computation time reduced from hours to minutes, minimizing the risk of crew duty time violations and improving frontline staff rostering satisfaction. In the ground staff rostering scenario, shift arrangements for over 500,000 person-times are completed annually, achieving a success rate of 97.57%, reducing redundant staffing and training costs. In flight recovery scenarios, multiple feasible adjustment plans can be generated within 10 minutes under large-scale disruptions, effectively mitigating the impact of flight delays on passenger travel. Over the three years since its deployment, total returns have reached RMB 63.6 million, achieving a Return-On-Investment (ROI) of 3.65. The average annual cost savings amount to RMB 12.2 million, with an average annual marginal contribution of RMB 9 million.

## 推动民航运行控制从经验驱动向算法驱动转型，打造行业数智化标杆

## Driving the Intelligent Transformation of Civil Aviation Operations Control from Experience-Driven to Algorithm-Driven, and Setting an Industry Benchmark for Digital and Intelligent Transformation

项目攻克了民航运营计划领域的核心技术难题，实现了业务模型、核心算法、工程架构三大维度的自主创新，形成了适配大型航司民航运筹优化场景的民航专用智能决策引擎“天策”，综合性能达到国际先进水平。从底层求解内核到上层业务应用具备全流程自主知识产权，改变了民航运行控制长期依赖人工经验与国际工具的行业格局，解决了行业内模型重复建设、难以协同的问题，推动民航运行控制从经验驱动向算法驱动转型，打造行业数智化标杆。标准化的产品体系让技术成果可在不同航司快速复制推广应用，带动了算法、算力、应用软件等上下游产业的协同发展，也为交通、物流等更广泛的大交通领域的智能化升级提供了可复用的范本。

The project has overcome the core technical challenges in the field of airline planning, achieving comprehensive independent innovation across three dimensions: airline business models, algorithms, and engineering architecture. The project has developed “Tiance”, a dedicated intelligent decision engine tailored to the operations research and optimization scenarios of large-scale airlines, with comprehensive performance reaching the internationally advanced level. With full-process independent intellectual property rights spanning from the underlying solution kernel to upper-level business applications, the project has transformed the industry landscape of civil aviation operation control, which had long relied on human experience and international tools. It has addressed the industry-wide challenges of redundant model development and lack of synergy across different scenarios, driving the transformation of civil aviation operation control from experience-driven to algorithm-driven decision-making, and setting an industry benchmark for digital and intelligent transformation. The standardized product system enables the rapid replication and deployment of technological achievements across different airlines, driving the coordinated development of upstream and downstream industries including algorithms, computing power, and application software. It also provides a replicable model for the intelligent upgrading of the broader transportation domain, including sectors such as transport and logistics.




天策航空求解器打造行业数智化标杆
“Tiance” Airline Solver: Setting an Industry Benchmark for Digital and Intelligent Transformation

## 学术成果与荣誉奖项
## Academic Achievements and Awards

项目构建了完善的知识产权体系，发表学术论文 17 篇，授权发明专利 13 项，登记软件著作权 12 项。成果先后荣获南航机务智慧维修创新大赛三等奖、中国航空运输协会民航科学技术奖一等奖、2025 数字中国创新大赛·信创赛道全国一等奖以及 2026 数字中国创新大赛·信创赛道交通行业赛一等奖等多项荣誉。

The project has established a comprehensive intellectual property system, including 17 academic papers published, 13 invention patents granted, and 12 software copyrights registered. The achievements have received multiple honors, including the Third Prize in the China Southern Airlines Smart Maintenance Innovation Competition, the First Prize of the Civil Aviation Science and Technology Award from the China Air Transport Association (CATA), the National First Prize in the XinChuang Track of the 2025 Digital China Innovation Contest (DCIC), and the First Prize in the Transportation Industry Track of the DCIC 2026·XinChuang Track.

学术论文

17篇



发明专利

13项



软件著作权

12项



奖励荣誉 4 项

南航机务智慧维修创新大赛




三等奖

中国航空运输协会民航科学技术奖




一等奖

2025数字中国创新大赛.信创赛道




全国一等奖

2026数字中国创新大赛·信创赛道




交通行业赛一等奖

本成果所获奖项、论文、专利、软著（部分）
Awards, Research Papers, Patents, and Software Copyrights (Partial) Related to This Achievement


2026WORLD
INTERNET
CONFERENCE

# 伏渊大模型矩阵——网络空间全域立体化安全风控大脑

## Velldepth Model Matrix: An Intelligent Brain for Comprehensive Cyberspace Security and Risk Control




伏渊大模型矩阵由御风、息壤、镇枢三大基模组成，分别面向内容安全、网络安全和业务风控，构建覆盖内容、环境、行为的全域立体化智能防护体系。三者协同实现风险发现、研判与处置闭环，支撑数字安全治理智能化升级

The Velldepth model matrix consists of three base models—Yuvion, XekRung, and ZenPivot—serving content safety, cybersecurity, and business risk control. Together, they build an intelligent protection framework spanning content, environment, and behavior, enabling a closed loop of risk discovery, analysis, and response for digital security governance

阿里巴巴集团控股有限公司
Alibaba Group

## 引言

伏渊大模型是阿里巴巴面向数字安全治理打造的垂域模型体系，覆盖内容安全、网络攻防和业务风控三大场景，构建立体化智能防护底座。模型在多项权威评测中领先，已实现规模化应用，显著提升风险发现、分析与决策能力。

## Introduction

Velldepth is Alibaba's domain-specific model system for digital security governance, covering content safety, cybersecurity offense and defense, and business risk control. It builds an integrated intelligent protection foundation across key security scenarios. The models have achieved industry-leading results in multiple authoritative evaluations and have been deployed at scale, significantly enhancing capabilities in risk discovery, analysis, decision-making, and response, while supporting the intelligent upgrade of digital security governance.

## 伏渊大模型突破安全智能关键瓶颈，构建国际领先的数字安全治理大模型体系

## Velldepth Breaks Through Key Bottlenecks in Security Intelligence, Establishing an Internationally Leading Foundation Model System for Digital Security Governance

伏渊大模型面向数字安全治理中风险复杂演化、攻击持续升级、业务场景高度对抗等难题，系统突破了通用大模型在安全领域专业知识不足、复杂推理不强、鲁棒性不足和落地适配困难等关键瓶颈。项目创新提出面向安全场景的 AI-Native 训练方法，将风险识别、知识注入、复杂推理、策略优化与工具调用统一建模；首创 Agentic RL 自进化攻防训练体系，实现模型在动态对抗环境中的持续学习和迭代优化；提出双引擎协同风控架构，兼顾实时响应与深度研判；并建立安全垂域大模型评测与知识工程标准体系。相关成果在内容安全、网络攻防和业务风控三大方向达到国际领先水平：内容安全能力较同尺寸开源模型最高领先 19.76 个百分点，网络安全 15 项评测综合领先国际同类模型 12.5 个百分点，CTI 提取提升 18.9%，风控 32B 模型整体效果超越 Qwen3-Max。

Velldepth addresses major challenges in digital security governance, including evolving risks, escalating attacks, and highly adversarial business scenarios. It systematically overcomes key limitations of general-purpose large models in security applications, such as insufficient domain knowledge, weak complex reasoning, limited robustness, and deployment difficulty. The project proposes an AI-native training methodology for security, unifying risk recognition, knowledge injection, complex reasoning, strategy optimization, and tool use; pioneers an Agentic RL-based self-evolving offense-defense training system for continuous learning in dynamic adversarial environments; introduces a dual-engine collaborative architecture for risk control that combines real-time response with deep analysis; and establishes an evaluation and knowledge-engineering standard system for security foundation models. These innovations have achieved internationally leading results across content safety, cybersecurity, and business risk control, including up to 19.76 percentage points over open-source counterparts, an overall lead of 12.5 percentage points across 15 cybersecurity evaluations over comparable international models, and 18.9% improvement in CTI extraction.



## 伏渊大模型实现超大规模应用推广，形成兼具经济、社会与生态价值的数字安全治理基础设施

## Velldepth Enables Large-Scale Deployment, Establishing Digital Security Governance Infrastructure with Economic, Social, and Environmental Value

伏渊大模型已在阿里巴巴安全、内容、风控三大核心治理领域实现规模化应用，覆盖 100 多个细分风险场景，支撑淘宝、天猫、闲鱼、阿里云、钉钉等 10 余条核心业务线，日均调用量达亿级。依托多模态理解、复杂推理、跨场景迁移和自主分析能力，项目在真实高并发环境中显著提升治理效能：整体运营效率提升 30% 以上，内容治理 70%+ 计件流量实现自动审核，风控案例分析可分钟级生成风险报告与策略建议，有效降低欺诈和黑灰产攻击损失，保障平台稳定运行与业务增长。作为服务超 10 亿用户的核心防护体系，项目实现涉政舆情识别覆盖率 100%、个人信息保护复杂链路识别准确率超 90%，并在版权保护、商品治理、野生动植物保护等公益与生态治理场景持续发挥作用，形成了可持续迭代、可跨场景迁移、可面向行业复制推广的智能治理新范式。

Velldepth has been deployed at scale across Alibaba's three core governance domains of security, content, and risk control, covering more than 100 subdivided risk scenarios and supporting over 10 major business lines, including Taobao, Tmall, Xianyu, Alibaba Cloud, and DingTalk, with average daily calls reaching the hundreds of millions. Leveraging multimodal understanding, complex reasoning, cross-scenario transfer, and autonomous analysis, it has delivered strong results in real high-concurrency environments: overall operational efficiency improved by over 30%, more than 70% of piece-rate traffic in content governance was automated, and risk-control case analysis can now generate reports and strategy recommendations within minutes. The system has effectively reduced losses from fraud and black-market attacks while supporting platform stability and business growth. Serving more than one billion users, Velldepth has achieved 100% coverage in politically sensitive content detection and over 90% accuracy in complex personal information protection workflows, while also contributing to copyright protection, product governance, and wildlife-related public-interest governance. It has become a replicable and scalable paradigm for intelligent digital security governance.

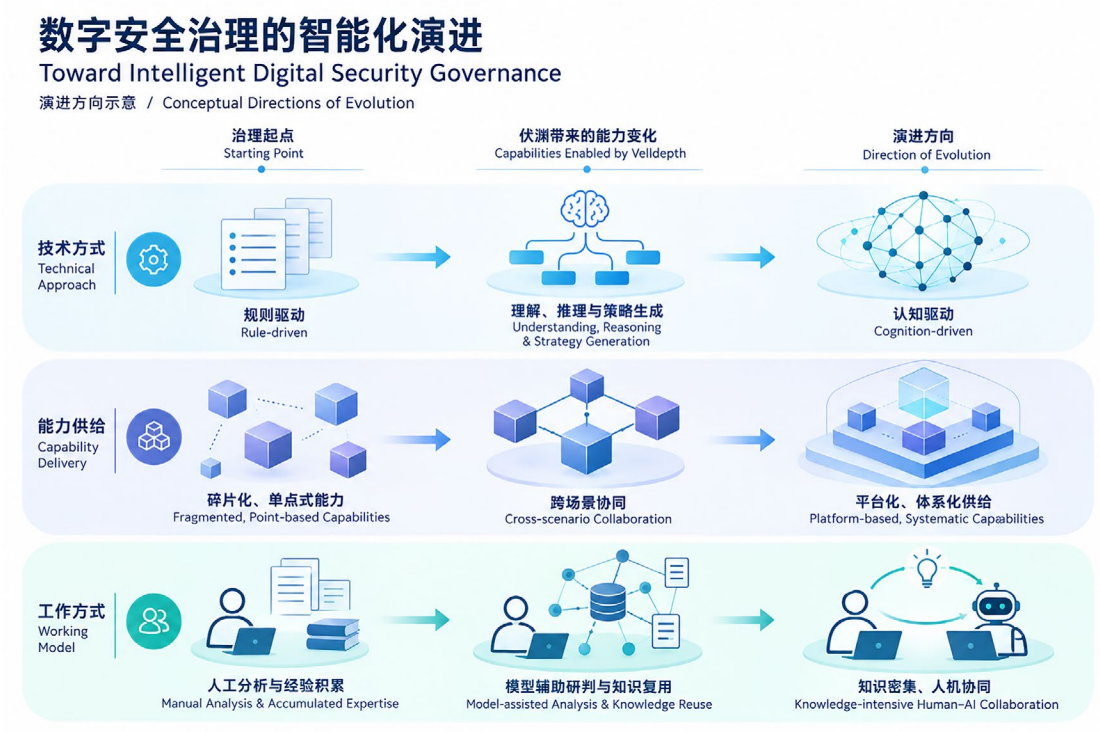


## 伏渊大模型推动数字安全从规则驱动迈向认知驱动，重塑安全产业智能化升级路径

## Velldepth Drives Digital Security from Rule-Based to Cognition-driven Governance, Reshaping the Path to Intelligent Security Industry Upgrading

伏渊大模型围绕内容安全、网络安全攻防和业务风控构建了系统化安全智能技术体系，对数字安全领域的技术进步和产业升级产生了重要影响。在技术层面，项目突破了安全场景中专业知识建模、复杂推理、自进化攻防训练和协同决策等关键问题，证明大模型可从传统识别分类工具升级为支撑研判、推演和策略生成的核心引擎，拓展了人工智能在安全领域的应用边界。项目已形成40余篇国际高水平论文、10余项专利及评测标准体系，相关成果发表于CVPR、ACL、ICML、ICSE等会议，并获得多项权威奖项。在产业层面，伏渊推动安全能力由碎片化、单点式供给向平台化、体系化、协同化供给转变，带动安全产业从劳动密集型向知识密集型、从项目制向平台化演进，为网络安全产业智能化升级和数字经济高质量发展提供了重要示范。

Velldepth has built a systematic security intelligence framework across content safety, cybersecurity offense and defense, and business risk control, generating important influence on technological progress and industrial upgrading in digital security. Technically, it breaks through key challenges in domain knowledge modeling, complex reasoning, self-evolving offense-defense training, and collaborative decision-making, demonstrating that foundation models can evolve from traditional recognition tools into core engines for threat assessment, chain inference, and strategy generation. This substantially expands the application boundary of AI in security. The project has produced more than 40 high-level international papers, over 10 patents, and a dedicated evaluation standard system, with publications at CVPR, ACL, ICML, and ICSE, and multiple authoritative awards. Industrially, Velldepth drives the security sector from fragmented, point-based capability supply toward platform-based, systematic, and collaborative intelligence, accelerating the transition from labor-intensive to knowledge-intensive development and providing a strong model for cybersecurity industry upgrading and high-quality digital economy growth.



## 建立安全大模型评测标准与成果转化体系，形成持续创新与行业示范能力

## Establish Evaluation Standards and Outcome Transformation System for Secure Large Models to Build Capabilities for Sustained Innovation and Industry Demonstration

伏渊大模型除核心技术突破与规模化应用外，还建立了较完整的成果评估与转化支撑体系。项目构建了覆盖模型能力、场景效果和业务表现的多层次评测方法，形成内容安全、网络安全和业务风控三大方向的闭环评价机制，其中 CS-Eval 已成为安全大模型领域具有代表性的评测参考。项目累计形成 40 余篇国际高水平论文、10 余项专利，相关成果发表于 CVPR、ACL、ICML、AAAI、EMNLP、IEEE S&P、ICSE 等会议，并与多所高校开展产学研合作。基于御风衍生的 Yufeng xGuard 已成为具有代表性的 AI 安全护栏模型。上述成果进一步提升了项目的学术影响力、同行认可度和产业示范价值，为安全垂域大模型的持续迭代、第三方评估和行业推广提供了有力支撑。

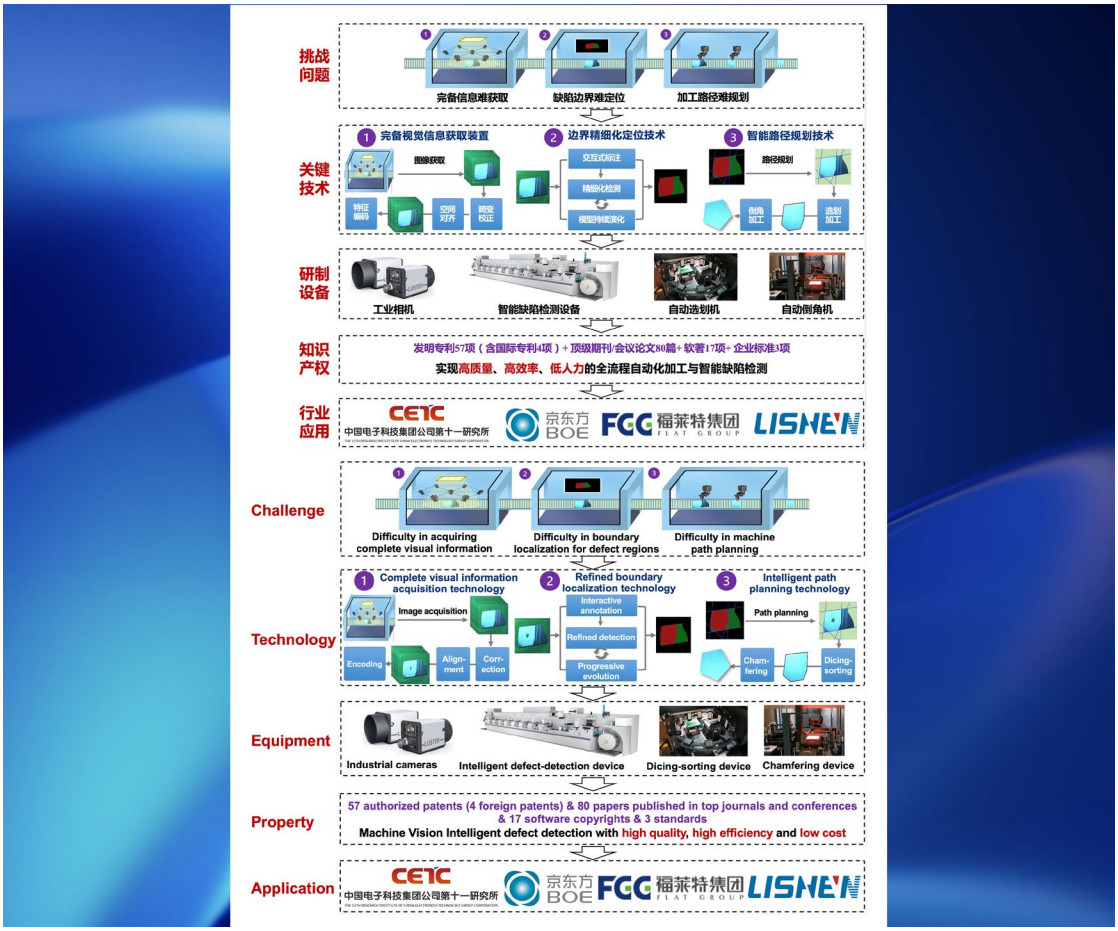
Beyond its core technical breakthroughs and large-scale deployment, Velldepth has established a relatively complete support system for evaluation, validation, and technology transfer. The project has developed a multi-layered assessment framework covering model capability, scenario effectiveness, and business performance, forming a closed-loop evaluation mechanism across content safety, cybersecurity, and business risk control. Among them, CS-Eval has become a representative benchmark reference in the field of security foundation models. The project has produced more than 40 high-level international papers and over 10 patents, with publications at CVPR, ACL, ICML, AAAI, EMNLP, IEEE S&P, and ICSE, and has supported industry-academia collaboration with multiple universities. Yufeng xGuard, derived from Yuvion, has become a representative AI safety guardrail model. These achievements further strengthen the project's academic influence, peer recognition, and industrial demonstrative value, providing strong support for continuous iteration, third-party evaluation, and broader industry adoption.




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# 机器视觉智能感知关键技术及应用

## Key Technologies and Applications of Machine Vision Intelligent Perception




本项目的主要创新技术、研发系统及研制设备图
Our Main Innovative Technologies, Systems and Equipment

北京交通大学
Beijing Jiaotong University

太原科技大学
Taiyuan University of Science and Technology

中国电子科技集团公司第二研究所
The 2nd Research Institute of China Electronics Technology Group Corporation

凌云光技术股份有限公司
LUSTER LightTech Co., Ltd.

CETC 中国电子科技集团公司第二研究所

LUSTER 凌云光

## 引言

针对机器视觉智能存在的挑战问题，本项目提出了完备视觉信息获取技术、边界精细化定位技术和智能路径规划技术，研制了半导体自动选划机、倒角机等智能加工设备和智能缺陷检测设备，经济效益和社会效益显著。

## Introduction

To address the challenges existing in machine-vision-based intelligent perception, this project proposes complete visual information acquisition technology, refined boundary localization technology and intelligent path planning technology. Intelligent processing equipment including automatic semiconductor dicing-sorting machines and chamfering machines, as well as intelligent defect-inspection equipment, have been developed, achieving remarkable economic and social benefits.

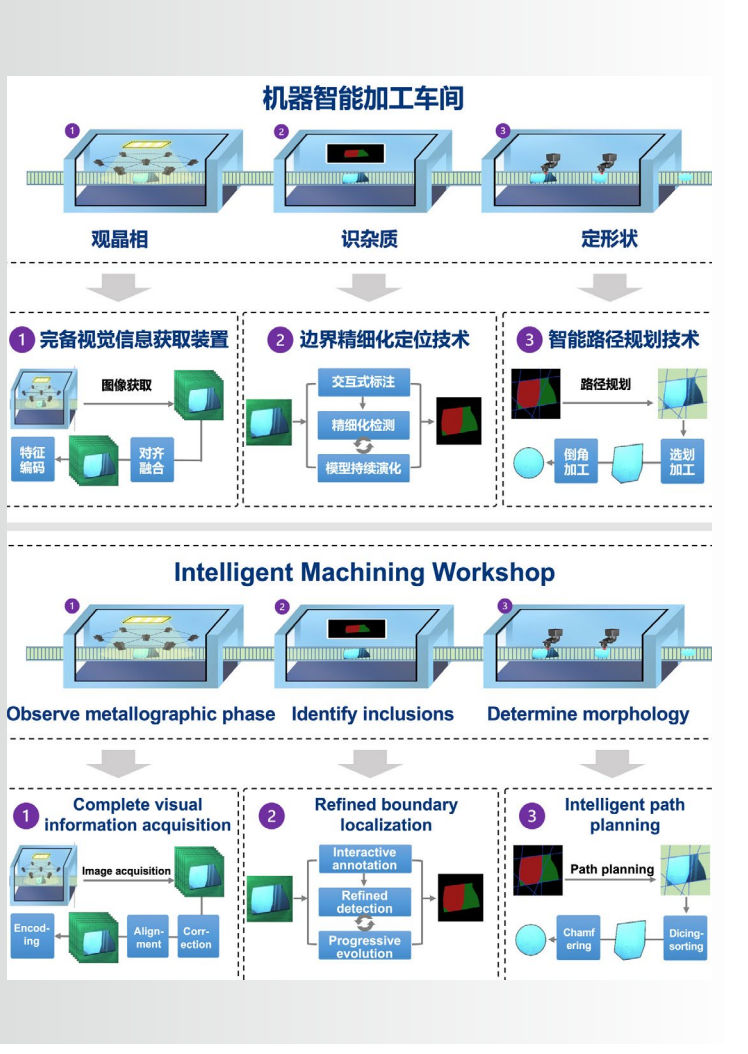
## 自主工业相机、漏检率低于 2‰的缺陷检测与微米级异形晶片选划倒角技术取得国际领先突破

## Internationally Leading Breakthroughs in Self-Developed Industrial Cameras, Defect Inspection with a Miss Rate Below 2‰, and Micrometer-Scale Dicing-Sorting/Chamfering for Special-Shaped Wafers

1. 针对完备视觉信息难获取的挑战，提出显式次序畸变表征的图像畸变精准校正方法，构建同参异质变换的多相机鲁棒对齐模型，研制高分辨低噪声高帧率工业相机，研发全景式视觉信息获取装置。

2. 针对缺陷区域边界难定位的挑战，创建人机协同的高效像素级标注架构，提出多尺度特征聚合的复杂边界定位方法，构建多源预训练集成学习的智能缺陷检测系统，发明历史表征约束的持续演化分割技术，漏检率低于 2‰，优于同期 1 个数量级。

3. 针对加工路径难规划的挑战，提出语义图引导的选划路径优化方法，发明自适应修磨倒角路径规划技术，实现了异形半导体晶片选划倒角加工工艺，选划倒角精度从毫米级跨越到微米级。




本项目的主要创新技术图
Diagram of Major Innovative Technologies

1.To tackle the challenge of difficulties in acquiring complete visual information, it propose an accurate image distortion correction method with explicit sequential distortion characterization, and establish a robust multi-camera alignment model based on isomorphic-parameter heterogeneous transformation. Independently controllable industrial cameras with high resolution, low noise and high frame rate are developed, and a panoramic visual-information acquisition device is realized.
2.To address the challenge of difficult boundary localization for defect regions, an efficient human-machine collaborative pixel-level annotation architecture is proposed. A complex-boundary localization method via multi-scale feature aggregation is put forward, and an intelligent defect-detection system integrating multi-source pre-trained learning is constructed. A continuously-evolving segmentation technique constrained by historical representations is invented. The missing-detection rate is lower than 2‰, outperforming contemporary counterparts by one order of magnitude.
3.To cope with the challenge of difficult processing-path planning, a semantic-map-guided optimization method for dicing-sorting paths is proposed, and an adaptive-grinding chamfering path-planning technology is invented. The dicing-sorting and chamfering process for special-shaped semiconductor wafers is achieved. The dicing-sorting and chamfering accuracy is improved from the millimeter level to the micrometer level.

## 服务千余家企业、全国市场占有率第一、三年效益55.91亿元

## Serving Over 1,000 Enterprises, Ranking No.1 in National Market Share, and Generating RMB 5.591 Billion in Three Years

本项目从研发图像获取器件(高分辨低噪声高帧率工业相机)，到研发视觉系统(视觉智能缺陷检测系统、异形半导体晶片选划倒角视觉智能系统)，再到研制设备(智能缺陷检测装置、异形半导体晶片选划机和倒角机)，形成机器视觉智能系列产品，应用于半导体加工、缺陷检测和工业相机等行业。成功研发中国微米级自动选划机和倒角机。研发智能缺陷检测设备落地京东方、夏普、福莱特等头部企业及千余家印刷企业，全国市场占有率第一。近三年创造经济效益55.91亿元。相关成果获中国电子学会科技进步一等奖等。培养国家高层次人才3人、IEEE Fellow 1人、《麻省理工科技评论》中国区“35岁以下科技创新35人”入选者1人等。

This project develops the image-acquisition devices (industrial cameras with high resolution, low noise and high frame rate), vision systems (intelligent vision-based de-




本项目成果的应用及推广情况
Application of the achievements

fect-detection system, and intelligent vision system for dicing-sorting and chamfering of special-shaped semiconductor wafers), fabricate equipment (intelligent defect-detection device, special-shaped semiconductor wafer dicing-sorting machine and chamfering machine). A series of intelligent machine-vision products have been formed and applied to industries including semiconductor processing, defect inspection, and industrial camera manufacturing. This project has successfully developed China's micron-level automatic dicing-sorting machine and chamfering machine. The self-developed intelligent defect-inspection equipment has been deployed at leading enterprises such as BOE, Sharp and Flat Group, as well as more than one thousand printing enterprises, achieving the No. 1 market share nationwide. This project has generated economic benefits of 5.591 billion RMB in the past three years. Relevant achievements have won honors including the First Prize for Science and Technology Progress of the Chinese Institute of Electronics. The project has fostered 3 national high-level talents, 1 IEEE Fellow, and 1 recipient of MIT Technology Review Innovators Under 35 (China Region).

## 国际领先鉴定背书，机器视觉装备替代进口并实现规模化应用

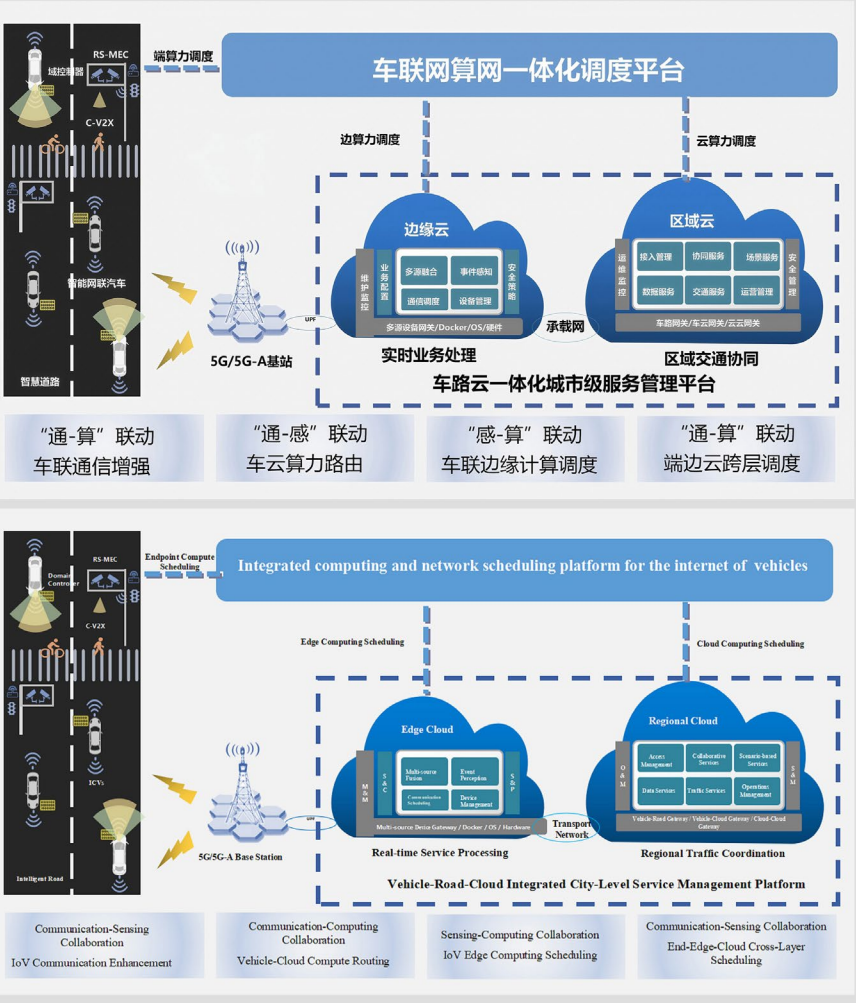
## Internationally Leading Appraisal Backing: Machine-Vision Equipment Replaces Imports and Achieves Large-Scale Application

本项目授权专利 57 项，登记软著 17 项，制定标准 3 项。发表 IEEE TPAMI 9 篇，他引逾 1.6 万次 ( 单篇最高引用 3576 次 )。获诺奖、图灵奖得主及 142 位 IEEE Fellow 的肯定。经戴琼海院士领衔的专家组鉴定：整体达到国际先进水平，其中半导体晶相边界定位技术、晶片选划及倒角技术达到国际领先水平。研发了中国微米级自动选划机和倒角机，替代了进口设备，异形半导体晶片多形状加工路径自动规划技术超越进口设备。研发了智能缺陷检测装置、智能缺陷检测设备，市场占有率居中国第一。自动选划机和倒角机已批量应用于中电科 11 所等大型半导体生产企业。智能缺陷检测设备应用于京东方、夏普等显示屏企业，福莱特、通威太阳能等太阳能企业，及印钞造币总公司、恩捷等千余家印刷企业。

We have obtained 57 authorized patents and 17 registered software copyrights, and formulated 3 standards. Nine papers have been published in IEEE TPAMI, with over 16 000 non-self citations (the highest single-paper citation reaches 3 576). Our work has been recognized by Nobel laureates, Turing Award winners, and 142 IEEE Fellows. Appraised by an expert group led by Academician Dai Qionghai, the overall technology has reached the international advanced level; in particular, the semiconductor crystal-phase boundary positioning technology, as well as wafer dicing and chamfering technologies, have achieved the internationally leading level. We have developed China's micron-level automatic dicing machines and chamfering machines to substitute imported equipment. The automatic-planning technology for multi-shape machining paths of special-shaped semiconductor wafers outperforms that of imported counterparts. Intelligent defect-detection devices and equipment have been developed, ranking first in China in terms of market share. The automatic dicing and chamfering machines have been deployed in mass-production at large-scale semiconductor manufacturers including CETC No.11 Research Institute. The intelligent defect-detection equipment has been adopted by more than one thousand enterprises, covering display manufacturers such as BOE and Sharp, solar-energy enterprises including Flat Glass Group and Tongwei Solar, as well as printing-industry players such as China Banknote Printing and Minting Corporation and Semcorp.

# 基于通感算一体化的智能车联网系统

## Intelligent Internet of Vehicles System Based on Integrated Communication, Sensing, and Computing




基于通感算一体化的车联网技术架构
A Perception-Computing Integrated Architecture for Vehicle Networking

联通智网科技股份有限公司
China Unicom Smart Connection Technology Limited.

中国联合网络通信集团有限公司
China United Network Communications Group Co., Ltd.

联通数字科技有限公司
China Unicom Digital Technology Co., Ltd.

## 引言

本项目围绕 5G-A 车联专网、IPv6+ 车云算力路由及端边云协同调度等关键技术开展攻关，最终形成包含 1 个系统架构、1 套系统平台、2 套调度引擎、3 类智能终端设备和 5 套技术方案在内的完整成果体系。

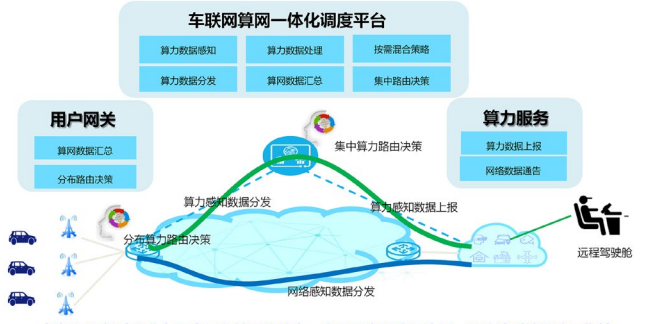
## Introduction

This project focuses on tackling key technologies such as 5G-Advanced dedicated networks for connected vehicles, IPv6+ based vehicle-cloud compute routing, and end-edge-cloud collaborative scheduling. The ultimate deliverables form a comprehensive outcome system comprising one system architecture, one system platform, two scheduling engines, three categories of intelligent terminal devices, and five technical solution packages.

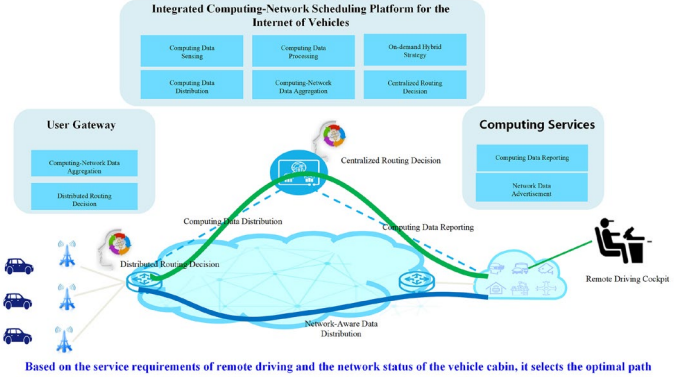
## 构建端边云协同算网，突破 5G-A/IPv6+ 调度技术并完成多地验证

## Building an End-Edge-Cloud Collaborative Computing Network with Breakthroughs in 5G-A/IPv6+ Scheduling and Multi-Site Verification

本成果构建了完整的“端 - 边 - 云”协同算力网络服务体系，有效解决了车联网场景下算力分散、时延敏感与业务动态多变等挑战。在架构层面，提出基于运营商网络的车联网算力网络架构，形成面向全球运营的算网服务能力。网络技术上，建成端到端 5G-A 车联专属网络，构建双“20”网络技术体系，实现广域稳定低时延。路由方面，提出混合式车云算力路由方案，融合集中式与分布式调度，支撑灵活差异化的算网一体服务。基于 IPv6+ 打造车联网端到端方案，实现网络智能感知和多域故障定界。研发一体化调度平台，突破端侧轻量化和车路云调度技术。此外，建设京津冀城市群 MEC 与 C-V2X 融合测试床，发布远程驾驶 2.0 产品及协同自主泊车方案，并分别在天津、苏州等地完成验证。




根据远程驾驶的业务需求及车舱网络状态，实现最优的路径选择，保障端到端链路可靠性




Based on the service requirements of remote driving and the network status of the vehicle cabin, it selects the optimal path to ensure end-to-end link reliability.

This work has established a comprehensive end-edge-cloud collaborative computing-network service system, effectively tackling the challenges of fragmented computing resources, stringent latency demands, and highly dynamic service variations in IoV scenarios. Architecturally, this project proposes a carrier-network-based computing network architecture for the Internet of Vehicles, which enables service capabilities geared toward global operations. On the networking front, an end-to-end 5G-Advanced dedicated network for connected vehicles has been deployed, along with a dual-20 network technology framework, ensuring stable low-latency performance over wide areas. For routing, a hybrid vehicle-cloud compute routing scheme is introduced, combining centralized and distributed scheduling to support flexible, differentiated integrated

computing-network services. With IPv6+, this project has built an end-to-end solution for the IoV that delivers intelligent network awareness and multi-domain fault isolation. Additionally, an integrated scheduling platform has been developed, achieving breakthroughs in lightweight end-side processing and vehicle-road-cloud coordination. Furthermore, a testbed integrating MEC and C-V2X has been set up in the Beijing-Tianjin-Hebei urban cluster, and we have released the Remote Driving 2.0 product along with a collaborative autonomous parking solution, with successful verifications carried out in Tianjin, Suzhou, and other cities.

## 落地多场景智慧交通，实现商用推广与生态共建
## Deploying Smart Transportation across Multiple Scenarios, with Commercial Rollout and Ecosystem Collaboration

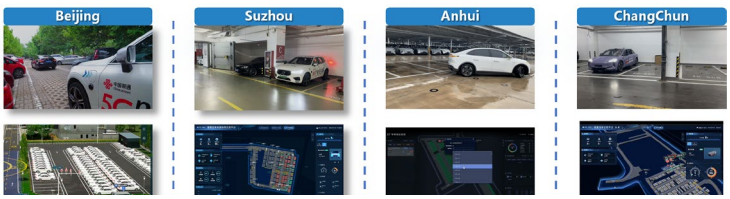
本项目基于“5G+ 算网一体化”与车路协同核心技术，打造了矿山、园区、开放道路、车企运维等多场景的智慧交通应用体系。经济效益方面，2022 年在山西实现全矿无人运输商用落地，人力与运营成本大幅降低，获山西省委、省政府肯定，被列为全省重点推广项目；同年在宜宾建成开放式车路协同示范线，形成可复制的智慧接驳商业模式；2024 年为宝马集成算网监控方案，实现租户分级分权管理，显著提升运维效率。社会效益方面，在博鳌东屿岛 5G 车联网示范区，提供无人出租车、无人公交等 4 类运营服务；在北京亦庄、苏州博览中心落地自主泊车方案，极大改善停车体验。同时牵头成立“IPv6+ 算网车联网联合创新实验室”，推动 OpenV2X 开源社区及桐乡“车路云一体化创新应用基地”建设，构建开放行业生态，引领产业协同发展。

This project leverages two foundational technological pillars-“5G-enabled integrated computing and networking” and vehicle-infrastructure cooperation (VIC)-to develop a scalable, scenario-adaptive intelligent transportation application system. The system has been deployed across diverse operational environments, including open-pit mines, industrial parks, public road networks, and original equipment manufacturer (OEM) operation and maintenance ecosystems. Economically, the project delivered several landmark achievements: In 2022, a province-wide deployment of fully autonomous mining transportation systems was successfully launched in Shanxi Province, resulting in substantial reductions in both labor requirements and operational expenditures. The initiative received high commendation from the Shanxi Provincial Party Committee and Provincial Government and has been officially designated as a provincial key demonstration and promotion project. Concurrently, Yibin established an open-road vehicle-infrastructure cooperative demonstration line, thereby establishing a scalable and replicable smart mobility business model. In 2024, the project delivered a customized computing-and-networking monitoring solution for BMW, introducing a hierarchical, tenant-isolated management architecture that significantly enhanced operational agility and resource efficiency. Socially, the project advanced public-facing intelligent mobility services: In the Boao Dongxiu Island 5G vehicular networking demonstration zone, four categories of autonomous mobility services-including driverless taxis and autonomous shuttle buses-were launched and operated continuously. In Beijing Yizhuang and the Suzhou International Expo Center, AI-powered autonomous parking systems were deployed, markedly improving user convenience, space utilization, and parking throughput. Furthermore, the project spearheaded the establishment of the “IPv6+ Computing-Network-Vehicular Networking Joint Innovation Laboratory”, catalyzed the growth of the OpenV2X open-source community, and supported the development of the Tongxiang “Ve-

中国联通汽车工厂无人驳运系统




China Unicom Unmanned Transport System for Automobile Plants



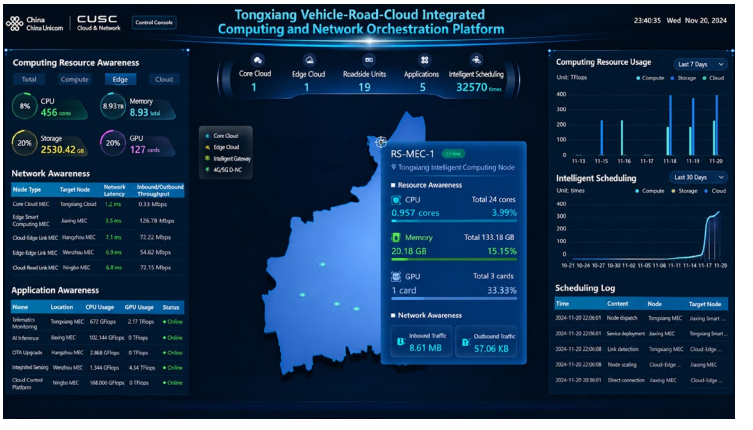
hicle-Road-Cloud Integrated Innovation Application Base", thereby fostering an open, collaborative, and interoperable industry ecosystem that accelerates cross-sectoral coordination and standardization.

## 推动车联网算网融合演进，加速商用与产业协同，驱动数字交通升级

## Advancing IoV Computing-Network Convergence, Accelerating Commercialization and Industrial Synergy, and Driving Digital Transportation Upgrades

该成果围绕车联网低时延、高可靠等需求，提出运营商网络下的分层算力系统架构，将车路云通信时延压至 5ms 以内，较行业水平降低 50% 以上；构建业务需求驱动的感知技术体系，实现算网状态的精细化感知。基于 IPv6+ 与 5G+AI 融合，建成跨域互联示范平台，推出 L4 级自主泊车及 OTA 高效升级方案，提升了边缘计算效率与资源利用率。成果推动车联网从“单一连接”向“算网融合”演进，促进通信、汽车、交通等跨行业标准与生态协同。通过统一纳管算力、标准化接口及多源数据融合，加速路侧基础设施规模化部署，为自动驾驶和智慧交通运营提供可复制实践样本，有力支撑产业从试点走向商用，显著提升产业链协同效率，对数字交通基础设施升级和新兴产业生态构建具有重要驱动作用。




This achievement addresses the low-latency and high-reliability requirements of the Internet of Vehicles by proposing a hierarchical computing architecture within carrier networks. This architecture reduces vehicle-road-cloud communication latency to within 5 ms, cutting it by over 50% compared to industry benchmarks. It also establishes a service-demand-driven sensing technology framework that enables fine-grained awareness of computing-network status. By integrating IPv6+ with 5G and AI, a cross-domain interconnected demonstration platform has been built, and L4 autonomous parking solutions along with efficient OTA upgrade schemes have been introduced, which significantly improve edge computing efficiency and resource utilization. The achievement drives the evolution of the IoV from “mere connectivity” toward “integrated computing and networking”, fostering cross-industry coordination of standards and ecosystems among telecommunications, automotive, and transportation sectors. Through centralized management of computational resources, standardized interface design, and seamless integration of heterogeneous multi-source data, large-scale deployment of roadside infrastructure can be significantly accelerated. This approach yields scalable, replicable implementation models for autonomous driving and intelligent transportation systems—thereby facilitating the industry’s transition from pilot validation to commercial deployment. Moreover, it enhances cross-sectoral coordination efficiency across the value chain and serves as a strategic enabler for upgrading digital transportation infrastructure and cultivating an emerging intelligent mobility ecosystem.

# 基于微时空辐照度预测与智能运维的光伏高效跟踪系统

## High-Efficiency Photovoltaic Tracking System Based on Micro-Spatiotemporal Irradiance Forecasting and Intelligent Operation




基于地基云图的微时空辐照预测与智能跟踪系统技术架构图

Technical architecture diagram of micro-spatiotemporal irradiance forecasting and intelligent tracking system based on ground-based cloud images

恩克拉维再生能源有限责任公司
NCLAVE RENEWABLE SOCIEDAD DE RESPONSABILIDAD LIMITADA

上海交通大学
Shanghai Jiao Tong University

天合光能股份有限公司
Trina Solar Co., Ltd.

## 引言

本成果为软硬件一体化智能光伏跟踪系统，构建“感知 - 预测 - 跟踪 - 运维”全链路数智化管控体系，实现电站全生命周期智能管理。成果在全球 60+ 国家、700+ 项目中得到应用，有效提升电站发电量，推动行业向智能化方向发展。

## Introduction

This achievement is an integrated software-hardware intelligent PV tracking system that builds a full-link digital-intelligent management system covering sensing, forecasting, tracking and O&M, enabling intelligent management throughout the entire lifecycle of PV power plants. Deployed in over 700 plants across more than 60 countries worldwide, it effectively improves power generation efficiency and drives the intelligent upgrading of the PV tracking industry.

## 突破高精度辐照预测与智能逆跟踪关键技术，创新免维护球形轴承设计，实现最高 3.24% 发电增益

## Overcome Micro-Spatiotemporal Irradiance Forecasting and Micro-Shading Reverse-Tracking Challenges, Invent Maintenance-Free 3D Spherical Bearings, and Achieve an Internationally Leading 3.24% Power Generation Gain

本项目开发了多视角地基云图微时空辐照预测技术及多视角云图采集系统，实现平方米级辐照分布预测与 30 分钟超短期辐照预测，预测误差降低 14%。

项目发明了双辐照计直射辐照比例推测方法，构建晴天指数推演模型，可实现秒级百分等级天气识别，有效规避伪阴天误判，该方法获第二十五届中国专利银奖。同时，开发微遮挡智能逆跟踪技术，综合输出全局性能最优角度群组，有效提升系统发电量。

项目研发了光伏跟踪支架三维球形轴承技术，授权 7 项全球专利；模块化分体结构将零件减至 3 种；PA66+GM30 壳体搭配 POM 球体复合材质，实现全生命周期自润滑、零维护。

结合故障诊断算法及 Trina SmartCloud 云平台的研究应用，本项目成果较常规跟踪算法最高可实现 3.24% 光伏电站发电增益。

This project has developed a multi-view ground-based cloud image micro-spatio-temporal irradiance forecasting technology and a multi-view cloud image acquisition system, achieving square-meter-level irradiance distribution forecasting and 30-minute ultra-short-term irradiance forecasting, with a prediction error reduction of 14%.

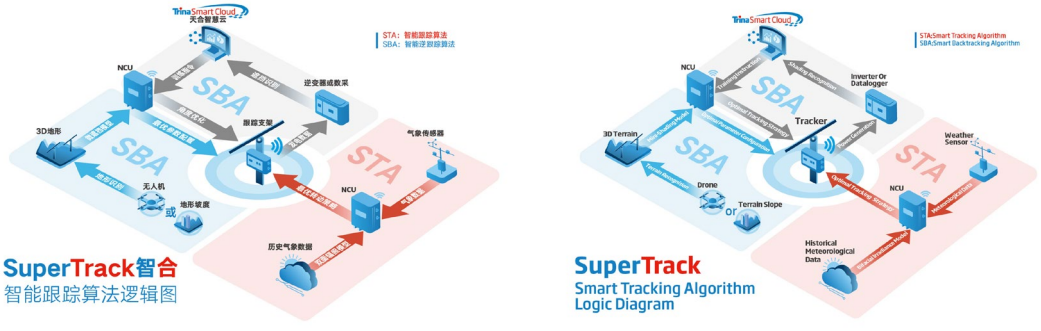
The project has invented a method for estimating the direct irradiance ratio using dual pyranometers, and established a clearness index derivation model that enables second-level percentile weather recognition, effectively avoiding misjudgment of false cloudy conditions. This method was awarded the Silver Award of the 25th China Patent Award.Meanwhile, it has developed a micro-shading intelligent reverse-tracking technology that comprehensively outputs the optimal angle group for global performance, effectively increasing the system's power generation.

The project has developed a three-dimensional spherical bearing technology for photovoltaic tracking brackets, with 7 global patents granted; the modular split structure reduces part types to 3; the PA66+GM30 shell combined with a POM spherical composite material enables self-lubrication and zero maintenance throughout the entire lifecycle.

Combined with fault diagnosis algorithms and the research application of the Trina SmartCloud platform, the achievement of this project can achieve up to 3.24% power generation gain for PV plants compared with conventional tracking algorithms.




项目发明的“一种双辐照计推测直射辐照比例的方法”获第二十五届中国专利银奖
The project invention, titled “Method for Estimating Direct Irradiance Fraction Using Dual Pyranometers,” won the Silver Award of the 25th China Patent Award




智能跟踪算法逻辑图
Smart Tracking Algorithm Logic Diagram

## 形成高效高可靠智能光伏跟踪组件与系统成套技术，实现 GW 级规模化应用，出货量全球前六

## GW-Scale Deployment and Top-Six Global Shipments of High-Efficiency High-Reliability Intelligent PV Tracking Systems

本成果已形成高效高可靠智能光伏跟踪组件与系统成套技术，可应用于沙漠、平原、丘陵、高海拔、低温、高腐蚀、超高温和复杂地形等多种场景。本成果已获得国外多家产品认证、市场准入资格，现已广泛应用于全球多个大型光伏示范电站项目中：如全球第一条专供清洁能源输送的特高压通道——青海 - 河南 ±800 千伏特高压直流工程、国家能源局 250MW 光伏技术“领跑者”铜川项目、875MW 卡塔尔工业城电站等全球 60 余个国家、700 多个光伏电站项目，极大提高了光伏电站整体发电量。

截至 2025 年，本项目成果全球累计出货量超 35GW，其中近 3 年全球出货量约 23.55GW, 实现销售收入约 74.52 亿元。2025 年度，在 S&P Global Energy 发布《Solar Tracker Market Report》报告中，TrinaTracker 智能跟踪支架全球出货量约 6.7GW，排名前六。

The achievement has developed a complete set of technologies for high-efficiency, highly reliable intelligent photovoltaic tracking modules and systems, which are applicable to a wide range of scenarios including deserts, plains, hills, high-altitude areas, low-temperature environments, highly corrosive environments, ultra-high-temperature regions, and complex terrains. The achievement of this project has obtained product certifications and market access qualifications from multiple overseas countries, and has now been widely applied in numerous large-scale PV demonstration power plant projects around the globe. These include the Qinghai–Henan ±800 kV UHV DC transmission project – the world's first ultra-high-voltage direct-current channel dedicated to clean energy transmission; the 250MW PV Technology “Top Runner” Project in Tongchuan, sponsored by the National Energy Administration; and the 875MW Qatar Industrial City PV plant, among others. In total, the achievement has been deployed in more than 60 countries and over 700 PV power plant projects worldwide, significantly improving the overall power generation of these PV plants.

As of 2025, the cumulative global shipment volume of this achievement has exceeded 35 GW. Among them, the global shipment volume in the past three years reached approximately 23.55GW, generating sales revenue of about RMB 7.452 billion. In 2025, according to the Solar Tracker Market Report released by S&P Global Energy, TrinaTracker's intelligent tracking system achieved a global shipment volume of approximately 6.7GW, ranking among the top six worldwide.



成果应用于 250 MW 铜川光伏技术“领跑者”项目
The achievement has been implemented in the 250 MW Tongchuan PV Technology “Top Runner” project

## 制定团体标准，规范化跟踪性能测试，推动行业向智能化方向发展

## Establish Group Standards, Standardize Tracking Performance Testing, and Drive the Industry Toward Intelligent Development

2024 年 8 月，标准《光伏跟踪支架智能跟踪性能测试方法》正式发布，该标准由成果联合申报机构天合光能主导、以本成果为核心基础，规定了光伏跟踪支架智能跟踪性能的测试方法，为光伏行业智能跟踪技术的规范化发展奠定了重要基础。

本成果将支架结构、智能控制器、通信控制器、云图采集装置、数据处理平台、设备监控平台和运维装备协同集成，形成兼具感知、预测、控制、保护和运维能力的智能光伏跟踪系统，带动物联网、大数据、人工智能与新能源产业深度融合。智能跟踪电控系统、极端天气保护策略、差分 OTA 固件升级、远程调试等功能的开发应用，提高了产品的智能化、可靠性和现场部署效率，使光伏跟踪产品的价值由单一硬件制造延伸至算法、数据、控制和运维服务。


ICS 27.160
CCS F12

团　体　标　准

T/CPIA 0082—2024

光伏跟踪支架智能跟踪性能测试方法

Test method for smart tracking performance of solar tracker

CPIA
中国光伏行业协会

2024－08－30 发布　　2024－09－15 实施

中国光伏行业协会　发布

成果参与单位天合光能主导编制并发布团体标准《光伏跟踪支架智能跟踪性能测试方法》
Trina Solar Co., Ltd., as a participating entity in the achievement, led the formulation and publication of the group standard “Test method for smart tracking performance of solar tracker”

In August 2024, the standard Test Method for Smart Tracking Performance 0f Solar Tracker was officially released. Led by Trina Solar – one of the co-applicant organizations of this project – and based on the achievement of this project as its core foundation, the standard specifies the test methods for intelligent tracking performance of PV tracking brackets, thereby laying an important foundation for the standardized development of intelligent tracking technology in the PV industry.

The achievement of this project synergistically integrates bracket structures, intelligent controllers, communication controllers, cloud-image acquisition devices, data processing platforms, equipment monitoring platforms, and operation and maintenance (O&M) equipment, forming an intelligent PV tracking system that combines capabilities of perception, prediction, control, protection, and O&M. This drives the deep integration of the Internet of Things (IoT), big data, and artificial intelligence with the new energy industry. The development and application of features such as intelligent tracking electronic control systems, extreme weather protection strategies, differential over-the-air (OTA) firmware upgrades, and remote debugging have enhanced the intelligence, reliability, and on-site deployment efficiency of the products, extending the value of PV tracking products from pure hardware manufacturing to encompass algorithms, data, control, and O&M services.

# 量子 + 能源电力：构建新型电力系统量子测量体系

## Quantum + Energy and Power: Building a Quantum Measurement Framework for New Power Systems




电力量子测量及量值传递溯源体系示意图

Schematic of quantum measurement and measurement traceability in power systems

葡萄牙能源研究中心
Centro de Investigação em Energia REN – State Grid, S.A. (R&D Nester)

中国电力科学研究院有限公司
China Electric Power Research Institute Co., Ltd.

华中科技大学
Huazhong University of Science and Technology

中国科学技术大学
University of Science and Technology of China

## 引言

葡萄牙能源研究中心（R&D Nester）联合中方研究院、高校，面向电力系统可信量测，融合约瑟夫森量子电压标准与金刚石 NV 色心传感，研制数字化量子溯源装置和量子电流互感器，探索精密计量向电力现场延伸的技术路径。

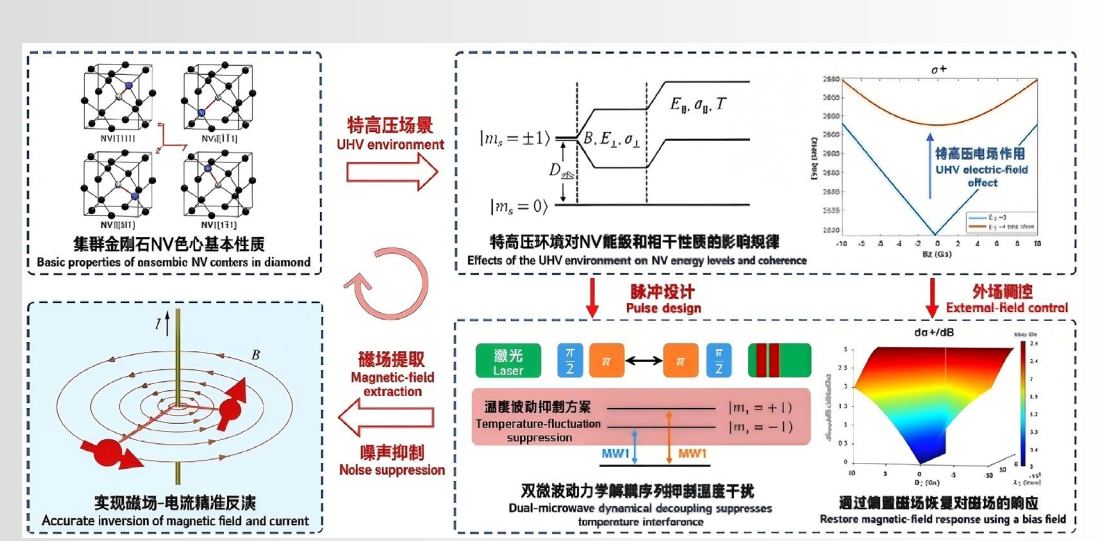
## Introduction

R&D Nester in Portugal collaborates with Chinese research institutes and universities on trustworthy power system measurements. Integrating Josephson quantum voltage standards with diamond nitrogen-vacancy (NV) sensing, the partners develop digital quantum traceability devices and quantum current transformers, exploring how to extend precision metrology to power system field applications.

## 量子赋能可信测量，衔接基准与现场
## Quantum-Enabled Trustworthy Measurement Connecting Standards with Field Applications

团队关联约瑟夫森量子电压标准与固态自旋共振频率，建立“自然常数—频率基准—数字量测”机制。前者以幅相同步、差分采样传递量值；NV 色心以光探测磁共振读取频率，由磁场分布及探头几何反演电流，光纤提供电气隔离。溯源不确定度优于 $1\times10^{-5}$；互感器准确度 0.2%、采样率 20 kHz，关键模块小于 5 cm×5 cm×5 cm。聚焦封装加工、光路共模降噪、微波调制解调、远端模块优化，结合温度补偿、频率跟踪、位置误差控制，探索远程校准与溯源网络。

The team links Josephson quantum voltage standards with solid-state spin resonance frequencies to connect fundamental constants, frequency references and digital measurements. A programmable Josephson quantum voltage standard transfers reference values through amplitude and phase synchronization and differential sampling. NV centres measure spin resonance frequencies through optically detected magnetic resonance; magnetic field distributions and probe geometry enable current reconstruction, while fibre links provide electrical isolation. Quantum traceability uncertainty is below $1 \times 10^{-5}$. The transformer achieves 0.2% accuracy and 20 kHz sampling, with a key module smaller than 5 cm × 5 cm × 5 cm. Engineering research covers packaging and fabrication, optical common-mode noise suppression, microwave modulation and demodulation, and remote module optimization. Temperature compensation, frequency tracking and position error control support research on remote parameter calibration and traceability networks.



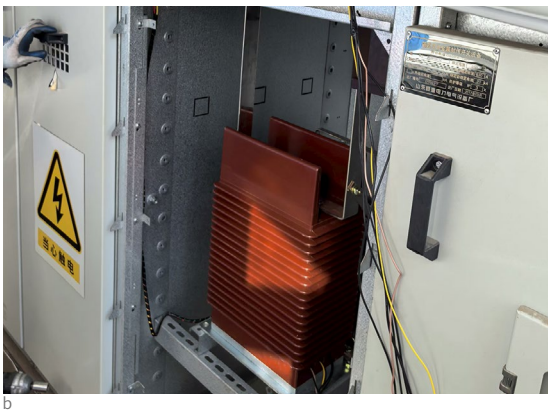

特高压环境下 NV 色心磁场精准反演流程图
Workflow for accurate magnetic field reconstruction using NV centres in an ultra-high-voltage environment

## 从实验平台走向电力现场
## From Laboratory Platforms to Power System Field Applications

葡方研制可编程约瑟夫森量子电压标准及数字化溯源装置，中方支撑工程化与现场验证。量子电流互感器样机已在合肥 110 kV 潜水变电站及 10 kV 专变用户挂网测试，面向智能变电站原位溯源。长期稳定性、准确度测试与场景比对将支撑样机迭代、设备监测、故障预警和智能运维。按潜在效益测算，单站 10 万 –30 万美元替代部分高端测量设备，对应约 7 亿 –20 亿美元；免校准每年可节省全球超 2 亿美元现场校准支出。智能电网改造及超 2000 万台充电设施升级可形成十亿美元级增量空间。若新能源利用率提高 1%–2%，年增清洁电量约 100 亿 –200 亿千瓦时、减排二氧化碳约 584 万 –1168 万吨。

Digital quantum traceability devices and passive quantum current transformer prototypes target in situ traceability at smart substations. The Portuguese team develops programmable Josephson quantum voltage standards and traceability devices; Chinese partners support engineering and field validation. Prototypes have undergone grid-connected testing at Hefei's 110 kV Qianshui Substation and a dedicated 10 kV customer installation. Long-term stability and accuracy tests and site comparisons will guide refinement, supporting equipment monitoring, early fault warning and intelligent operation and maintenance. Potential benefit estimates suggest that replacing some high-end measurement equipment, at USD 100,000–300,000 per substation, could represent USD 0.7–2 billion; calibration-free operation could save over USD 200 million annually in field calibration worldwide. Smart grid retrofits and upgrades to over 20 million charging facilities could create a billion-dollar opportunity. Assuming a 1%–2% increase in renewable energy utilization, annual gains could include 10–20 billion kWh of additional clean electricity and 5.84–11.68 million tonnes of avoided $CO_2$ emissions.


a


b


c


d

中方现场验证场景与实验室样机：
（a）合肥 110 kV 潜水变电站（b）10 kV 专变用户（c）实验室 500 kV 样机（d）实验室 110 kV 样机

Chinese field validation sites and laboratory prototypes:
(a) the 110 kV Qianshui Substation in Hefei (b) a dedicated 10 kV customer installation (c) a 500 kV laboratory prototype (d) a 110 kV laboratory prototype




葡中联合获奖证书及研究成果
Joint Portuguese–Chinese award certificate and related research outputs

## 以标准化连接研发与工程应用
## Connecting Research and Engineering Applications Through Standardization

成果贯通量子标准与现场测量，推动模拟逐级传递转向数字直接溯源，推动装备小型化、数字化，带动量子材料、光电器件、微波调控、超导器件及电力仪表研发。团队获授权专利 11 项（含日本专利 1 项）、论文 25 篇、论著 2 部；葡中量子电流互感器获 2026 年第 51 届日内瓦国际发明展银奖。中方牵头立项 GB/Z《基于固态自旋体系的电流量子测量方法指南》，以装置比对、可靠性试验、不确定度评估完善规范，联动研发、集成与校准。2030 年全球量子精密测量市场预计约 25 亿美元，电力量子测量市场有望约 10 亿美元。

The achievement bridges quantum standards with field measurements, driving a shift from staged analogue transfer to direct digital traceability, promoting equipment miniaturization and digitalization, and spurring the R&D of quantum materials, optoelectronic devices, microwave control, superconducting devices, and electrical instrumentation. Related research has yielded 11 granted patents, including one in Japan, 25 papers and two monographs. The jointly developed quantum current transformer won a silver medal at the 51st International Exhibition of Inventions Geneva in 2026. The Chinese-led GB/Z project, Guide to Quantum Current Measurement Methods Based on Solid-State Spin Systems, is approved for development. Device comparisons, reliability tests and uncertainty evaluation will refine testing specifications and support coordination across component development, system integration and calibration services. Connecting quantum standards with field measurements shifts metrology from staged analogue value transfer towards direct digital traceability, supporting quantum materials, optoelectronics, superconducting devices and high-end instrumentation. By 2030, the global quantum precision measurement market could reach about USD 2.5 billion, with quantum measurement for power systems potentially forming a USD 1 billion segment.

## 葡中协作推动量子计量应用
## Portuguese–Chinese Collaboration Advances Quantum Metrology Applications

R&D Nester 牵头申报，依托葡萄牙量子电压与数字化计量平台开展合作。中国电科院配合工程化与应用验证，华中科技大学支撑量子材料制备，中国科学技术大学支撑固态量子相干调控。围绕 2024—2026 年量子计量合作项目，双方研究量子电压芯片计量特性及溯源应用，开展联合实验、设备调试和技术交流，促进研究方法与工程经验互通，推动量子计量技术成果共享与工程应用，为共建“一带一路”和深化中葡政府间科技合作提供务实支撑。

R&D Nester leads the application, drawing on Portugal's quantum voltage and digital metrology platforms. China Electric Power Research Institute supports engineering and application validation; Huazhong University of Science and Technology supports quantum material preparation; the University of Science and Technology of China supports coherent control of solid-state quantum systems. Through the 2024–2026 quantum metrology cooperation project, the partners investigate the metrological characteristics of quantum voltage chips and their traceability applications. Joint experiments, equipment commissioning and technical exchanges facilitate the sharing of research methods and engineering experience, promoting shared technological outcomes and engineering applications. The collaboration provides practical support for the Belt and Road Initiative and closer China–Portugal intergovernmental cooperation in science and technology.

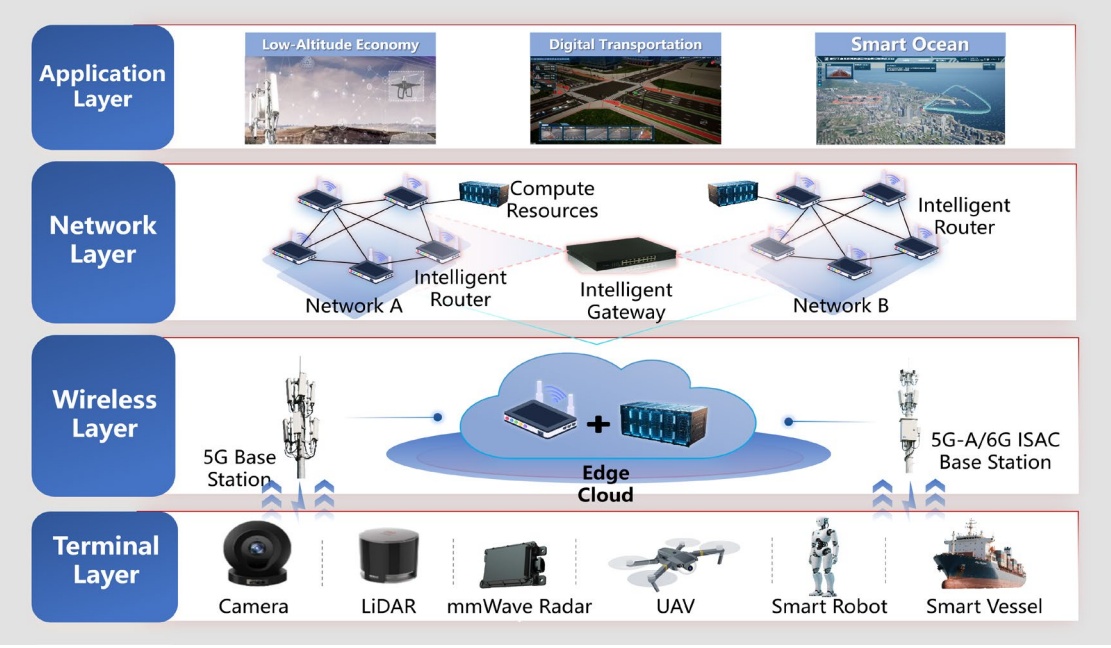


葡中量子平台调试与技术交流
Portuguese–Chinese quantum platform commissioning and technical exchange


2026WORLD
INTERNET
CONFERENCE

# 面向低空经济与立体交通的 5G-A/6G 通感融合网络关键技术及应用

## Key Technologies and Applications of 5G-A/6G ISAC Networks for the Low-Altitude Economy and Three-Dimensional Transportation




面向立体交通的 5G-A/6G 通感融合网络总体架构
Overall Architecture of 5G-A/6G ISAC Networks for the Three-Dimensional Transportation

中国联合网络通信有限公司
China United Network Communications Group Co., Ltd.

北京交通大学
Beijing Jiaotong University

中兴通讯股份有限公司
ZTE Corporation

北京邮电大学
Beijing University of Posts and Telecommunications

## 引言

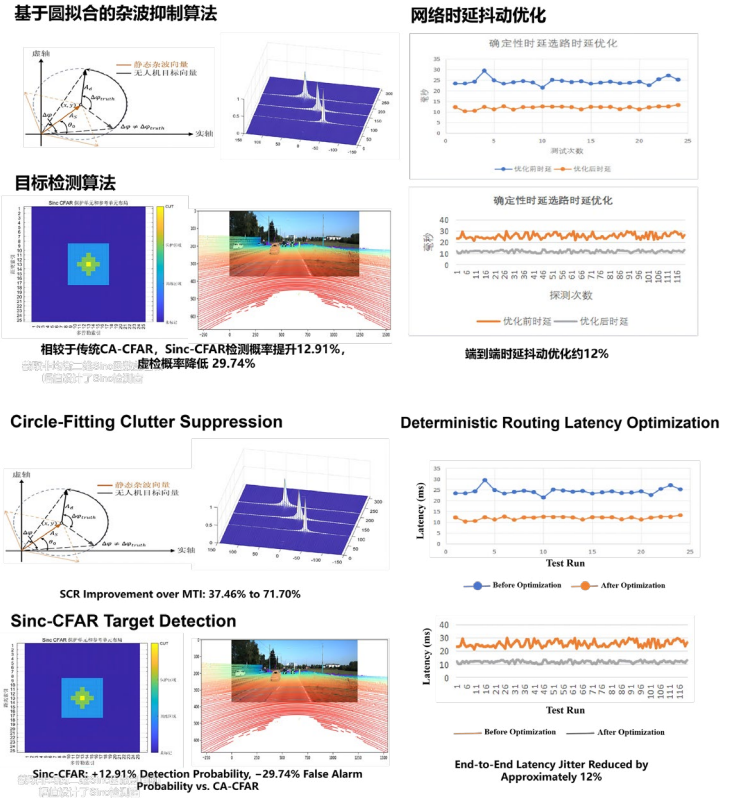
信息领域正从“万物互联”迈向“感知万物”。5G-A/6G 通感融合网络将感知能力融入移动通信体系，打造“一网两用”新型数字基础设施，为低空经济与立体交通提供实时通信、精准感知和智能监管能力。

## Introduction

The ICT landscape is shifting from connecting everything to sensing everything. By embedding sensing capabilities into mobile networks, 5G-A/6G integrated sensing and communication networks are emerging as a new digital infrastructure that delivers both communication and sensing over a single network, enabling real-time communications, high-precision sensing, and intelligent supervision for the low-altitude economy and three-dimensional transportation.

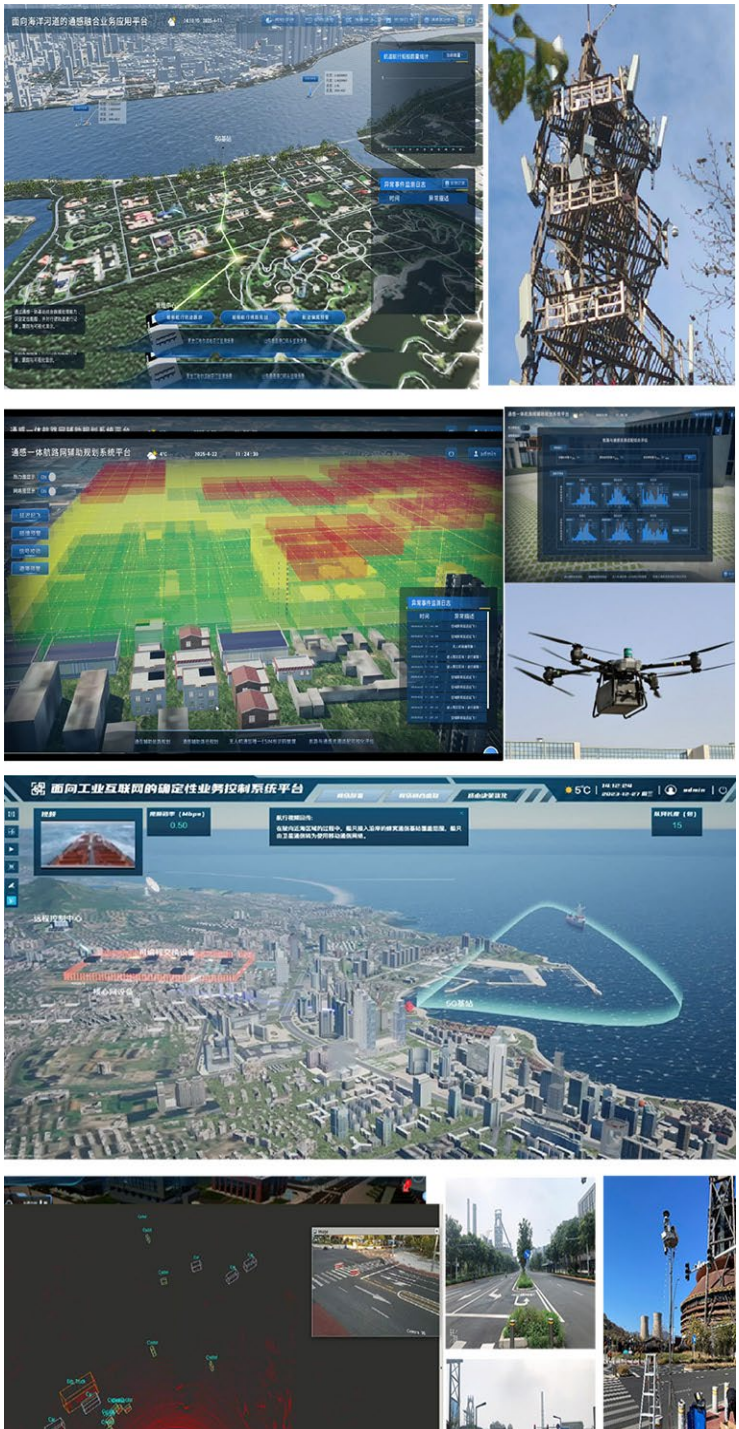
## 精准感知、可靠传输的 5G-A/6G 通感融合网络
## 5G-A/6G ISAC Networks with High-Precision Sensing and Reliable Transmission

面向低空经济与立体交通中“低小慢”目标易受杂波干扰、感知数据跨域传输不稳定及复杂环境时空建模困难等问题，本成果围绕感知、传输与建模开展协同创新。提出多目标均衡感知、圆拟合杂波抑制和 Sinc-CFAR 目标检测方法，并融合通感、视觉与雷达多源信息，实现米级至亚米级感知精度，目标检测成功率超过 95%，支持不少于 256 个目标同步追踪，轨迹识别准确率约 96%；面向动态异构网络环境，构建基于业务特征与网络状态的资源柔性适配及路径优化机制，实现时隙、带宽和链路的按需编排，网络整体端到端时延抖动优化约 12%；进一步形成全域时空数字孪生建模能力。相关关键技术经专家鉴定达到国际先进水平。




多源感知增强与网络时延抖动优化效果
Performance of Multi-Source Sensing Enhancement and Network Latency Jitter Optimization

To address the challenges of clutter interference in detecting low-altitude, slow-speed, and small (LSS) targets, unstable cross-domain transmission of sensing data, and complex spatiotemporal modeling in low-altitude economy and three-dimensional transportation scenarios, this achievement delivers coordinated innovations in sensing, transmission, and modeling. It proposes multi-target balanced sensing, circle-fitting-based clutter suppression, and Sinc-CFAR target detection methods, while ISAC, vision, and radar data for multi-source perception. The system achieves sensing accuracy ranging from meter level to sub-meter level, a target detection success rate above 95%, simultaneous tracking of at least 256 targets, and a trajectory recognition accuracy of approximately 96%. For dynamic heterogeneous network environments, a flexible resource adaptation and path optimization mechanism is developed based on service characteristics and network conditions, enabling on-demand orchestration of time slots, bandwidth, and links, with approximately 12% reduction in overall end-to-end latency jitter. In addition, an all-domain spatiotemporal digital twin modeling capability has been established. The relevant key technologies have been evaluated by experts as reaching an internationally advanced level.




## 多域融合、规模推广的通感融合创新应用

## Innovative Multi-Domain ISAC Applications for Scalable Deployment

依托 5G-A/6G 通感融合关键技术，本成果已形成面向低空、水面、道路等多类场景的应用体系。在哈尔滨亚冬会期间，支撑低空无人机监管、异常事件提醒和水面船舶检测等业务，提升重大活动安全保障能力；在河南安阳低空示范区，开展低空航路规划与避障验证；在青岛完成船舶监管、远程操控及航行视频监测；在北京首钢园等场景开展道路交通主体感知识别、定位与追踪。相关成果已形成可复制、可推广的行业解决方案，累计实现经济效益上千万元，为低空经济、智慧海洋和数字交通等领域提供规模化应用路径。

Building on the key technologies of 5G-A/6G integrated sensing and communication, this achievement has established a portfolio of applications covering diverse scenarios across low-altitude airspace, water surfaces, and road transportation. During the Harbin Asian Winter Games, the system supported low-altitude UAV supervision, abnormal event alerts, and surface vessels detection, enhancing security capabilities for major events. In the Anyang Low-Altitude Demonstration Zone in Henan, it was applied to route planning and obstacle avoidance verification. In Qingdao, it enabled supervision and remote operation of vessel, and navigation video monitoring. At Beijing Shougang Park and other sites, it supported the sensing, recognition, localization, and tracking of road traffic participants. These deployments have led to replicable, industry-ready solutions, generating cumulative economic benefits exceeding RMB 10 million and providing a practical pathway for large-scale adoption in low-altitude economy, smart ocean applications, and digital transportation.

5G-A/6G 通感融合技术在低空经济、智慧海洋与数字交通等场景的应用示范

Demonstration of 5G-A/6G ISAC Applications in Low-Altitude Economy, Smart Ocean and Digital Transportation

## 标准协同、生态共建的通感融合产业实践
## ISAC Industry Development through Standardization and Ecosystem Collaboration

本成果积极参与全球通感融合技术标准与产业生态建设，在 ITU、5GAA、TM Forum、CCSA、IMT-2030（6G）推进组等组织开展标准化工作，承担近 10 项国际标准相关项目，并围绕感知同步、无线感知、协同感知等方向申请国际发明专利 10 余项，覆盖美国、欧洲、日本等主要市场。依托运营商、高校、设备厂商协同创新，形成从前沿技术研究、标准制定、设备研发到网络部署和行业应用的完整创新链条，持续推动通感融合技术由单点验证向规模化应用演进，为 5G-A 向 6G 演进及低空经济、智慧海洋、智能交通等产业升级提供支撑。

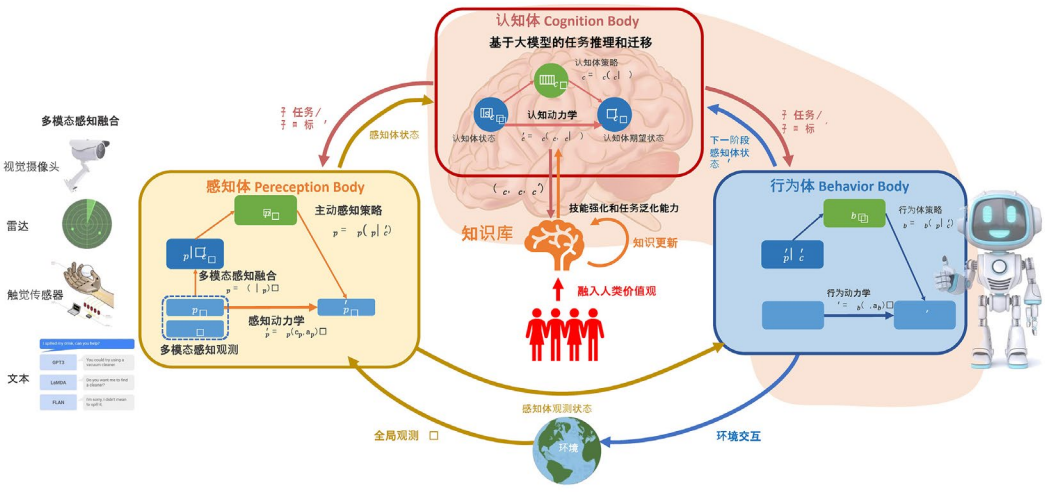
This achievement contributes to global standardization and ecosystem development for integrated sensing and communication. The project team has participated in standardization activities within ITU, 5GAA, TM Forum, CCSA, and the IMT-2030 (6G) Promotion Group, and has undertaken nearly 10 international standardization projects. More than 10 international patent applications have been filed in major markets including the United States, Europe, and Japan. Through collaboration among operators, universities, and equipment vendors, the project has built an innovation chain spanning research, standardization, equipment development, network deployment, and industry applications, supporting scalable ISAC deployment and the evolution from 5G-Advanced (5G-A) to 6G, while supporting industrial upgrading in the low-altitude economy, smart ocean and intelligent transportation sectors.




通感融合领域标准、专利、论文及专著等代表性创新成果
Representative Achievements in ISAC, including Standardization, Patents, Publications, and Monographs

# 面向机器人灵巧操作的融合感知与行为学习

## Integrated Perception and Behavior Learning for Robotic Dexterous Manipulation




“知行体”理论框架
Bcent Theoretical Framework

清华大学
Tsinghua University

## 引言

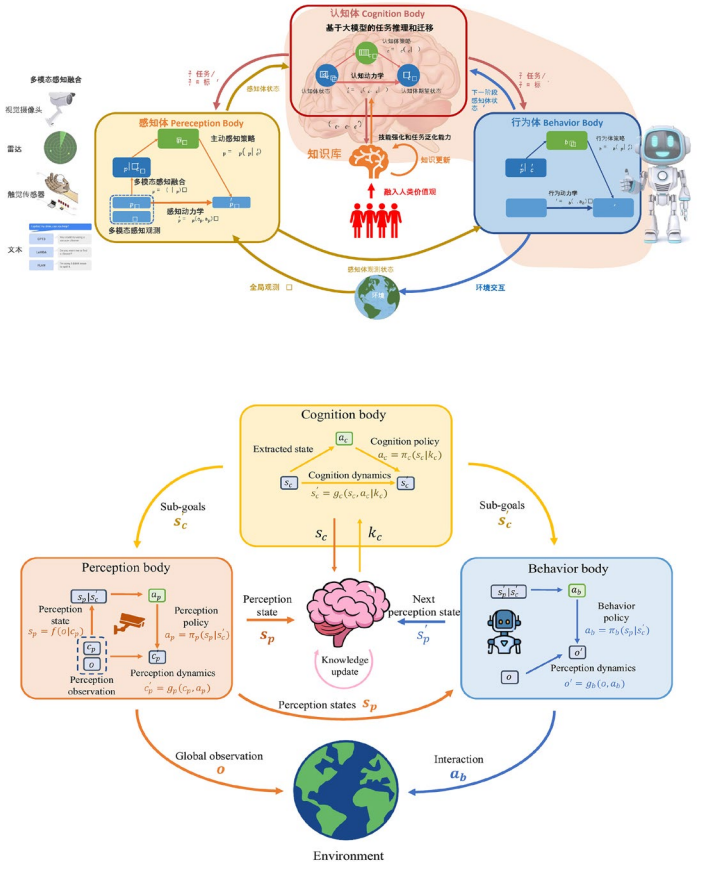
针对机器人灵巧操作中感知被动、知识稀疏、迁移困难等核心瓶颈，提出“知行体 Bcent”一体化具身智能理论框架，融合主动感知、知识驱动学习与行为协同进化，构建物理数字系统驱动的虚实交互技能学习体系，实现跨场景通用操作技能的自主习得与持续进化，并在航天、3C 制造及医疗康复等多领域实现规模化应用验证。

## Introduction

This project proposes the Bcent integrated embodied intelligence framework to address the core bottlenecks of passive perception, sparse knowledge, and transfer difficulties in robotic dexterous manipulation, which unifies active perception, knowledge-driven learning, and morphology-behavior co-evolution, constructs a physical-digital system-driven skill learning system with virtual-real interaction, enables autonomous acquisition and continuous evolution of cross-scenario general manipulation skills, and has been validated in large-scale applications across aerospace, 3C manufacturing, and medical rehabilitation.

## 构建知行一体化理论框架
## Proposing the Integrated Bcent Theoretical Framework

本项目聚焦开放动态环境下机器人灵巧操作难题，攻克了感知—动作割裂、技能泛化不足及虚实迁移不可靠等长期制约具身智能发展的核心瓶颈，通过提出“知行体 Bcent”一体化理论框架，在感知层面揭示多尺度目标高效发现与多模态统一表征机理，发展无锚框检测、超特征融合及视触觉融合方法，实现从被动感知向主动统一感知的跨越，其中 FoveaBox 方法获马尔奖认可并入选 ESI 高被引；在认知层面建立多维多层次技能知识化表达与物理数字系统建模理论，首次推导虚实迁移策略偏差上界，为规模化技能学习提供理论保证，并构建知识驱动的 3C 智能装配系统；在行为层面提出形态—行为协同学习与几何等变强化学习，突破异构机器人策略迁移与自主进化障碍，研制刚柔耦合仿生灵巧手等实体系统，相关成果发表于 TPAMI、Engineering、Nature Machine Intelligence 等顶刊，并受邀在 ICRA 2021 作 Plenary Talk、IROS 2025 作 Keynote；技术已成功应用于空间站在轨维修、手机精密装配及医疗康复等重大场景，实现了机器人从“被动响应”到“自主理解与持续进化”的本质跨越。




“知行体”理论框架
Bcent Theoretical Framework

This project addresses the challenges of robotic dexterous manipulation in open and dynamic environments, overcoming the core bottlenecks that have long constrained embodied intelligence—namely, perception–action decoupling, insufficient skill generalization, and unreliable sim-to-real transfer. By proposing the integrated “Bcent (Body-Knowledge-Action)” theoretical framework, the project achieves the following breakthroughs: At the perception level, it reveals the mechanisms of efficient multi-scale object discovery and unified multi-modal representation, developing anchor-free detection, hyper-feature fusion, and visuo-tactile fusion methods. This enables a transition from passive perception to active unified perception, with the FoveaBox method receiving the Marr Prize recognition and being listed as an ESI Highly Cited Paper. At the cognition level, it establishes a multi-dimensional, multi-level knowledge representation for manipulation skills and a physical-digital system modeling theory, for the first time deriving an upper bound on the sim-to-real transfer policy bias, thereby providing a theoretical guarantee for large-scale skill learning. A knowledge-driven 3C intelligent assembly system has also been constructed. At the behavior level, it proposes morphology-behavior co-learning and geometric equivariant reinforcement learning, overcoming barriers to policy transfer and autonomous evolution across heterogeneous robots. Physical systems such as rigid-flexible coupled bionic dexterous hands have been developed. Related results have been published in top journals including TPAMI, Engineering, and Nature Machine Intelligence, and the work has been invited for a Plenary Talk at ICRA 2021 and a Keynote at IROS 2025. The technologies have been successfully applied to major scenarios including on-orbit satellite maintenance, precision mobile-phone assembly, and medical rehabilitation, achieving a fundamental leap for robots from “passive response” to “autonomous understanding and continuous evolution”.

## 知行体 Bcent 理论框架推动机器人精准操作与多场景应用

## The Bcent Theoretical Framework Advances Precise Robotic Manipulation and Multi-Scenario Applications

知行体 Bcent 理论框架，通过探究机器人在精准操作过程中的智能化感知与行为优化理论方法，构建融合物理特性的虚实交互物理数字系统，实现知识引导下跨场景、多任务通用操作技能的学习与增强。成果应用于手机上下料、前摄、SIM 卡、软排线与同轴缆等装配场景，并在比亚迪试制线开展示范性应用，显著提升装配效率，并获得日内瓦国际发明展金奖。相关技术同步拓展应用于航天在轨卫星检修及仓储精细操作等作业场景，累计产生约 6.6 亿元经济效益。


DIPLÔME

Inventions Geneva

SALON INTERNATIONAL DES INVENTIONS GENÈVE

Après examen, le Jury a décidé

de remettre à: Tsinghua University; Sun Fuchun, Zhou Huaidong, Huang Haiming, Liu Huaping, Fang Bin, Song Yixu

pour l'invention: Transfert Sim2real basé sur la connaissance système d'assemblage intelligent 3C

MÉDAILLE D'OR GOLD MEDAL GOLDMEDAILLE

Genève, le 15 mai 2024

Le Président du Jury: David Tay

Le Président du Salon: Jean-Luc Vincent

日内瓦国际发明展金奖
Geneva International Invention Gold Medal

The Bcent (Embodied Cognition-Action) theoretical framework investigates theoretical methods for intelligent perception and behavior optimization during robotic precise manipulation. It constructs a physical-digital system with virtual-real interaction that incorporates physical characteristics, enabling knowledge-guided learning and enhancement of general manipulation skills across diverse scenarios and tasks. The outcomes have been applied to assembly scenarios including mobile-phone loading/unloading, front cameras, SIM cards, flexible flat cables, and coaxial cables, with pilot demonstrations on BYD's trial production line that have significantly improved assembly efficiency, and the work received a Gold Medal at the International Exhibition of Inventions Geneva. The related technologies have also been extended to on-orbit satellite maintenance and precision warehouse operations, generating cumulative economic benefits of approximately 660 million RMB.

## 项目相关技术已实现多领域规模化应用与认可
## The Project's Technologies Have Achieved Large-Scale Application and Recognition Across Multiple Domains

项目相关技术已实现多领域规模化应用与认可：在消费电子制造领域，核心技术成功应用于小米多品类电子产品的生产制造；通道交换多任务感知技术可在单一检测模型中同时实现缺陷分割、尺寸测量等多类任务，有助于减少产线检测设备数量、降低算力部署成本。在医疗康复领域，基于该技术开发的假肢灵巧手产品，在北京积水潭医院、国家康复中心、南京14所等单位投入使用，显著提升残疾人的生活自理能力，成果获央视专题报道，该产品通过专业检测并获CNAS认证，质量与性能获得权威认可。提出的高分辨率触觉感知方法已拓展应用于布料缺陷检测，显著提升检测准确率，获得国际机器人顶会ICRA2021最佳论文提名；动态空间建模技术可拓展应用于康复机器人的人体动作追踪与运动评估，支撑康复效果的量化分析。

The project's related technologies have achieved large-scale application and recognition across multiple domains: In consumer electronics manufacturing, core technologies have been successfully applied to the production of Xiaomi's diverse electronic products. The channel-switching multi-task perception technology enables simultaneous execution of multiple tasks—such as defect segmentation and dimension measurement—within a single detection model, effectively reducing the number of inspection devices on production lines and lowering computational deployment costs. In medical rehabilitation, a dexterous prosthetic hand developed based on these technologies has been deployed at Beijing Jishuitan Hospital, the National Rehabilitation Center, and the 14th Research Institute of CETC in Nanjing, significantly improving the daily living abilities of individuals with disabilities. The outcomes received special coverage by CCTV, and the prosthetic product has passed professional testing and obtained CNAS certification, affirming its quality and performance. The proposed high-resolution tactile perception method has been extended to fabric defect detection, markedly enhancing detection accuracy and earning a nomination for the Best Paper Award at ICRA 2021. The dynamic spatial modeling technology has also been adapted for human motion tracking and movement assessment in rehabilitation robotics, supporting quantitative analysis of rehabilitation outcomes.




2025 吴文俊人工智能科技贡献奖
2025 Wu Wenjun Artificial Intelligence Science and Technology Awards

# OEX 正交超节点：开放协同构建 TCO 最优 AI 工厂

## OEX SuperPod: Building TCO-Optimal AI Factories with Openness and Collaboration



中兴 OEX 超节点
ZTE OEX SuperPod

中兴通讯
ZTE

ZTE中兴

## 引言

面向大模型规模化发展所带来的算力密度、互联带宽与系统扩展瓶颈，中兴通讯推出 OEX（Orthogonal Electrical eXchange）正交无背板互联架构，通过开放解耦与多芯协同，重构 AI 超节点底座，驱动基础设施从“芯片堆叠”向“系统级协同”的架构演进。

## Introduction

To overcome the bottlenecks in computing density, interconnect bandwidth, and system scalability brought by AI model scaling, ZTE unveils the Orthogonal Electrical eXchange (OEX) backplane-free architecture. Built upon openness and decoupling as well as multi-chip collaboration, this architecture redefines the AI infrastructure, driving the evolution from “chip stacking” to “system-level synergy”.

## 首创 OEX 正交无背板互联架构，以多芯协同与超高带宽互联实现 AI 超节点系统级突破

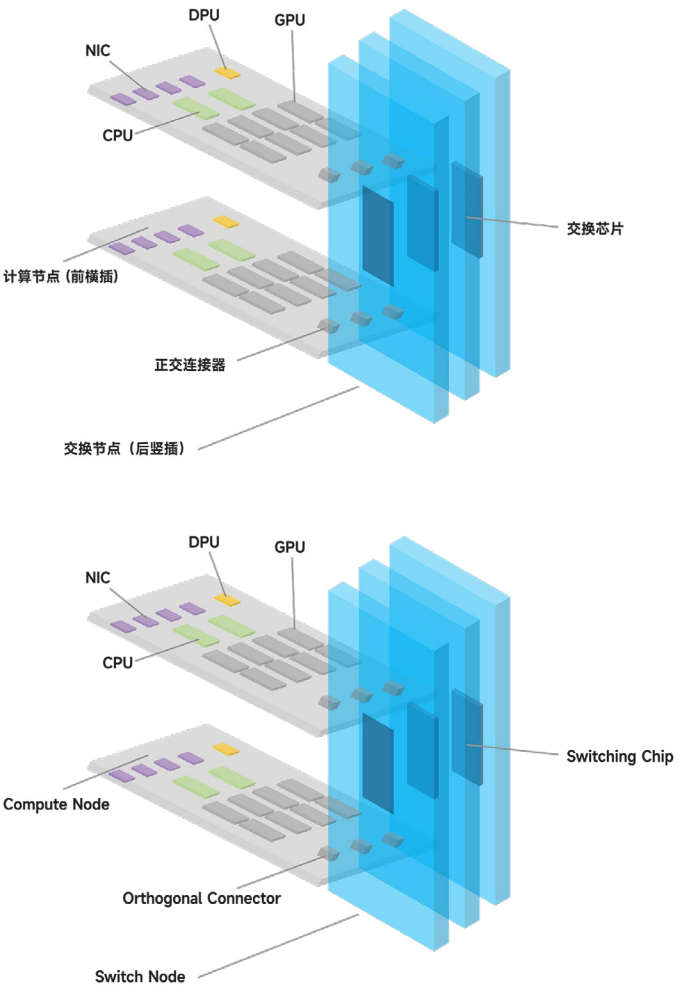
## Innovative OEX Backplane-Free Architecture: System-Level Breakthroughs in AI SuperPod via Multi-Chip Collaboration and Ultra-High-Bandwidth Interconnects

本成果攻克了三大核心技术难题：

一是传统线缆方案在高密度场景下信号衰减严重、可靠性差的问题，通过业界首创 OEX 正交无背板互联架构，实现机柜内零线缆，SerDes 链路缩短 30% 以上，消除 6.5dB 插损，在标准机柜内实现 128 卡高带宽域高密集成；

二是多芯片协同的生态壁垒问题，通过开放 OEX 机械与电气接口规范，支持多厂商 CPU、GPU、DPU 灵活组合，适配周期缩短至 3-6 个月，构建开放解耦生态；

三是大模型训练的“通信墙”问题，依托大容量交换芯片构建大规模交换互联拓扑，互联带宽跃升至 TB/s 级，时延压降至百纳秒级，支撑大规模 GPU 开放互通与超带宽互联，满足大规模 AI 模型训练与推理需求。




OEX：正交无背板互联交换
OEX: Orthogonal Electrical eXchange

This achievement tackles three core technical challenges:

1. Severe signal attenuation and low reliability of traditional cabling solutions in high-density computing scenarios. The innovative OEX backplane-free architecture eliminates all cables within the rack, which reduces SerDes link length by over 30% and eliminates 6.5 dB of insertion loss, thereby achieving high-density integration of 128 GPUs within a high-bandwidth domain in a standard rack.

2. Barriers to multi-chip collaboration in the ecosystem. The OEX architecture adopts open mechanical and electrical interface specifications, supporting flexible combinations of CPUs, GPUs, and DPUs from multiple vendors. It compresses the adaptation cycle to 3–6 months, fostering an open, decoupled ecosystem.

3. Interconnect bottlenecks in large AI model training. With advanced switching fabric built on high-capacity switching chip, the architecture boosts interconnect bandwidth to the terabit-per-second (Tb/s) level and reduces latency to below 100 nanoseconds, enabling interoperability and ultra-high-bandwidth interconnects among GPUs to meet the demands of large-scale AI model training and inference.

## 打造“OEX 算力集装箱”，加速多元异构芯片适配，实现算力成本显著降低与规模化普惠推广

## “OEX Computing Power Container”: Accelerating Heterogeneous Chip Adaptation to Significantly Cut Costs and Scale Deployment

本成果已在互联网、运营商等多个智算中心实现规模化落地。

经济效益层面，OEX 正交无背板设计彻底消除机柜内数千根高速线缆及连接器开销，显著降低组网成本；通过芯片、整机、集群与软件全栈协同，大幅降低单 Token 生产成本。算力仿真平台支持数字孪生式预先推演最优配置，规避技术选型风险，缩短集成调试周期。

社会效益层面，已与多款主流 GPU 完成深度互认证，有效打破高端算力垄断格局，降低中小企业获取高性能 AI 算力的门槛；同时，机械与电气接口全面开放，首创前置式开发流程，将芯片发布到商用部署周期压缩至 3～6 个月，以统一工程语言与可复制范式大幅缩短上下游适配周期，高效支撑多元异构芯片标准化接入，有力推动算力产业向普惠、绿色方向持续演进。

The OEX architecture has been deployed at scale across multiple AI computing centers in the Internet and telecom sectors.

In terms of economic benefits, the OEX backplane-free architecture eliminates thousands of high-speed cables and connectors within the rack, significantly reducing fabric costs. Through full-stack synergy across chips, equipment, clusters, and software, it substantially lowers per-token compute costs. In addition, the compute simulation platform supports pre-deployment configuration optimization powered by digital twins, mitigating technology sourcing risks and shortening integration and debugging cycles.

As for social benefits, the OEX architecture has completed compatibility with multiple mainstream GPUs, breaking the monopoly of high-end compute resources and lowering the threshold for SMEs to access high-performance AI compute resources. Meanwhile, with fully open mechanical and electrical interfaces and the innovative front-loaded development process, the architecture compresses the cycle from chip launch to commercial deployment to just 3–6 months. By providing unified engineering specifications and a replicable paradigm, it greatly shortens adaptation cycles for upstream and downstream partners, and supports standardized integration of heterogeneous chips, driving the computing industry toward inclusive, green, and sustainable development.

## 以系统级协同重塑算力底座，引领智算标准向开放、绿色方向升级

## Reshaping the AI Infrastructure Through System-Level Synergy and Leading Intelligent Computing Standards Toward Open and Green Development

本成果从技术路径、生产模式、产业生态三个维度推动算力产业的结构性变革。

在技术路径上，突破单芯片性能极限，通过高带宽互联实现芯片系统级协同，将评价标准从算力峰值转向每瓦 Token 数，引导产业追求实际效能。

生产模式上，前置式开发，打造 “算力集装箱”，将 AI 基础设施建设从碎片化项目制升级为可批量复制的现代化工厂，以最佳工程力加速芯片商用，商业价值转化周期显著缩短。

产业生态上，开放 OEX 接口规范并在 ODCC 发布，支持多厂商芯片接入，打破封闭生态下的技术锁定，构建开放协同的多元算力生态。

This achievement drives structural transformation of the computing industry across three dimensions: technology roadmap, production model, and industry ecosystem.

Technology roadmap: The architecture pushes beyond the performance limits of a single chip by enabling system-level synergy via high-bandwidth interconnects. This shifts the key evaluation metric from peak FLOPs to tokens per watt, thereby guiding the industry’s pursuit of real-world energy efficiency.

Production model: With front-loaded development, ZTE has built the “OEX Computing Power Container” solution. It transforms AI infrastructure deployment from fragmented, project-specific delivery into a replicable, factory-style production model. With optimal engineering efficiency, it accelerates the commercialization of

chips and shortens the cycle for business value realization.
Industry ecosystem: ZTE has publicly released the OEX interface specifications through the ODCC, enabling seamless integration of chips from multiple vendors. This effectively breaks technological lock-in imposed by closed ecosystems and fosters an open, collaborative, and diverse computing ecosystem.

## 以开放标准和持续演进构建 AI 基础设施长期竞争力
## Building Long-Term Competitiveness in AI Infrastructure Through Open Standards and Continuous Evolution

本成果坚持架构开放与标准化演进，围绕 OEX 正交互联建立机械、电气及系统接口规范，推动相关技术纳入产业标准体系。通过开放接口、多芯协同及标准化工程方法，OEX 不仅有效解决超节点高密度部署难题，更预留面向未来 6 至 8 年的持续演进空间。成果入选 2025 中国算力大会“年度重大技术突破”，并连续两年（2025、2026）荣获世界人工智能大会 WAIC SAIL 奖，充分彰显产业界对其技术创新力与工程价值的权威认可。

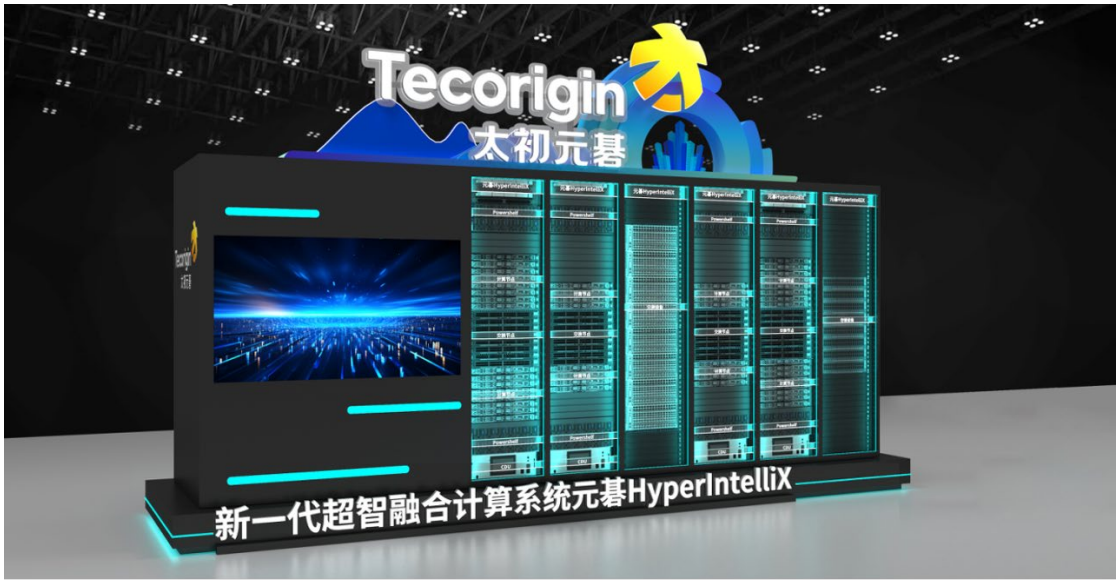
This achievement is built upon open architecture and standards-driven evolution. ZTE has established mechanical, electrical, and system interface specifications for OEX interconnects, and promoted the inclusion of related technologies into industry standards. Through open interfaces, multi-chip collaboration, and standardized engineering methodologies, OEX not only effectively resolves the high-density deployment challenges of AI SuperPods but also provides a clear path for future evolution over the next 6 to 8 years. OEX was named the “Major Breakthrough of the Year” at 2025 China Computational Power Conference, and received the WAIC SAIL Award in both 2025 and 2026. This fully demonstrates the industry’s recognition of its technological innovation and engineering value.




2026 世界人工智能大会：2026 年 SAIL 之星
WAIC 2026: SAIL Star

# 太初元碁异构众核算力体系——从 E 级智算集群到全栈自研开放 AI 生态

## Tecorigin Heterogeneous Many-Core Architecture: From Exascale AI Computing Cluster to a Full-Stack Autonomous AI Ecosystem




新一代超智融合计算系统元碁 HyperIntellix
Next-Generation HPC+AI Converged Computing System—Tecorigin HyperIntellix

太初（杭州）集成电路有限公司
Tecorigin (Hangzhou) Integrated Circuit Co., Ltd.

国家超级计算无锡中心
National Supercomputing Center in Wuxi

## 引言

本成果打造太初元碁异构众核算力体系，突破三级异构融合等核心技术，实现软硬件全链路技术创新。构建 E 级智算集群与开放 AI 生态，兼顾大模型与 AI4S 场景，为全球提供高性能、可规模化的通用算力基础设施。

## Introduction

This achievement delivers the Tecorigin heterogeneous many-core computing system, achieving breakthroughs in three-tier heterogeneous integration and end-to-end innovation across chips, hardware and software stacks. It builds exascale AI computing clusters and an open AI ecosystem for large-model workloads and AI4S research. Supported by industry-university-research collaboration, it provides high-performance, scalable general-purpose computing infrastructure globally.

## 首创主 - 从 - 微三级异构融合算力架构，实现 HPC+AI 融合全栈技术突破

## Pioneering the Master-Slave-Micro Three-Tier Heterogeneous Integrated Computing Architecture and Achieving Full-Stack Technological Breakthroughs in HPC+AI Convergence

本成果针对数据中心集群计算痛点，突破主 - 从 - 微三级异构融合体系架构、在线计算与数据空间动态折中、低精度混合精度协同计算关键技术。该异构架构通过主控核、从属核、微核深度协同，精细化调度计算资源，解决复杂 AI 混合负载的资源争抢问题，打造具备高算力密度与高能效水平的异构众核处理器。研发动态折中技术提升片上缓存利用率，依托高速双向互联能力，缓解大规模集群“存储墙”与数据搬运延迟；借助混合精度协同计算，在保障精度前提下提升推理吞吐量。构建 HPC-AI 双模式操作系统与 SDAA 软硬协同软件栈，把主流大模型适配周期从月级压缩至天级，完成四十余款主流大模型原生适配。技术体系打通高性能计算与人工智能场景边界，将算力底座拓展至气象、地球物理、量子计算、材料分析科研领域，为 E 级智算中心建设提供完整软硬件方案，为全球融合算力发展提供新的技术实现路径。




HPC+AI 融合全栈技术体系
Full-Stack HPC+AI Converged Technology System

This achievement addresses pain-points in data-center cluster computing by making breakthroughs in key technologies: the master-slave-micro three-tier heterogeneous integrated architecture, dynamic trade-off between in-network computing and data movement, and low-precision & mixed-precision collaborative computing. Through deep coordination among master cores, slave cores and micro-cores, this heterogeneous architecture enables fine-grained computing-resource scheduling to resolve resource contention under complex mixed-AI workloads, delivering a heterogeneous many-core processor with high computing density and energy efficiency. The dynamic trade-off technology boosts on-chip cache utilization. Supported by high-speed bidirectional interconnection capabilities, it mitigates the memory-wall bottleneck and data-movement latency in large-scale clusters. Mixed-precision collaborative computing raises inference throughput while preserving computing accuracy. A dual-mode HPC-AI operating system and the SDAA hardware-software co-optimized software stack shorten the adaptation cycle for mainstream large-language models from months to days, achieving native compatibility with more than forty mainstream large-language models. Breaking the scenario boundary between high-performance computing and artificial intelligence, this technical system extends the computing foundation to research fields including meteorology, geophysics, quantum computing and material analysis. It delivers a complete hardware-software solution for Exascale-level intelligent computing hubs and offers a new technical implementation path for the development of global converged computing power.

## 规模化落地融合算力基础设施，面向科研与产业实现开放共享应用

## Large-Scale Deployment of Converged Computing Infrastructure for Open and Shared Applications in Research and Industry

依托三级异构融合架构与 SDAA 软硬件协同技术，本成果落地多座大型智算中心，构建 E 级规模融合算力集群，面向全球高校、科研机构与行业企业开放算力服务。联合多家科研单位开展气象、地球物理、量子计算、材料分析等 AI4S 方向科研攻关，完成 AlphaFold3 等典型科研模型复现，支撑四十余款主流大模型高效运行。依托产学研协同搭建开发实践平台，助力算力领域人才培养。项目带动芯片、服务器、基础软件、行业应用上下游产业链协同发展，形成从技术原型到规模化商用的完整闭环。作为开放型算力基础设施，为数字产业智能化升级提供底层支撑，向全球科研共同体输出通用融合算力方案，具备突出的产业示范价值与社会公共效益。

Leveraging the three-tier heterogeneous integrated architecture and SDAA hardware-software co-optimization technologies, this achievement has deployed multiple large-scale intelligent computing centers and built exascale AI computing clusters to provide open computing services for global universities, research institutes and industrial enterprises. In cooperation with research organizations, it advances AI4S research covering meteorology, geophysics, quantum computing and material analysis. It reproduces representative scientific models such as AlphaFold3 and supports more than forty mainstream large-language models. Industry-university-research collaboration supports talent cultivation in computing. Boosting coordinated growth across upstream and downstream industrial chains, it forms a full closed-loop from technical prototype to large-scale commercial usage. As an open computing infrastructure, it underpins the intelligent upgrade of digital industries and delivers universal converged-computing solutions for the global research community, creating remarkable industrial demonstration value and public social benefits.




融合 AI4S 多领域科研与产业应用
Converged Computing Empowers Multi-domain AI4S Research and Industrial Applications

## 创新异构融合算力范式，推动算力技术进步与数字产业体系升级

## Innovating the Paradigm of Converged Heterogeneous Computing to Drive Technological Progress and Upgrade of Digital Industrial System

本成果提出主 - 从 - 微三级异构融合全新技术范式，打破传统同构架构性能天花板，攻克存储墙、软硬件适配难等行业共性难题，为全球 HPC-AI 融合计算提供新的技术路线，丰富算力领域技术多元化发展路径。补齐异构算力硬件性能强、软件生态薄弱的行业短板，完善从底层架构、操作系统到上层应用的全链路技术体系，推动高性能计算与人工智能交叉领域的技术进步。成果带动芯片、服务器、基础软件、行业应用上下游协同发展，促进算力产业链结构优化，推动科研范式向数据算力双轮驱动转型。依托产教融合平台完善人才培养链条，缓解算力行业人才结构性缺口，构建 “技术研发 - 产业落地 - 人才培育” 良性循环。同时为多行业数字化智能化转型提供算力底座，对数字产业整体升级起到重要示范与牵引作用。

This achievement puts forward a brand-new technical paradigm of master-slave-micro three-tier heterogeneous integration, breaking the performance ceiling of conventional homogeneous architectures. It addresses common industry challenges including the memory wall and difficult hardware-software adaptation, offering a new technical route for global HPC-AI converged computing and diversifying technical paths in the computing sector. It mitigates the long-standing gap between powerful heterogeneous hardware and immature software ecosystems, improving the full-stack technical system from underlying architecture and operating system to upper-layer applications and advancing R&D in the intersection of HPC and AI. It fuels coordinated development across upstream-downstream chains including chips, servers, foundational software and industrial applications, optimizes computing-industry structure, and accelerates the shift toward data-and-computing-driven research paradigms. Industry-education mechanisms relieve structural talent shortages and build a virtuous cycle of "R&D-deployment-talent cultivation". It provides computing foundations for digital transformation across industries and delivers demonstrative driving effects for overall digital-industry upgrading.




测试认证及知识产权
Testing, Certification and Intellectual Property




奖项与成就
Awards and Achievements

# 网络空间测绘技术和平台

## Cyberspace Mapping Technology and Platforms




网络空间测绘技术和平台
Cyberspace Mapping Technology and Platforms

清华大学
Tsinghua University

三六零数字安全科技集团有限公司
360 Digital Security Group

腾讯科技（深圳）有限公司
Tencent Technology (Shenzhen) Co., Ltd.

## 引言

网络空间是与物理空间并行的数字空间，却长期缺乏自身的空间基准和地图。项目对标传统测绘科学，原创网络空间测绘技术体系，突破域内高精度和域间大规模测绘关键技术，建成全球网络空间测绘平台，为网络空间安全与治理提供基础支撑。

## Introduction

Cyberspace has emerged as a new digital domain parallel to the physical world, yet it has long lacked its own coordinate system, standardized maps, and systematic mapping capabilities. Inspired by traditional surveying and mapping, the project establishes an innovative cyberspace mapping technology framework, advances key technologies for high-precision intra-domain and large-scale inter-domain mapping, and builds a global cyberspace mapping platform, providing foundational technological support for cybersecurity, network operations, and global cyberspace governance.

## 创建网络空间测绘科学技术体系，奠定网络空间全景认知基础

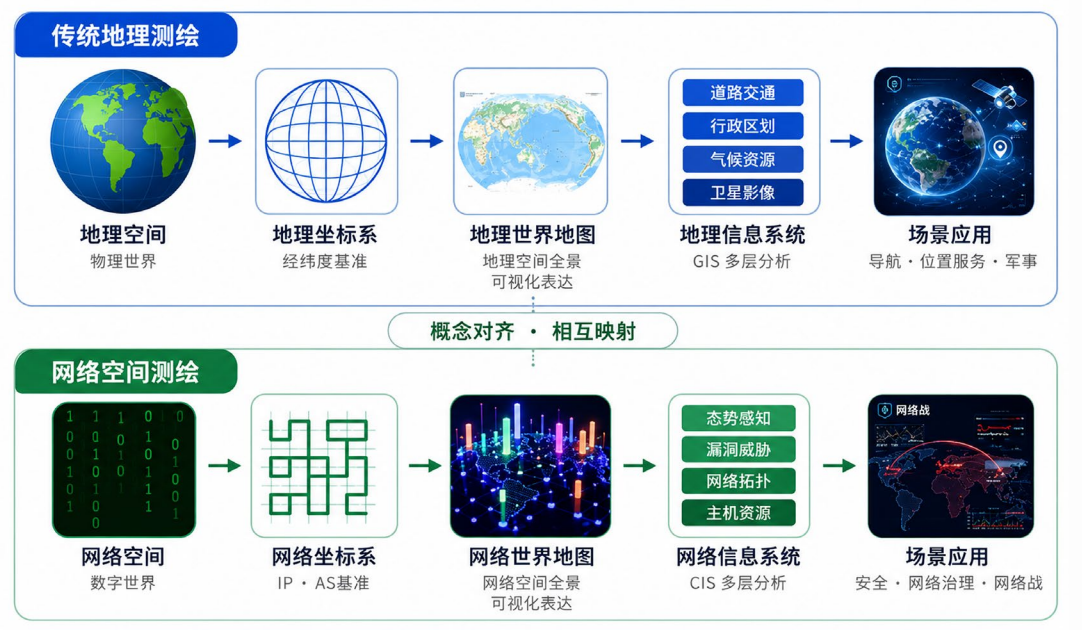
## Pioneering a Cyberspace Mapping Technology System to Enable Panoramic Understanding of Cyberspace

网络空间作为与物理世界并行的新型数字空间，长期缺乏自身的空间基准和系统化测绘方法。项目对标传统地理测绘科学技术体系，创建网络空间测绘科学技术体系，在全球首次系统提出网络空间本源坐标系、网络空间地图、资源分类和网络空间信息系统等基础模型与方法，建立对应地理测绘“坐标系、地图、地理信息系统”的理论框架，使网络空间资源实现统一定位、精准测量和系统表达。

项目主持制定网络空间测绘领域首批 3 项奠基性国家标准；提出网络空间信息系统 CIS，对标地理信息系统 GIS，支撑网络资源多维表达、融合展示和动态分析；绘制全球首张基于网络空间本源坐标系的网络空间世界地图，实现网络空间全景展示和动态表达，为网络空间地图应用和未来网络空间治理奠定重要基础。

As a new digital domain parallel to the physical world, cyberspace has long lacked its own spatial reference and systematic mapping methodology. Drawing on traditional surveying and mapping, the project pioneered a cyberspace mapping science and technology system. It systematically introduced foundational models and methods for native cyberspace coordinate systems, cyberspace maps, resource classification, and the Cyberspace Information System (CIS), establishing a theoretical framework corresponding to the “coordinate system, map, Geographic Information System (GIS)” architecture of the physical world.

The project led the development of the first three foundational national standards for cyberspace mapping. It developed CIS as the cyberspace counterpart to GIS, supporting multidimensional representation, integrated visualization, and dynamic analysis of network resources. It also produced the world’s first cyberspace world map based on a native cyberspace coordinate system, laying an important foundation for cyberspace map applications and future cyberspace governance.




传统地理测绘和网络空间测绘对比
Comparison of Traditional Geographic Mapping and Cyberspace Mapping

## 突破域内域间关键技术，从核心网络设备走向全球测绘平台

## From Key Technology Breakthroughs to Core Network Equipment and a Global Mapping Platform

项目突破域内高精度测绘和域间大规模协同测绘关键技术，推动网络空间测绘从技术创新走向设备产业化和全球平台应用。在域内测绘方面，首创光传输网络遥测技术，将遥测能力从 IP 网络层延伸至光传输层，形成设备级解决方案，支持华为、新华三、光迅等主流设备率先实现产业化应用，相关产品广泛部署于全球百余个国家和地区；并在腾讯全球骨干网络规模化应用，为全球数百万家企业和超过 12 亿终端用户提供高质量网络服务。

在域间测绘方面，首创基于互联网开放资源的大规模网络空间测绘方法，整合全球开放资源和国际合作伙伴资源，建成覆盖全球 170 余个国家和地区的测绘探针网络和全球网络空间测绘平台，累计汇聚百万亿级测绘数据。

相关成果已广泛应用于政府、运营商、互联网、教育科研、交通、制造、能源等领域，覆盖超百万政企客户和 12 亿大众用户。

The project achieved key breakthroughs in high-precision intra-domain mapping and large-scale collaborative inter-domain mapping, advancing cyberspace mapping from technological innovation to commercial network equipment and global platform deployment. For intra-domain mapping, the project pioneered optical network telemetry, extending telemetry capabilities from the IP layer to the optical transport layer. The resulting device-level solutions have been commercialized in mainstream equipment from Huawei, H3C, Accelink, and other vendors, with related products deployed in more than 100 countries and regions. The technologies have also been deployed at scale across Tencent's global backbone network, serving millions of enterprises and more than 1.2 billion end users.

For inter-domain mapping, the project pioneered a large-scale cyberspace mapping approach based on open Internet resources. By integrating globally distributed open resources with resources contributed by international partners, it has built a global probe network and cyberspace mapping platform covering more than 170 countries and regions and accumulated mapping data at the hundred-trillion-record scale.

The technologies have been widely deployed across government, telecommunications, Internet services, research and education, transportation, manufacturing, and energy, serving more than one million government and enterprise customers and 1.2 billion end users.




域间大规模网络测绘
Large-Scale Inter-Domain Network Mapping

## 推动网络测绘技术体系升级，拓展网络空间地图应用新空间

## Advancing Network Mapping Technologies and Expanding New Applications for Cyberspace Maps

项目推动网络测绘从单点、单层感知向跨层、跨域、全球协同测绘演进：域内测绘由 IP 网络层延伸至光传输层，推动核心网络设备具备高精度、实时感知能力；域间测绘由依赖专用探针向多源开放资源协同转变，实现全球互联网低成本、可持续动态测绘；网络空间表达则由传统拓扑关系展示向“坐标系、地图、CIS”的空间化认知演进。

由此，项目逐步形成与物理世界“遥感、地图、GIS”相对应的“网络测绘、网络空间地图、CIS”技术链条，推动网络空间测绘与网络安全、智能运维、数字治理等场景深度融合。项目已获授权发明专利 37 项，其中国际专利 5 项，软件著作权 14 项，形成覆盖基础模型、关键技术和平台系统的知识产权体系，为网络空间地图和信息系统等新型应用与产业发展拓展空间。

The project advances network mapping from isolated, single-layer observation toward cross-layer, cross-domain, and globally collaborative mapping. Intra-domain mapping has expanded from the IP layer to the optical transport layer, enabling core network equipment to provide high-precision, real-time observability. Inter-domain mapping has evolved from dependence on dedicated probes toward collaborative use of heterogeneous open resources, enabling sustainable and cost-effective global Internet mapping. Meanwhile, cyberspace representation is evolving beyond conventional topology visualization toward spatial understanding based on coordinate systems, maps, and CIS.

Together, these advances are establishing a technology chain corresponding to the “remote sensing, map, GIS” model of the physical world: “network mapping, cyberspace map, CIS”. This technology chain promotes the integration of cyberspace mapping with cybersecurity, intelligent network operations, digital governance, and other application scenarios. The project has secured 37 granted invention patents, including five international patents, and 14 software copyrights, establishing an intellectual property portfolio covering foundational models, key technologies, and platform systems. These achievements are creating new opportunities for emerging applications and industries based on cyberspace maps and information systems.




项目相关知识产权：国家标准、中国发明专利、美国发明专利、计算机软件著作权
Project-Related Intellectual Property: National Standards, Chinese and U.S. Invention Patents, and Computer Software Copyrights




全球网络空间测绘合作伙伴
Global Distribution of Cyberspace Mapping Project Partners

## 构建全球协同测绘生态，推动开放共享与前沿研究
## Building a Global Collaborative Mapping Ecosystem for Open Sharing and Cutting-edge Research

项目牵头联合 27 个国家和地区的教育科研网络、高校和科研机构，构建覆盖五大洲的国际协同测绘网络，共享测绘资源、平台能力和研究成果，惠及全球数万个高校和科研机构、过亿教育科研人员。全球测绘平台入选 Common Good Cyber 网络空间测绘工具数据库，相关成果入选世界互联网大会 2025“年携手构建网络空间命运共同体”精品案例。

项目持续产出国际前沿研究成果，累计发表 CCF-A 类论文 40 篇。2026 年，团队发表于 IEEE S&P 的 One Char to Rule Them All 揭示长期未被发现的 DNS 逻辑缺陷，并获 Pwnie Awards 2026 “Best Innovative Research”奖。

The project has brought together research and education networks, universities, and research institutions across 27 countries and regions, establishing a collaborative mapping network spanning five continents. Through shared mapping resources, platform capabilities, and research outcomes, the initiative benefits tens of thousands of universities and research institutions and more than 100 million members of the global research and education community. The global mapping platform has been included in the Common Good Cyber cyberspace mapping tools database, while related achievements were selected as a 2025 World Internet Conference Outstanding Case of Jointly Building a Community with a Shared Future in Cyberspace.

The project also continues to produce internationally recognized research, with 40 CCF-A publications. In 2026, One Char to Rule Them All, published at IEEE S&P, revealed previously overlooked logical flaws in DNS resolution and received the Pwnie Awards 2026 for Best Innovative Research.

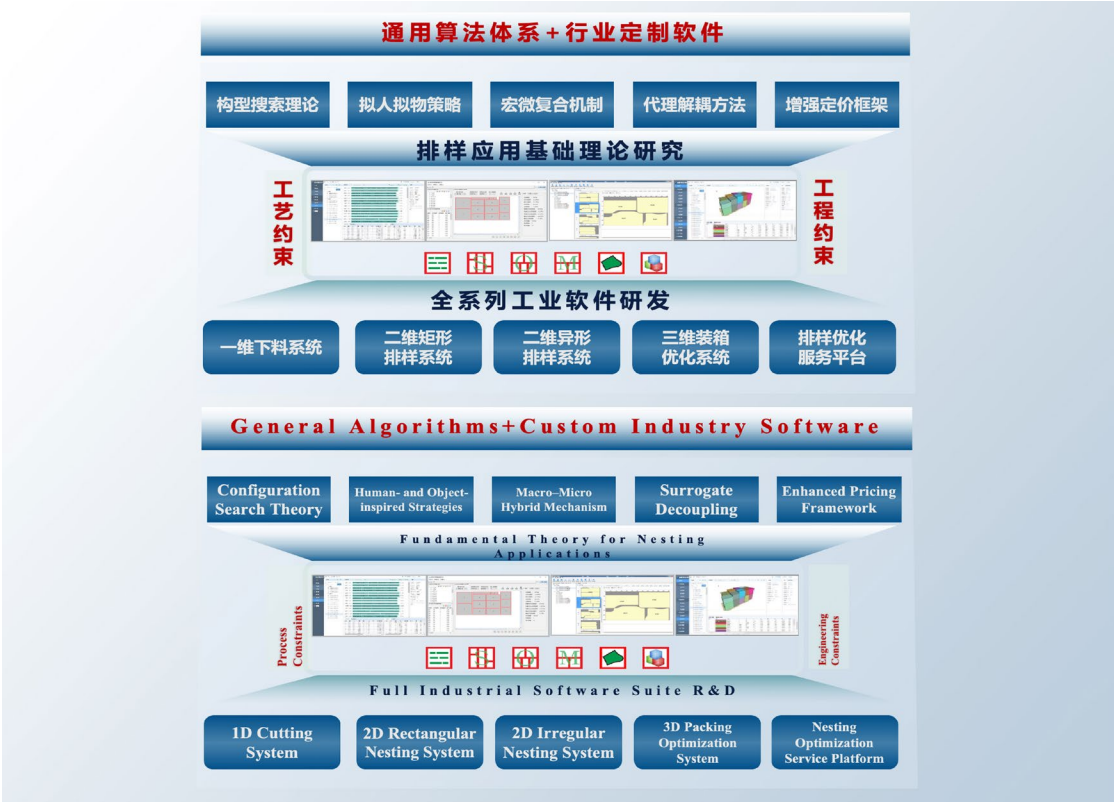


国际伙伴应用证明
Application Letters from International Partners


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# 智能排样优化系统关键技术与装备集成应用

## Key Technologies and Equipment Integration Application of Intelligent Nesting Optimization System




排样通用算法体系 + 行业定制软件
General Nesting Algorithms+Custom Industry Software

广东工业大学
Guangdong University of Technology

## 引言

本成果面向制造业下料排样优化需求，搭建智能排样优化与装备集成技术体系，研发全系列排样软件与成套装备，实现多行业规模化落地，多项核心技术指标达到国际领先水平。

## Introduction

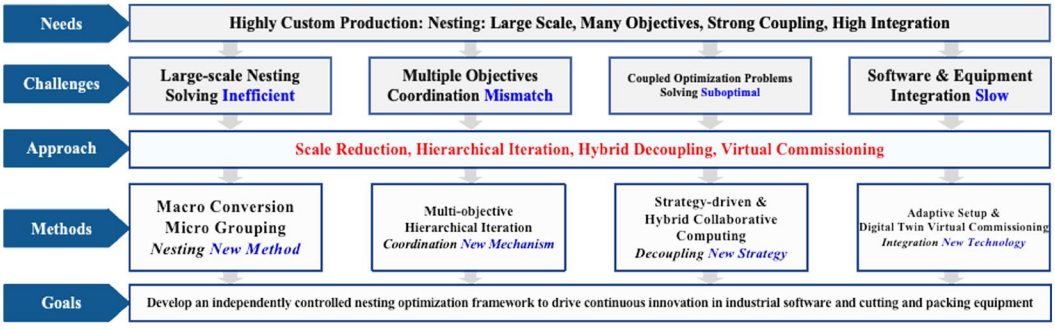
Targeting nestingoptimization demands for manufacturing cuttingout, this achievement establishes a technical system for intelligent nesting optimization and equipment integration. It develops fullrange nesting software and complete equipment, realizes largescale multiindustry deployment, with multiple core technical indicators reaching internationallyleading levels.

## 突破排样与装备集成系列关键技术
## Breakthroughs in Key Technologies for Nesting Optimization and Equipment Integration

成果针对大规模排样求解效率低、多目标优化难以协同、多优化问题耦合求解效果不佳、软件与产线装备集成周期长等技术难点，提出宏观 - 微观组化排样、多目标分层迭代协同、策略 - 计算协同混合解耦、自适应配置结合数字孪生虚拟调试四大创新方法。项目拥有 4 件美国发明专利、42 件中国发明专利，发表高质量论文 20 篇，牵头 2 项团体标准。第三方鉴定表明，整体技术处于国际先进水平，二维排样利用率达到国际领先，多项算法性能优于全球公开文献同类算法。

This work addresses bottlenecks including low efficiency in large-scale nesting computation, poor multiobjective coordination, suboptimal coupledproblem solving and long softwaretoequipment integration cycles. Four innovative methodologies are proposed: macromicro grouping nesting, multiobjective hierarchical iterative coordination, strategycomputation hybrid decoupling, and adaptive configuration with digitaltwin virtual commissioning. The portfolio includes 4 U.S. invention patents, 42 Chinese invention patents, along with 20 highquality papers. It leads 2 association standards. Thirdparty evaluation confirms internationallyadvanced overall performance and internationallyleading 2D nesting utilization; several algorithms outperform counterparts in global public literature.



## 实现软件装备商业化落地，获得多元综合效益
## Commercial Deployment of Software and Equipment, Delivering Multifaceted Benefits

成果技术成熟稳定，开发一维、二维、三维全谱系排样软件，配套 6 大类智能切割、码垛装箱装备，在家具、玻璃、3C 电子、钣金、皮革、船舶等行业商用。累计销售排样软件 3600 余套，集成装备 24000 余套，新增营收 42.22 亿元，新增利润 6.85 亿元，出口额 10.80 亿元。技术提升原材料利用率，降低物料消耗与废弃物产出，实现资源节约。产品完成 9 种语言本地化，销往全球多国，已在多家行业头部企业长期投产，各项生产指标经过现场实测验证。

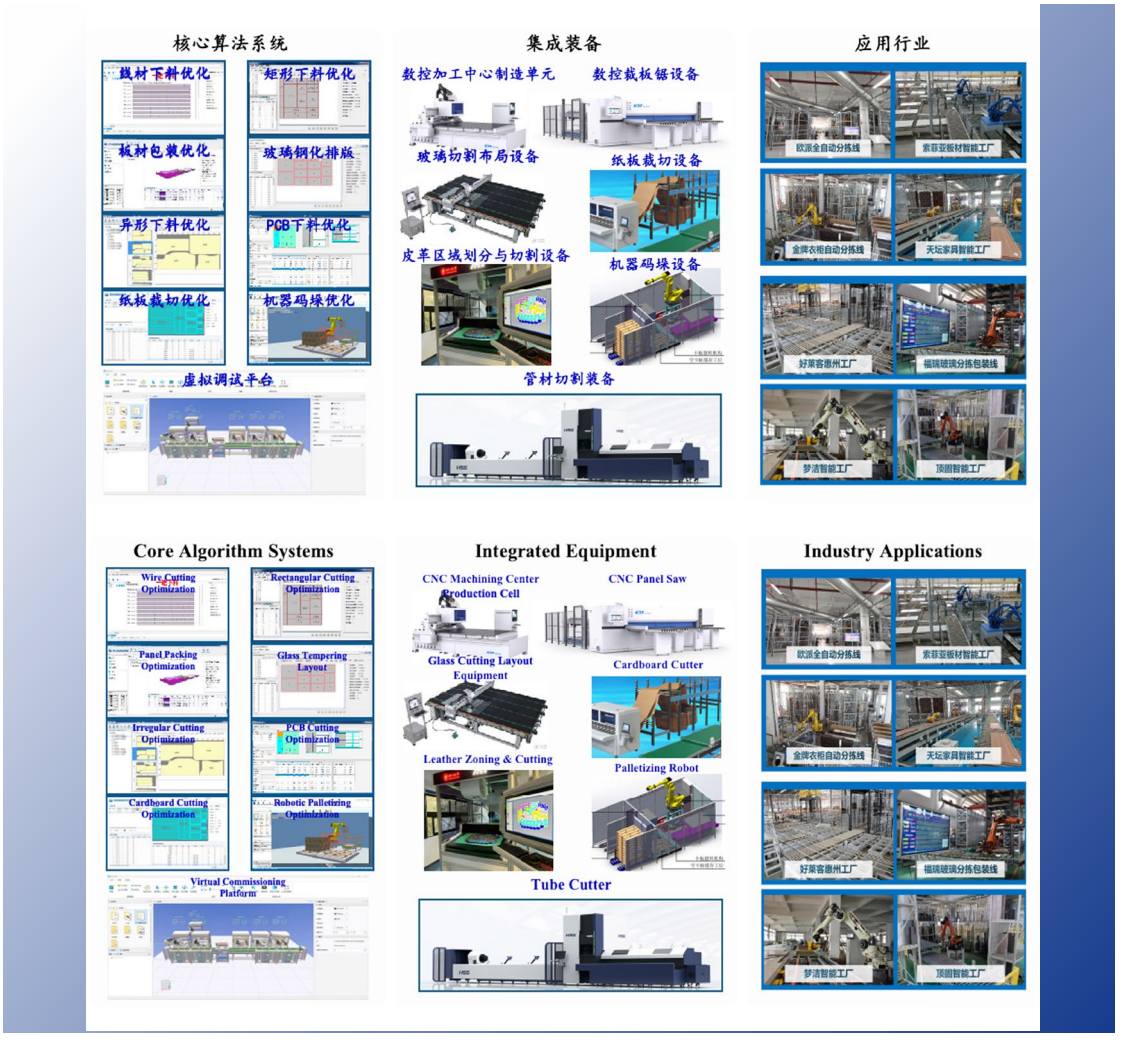
Proven mature and stable, the solution covers 1D/2D/3D full-spectrum nesting software and six categories of intelligent cutting, palletizing and packaging equipment for furniture, glass, 3C electronics, sheetmetal, leather and shipbuilding industries. More than 3,600 nestingsoftware sets and over 24,000 integrated equipment sets have been sold, bringing incremental revenue of 4.222 billion RMB, incremental profit of 685 million RMB and exports of 1.08 billion RMB. The technology improves raw material utilization, reduces material consumption and contributes to resource conservation. The products have been localized into nine languages, products are delivered across the globe and have been running stably at multiple leading manufacturers with fieldvalidated performance metrics.



## 构建协同创新链条，塑造全球制造领域行业影响力
## Building a Collaborative Innovation Ecosystem and Strengthening Global Influence in Manufacturing

成果依托高校、软件企业、装备厂商深度协同，打通算法研发、软件开发、装备集成到产业落地完整链路，为制造业提供成套数字化排样下料解决方案。板材柔性分拣成套装备中国市场占有率 42.24%，全球市场占有率 17.88%。技术支撑 400 余套智能化产线建设，服务多家全球知名制造企业。项目在排样、切割、装箱、码垛优化方向积累大量专利，获得多项行业重要科技奖项，可为全球定制离散制造提供可复用优化范式。

Through deep collaboration among universities, software firms and equipment manufacturers, a fullvalue chain from algorithm R&D, software development and hardware integration to industrial rollout is established, delivering complete digital nesting-cutting solutions for manufacturing. Its flexible panel-sorting equipment holds 42.24% market share in China and17.88 % globally. The technology underpins more than 400 intelligent production lines serving wellknown global manufacturers. With substantial patents on nesting, cutting, packaging and palletizing optimization and multiple major industrial awards, it provides replicable optimization paradigms for global custom discrete manufacturing.




核心算法系统、装备与应用案例
Core Algorithm Systems, Equipment and Applications



# 科技之魅

CHARM OF SCIENCE AND TECHNOLOGY

# 02

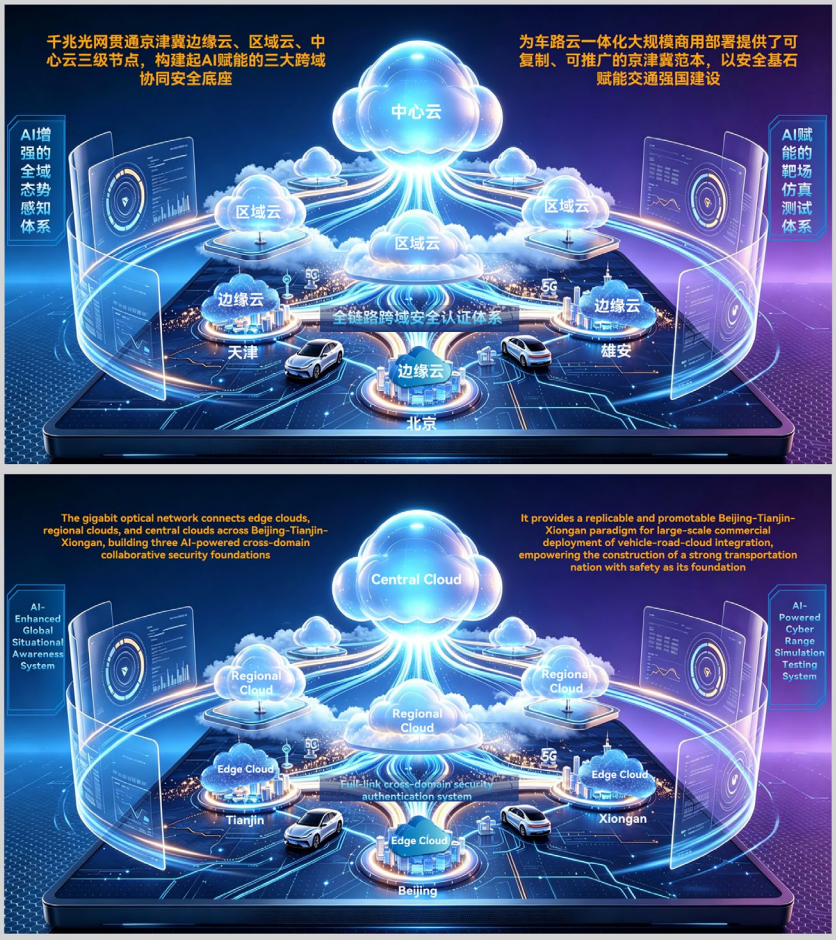
## 世界互联网大会
## 领先科技奖收录成果

Collection of World Internet Conference
Awards for Pioneering Science and Technology

# 工程研发组
# Engineering Research and Development Group

# AI 融核的车路云一体化跨域跨层网络安全防护示范应用

## Demonstration Application of Cross-Domain and Cross-Layer Cybersecurity Protection for AI-Integrated Vehicle-Road-Cloud System




AI 融核的车路云一体化跨域跨层网络安全防护架构图

The Integrated Cross-Domain and Cross-Layer Network Security Protection Architecture of AI Fusion Core for Vehicle-Road-Cloud Integration

联通智网科技股份有限公司
China Unicom Smart Connection Technology Limited.

联通数字科技有限公司
China Unicom Digital Technology Co., Ltd.

中讯邮电咨询设计院有限公司
China Information Consulting & Designing Institute Co., Ltd.

广东为辰信息科技有限公司
Guangdong Vecentek Information technology Co., Ltd.

## 引言

面向智能网联汽车规模化商用的系统性安全风险，本项目以“AI 增强”为核心理念，深度赋能车、路、云、网、边安全防护，构建跨域跨层纵深防御体系，为行业规模化商用提供可复制的安全标杆。

## Introduction

Addressing the systemic security risks in large-scale commercial deployment of intelligent connected vehicles, this project adopts “AI integration” as its core concept, deeply empowering security protection across vehicles, roads, clouds, networks, and edges. It constructs a cross-domain, cross-layer deep defense system, providing a replicable security benchmark for the industry’s large-scale commercialization.

## AI 驱动，车路云一体化网络安全防护体系创新突破
## AI-Driven, Integrated Vehicle-Road-Cloud Cybersecurity Protection System Achieves Innovative Breakthroughs

本项目以人工智能为安全使能引擎，在行业内率先实现跨省域、跨层级、策略联动的智能网联纵深防御安全体系，形成四维协同的核心技术能力：

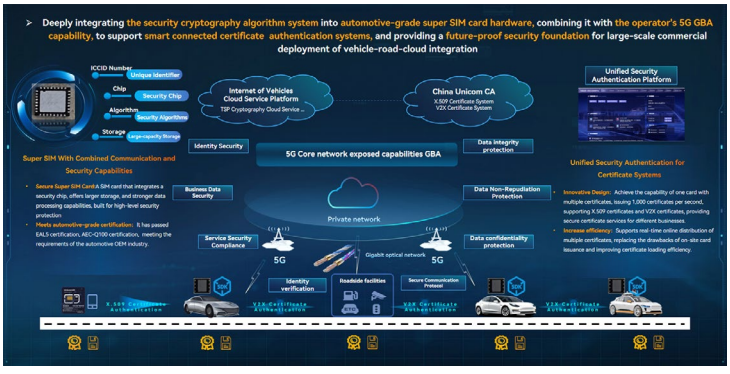
1. 以车载超级 SIM 卡为信任锚点的认证体系：融合安全算法与 V2X CA/X.509 CA 双证书，实现百万级终端并发认证，证书签发达 1000 张 / 秒，CRL 更新流量降低 80%。

2.AI 增强的态势感知体系：部署端侧轻量 AI 探针，融合 UEBA、攻击链还原等技术，实现全域风险智能研判；通过 AI+SOAR 将安全事件响应压缩至分钟级，威胁检测准确率≥ 95%。

3.AI 协同赋能的虚实结合安全靶场：突破高精度仿真与硬件在环融合技术，内置 AI 驱动的自动化渗透测试引擎，挖掘到的漏洞特征可自动转化为威胁情报实现实时同步。

4. 座舱大模型系统级安全防护：构建上车前检测、运行期防护与供应链治理的全链路闭环体系，覆盖 OWASP LLM Top 10 风险，拦截准确率≥ 95%。




以车载超级 SIM 卡为信任锚点的车路云安全认证体系
Vehicle-Road-Cloud Security Authentication System Based on a Automotive Super SIM Card as the Trust Anchor Point

This project uses artificial intelligence as the security enabling engine, and is the first in the industry to achieve a cross-provincial, cross-level, and strategy-coordinated intelligent networked in-depth defense security system, forming core technical capabilities in four dimensions:

1.Authentication system based on automotive super SIM card as the trust anchor: integrates security encryption algorithms and V2X CA/X.509 CA dual certificates, enabling concurrent authentication for millions of terminals, with certificate signing reaching 1,000 per second, and CRL update traffic reduced by 80%.




基于 AI 的车路云一体化靶场安全测试体系
AI-Based Integrated Vehicle-Road-Cloud Cyber Range System for Security Testing

2.AI-enhanced situational awareness system: deploys lightweight AI probes at the edge, integrates UEBA, attack chain reconstruction and other technologies, achieving intelligent risk assessment across the entire domain; through AI + SOAR, security incident response is compressed to minutes, with threat detection accuracy reaching ≥ 95%.

3.AI-coordinated-enabled virtual-real integrated security range: breaks through high-precision simulation and hardware-in-the-loop integration technology, integrates an AI-driven automated penetration testing engine, and the vulnerability features discovered can be automatically converted into threat intelligence for real-time synchronization.

4.Cabin large model system-level security protection: builds a closed-loop system covering pre-vehicle detection, operation protection and supply chain governance, covering OWASP LLM Top 10 risks, with interception accuracy reaching ≥ 95%.

## 车路云网边全域覆盖，降本增效与多场景应用示范成效显著

## The vehicle-road-cloud-network-edge is fully covered, achieving significant results in cost reduction and efficiency improvement, as well as demonstrating effectiveness in multiple application scenarios

项目覆盖车、路、云、网、边全域，形成可复制、可运营的解决方案，已呈现出良好的经济、社会及生态效益，概述如下：

1. 降本增效效果可观：主要服务于全球主流车企及示范区。车载超级 SIM 卡较外挂方案成本降低 30%；AI+SOAR 自动化响应使安全运营效率提升 30%，每年为客户节省运营成本百万元；AI 渗透测试缩短车型上市周期 2-3 个月。

2. 社会价值显著：AI 增强的实时防护体系为智能网联交通系统注入主动免疫能力，降低网络攻击引发事故的风险；依托于运营商低时延、高可靠的网络，可实现示范区集群的高效同步管理。

3. 生态效益突出：中国联通 5G 车联网 Openlab 实验室已支撑多款整车及零部件入网安全检测；中国联通车联网创新联合体汇聚超 90 家产业链伙伴，形成“研发 - 测试 - 演练 - 运营”的生态闭环。

The project covers the entire domains of vehicles, roads, clouds, networks and edges, forming a replicable and operable solution. It has demonstrated excellent economic, social and ecological benefits, as outlined below:

1.Significant cost reduction and efficiency improvement: Mainly serving global mainstream automakers and demonstration zones. The automotive super SIM card is 30% cheaper than the external attachment solution; AI + SOAR automated response increases safety

operation efficiency by 30%, saving customers 1 million yuan in annual operation costs; while AI penetration testing shortens the vehicle model launch cycle by 2-3 months.

2.Remarkable social value: The AI-enhanced real-time protection system injects active immunity capabilities into the intelligent connected transportation system, reducing the risk of accidents caused by network attacks; Relying on the low latency and high reliability network of the operator, efficient synchronous management of the demonstration zone cluster can be achieved.

3.Outstanding ecological benefits: The 5G Connected Vehicle Openlab Laboratory of China Unicom has supported the network security testing of multiple complete vehicles and components; The China Unicom Connected Vehicle Innovation Consortium brings together over 90 industrial chain partners, forming an ecological closed loop of “research and development - testing - drill - operation”.







项目应用成效
Project Application Effectiveness

## 车路云一体化安全从“示范试点”迈向“规模商用”的行业标杆

## The Integrated Security of Vehicle-Road-Cloud from “Demonstration Pilot” to “Large-Scale Commercial Application” Has Become an Industry Benchmark

在车路云一体化从“示范试点”迈向“规模商用”的关键阶段，行业主流安全方案长期呈现“单点化、竖井式”，缺乏统一的跨域协同语言与联动机制。项目构建了业界首个“可信身份基石—智能感知中枢—实战验证引擎—座舱 AI 安全”四位一体协同防御体系，其先进性不在于单一技术的突破，而在于从架构层面统一了跨域跨层安全的协同语言与联动机制，填补了车路云一体化安全领域系统性架构的空白。

依托联通智网科技覆盖 92 家车企、超 1 亿联网车辆的产业基础，成果已在北京、成都、宁波、上海等 10 余个城市规模化落地，形成了从标杆建设到规模化复制的成熟路径。作为首批可落地的车路云一体化安全体系，可快速复制推广至全国 20 个试点城市及广大车企，为行业从示范验证走向大规模商用扫清核心安全障碍，提供了可复制的安全范式。

During the critical stage of the vehicle-road-cloud integration moving from “demonstration pilot” to “large-scale commercial application”, the mainstream security solutions in the industry have long presented a “single-pointed, isolated” pattern, lacking a unified cross-domain collaborative language and linkage mechanism. The project has constructed the industry’s first “trusted identity foundation -intelligent perception center-practical verification engine-cabin AI security” integrated collaborative defense system. Its advancement does not lie in the breakthrough of a single technology, but lies in unifying the cross-domain and cross-layer security collaborative language and linkage mechanism at the architectural level, filling the gap in the systematic architecture of vehicle-road-cloud integrated security.

Leveraging China Unicom Smart Connection Technology Limited, serving 92 automotive enterprises and connecting over 100 million connected vehicles, the solution has been deployed at scale across more than ten cities in China, establishing a proven path from pilot projects to large-scale replication. Designed for mass commercial deployment, the system can be rapidly replicated and rolled out to 20 pilot cities in China and numerous automakers worldwide, providing critical security support and a replicable safety model to drive the intelligent connected vehicle industry from demonstration validation to large-scale commercialization.



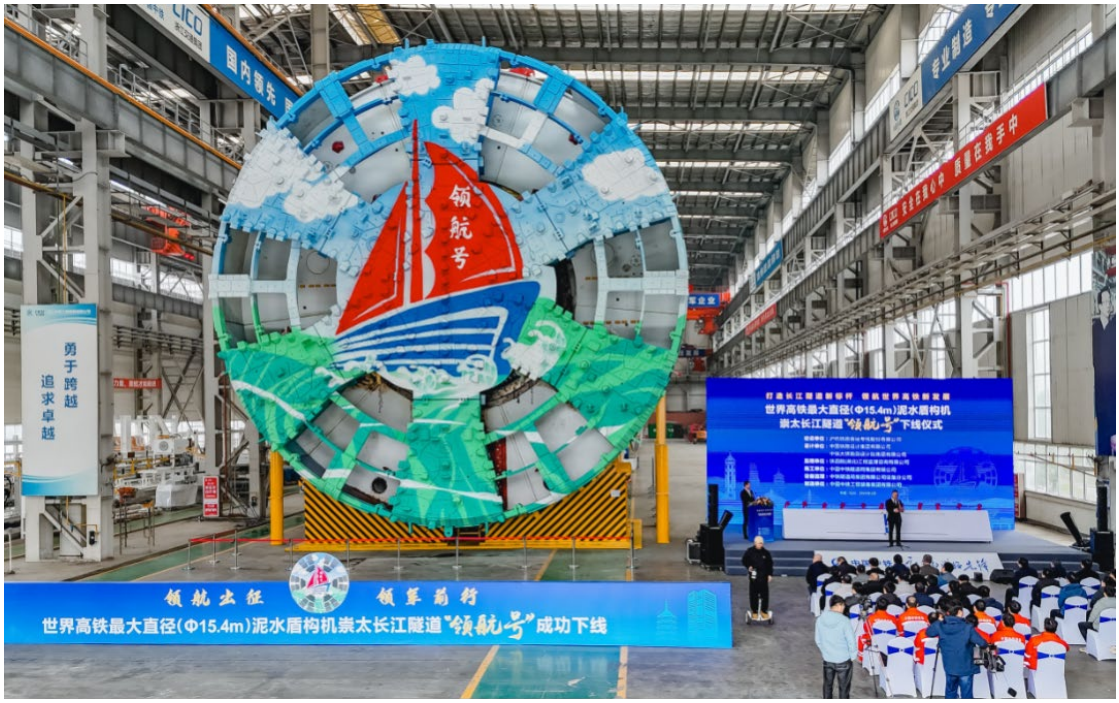

中国各省市车路云示范区安全认证与态势感知平台建设与运营

Construction and Operation of the Security Authentication and Situational Awareness Platform for Vehicle-Road-Cloud Demonstration Zones in China’s Provinces and Cities


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# 基于大数据技术的盾构 TBM 智能化选型与掘进技术

## Intelligent Selection and Boring Technology of Tunnel Boring Machine Based on Big Data Technology




项目成果支撑超大直径泥水平衡盾构机设计和施工

Project outcomes underpinned the design and construction of ultra-large-diameter slurry shield machine

盾构及掘进技术国家重点实验室
State Key Laboratory of Shield Machine and Boring Technology

中铁隧道局集团有限公司
China Railway Tunnel Group Co.,Ltd.

## 引言

盾构 /TBM 作为全球隧道工程建设的主力装备，利用大数据、人工智能赋能装备选型、设计、应用全寿命周期，加速隧道建造数智化转型，不断拓展人类生存与发展空间。

## Introduction

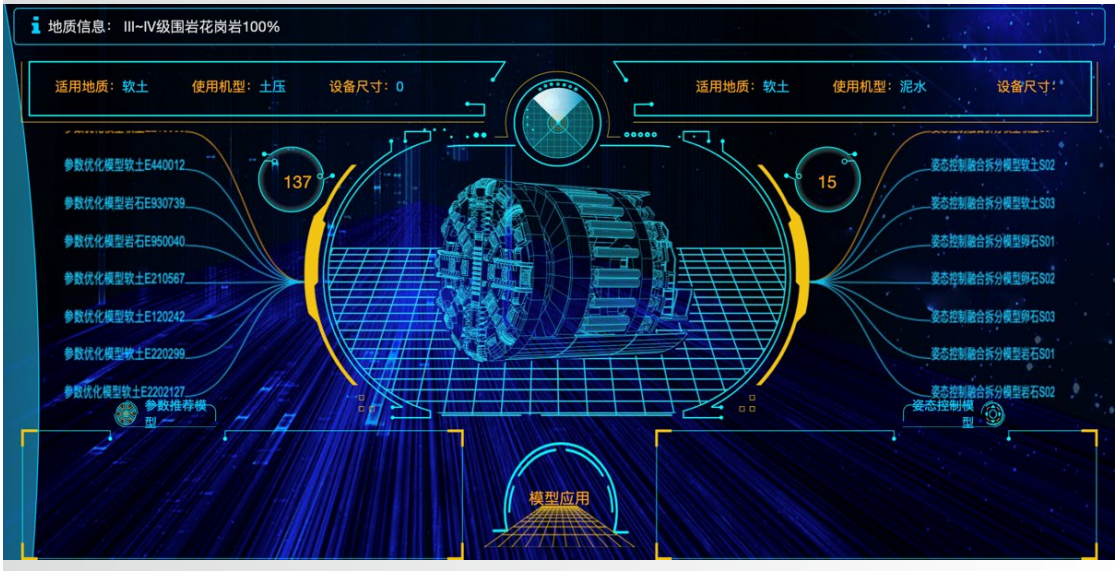
As the primary workhorse for tunnel construction projects worldwide, shield Tunnel Boring Machines are being empowered by big data and artificial intelligence throughout their entire life cycle—from selection and design to application—thereby accelerating the digital and intelligent transformation of tunnel construction and continuously expanding the horizons of human living and development space.

## 以大数据为基础，人工智能重塑盾构 TBM 选型、设计与掘进

## Based on Big Data, Artificial Intelligence is Reshaping TBM Selection, Design, and Tunneling

盾构 /TBM 是隧道建造核心装备，其适应性与智能化关乎工程安全与效率。针对全球“选型靠经验、掘进靠人工、预警靠事后”的痛点，每年仅中国损失数十亿元，项目构建了数据采集—智能选型—自主掘进—预警控制全链条技术体系，以数据驱动替代经验决策，提升装备全寿命周期决策效率与精度。攻克多项核心技术：建成覆盖 200 余条线路、200TB 的行业最大盾构 /TBM 工程大数据平台；提出数据 - 机理混合驱动选型方法，开发自动化选型系统；搭建云边端智能控制架构，研制盾构自动驾驶系统，实现常规地层“一键启动”自主掘进。获授权发明专利 11 项、软著 14 项，发表论文 14 篇。成果在崇太长江隧道创造 15 米级大直径盾构独头掘进 11.3 公里、月进尺 718 米的世界纪录。

TBMs are core equipment in tunnel construction, and their adaptability and intelligence directly determine project safety and efficiency. To tackle the long-standing global challenges of “experience-based selection, manual tunnelling control, and post-event warning” – which alone cost China billions of yuan annually – this project has established a full-chain technical framework encompassing data acquisition, intelligent selection, autonomous tunnelling, and proactive warning. The framework replaces experience-driven decisions with data-driven approaches, markedly improving the efficiency and accuracy of decision-making throughout the equipment lifecycle. The team has overcome several key technical hurdles: building the industry’s largest TBM engineering big-data platform, covering over 200 routes and 200 TB of data; proposing a hybrid data-mechanism driven selection method and developing an automated selection system; and designing a cloud-edge-device intelligent control architecture with an autonomous TBM driving system, enabling “one-button start” autonomous tunnelling in normal ground conditions. The project has been granted 11 invention patents, 14 software copyrights, and 14 papers have been published.These innovations have been applied in the Chongtai Yangtze River Tunnel, where they set a world record for a 15-metre-class large-diameter shield machine with boring distance of 11.3 kilometres and a monthly advance rate of 718 metres.



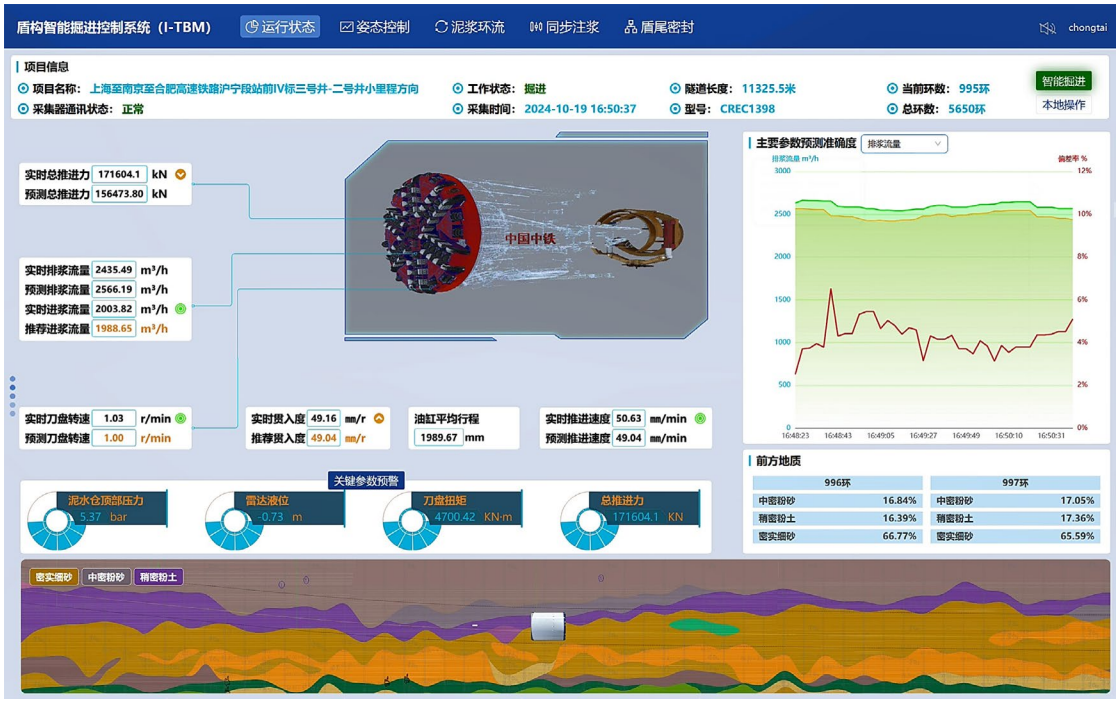

盾构 TBM 选型系统
Type Selection System of TBM

## 数据筑基，AI 赋能装备设计与隧道建造，推动行业迈入数智化

## Data as the Foundation, AI Empowers Equipment Design and Tunnel Construction, Driving the Construction Industry Toward Digital and Intelligent Transformation

成果已形成覆盖“数据采集—智能选型—自主掘进—预警控制”全链条的技术体系，在十余项超大直径盾构工程中深度应用。选型系统贯通地质条件到装备设计的自动化链路，设计周期缩短 30%，装备出口意大利、新加坡。智能掘进系统成功应用于崇太长江隧道、深江铁路珠江口隧道等重大工程，掘进效率提升 15%，轴线偏差控制在 ±10 毫米以内；设备能耗降低 8% ～ 10%，单个工程碳排量平均减少 9%，近三年累计新增经济效益约 5.2 亿元。目前，成果正推广至南京上元门过江通道、甬舟高速二期金塘海底隧道等工程，技术持续迭代，推动隧道建造技术体系与高端装备的全球化应用，经济社会效益深远。

A mature technological system has been developed, covering the entire chain of data acquisition, intelligent type selection, autonomous tunneling, and early-warning control. It has been extensively applied in more than ten ultra -large-diameter shield tunneling projects. The type-selection system establishes an automated link from geological conditions to equipment selection and key component design, shortening the design cycle by 30%, while the resulting equipment has been exported to Italy and Singapore. The intelligent tunneling control system has been successfully deployed in major projects such as the Chongtai Yangtze River Tunnel and the Shenjiang Railway Pearl River Estuary Tunnel, boosting tunneling efficiency by 15%, keeping axis deviation within ±10 mm. Energy consumption has been reduced by 8%–10%, average carbon emissions per project cut by 9%, and cumulative additional economic benefits over the past three years have reached approximately RMB 520 million. The technology is now being rolled out to other key projects, including the Nanjing Shangyuanmen River-crossing Passage and the Ningbo-Zhoushan Expressway Phase II Jintang Subsea Tunnel. Through continuous iterative refinement, the project is advancing the global application of tunnel construction technology systems and high-end equipment, delivering far-reaching economic and social benefits.




智能掘进控制系统
Intelligent TBM Control System



项目获得中施协科技进步一等奖并得到国际隧协主席的高度称赞
The project has been granted the First Prize of the Science and Technology Progress Award by CACEM and has drawn high acclaim from the ITA President

## 隧道建造智能化水平大幅提升，得到全球认可
## The Intelligent Level of Tunnel Construction Has Been Significantly Improved and Globally Recognized

国际隧道与地下空间协会（ITA）主席阿诺德·迪克斯在实地考察深江铁路珠江口隧道时，深入了解了项目自主研发的智能掘进系统成果，对智能化技术手段显著提升施工管理效率给予高度评价，与会来宾亦对中国隧道建造技术的飞速发展表示由衷赞叹。在崇太长江隧道工程中，世界最大直径高铁盾构机“领航号”集成项目开发的智能掘进系统，具备“独立思考、智能分析、自主判断”能力，实现全系统算法控制下的无人化智能掘进常态化应用，创造了 15 米级高铁隧道月掘进 718 米的世界纪录。

During his on-site inspection of the Pearl River Estuary Tunnel on the Shenjiang Railway, Professor Arnold Dix, President of the International Tunnelling and Underground Space Association (ITA), was profoundly impressed by the intelligent tunnelling system developed under this project. He acknowledged the substantial impact of intelligent technological measures on enhancing construction management efficiency. The attending delegates also expressed sincere admiration for the rapid and remarkable advancement of China’s tunnelling construction technology.

At the Chongtai Yangtze River Tunnel, the world’s largest-diameter high-speed railway shield tunnel boring machine, designated “Linghang”, has been integrated with the project’s intelligent tunnelling system. The system is endowed with capabilities of independent reasoning, intelligent analysis, and autonomous decision-making, thereby enabling the routine application of unmanned intelligent tunnelling under full algorithmic control.



工程建设科学技术进步奖

证 书

为表彰工程建设科学技术进步奖获得者，特颁发此证书。

项目名称：基于大数据技术的盾构 TBM 智能化选型与掘进技术研究

奖励等级：一等

获 奖 者：中铁隧道局集团有限公司

2025年12月

证书号：2025-J-1-004-D01



工程建设科学技术进步奖

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获 奖 者：盾构及掘进技术国家重点实验室

2025年12月

证书号：2025-J-1-004-D02

# 面向海量用户的多模态智能交互技术及重大工程应用

## Multimodal Intelligent Interactive Technology for Massive User Bases and Its Major Engineering Applications




面向海量用户的多模态智能交互技术体系与应用总览
Overview of the multimodal intelligent interactive technology system and its applications for massive user bases

浙江大学
Zhejiang University

支付宝（杭州）数字服务技术有限公司
Alipay

中国电子技术标准化研究院
China Electronics Standardization Institute

## 引言

针对海量用户场景下的超高并发、低时延与多模态交互挑战，构建了“端边云智能调度—超大规模图谱推荐—情感计算驱动交互”一体化技术体系，支撑服务了国际大型赛事数字化标杆工程，达到国际领先水平。

## Introduction

To address the challenges of ultra-high concurrency, low latency, and multimodal interaction in large-scale user environments, the project established an integrated technology system spanning Device-Edge-Cloud intelligent scheduling, large-scale graph-based recommendation, and affective-computing-driven interaction. The system has supported a benchmark digital project for a major international sporting event and achieved an internationally leading level.

## 突破端边云协同调度、超大规模图谱推荐与多模态情感交互三大核心技术瓶颈

## The project overcame three core technical bottlenecks: Device-Edge-Cloud Collaborative Scheduling, Large-Scale Graph-Based Recommendation, and Affective-Computing-Driven Interaction

针对海量用户场景下的算力峰谷波动与能耗挑战，团队突破了传统中心化调度范式，构建基于用户行为划分的毫秒级端边云协同调度机制，实现全链路算力弹性互补，总体算力资源节省 41%，核心算法被鉴定为国际领先水平。在智能推荐领域，构建了覆盖千万实体节点、亿级边关系的超大规模中文实体图谱，提出知识融合预训练冷启动推荐机制，在十亿级用户环境中推荐准确度较国际前沿算法平均提升 16.2%。在交互技术方面，发明视觉知识驱动的数字产品智能生成方法，情感交互类数字人制作效率较传统方式提升 30 倍，并参与制定了情感计算国际标准。

To address fluctuations in computing demand between peak and off-peak periods, as well as energy-consumption challenges in scenarios involving massive user bases, the team moved beyond the conventional centralized scheduling paradigm and developed a millisecond-level Device-Edge-Cloud collaborative scheduling mechanism based on user-behavior segmentation. The mechanism enables elastic balancing of computing capacity across the entire service chain, reducing overall computing-resource consumption by 41%. The core algorithm was determined by an authoritative expert panel to have reached an internationally leading level. For intelligent recommendation, the team constructed a large-scale Chinese entity graph covering tens of millions of entity nodes and hundreds of millions of relational edges, and proposed a knowledge-fusion pretraining mechanism for cold-start recommendation. In a billion-user environment, recommendation accuracy improved by an average of 16.2% over state-of-the-art international algorithms. For interactive technologies, the team developed a visual-knowledge-driven method for intelligent generation of digital products. The production efficiency of affective-interaction digital humans increased by 30 times compared with conventional approaches. The team also participated in the formulation of an international standard for affective computing.



## 全面赋能数字政务、文体、交通等业务，创造显著的经济、社会与生态效益
## The Project Comprehensively Empowers Digital Government, Culture and Sports, Transportation, and Other Sectors, Generating Significant Economic, Social, and Ecological Benefits

该成果已形成高度成熟的技术体系与产业化能力，全面支撑支付宝小程序的稳定运行，深度覆盖政务、出行等多元场景，服务支付宝平台用户。依托该技术底座打造的“智能亚运一站通”平台，在国际大型赛事期间服务注册用户超 1 亿。在生态层面，通过端边云算力调度优化，平台实现同收益下总体算力节省 41%，有效降低基础设施能耗；相关低能耗算法底座支撑公益平台稳定运行，在绿色环保、碳减排等方面发挥了积极作用。

The project has established a mature technology system and robust industrial deployment capabilities, providing stable support for Alipay Mini Programs and extensive coverage across government services, mobility, and other diverse scenarios, cumulatively serving Alipay users. Built on this technology foundation, the SMART HANGZHOU 2022 application platform served more than 100 million registered users during the international sporting event. From an ecological perspective, optimization of Device-Edge-Cloud computing-resource scheduling reduced overall computing-resource consumption by 41% while maintaining equivalent service performance, thereby lowering infrastructure energy consumption. The resulting low-energy algorithmic foundation has also supported the stable operation of public welfare platforms and contributed to environmental sustainability and carbon reduction.




## 推动国际标准与产业生态建设
## The Project Has Contributed to International Standards and Industrial Ecosystem Development

项目成果已在蚂蚁集团、杭州亚组委、上海大数据中心等核心单位实现规模化部署，技术成熟度与可靠性经受了实际用户场景的长期检验。团队参与制定了情感计算国际标准《Information technology — Affective

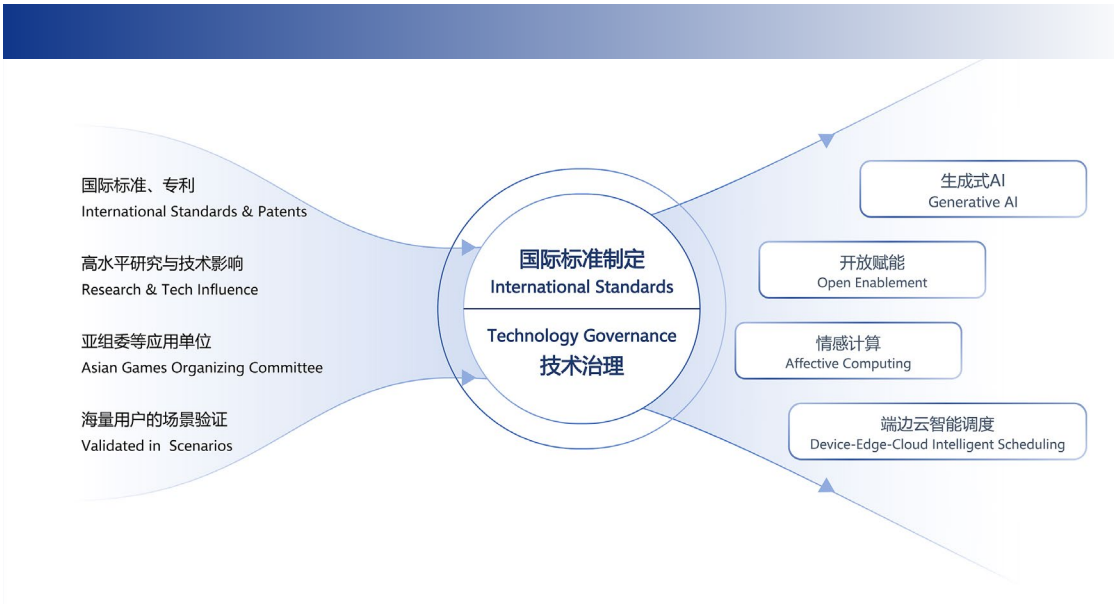
computing user interface (AUI)》(ISO/IEC)，建立了多模态交互领域国际技术规范。经权威专家委员会鉴定，“项目总体技术达到国际先进水平，核心算法达到国际领先水平”。此外，团队相关论文发表于 ICML、KDD、SIGIR 等顶级会议，形成了广泛的国际学术与技术影响力。

The project's outcomes have been deployed at scale across key organizations, including Ant Group, the Hangzhou Asian Games Organising Committee, and the Shanghai Big Data Center. The technology's maturity and reliability have been validated over the long term in real-world user scenarios. The team participated in the formulation of the international standard Information technology-Affective computing user interface (AUI) (ISO/IEC), establishing international technical specifications for multimodal interaction. An authoritative expert panel found the project's overall technology to be internationally advanced and its core algorithms to be internationally leading. Related papers have been published at leading conferences such as ICML, KDD, and SIGIR, generating broad international academic and technological influence.

## 持续推动技术普惠与全球标准化进程
## Continuously Advancing Technology Inclusion and Global Standardization

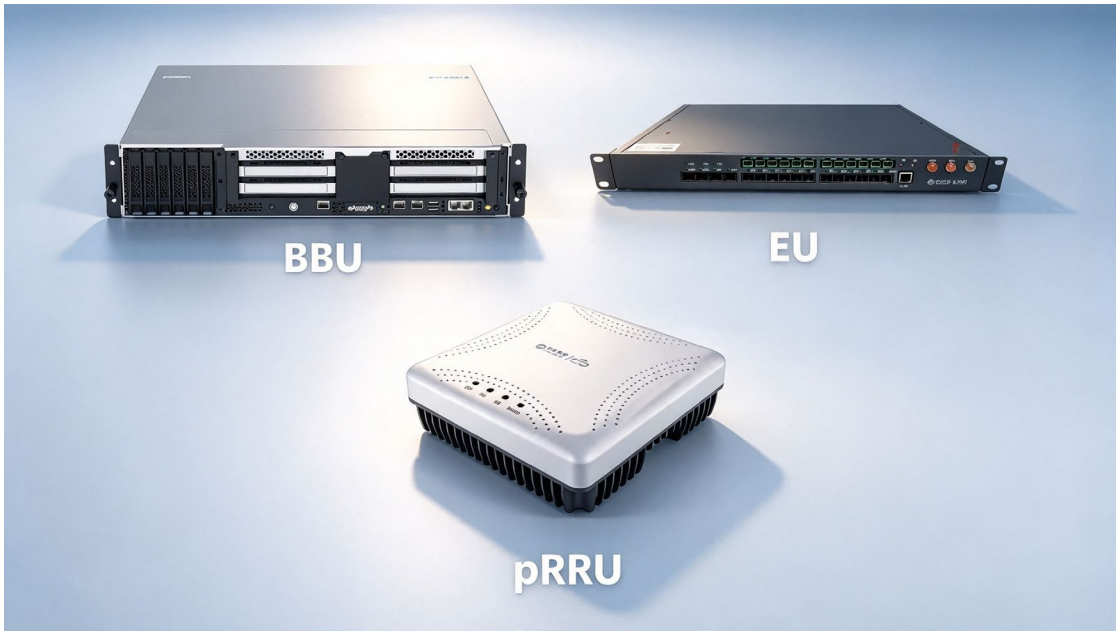
项目团队积极参与全球技术治理，主持和参与制定多项国际、国家及行业标准，涵盖知识图谱构建、互联网金融身份识别等领域，推动多模态智能交互产业的规范化发展。科技查新报告证实，项目提出的核心关键技术具有高度独创性。未来，团队将持续深化端边云智能调度、生成式 AI 与情感计算的融合创新，推动技术成果在全球更广泛领域的应用与赋能。

The team actively participates in global technology governance and has led or contributed to multiple international, national, and industry standards covering areas such as knowledge-graph construction and digital identity verification, supporting the standardized development of the multimodal intelligent-interaction industry. A scientific and technical novelty search confirmed the high originality of the project's core technologies. Going forward, the team will deepen the integration of Device-Edge-Cloud intelligent scheduling, generative AI, and affective computing, promoting the application and broader enablement of these technological outcomes worldwide.



# 面向通算智一体化的中国异构加速关键技术与规模应用

## Key Technologies and Large-scale Application of Chinese Heterogeneous Acceleration Oriented to Integrated Communication, Computing and Intelligence




5G 云基站产品外观
5G Cloud-RAN Base Station Product Appearance

中国移动通信集团设计院有限公司
China Mobile Group Design Institute Co., Ltd.

中国移动通信有限公司研究院
CMRI(China Mobile Research Institute)

## 引言

本成果面向全球无线接入网架构封闭、通算协同不足等难题，原创提出“通用化硬件平台＋抽象化异构加速器”通算智一体无线云架构，构建全栈异构加速技术体系，为推动全球 6G 通算智融合网络演进提供技术实践与解决方案。

## Introduction

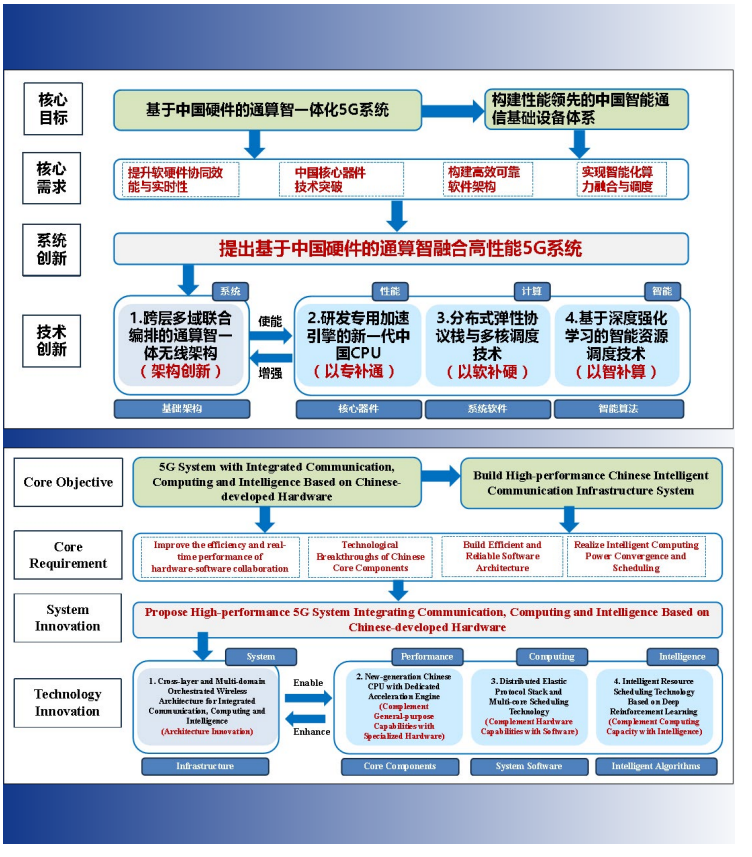
This achievement addresses the common challenges of closed architecture and insufficient coordination in global wireless access networks by originally proposing an integrated communication-computing-intelligence wireless cloud architecture based on “general-purpose hardware platform + abstracted heterogeneous accelerator”. It establishes a full-stack heterogeneous acceleration technology system, providing replicable technical practices and solutions for promoting the global evolution toward 6G integrated communication-computing-intelligence networks.

## 首创通算智一体无线云架构，实现通信、计算、智能跨层多域联合编排与异构加速性能突破

## Pioneering an Integrated Communication, Computing, and Intelligence Wireless Cloud Architecture, Achieving Breakthroughs in Cross-Layer, Multi-Domain Orchestration and Heterogeneous Acceleration Performance

成果原创提出“通用化硬件平台 + 抽象化异构加速器”智能开放云原生无线接入网络架构，经中国电子学会鉴定为国际首创。在架构层面，构建硬件、平台、能力三层贯通及通信、智能、计算三域统一编排的新型体系，通过异构计算虚拟化与池化实现算力动态调度，调度时延降至微秒级，实时性能提升超 95%。在器件层面，创新“以专补通”策略，研发内置 PDCP 加解密硬件加速引擎的 ARM CPU，单核算力提升 100%，处理器性能提升 30%。在软件层面，通过协议栈弹性分布式部署与 PCIe 动态调度，单核 CPU 处理要求降低 50%，电源效率提升 6%。在算法层面，依托深度强化学习与业务感知均衡，算力资源利用率提升超 75%。成果已获授权专利 9 项，整体技术达国际先进水平。

This achievement originally proposes an intelligent open cloud-native radio access network architecture based on “general-purpose hardware platform + abstracted heterogeneous accelerator”, recognized as an international first by the Chinese Institute of Electronics. In architecture, it builds a novel system connecting hardware, platform, and capability layers with unified orchestration across communication, intelligence, and computing domains. Through heterogeneous computing virtualization and pooling, it enables dynamic scheduling of computing resources, reducing scheduling latency to microsecond level with over 95% real-time performance improvement. In devices, innovating a “specialization compensating for generalization” strategy, it develops an ARM CPU with built-in PDCP hardware encryption/decryption acceleration engine, achieving 100% single-core computing power improvement and 30% overall performance enhancement. In software, through elastic distributed protocol stack deployment and PCIe dynamic scheduling, single-core CPU processing requirements are reduced by 50% with 6% power efficiency improvement. In algorithms, leveraging deep reinforcement learning and service-aware balancing, computing resource utilization increases by over 75%. The achievement has been granted 9 patents, with overall technology reaching internationally advanced level.




提出基于中国硬件的通算智融合高性能 5G 系统

Propose High-Performance 5G System Integrating Communication, Computing and Intelligence Based on Chinese-developed Hardware

## 成果已在中国 16 省公网及 5 大垂直行业规模商用，累计创造直接经济效益超 3 亿元

## Achieving Large-Scale Commercial Deployment Across 16 Provinces in Chnia and Five Major Vertical Industries, Generating Over RMB 300 Million in Direct Economic Benefits

成果已在中国 16 省份公网及野外智能勘探、深海养殖、物联网安防等垂直行业规模落地，近三年累计直接经济效益超 3 亿元。打造开放云原生可扩展的新一代无线接入基础设施，为全球通信全产业链提供通用技术底座，推动 6G 通算智融合领域技术共建与标准共研。深度优化能效设计，同等覆盖下日均耗电仅为传统设备 66.89%，显著降低碳排放。搭建通信、计算、智能一体化协同编排底座，支撑泛在人工智能与万物智能互联，催生全新技术业态，为全球数字经济注入核心动能。规模化应用催生智慧海洋、智能勘探等新兴场景，带动技术研发、系统集成、网络运维等多领域人才需求，持续创造高端技术岗位与就业机会，增强信息通信行业对全球经济社会发展的辐射力与牵引力。

The achievement has been deployed in public networks across 16 provinces in China and vertical industries including intelligent field exploration, deep-sea aquaculture, and IoT security, generating cumulative direct economic benefits exceeding RMB 300 million over the past three years. It establishes an open, cloud-native, and scalable next-generation wireless access infrastructure, providing a common technology base for the global industry chain and promoting joint technology development and standardization in 6G communication-computing-intelligence convergence. It deeply optimizes energy efficiency, with average daily power consumption only 66.89% of traditional equipment under the same coverage, significantly cutting carbon emissions. It builds an integrated orchestration platform for communication, computing, and intelligence, supporting ubiquitous AI and intelligent interconnection, creating new technology sectors, and injecting core momentum into the global digital economy. Its large-scale application gives rise to emerging scenarios including smart ocean and intelligent exploration, driving talent demand across technology R&D, system integration, and network operations, continuously creating high-end technical positions and employment opportunities, and strengthening the driving force of the information and communication industry on global economic and social development.

## 成果系统性突破无线接入网共性难题，为全球 6G 通算智融合演进提供可复制技术实践

## Systematically Overcoming Common Challenges in Radio Access Networks and Providing Replicable Technical Practices for the Global Evolution of 6G Communication, Computing, and Intelligence Convergence

成果在技术先进性、投资回报、难点攻克、市场价值与社会效益方面形成系统性优势。NR 单用户上行峰值 248Mbps（较业界提升 19.8%），下行 1700Mbps（提升 25.9%），控制面时延 9ms（提升 55%），用户面时延 7.1ms（提升 29%），核心性能全面优于业界平均。经鉴定整体技术达国际先进水平，智能开放云原生无线接入架构属国际首创，科技查新确认未见相同文献报道。单核处理需求降低 50%，硬件成本下降 30% 以上，单站建设成本较传统降低 51.7%，直接经济效益超 3 亿元。成果已在中国 16 省份及 5 大行业规模商用，推动 5G 从示范向规模化转变，为运营商开辟新增长空间。相关技术于世界移动通信大会等国际展会展示，为全球无线接入网智能化演进提供可借鉴技术实践，具备显著行业示范效应与国际影响力。

The achievement forms systematic advantages in technological advancement, ROI, resolution of key difficulties, market value, and social benefits. NR single-user uplink peak reaches 248 Mbps (19.8% improvement), downlink 1,700 Mbps (25.9% improvement), control-plane latency 9 ms (55% improvement), user-plane latency 7.1 ms (29% improvement), with core performance comprehensively exceeding industry averages. The overall technology has reached internationally advanced level, with the intelligent open cloud-native radio access architecture recognized as an international first, and the sci-tech novelty search confirming no identical literature. Single-core processing requirements are reduced by 50%, hardware costs decreased by over 30%, and construction cost per base station reduced by 51.7%, generating direct economic benefits exceeding RMB 300 million. The achievement has been commercially deployed in 16 provinces in China and 5 major industries, driving 5G from demonstration to large-scale deployment. Related technologies have been showcased at international exhibitions including MWC, providing referable technical practices for the intelligent evolution of global wireless access networks with significant industry demonstration effect and international influence.


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# 面向“一带一路”的网络能力聚合开放服务平台与规模化应用

## Network Capability Aggregation & Open Service Platform for the Belt and Road and Its Large-Scale Application




面向“一带一路”的网络能力聚合开放服务平台
Network Capability Aggregation & Open Service Platform for the Belt and Road

中国联合网络通信集团有限公司
China United Network Communications Group Co., Ltd.

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## 引言

中国联通整合全球运营商资源，建成面向“一带一路”的跨境网络能力聚合开放服务平台，实现跨境金融、车联网、公共服务等领域规模化商用。

## Introduction

By consolidating global operator resources, China Unicom has built a crossborder network capability aggregation and open service platform for the Belt and Road, achieving large-scale commercial deployment in cross-border finance, connected vehicles and public services.

## “平台联邦 + 联盟链”底座、标准化 API 能力聚合、分级管控治理，攻克跨境网络能力开放难题

## A Foundation of “Platform Federation + Consortium Blockchain”, Standardized API Capability Aggregation and Tiered Governance Enable Cross-Border Opening of Network Capabilities

一是打造“平台联邦 + 联盟链”的核心底座。基于面向“一带一路”的跨境网络能力技术基础，深度集成分布式资源调度、异步微服务架构、多级安全鉴权、全域能力编排等前沿技术，构建自主可控、安全可靠的底层技术支撑体系。

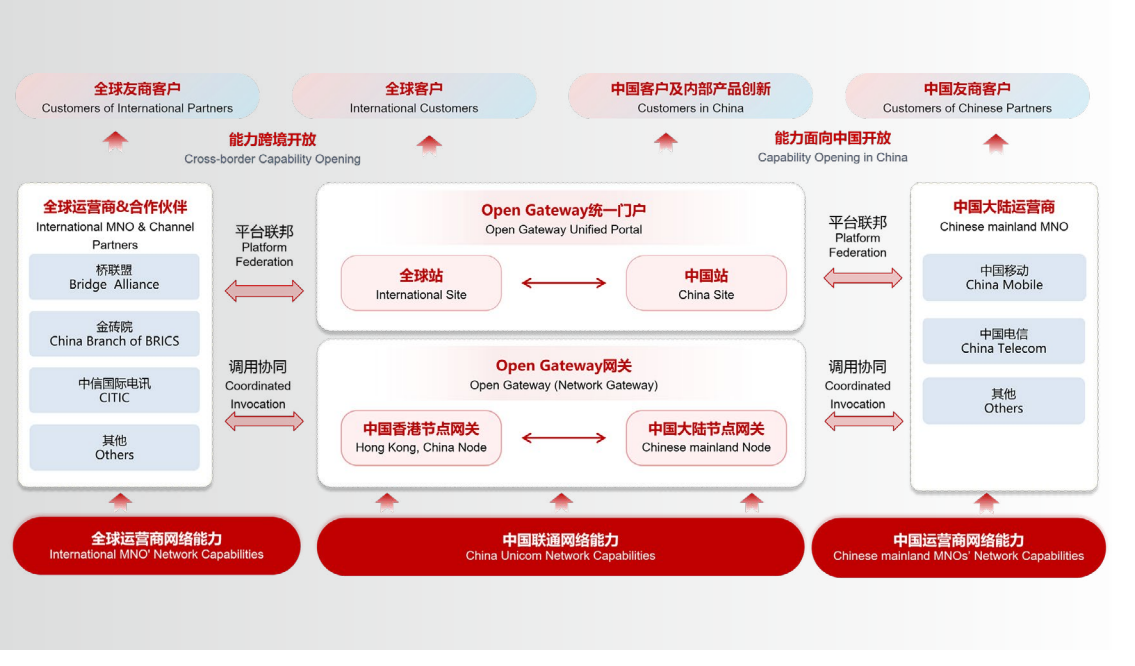
二是标准化 API 能力开放。采用全球统一的 GSMA Open Gateway 标准协议，并搭载 MCP 能力开放架构，为“一带一路”跨境数字合作筑牢长期技术基石，重点覆盖东南亚、欧洲、港澳等区域市场。

三是构建分级管控机制。针对传统跨境网络存在的能力割裂、权限难管控、数据流通缺标准、安全合规风险突出等短板，构建数据定级分类、分级授权准入、全链路行为溯源、全流程安全可控的全域一体化数据治理体系。

First, it builds the core foundation of “platform federation + consortium blockchain”. Based on the cross-border network capability technology foundation for the Belt and Road, it deeply integrates advanced technologies including distributed resource scheduling, asynchronous microservice architecture, multi-level security authentication and end-to-end capability orchestration, and establishes an autonomous, controllable, secure and reliable underlying technical support system.

Second, it opens capabilities through standardized APIs. Adopting the globally unified GSMA Open Gateway standard protocol and equipped with an MCP capability opening architecture, it lays a long-term technical foundation for Belt and Road cross-border digital cooperation, with a focus on regional markets in Southeast Asia, Europe, and Hong Kong and Macao, China.

Third, it establishes a tiered governance mechanism. To address the shortcomings of traditional cross-border networks, including fragmented capabilities, hard-to-control permissions, absence of standards for data flows and prominent security and compliance risks, it builds a full-domain integrated data governance system featuring data classification and grading, tiered authorization and access control, end-to-end behavior traceability and full-process security control.




中国联通 Open Gateway 网络能力开放平台系统架构
China Unicom Open Gateway Capability Platform System Architecture

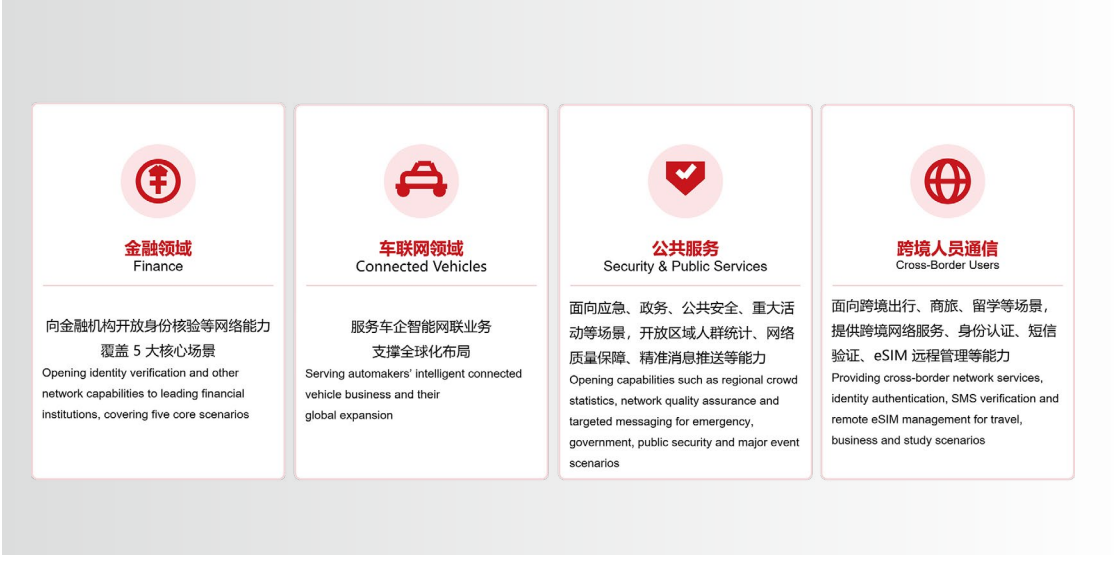
## 规模化商用，跨境网络能力变现超 3.94 亿元
## Large-Scale Commercial Deployment Delivers over 394 Million Yuan in Network Capability Monetization

在能力建设方面，平台已对接全球 30 余家主流运营商，上架 119 项标准化网络能力 API，覆盖全球 100 余个市场，触达超 20 亿移动用户。两年间平台网络能力商业变现超 3.94 亿元，API 年调用量突破 16.92 亿次。

在行业应用方面，平台面向金融行业，服务 30 余家头部机构，人工校验成本降低 60%，业务办理效率提升 50%。在车联网领域，服务 92 家车企、覆盖 8730 万联网车辆，市场覆盖率超 70%，单车数字化服务成本下降 35%。面向应急、公共服务和重大活动，完成超百次安全保障任务，身份冒用拦截率不低于 99%，异常欺诈封堵率超 99.5%，年均服务千万级跨境出行人员和留学人员。

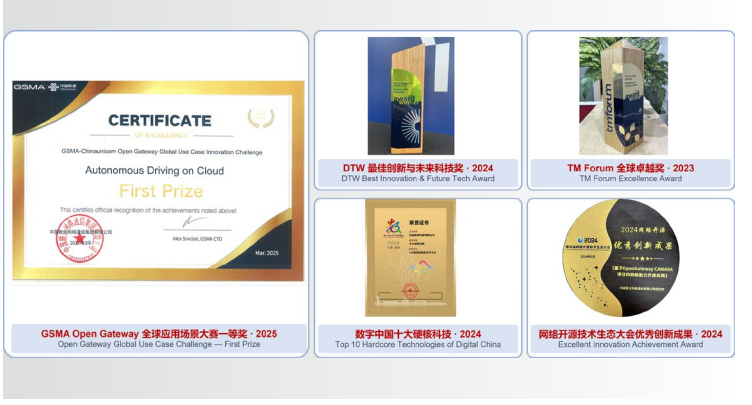
From the perspective of capability building, the platform has connected more than 30 leading global operators and launched 119 standardized network-capability APIs. It covers over 100 global markets and reaches more than 2 billion mobile users. Within two years, network-capability monetization has exceeded 394 million yuan, with annual API calls surpassing 1.692 billion.

In industry applications, it serves more than 30 leading financial institutions, cutting manual-verification costs by 60 % and improving processing efficiency by 50 %. In the connected-vehicle sector, it serves 92 automakers, covering 87.3 million connected vehicles, with market coverage exceeding 70 % and per-vehicle digital service cost reduced by 35 %. For emergency response, public services and major-event scenarios, it has completed more than 100 security assignments. It achieves an identity-theft interception rate of no less than 99 % and a fraud-blocking rate of over 99.5 %. It serves millions of cross-border travelers and overseas students every year.




平台跨境多领域典型应用场景
Typical crossborder multisector application scenarios of the platform

# 构建全球开放协作生态，输出网络能力开放实践方案
# Building a Global Open Collaboration Ecosystem and Delivering Replicable Practices




国际奖项与荣誉
International Awards and Honors




| # | API（中 / 英） | 所属 Portfolio | 版本 | 发布日期 |
|---|---|---|---|---|
| 01 | 区域设备数量 Region Device Count | Location Services | v0.2.0 | 2025-09-15 |
| 02 | 网络切片预订 Network Slice Booking | Communication Quality | v0.2.0 | 2026-06-04 |
| 03 | 签约状态 Subscription Status | Auth. & Fraud Prevention | v0.1.0 | 2025-09-15 |
| 04 | 网络健康度评估 Network Health Assessment | NetworkInsights | v0.1.0 | 2026-06-25 |
| 05 | 网络流量分析 Network Traffic Analysis | NetworkInsights | v0.1.0 | 2026-06-25 |
| 06 | 网络切片分配 Network Slice Assignment | Communication Quality | v0.1.0 | 2026-06-04 |

部分论文、专利与 GSMA API 标准化建设情况
Selected Papers, Patents and GSMA API Standardization




国际交流与创新大赛现场：行动计划发布、大赛启动与颁奖、伙伴闭门交流
Global Engagement: Plan Launch, Innovation Challenge Kick-off and Awards, Partner Exchange

项目斩获 TM Forum 全球卓越奖、GSMA Open Gateway 全球应用场景设计开发大赛一等奖等国际奖项，入围 2026 MWC 全球移动大奖短名单。

团队主导十余项国际 API 标准立项，其中 6 项已在 CAMARA 正式发布；7 项 API 通过 GSMA Open Gateway 认证；牵头制定 TM Forum 全球首个《Open Gateway 自智运营框架》；申请专利 40 余项，发表论文 20 余篇。

中国联通作为 GSMA Open Gateway 中国工作组主席单位，发起全球创新赛事，吸引来自 23 个国家的 140 余支团队参与。成果在 MWC 巴塞罗那、MWC 上海、世界互联网大会发布，媒体报道 5203 篇，技术方案被全球多家运营商借鉴。

The project has received international awards including the TM Forum Excellence Award and the First Prize of the GSMA Open Gateway Global Use Case Innovation Challenge, and has been shortlisted for the 2026 MWC Global Mobile Awards.

The team has led more than 10 international API standard initiatives, six of which have been released by CAMARA; seven APIs have passed GSMA Open Gateway certification; it led the development of the world's first TM Forum Open Gateway Autonomous Operation Framework; more than 40 patent applications have been filed and more than 20 papers published.

As Chair of the GSMA Open Gateway China Working Group, China Unicom has launched a global innovation challenge attracting more than 140 teams from 23 countries. Presented at MWC Barcelona, MWC Shanghai and the World Internet Conference, with 5,203 media reports worldwide, its technical solutions have been referenced by multiple operators worldwide.

# 全球首个多智能体协同的超大规模省级电网 AI 调度员明月

## Mingyue: The World's First AI Dispatcher for Ultra-Large-Scale Provincial Power Grids Based on Multi-Agent Collaboration




AI 调度员“明月”
Mingyue, AI Dispatcher

广东电网有限责任公司电力调度控制中心
Guangdong Power Grid Co., Ltd. Power Dispatch and Control Center

香港中文大学（深圳）
The Chinese University of Hong Kong (Shenzhen)

深圳市人工智能与机器人研究院
Shenzhen Institute of Artificial Intelligence and Robotics for Society (AIRS)

国电南瑞科技股份有限公司
NARI Technology Co., Ltd.

## 引言

为了响应国家新型电力系统建设与电力现货市场改革战略，电力调度面临控制对象激增、运行场景多变等挑战，本项目由广东电网等单位共同研发，是全球首个“多智能体协同、大小模型协同”的省级电网 AI 代人调度体系。

## Introduction

In response to the national strategy for developing a new power system and reforming the electricity spot market, power dispatching is confronted with challenges such as a sharp surge in controlled objects and diverse operating scenarios. Jointly developed by organizations including China Southern Power Grid Guangdong Power Grid, this project delivers the world's first provincial-level grid AI human-replacing dispatching system featuring “Multi-agent Collaboration and the Synergy of Large and Small Models”.

## 全球首个多智能体协同的超大规模省级电网 AI 调度员明月

## World's First Multi-Agent Collaborative Ultra-Large-Scale Provincial Power Grid AI Dispatcher Mingyue

核心技术成果包括：一是实现了全景降维感知，利用多模态大模型技术，将电网海量异构数据处理正确率提升至 99.7%；二是建立了高可信决策机制，融合物理 - 因果双重引导技术，将复杂故障决策时间由小时级降至 1 分钟以内，方案可执行率达 98.8%；三是实现了精准协同控制，通过分层多智能体架构，实现了源网荷储的秒级响应。

发表 SCI 等高水平论文、获得专利等知识产权 178 项，由中国人工智能学会举办的应用场景创新挑战赛总决赛特等奖、全国人工智能应用场景典型案例，在核心技术架构创新、物理因果理论创新、跨模态融合方法创新、基于国产大模型底座的工程创新及产学研用一体化的协作模式创新等五个维度实现了创新与突破，经鉴定，项目整体达到国际领先水平。

Its core technical achievements are as follows. First, panoramic dimensionality reduction perception is realized. By adopting multimodal large model technology, the processing accuracy of massive heterogeneous power grid data has been raised to 99.7%. Second, a high-reliability decision-making mechanism is established. Integrating physical-causal dual guidance technology, it reduces the decision-making time for complex faults from the hour level to less than one minute, with an implementable scheme rate of 98.8%. Third, precise collaborative control is achieved. With a hierarchical multi-agent architecture, second-level response of source-grid-load-storage is realized.

The project has published high-level papers including SCI papers and obtained 178 intellectual property rights such as patents. It was awarded the Grand Prize at China's Innovation Challenge on Artificial Intelligence Application Scene (CICAS) and was selected as a National Typical Case of AI Application Scenarios. Innovations and breakthroughs have been made in five dimensions: innovation in core technical architecture, innovation in physical-causal theory, innovation in cross-modal fusion methods, engineering innovation based on domestic large model foundation, and innovation in the integrated industry-university-research-application collaboration model. Appraisal results show that the overall technology of the project reaches the internationally advanced level.


全国人工智能应用场景创新挑战赛

获奖证书

参赛单位：广东电网有限责任公司电力调度控制中心、香港中文大学（深圳）、深圳市人工智能与机器人研究院、南京南瑞信息通信科技有限公司

项目名称：超大规模电网多智能体协同高可信 AI 调度关键技术及应用

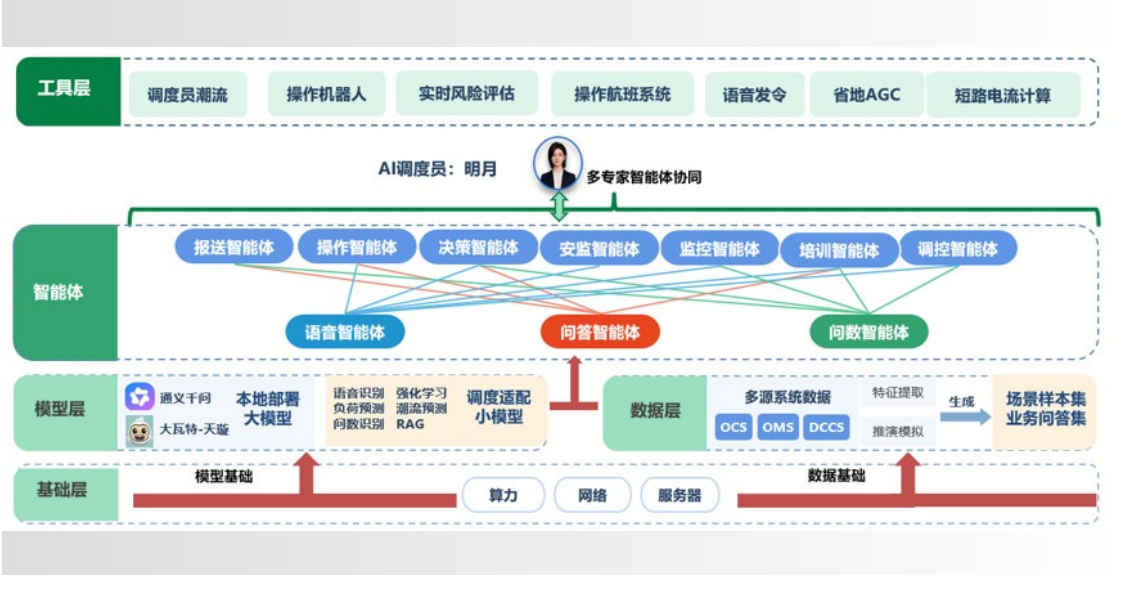
项目负责人：郭乾

项目成员：黄建伟、江里舟、赵俊华、董锴、孟子杰、蔡新雷、陈章国、庞凯元、喻振帆、侯珏、程裕恒、吴居晋、闵梦帆、沈思琦

您在 全国总决赛 中，荣获成长组 特等奖。

证书编号：CICAS-2025ZJS-CZ-TD

全国人工智能应用场景创新挑战赛总决赛特等奖
Grand Prize of China International Competition for AI Application Scenarios (CICAS)




大小模型协同、多智能体协同架构图
Multi-agent Collaboration and Collaboration Between Large and Small models

## 明月于 2025 年 4 月正式上线，已在广东电网省地调度、变电站、电厂新能源厂站全面推广，经济社会效益显著

## Mingyue Officially Launched in April 2025, Fully Deployed Across Guangdong Power Grid with Significant Economic and Social Benefits

明月于 2025 年 4 月正式上线，已在广东电网省地调度、变电站、电厂新能源厂站全面推广，典型应用场景包括：

1. 在多重复杂故障场景下，事故分析和应急处置效率由小时级缩短至分钟级，及时保障人民群众以及电网资产安全。

2. 针对电网设备计划检修，AI 调度操作序列自动生成、全链条智能执行，实现安全风险事件双清零，效率提升 75%。

3. 针对调度电话业务，通过智能语音系统多智能体协同实现省地协同安监高效， 2025 年市场操作合规率 100%。

核心调度业务智能运作覆盖率达 95% 以上，人机协同准确率 100%，年均新增经济效益超过 1.3 亿元，促消纳、提效能、保安全等方面产生巨大社会效益，获得 CCTV、新华社、央广网等主流媒体报道，是电力行业 AI 垂直落地的标杆。




全运会期间获 CCTV 频道采访 AI 调度员系统运行

The AI dispatcher system was interviewed by CCTV during the National Games for its operation




获得 CCTV、新华社、央广网、南方电网、电力工业网等主流媒体报道

The AI dispatcher system was covered by major media outlets including CCTV, Xinhua News Agency, CNR, China Southern Power Grid, and China Electric Power Industry Network

Mingyue was officially launched in April 2025 and has been fully deployed across provincial and prefectural power dispatching centers, substations, and new energy power plants under Guangdong Power Grid. Its typical application scenarios are as follows:

1.Under multiple complex fault conditions, the efficiency of accident analysis and emergency response has been shortened from the hour level to the minute level, effectively safeguarding public safety and power grid assets.

2.For scheduled maintenance of power grid equipment, the AI automatically generates dispatching operation sequences and executes them intelligently across the whole workflow, achieving zero safety risk incidents in both categories and boosting efficiency by 75%.

3. For dispatching telephone services, multi-agent collaboration of the intelligent voice system enables efficient safety supervision in provincial-prefectural coordination, with a 100% compliance rate of market operations in 2025.

The intelligent operation coverage of core dispatching businesses exceeds 95%, and the human-machine collaboration accuracy reaches 100%. The project generates an annual incremental economic benefit of over 130 million yuan. It delivers substantial social benefits in promoting renewable energy consumption, improving operational efficiency and ensuring grid safety. Covered by mainstream media including CCTV, Xinhua News Agency and China National Radio Network, Mingyue serves as a benchmark for vertical AI implementation in the power industry.

## 经济效益和社会效益
## Economic And Social Benefits

1. 经济效益：

(1) 成本节约：“明月”系统目前每天替代超 1000 人次调度员进行拟票工作，将拟票时间缩短了 95%，人力成本节省约 80%，年均新增经济效益超过 1.5 亿元。

(2) 灾害损失：挽回在“桦加沙”台风等极端灾害中，成功挽救了珠三角地市负荷，避免上百万居民停电，挽回经济损失超 48 亿元。

2. 社会效益：

(1) 安全稳定：系统实现了全天候智能监控百万数量级电力设备，支撑电网频率、电压的安全稳定。

(2) 效率提升：相比人工或规则化流程，感知效率提升约 200 倍、方案生成效率提升约 30 倍。

(3) 助力低碳: 通过精准协同控制与源网荷储高效互动，新能源消纳能力提升 28%，产生巨大的生态环境效益。

1. Economic Benefits

(1) Cost Savings: The Mingyue system currently replaces more than 1,000 dispatcher-person-days of ticket preparation work daily. It cuts ticket preparation time by 95% and reduces labor costs by approximately 80%, delivering an annual incremental economic benefit of over 150 million yuan.

(2) Disaster Loss Mitigation: During extreme disasters such as Typhoon Ragasa, the system successfully preserved power loads in cities of the Pearl River Delta, prevented power outages for over one million residents, and recovered economic losses exceeding 4.8 billion yuan.

2. Social Benefits

(1) Safety and Stability: The system enables round-the-clock intelligent monitoring of millions of power equipment units, supporting the safe and stable control of grid frequency and voltage.

(2) Efficiency Improvement: Compared with manual work or rule-based workflows, the perception efficiency is boosted by roughly 200 times, and the scheme generation efficiency rises by around 30 times.

(3) Low-carbon Empowerment: Through precise collaborative control and efficient source-grid-load-storage interaction, the system increases new energy accommodation capacity by 28%, bringing substantial ecological and environmental benefits.



# 算力互联互通关键技术体系及在国际科研合作中的规模化应用

## Key Technologies for Computing Power Interconnection and Its Large-scale Application in International Scientific Research Cooperation




中国信息通信研究院
China Academy of Information and Communications Technology

中国科学院计算机网络信息中心
Computer Network Information Center, Chinese Academy of Sciences

生态环境部信息中心
Information Center of Ministry of Ecology and Environment

湖南大学
Hunan University

## 引言

面向全球跨区域算力协同需求，成果构建覆盖中国 265 座城市并联接欧洲、东盟、非洲、澳大利亚、日本的算力互联体系，汇聚 455 EFLOPS 资源，实现跨洲异构算力统一接入、智能调度与协同，支撑国际科研合作和低碳发展。

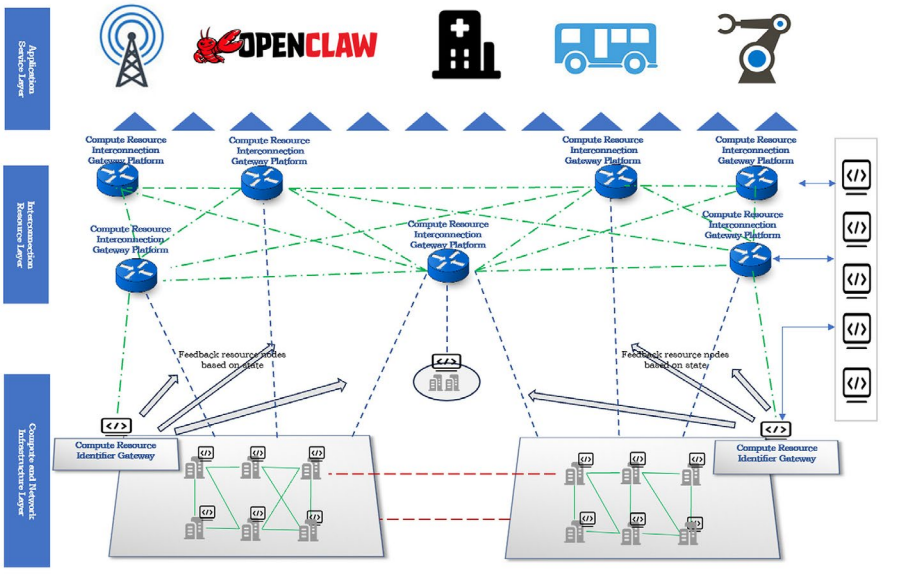
## Introduction

In response to the global demand for cross-regional computing-power collaboration, the initiative has established a computing-power interconnection system spanning 265 Chinese cities and linking Europe, ASEAN, Africa, Australia, and Japan. Aggregating 455 EFLOPS of computing resources, this system enables the unified access, intelligent scheduling, and coordinated orchestration of cross-continental heterogeneous computing infrastructure, thereby underpinning international scientific research collaboration and low-carbon development.

## 以统一架构、无状态 RDMA、极速调度和云原生互联，突破跨域异构算力协同瓶颈
## Breaking Through Bottlenecks in Cross-Domain Heterogeneous Computing Collaboration with a Unified Architecture, Stateless RDMA, Ultra-Fast Scheduling, and Cloud-Native Interconnection

算力互联互通工程体系遵循“分层解耦、协同闭环”原则，聚焦架构、传输、调度、适配，形成四项原创技术创新，多项技术指标达到国际先进水平，攻克异构算力难兼容、跨域网络难协同、大规模 RDMA 并发性能下降、万节点路由计算与故障恢复慢、云原生容器跨域通信延迟高等难题。构建“统一标识、统一调度、统一传输”三层算网融合架构，实现算力资源可发现、可匹配、可调度、可传输，相关成果形成 ITU-T、GSMA 2 项国际标准。提出高扩展无状态 RDMA 技术，吞吐量达原生硬件网卡 4.13 倍，跨域 RDMA 平均吞吐量提升 30% 以上。首创万节点级拓扑模式路由查表技术，将路由计算开销降至数十微秒，故障自愈时间控制在 33 毫秒以内。提出云原生算力跨域高速互联技术，容器跨域建连速度提升 2.1 倍。相关成果被 IEEE 相关会议和期刊录用或发表，并获国际发明展银奖及中国通信学会科技奖二等奖。

The engineering system for computing power interconnection follows the principle of “layered decoupling and collaborative closed-loop.” Focusing on architecture, transmission, scheduling, and adaptation, it incorporates four original technological innovations, with multiple technical indicators reaching internationally advanced levels. It addresses key challenges including the incompatibility of heterogeneous computing resources, difficulties in cross-domain network coordination, RDMA performance degradation under massive concurrent connections, slow routing computation and fault recovery in networks with tens of thousands of nodes, and high latency in cross-domain cloud-native container communication. A three-layer computing-network convergence architecture featuring “unified identification, unified scheduling, and unified transmission” has been developed, enabling computing resources to be “discoverable, matchable, schedulable, and transmissible.” The related achievements have resulted in two international standards under ITU-T and GSMA. A highly scalable stateless RDMA technology has been proposed, achieving 4.13 times the throughput of native hardware network cards and improving average cross-domain RDMA throughput by more than 30%. A topology-pattern-based routing table lookup technology has been pioneered for networks with tens of thousands of nodes, reducing routing computation overhead to tens of microseconds and controlling fault self-healing time within 33 milliseconds. A cloud-native high-speed cross-domain computing interconnection technology has also been proposed, improving cross-domain container connection establishment speed by 2.1 times. Related results have been accepted by or published in relevant IEEE conferences and journals. The achievement has received a Silver Medal at an international invention exhibition and the Second Prize of the Science and Technology Award of the China Institute of Communications.



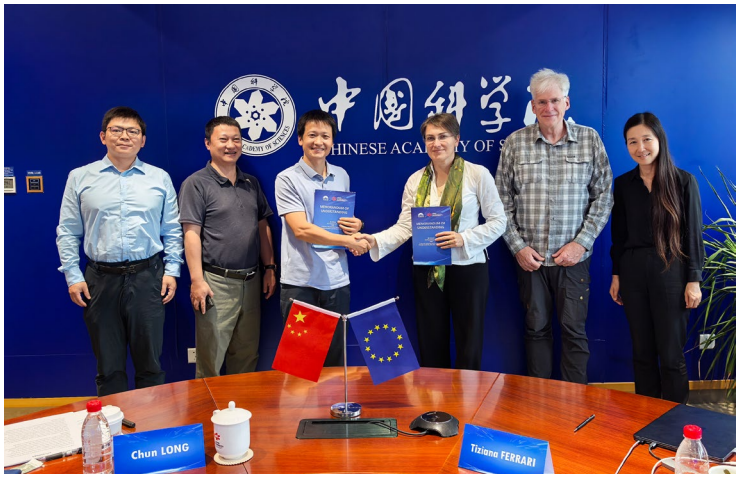

“统一标识、统一调度、统一传输”三层算网融合架构
Three-Layer Converged Computing-Network Architecture Featuring Unified Identification, Unified Scheduling, and Unified Transmission

## 算力互联互通赋能规模化应用
## Enabling Large-Scale Applications through Computing Power Interconnection

成果构建全球化算力互联互通调度体系，通过跨服务商资源汇聚、跨域智能检索，打破公有云、智算中心与边缘算力资源孤岛，实现异构算力一站式接入和全域互联。基础设施覆盖中国 265 座城市（含香港、澳门）及欧洲、东盟、非洲、澳大利亚、日本，汇聚 455 EFLOPS 算力，累计完成 2000 万卡时任务、750 万次需求调度，提升资源利用率与配置效率，带动上下游经济效益超 10 亿元。依托 GÉANT、AARNet、SINET 及 EGI 节点，形成跨洲科研云算资源池，支撑 AI 研发、大数据分析、生态环境决策、国际赛事、“一带一路”监测和开放科学云建设，促进中欧空间物理等合作。通过高效调度降低无效计算、网络冗余和能耗，依托高海拔岩洞算力舱完成高原绿色算力试验，获2025国际发明展银奖，为全球算力基础设施低碳可持续发展提供实践路径。




全球算力互联互通
Global Computing Power Interconnection




与欧盟计算网格建立资源互通合作
Establish resource interconnection and cooperation with the European Union Grid Computing Network

This achievement has established a global computing power interconnection and scheduling system. Through cross-provider resource aggregation and intelligent cross-domain discovery, it breaks down resource silos among public clouds, intelligent computing centers, and edge computing, enabling one-stop access to heterogeneous computing resources and full-domain interconnection. The infrastructure covers 265 cities in China, including Hong Kong and Macao, China, and connects Europe, ASEAN, Africa, Australia, and Japan. It aggregates 455 EFLOPS of computing resources and has cumulatively completed 20 million accelerator-card hours of task scheduling and 7.5 million computing-demand scheduling operations, improving resource utilization and allocation efficiency and generating more than RMB 1 billion in economic benefits across upstream and downstream industries. Through connections to GÉANT, AARNet, SINET, and EGI nodes, it has formed an intercontinental cloud-based scientific computing resource pool supporting AI research and development, big-data analysis, ecological and environmental decision-making, major international events, Belt and Road monitoring, and Open Science Cloud development, while facilitating China-Europe space physics collaboration. Efficient scheduling reduces ineffective computation, redundant network traffic, and energy consumption. Using high-altitude cavern-based computing cabins, the project completed a plateau green-computing interconnection experiment and received a Silver Medal at the 2025 International Invention Exhibition, providing a practical pathway for the low-carbon and sustainable development of global computing infrastructure.

## 以国际标准、科研网络和人才合作，推进开放可信的全球算力生态

## Advancing an Open and Trusted Global Computing Ecosystem through International Standards, Research Networks, and Talent Collaboration

本成果在算力互联关键技术领域实现突破，多项指标达到国际先进水平，为全球算力网络升级提供标准化方案。主导立项 ITU-T 跨区域计算资源连接国际标准，获巴西、赞比亚、尼日利亚等国家代表认可；参与 GSMA Open Gateway，形成“1 项国际标准 +10 项配套标准”（5 项进入报批），覆盖能力、接口和调度规则，并研发 CNCOS、AICOS、oneRDMA 等基础软件。成果获 Torsten Hoefler、Mahesh K. Marina 等国际学者引用评价；与 EGI、AICAD 合作，近三年为肯尼亚等国 180 余名从业者开展培训，推动全球南方数字能力建设。依托中国—东盟项目及全球产业交流平台，促进标准互通、设施互联、产业协同和算力生态融合。




APAN56 签约现场
Signing Ceremony at APAN56




算力标识推广签约
Signing Ceremony for the Promotion of Computing Resource Identifiers

This achievement delivers breakthrough innovations in key computing interconnection technologies, with multiple indicators reaching internationally advanced levels and providing a standardized solution for upgrading global computing networks. It led the initiation of an ITU-T international standard on cross-regional computing resource connection, which has received recognition from the representatives of Brazil, Zambia, Nigeria, and other countries. Through participation in the GSMA Open Gateway initiative, it helped establish a standards framework comprising one international standard and ten supporting standards, five of which have entered the approval process, covering capability requirements, interfaces, and scheduling rules. The team also developed the CNCOS cloud orchestration system, AICOS AI cloud operating system, and oneRDMA high-performance protocol. The work has been cited and positively evaluated by international scholars including Torsten Hoefler and Mahesh K. Marina. Through cooperation with EGI and AICAD, it has trained more than 180 practitioners in Kenya, Ethiopia, South Africa, Mongolia, and other regions through regular online and in-person technical programs over the past three years, supporting digital capacity building in the Global South. Through the China-ASEAN project and global industry platforms, it promotes standards interoperability, facility interconnection, industrial collaboration, and integration of the global computing ecosystem.

# 兴微达：基于人工智能制药工艺算法与智能化制药技术平台

## Nuevida: AI-Driven Pharmaceutical Process Algorithms and Intelligent Drug Manufacturing Platform




首创“AI+ 机理”双驱动制药算法模型技术平台

AI and mechanistic models jointly optimize pharmaceutical processes and support scale-up

兴微达有限公司
Nuevida Limited

## 引言

Nuevida 构建 AI 与机理模型双驱动的智能制药工艺平台，将化学工程、制药工程、数据建模与设备设计相结合，为原料药、制剂及药械组合产品提供从实验室研发、工艺放大到商业化转移的一体化解决方案。

## Introduction

Nuevida integrates artificial intelligence, mechanistic modeling, pharmaceutical engineering and equipment design. The platform supports active ingredients, formulations and drug-device combination products from laboratory development and process scale-up through commercial transfer.

## “AI+ 机理”双驱动，让制药工艺从经验试错走向可解释预测

## Dual AI and Mechanistic Modeling Makes Process Development Explainable and Predictive

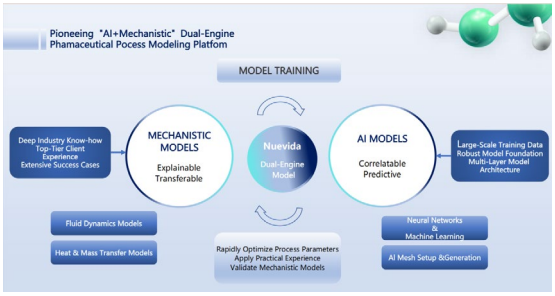
传统制药工艺开发依赖专家经验和多轮实验，跨尺度放大时还会受到流体行为、传热传质、物料属性和设备差异的共同影响。Nuevida 将流体力学、传热传质等机理模型与神经网络、机器学习模型耦合，以数据训练、机理约束和实验验证形成可解释、可关联、可预测、可推广的多层模型架构，用于快速优化关键工艺参数。平台进一步建设覆盖原料药、制剂与分析的 AI 制药工艺模型工厂，将实验室、中试和商业化生产数据沉淀为可复用模型。根据项目材料，平台已积累 200 余个研发制药模型，覆盖鼻脑给药、透皮控释、口服定位、眼部给药、连续流制造和结晶开发等领域。




开创性建立国内首个 AI 制药工艺模型工厂
Pioneering China's First AI Pharmaceutical Process Model Factory

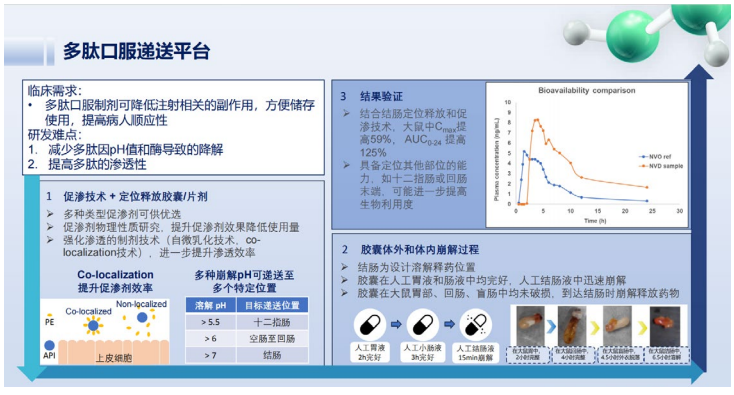
Conventional pharmaceutical process development often depends on expert judgment and repeated experiments, while scale-up is affected by fluid behavior, heat and mass transfer, material properties and equipment differences. Nuevida couples mechanistic models with neural networks and machine learning. Data training, mechanistic constraints and experimental validation create a multilayer architecture that is explainable, connected, predictive and transferable. Its model factory spans active pharmaceutical ingredients, drug products and analytics. According to company materials, more than 200 development models have been accumulated across targeted delivery, transdermal release, continuous flow and crystallization.

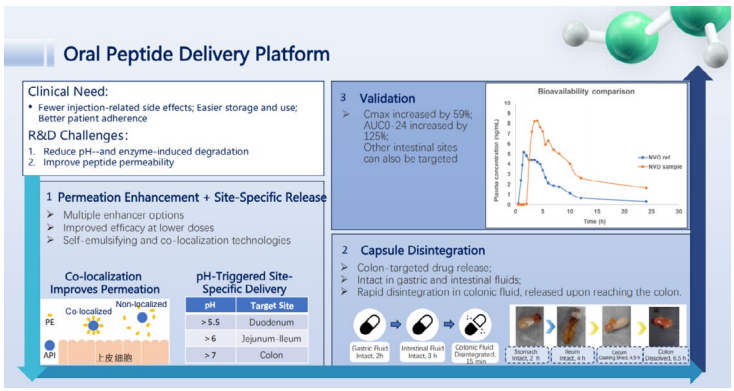



## 以精准递送与工程放大提升候选药物的可开发性
## Precision Delivery and Engineering Scale-up Improve Developability

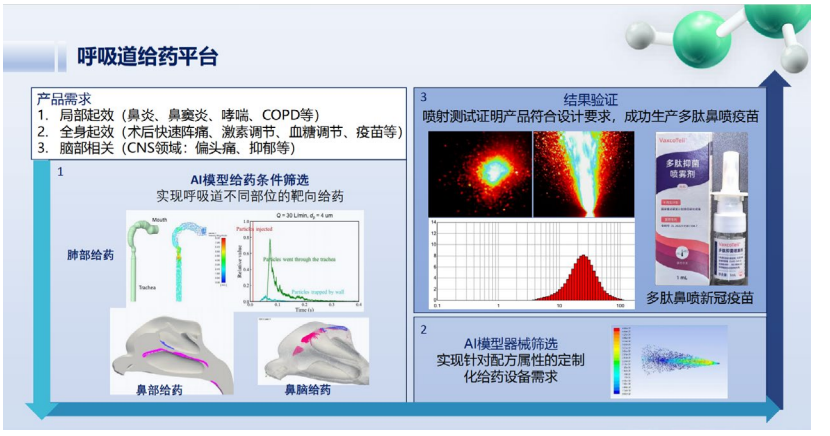
成果已具备较成熟的应用实施基础，形成覆盖 CMC 开发、工艺优化、放大生产、设备设计与技术转移的“工艺 + 设备”一体化服务链，并具备眼用溶液、片剂、胶囊剂、鼻喷雾剂等多剂型开发能力。多肽口服递送方案已完成动物验证，大鼠研究中 Cmax 提高 59%、AUC0-24 提高 125%；呼吸道平台可利用 AI 筛选给药条件和器械，支持鼻部、鼻脑及肺部靶向递送。经济方面，模型、制剂与装置协同设计可减少反复试验，缩短研发、放大和技术转移周期，降低原料、设备及试错成本。社会方面，新型口服和呼吸道给药方式有助于减少注射不便，提高患者依从性，拓展多肽药物应用。生态方面，可减少实验材料、溶剂、能源消耗及废弃物产生。该技术面向创新药、改良型新药及仿制药企业，具备研发服务、设备设计、技术转移和管线开发等市场价值。

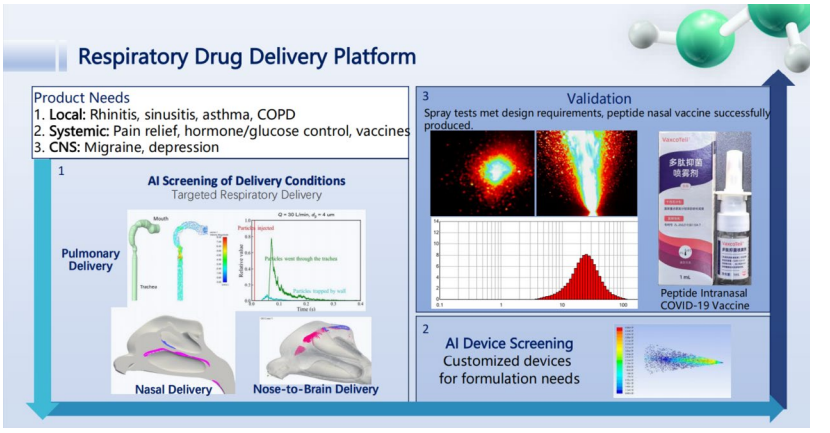



The platform is ready for practical implementation, offering integrated “process + equipment” services from CMC development and process optimization to scale-up, equipment design and technology transfer. It supports multiple dosage forms, including tablets, capsules, nasal sprays, injections and oral films. Its oral peptide delivery system increased Cmax by 59% and AUC0-24 by 125% in rats, while its AI-enabled respiratory platform supports nasal, nose-to-brain and pulmonary targeting.

By integrating models, formulations and devices, the platform reduces experimental iterations, development time, scale-up risks and costs. It can also lower material use, energy consumption and laboratory waste. Its delivery technologies may reduce injection burden, improve patient adherence and broaden peptide-drug applications. The platform offers clear market value in R&D services, equipment design, technology transfer and pipeline development.




## 以跨学科平台连接全球药物研发与产业化
## A Cross-Disciplinary Platform Connects Drug Development with Industrialization

Nuevida 依托化学工程、制药工程、人工智能和药物开发交叉团队，面向创新药、改良型新药、仿制药及生物技术企业提供研发与产业化服务。平台已服务 10 余家大型药企，形成 10 余类产品谱系，并积累了中美项目运营及从研发到商业化的协同经验。其服务覆盖原料药、中间体和制剂的工艺开发、放大生产、设备设计与技术转移，可通过模型、制剂和设备协同优化，减少反复试验，缩短研发及放大周期，降低开发成本和产业化风险。平台还与晶泰科技在口服多肽领域开展合作，将 AI 多肽研发与定位释放、促渗技术结合，推动多肽药物向更便捷的口服给药方式拓展，有助于减轻患者注射负担、提高用药依从性，并加快自免、代谢等领域产品的成果转化与市场应用。

Nuevida brings together expertise in chemical engineering, pharmaceutical engineering, artificial intelligence, and drug development to support innovative drug developers, generic pharmaceutical companies, and biotechnology firms. The platform has served more than 10 major pharmaceutical companies, established over 10 product categories, and gained experience in China–US operations and end-to-end development from R&D to commercialization. Its services cover process development, scale-up, equipment design, and technology transfer for APIs, intermediates, and drug products. By integrating predictive models, formulation development, and equipment design, the platform helps reduce repeated experiments, shorten development and scale-up timelines, lower costs and commercialization risks, and improve technology transfer efficiency. Nuevida has also partnered with XtalPi to combine AI-enabled peptide discovery with targeted release and permeation-enhancement technologies, supporting the development of convenient oral peptide therapies. This may reduce patients' reliance on injections, improve treatment adherence, and accelerate the commercialization of therapies for autoimmune and metabolic diseases.

## 商业模式

| nuevida | 研发服务 | 管线开发 |
|---|---|---|
| 目标客户 | 生物技术公司 / 生物制药公司<br>创新药企 / 仿制药企业 | 创新药企 / 仿制药企业 |
| 产品内容 | 面向原料药、中间体和制剂的研发解决方案：包括 CMC 开发、放大生产、设备设计等 | 已具备商业化条件的药品 / IND 后药品 |
| 收益模式与定价方式 | 按项目计费 / 咨询费用 / 设备销售 / 里程碑付款 / 一次性付款 / 利润分成 | 一次性付款 / 里程碑付款 / 利润分成 |

## Business Model

| nuevida | R&D Services | Pipeline Development |
|---|---|---|
| Customers | Biotech / Pharma<br>Innovative & Generic Drug Companies | Innovative<br>&<br>Generic Drug Companies |
| Offerings | API, Intermediate & Formulation R&D<br>CMC, Scale-Up & Equipment Design | Commercial-Ready<br>/ Post-IND Products |
| Revenue Model | Project / Consulting / Equipment Fees<br>Milestones / Upfront Payments<br>/ Profit Sharing | Upfront / Milestones<br>/ Profit Sharing |

## 全球大型药企客户服务与战略合作网络

| 战略合作 | 咨询与设计 | 产品合作 |
|---|---|---|
| 集成产业资源 | 帮助企业利润提升40% | 临床有效率达95% |

Elanco (NYSE: ELAN) 国际头部动物保健企业
NOVARTIS (NYSE: NVS; SIX: NOVN) 瑞士跨国大药企
LifeMine 美国基因组学精准治疗生物医药公司
SPH 上海医药 (SH:601607; HK:02607) 中国大型医药产业集团
XTY 跨行业化学科技企业
fulkon 富康集团 二甲双胍全球占有率No.1龙头企业
APELOA 普洛 (SZ:000739) 中国医药工业企业40强
CHENGDA 诚达药业 (SZ:301201) 国内领先的原料药产研企业
TY 天宇股份 (300702.SZ) 沙坦原料药龙头企业
明捷医药 Milestone 高强生态圈企业 国内头部分析公司
诺得药业 NUODE PHARM 天宇股份(SH:300702)子公司
中同药业 Zhong Tong Pharma 国邦医药（SH:605507）子公司
优峰生物 YoufengBIO Corporation 国际领先的li-key 投递技术平台
CHENPON 臣邦医药 专精特新企业

## Global Pharma Client & Partner Network

| Strategic Partnerships | Consulting & Design | Product Collaboration |
|---|---|---|
| Industry Resource Integration | 40% Profit Growth | 95% Clinical Effectiveness |

Elanco (NYSE: ELAN) Global Animal Health Leader
NOVARTIS (NYSE: NVS; SIX: NOVN) Swiss Global Pharma
LifeMine U.S. Precision Therapeutics Company
SPH 上海医药 (SH:601607; HK:02607) Major Chinese Pharma Group
XTY Diversified Chemical Technology Company
fulkon 富康集团 Global No. 1 Metformin Supplier
APELOA 普洛 (SZ:000739) China Top 40 Pharma
CHENGDA 诚达药业 (SZ:301201) Leading Chinese API Developer
TY 天宇股份 (300702.SZ) Leading Sartan API Manufacturer
明捷医药 Milestone Hillhouse Portolio Company Leading Analytics Firm
诺得药业 NUODE PHARM Tianyu Pharma (SH:300702) Subsidiary
中同药业 Zhong Tong Pharma Guobang Pharma (SH:605507) Subsidiary
优峰生物 YoufengBIO Corporation Leading li-Key Vaccine Platform
CHENPON 臣邦医药 Specialized and Innovative Enterprise

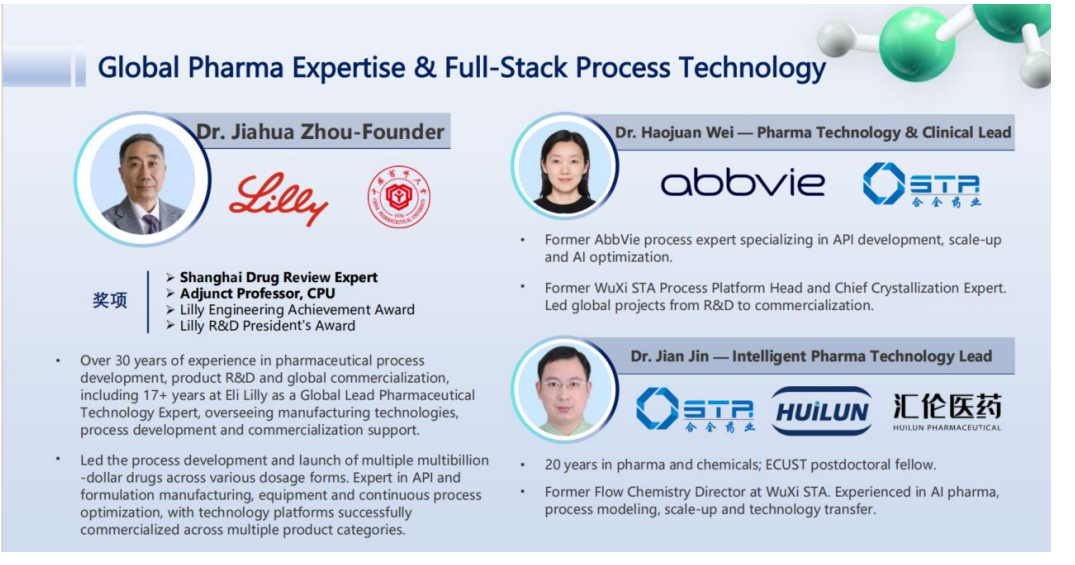
2026WORLD INTERNET CONFERENCE

## 跨学科团队让算法持续沉淀为可复用的工程能力
## A Cross-Disciplinary Team Converts Algorithms into Reusable Engineering Capabilities

平台核心团队覆盖原料药、制剂、质量研究与注册、生产工程及项目管理。创始人周家骅博士拥有 30 余年医药及化工工艺、产品研发与全球产业化经验；制药技术及临床负责人魏昊娟博士长期从事创新药原料药工艺开发、放大、转移和验证。团队将项目数据与工程经验持续转化为模型资产，并通过高校、科研机构和产业伙伴开展数据与模型共建，使平台能够在不同产品、设备和生产尺度间迭代，为更多剂型与应用场景提供一致、可追溯的工艺决策支持。

The core team covers active ingredients, formulations, quality and regulatory science, production engineering and project delivery. Founder Dr. Jiahua Zhou brings more than 30 years of pharmaceutical and chemical process development and commercialization experience. Dr. Haojuan Wei has extensive experience in process development, scale-up, transfer and validation. Project data and engineering knowledge are continuously converted into reusable models, enabling consistent and traceable decisions across products, equipment and manufacturing scales.



# 终端安全管理系统研发及应用

## Development and Application of an Endpoint Security Management System




终端安全威胁检测关键技术架构

Key Technical Architecture for Endpoint Security Threat Detection

## 引言

终端是访问重要信息系统的关键入口，本成果突破动静协同威胁检测、高效模型训练、内存指令执行序列检测三大关键技术，形成终端安全管理系统，已广泛应用于国家级重大活动和重点行业，处于全球终端安全领域领先地位。

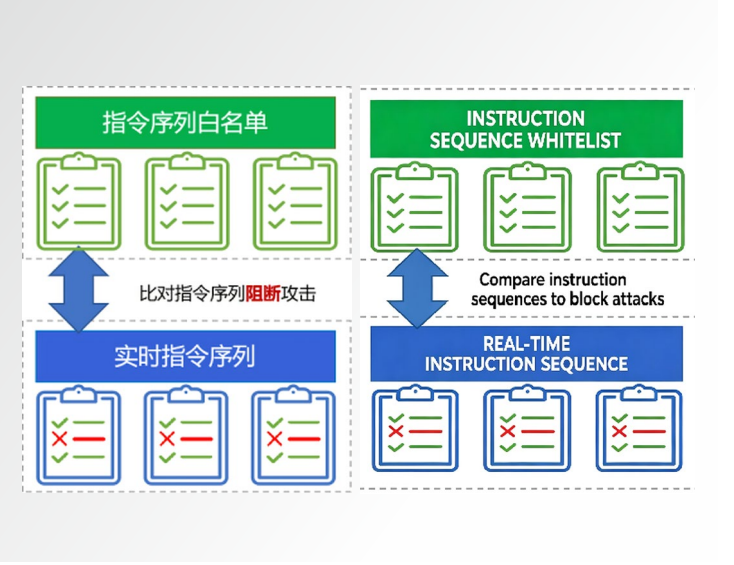
## Introduction

Endpoints serve as the primary entry points into critical information systems. This work delivers three key technological breakthroughs—collaborative dynamic-static threat detection, efficient model training, and memory instruction execution sequence detection—and builds an endpoint security management system that has been widely deployed in major national events and across key industries, establishing it as a leader in the global endpoint security market.

## 突破“测得准、检得快、防得住”三大关键技术，实现国际领先的终端威胁检测防护能力

## Breakthroughs in Three Key Technologies—Precise Detection, Rapid Detection, and Robust Protection—Deliver World-Leading Endpoint Threat Detection and Protection Capabilities

面向复杂高级威胁挑战，本成果突破三大关键技术。一是提出基于动静协同的威胁检测技术，构建“静态多引擎协同”与“动态行为深度解析”协同体系，ATT&CK 检测率达 98.77%，较微软 Defender 高 8.86 个百分点；二是提出基于分治策略驱动读写优化的高效模型训练技术，将全量训练周期从“数天”压缩至“小时级”，突破千万级样本处理瓶颈；三是提出基于内存指令执行序列的威胁检测技术，构建“指令序列白名单”机制，不依赖已知漏洞特征即可实现零日漏洞攻击防护，经院士专家组鉴定处于国际领先水平。

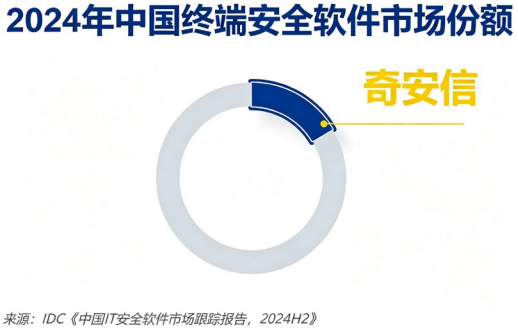



To address sophisticated advanced threats, this project has achieved breakthroughs in three key technologies. First, the Dynamic-Static Collaborative Threat Detection integrates static multi-engine collaboration with in-depth dynamic behavioral analysis, achieving a 98.77% detection rate on the MITRE ATT&CK benchmark, which is 8.86 percentage points higher than that of Microsoft Defender. Second, the Divide-and-Conquer-Driven I/O Optimization for Efficient Model Training compresses the full training cycle from days to hours, overcoming processing bottlenecks for tens of millions of samples. Third, the Memory Instruction Execution Sequence-Based Threat Detection implements an instruction-sequence whitelisting mechanism, enabling protection against zero-day vulnerabilities without relying on known vulnerability signatures. This achievement has been appraised as reaching an internationally leading level by an expert panel of academicians.

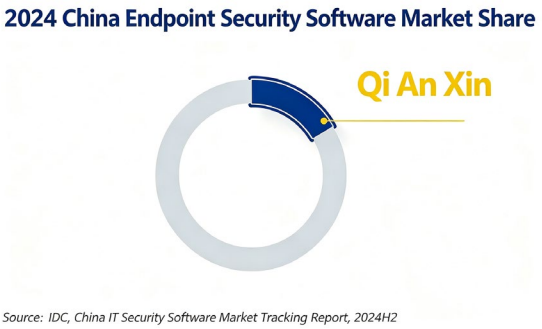
## 护航具有国际影响力的重大活动，深度覆盖重点行业，产生显著经济社会效益
## Providing Security Assurance for Major Events of International Significance, Achieving Deep Penetration Across Key Industries, and Delivering Substantial Economic and Social Benefits

本成果已在高强度实战场景中成熟应用。作为核心安保力量，成功护航北京 2022 冬奥会和冬残奥会、中非合作论坛、十五运等系列具有国际影响力的重大活动，冬奥会期间保障万余台终端安全，实现网络安全“零事故”。成果深度覆盖 90% 以上央企及 95% 以上银行，服务能源、通信等领域关键央企和大型金融机构，为业务连续性提供坚实支撑，近三年累计创造收入 17 亿元。同时积极参与埃及、阿曼、印尼等海外市场重点项目，为中国企业出海提供精准高效的威胁检测与未知攻击防护能力。

This achievement has been proven in mature, high-intensity real-world deployments. As a core security force, it successfully safeguarded a series of internationally influential major events, including the Beijing 2022 Winter Olympics and Winter Paralympics, the Forum on China-Africa Cooperation, and the 15th National Games; during the Winter Olympics it secured over 10,000 terminals with “zero incidents” in cybersecurity. It covers over 90% of central state-owned enterprises and over 95% of banks, serving key central enterprises and large financial institutions in energy, telecommunications, and other fields, providing solid support for business continuity, with cumulative revenue of 1.7 billion yuan over the past three years. It also actively participates in key overseas projects in Egypt, Oman, Indonesia, and elsewhere, providing precise and efficient threat detection and protection against unknown attacks for Chinese enterprises expanding overseas.




来源：IDC《中国IT安全软件市场跟踪报告，2024H2》




Source: IDC, China IT Security Software Market Tracking Report, 2024H2

2024 年中国终端安全软件市场份额
2024China Endpoint Security Software Market Share

## 获国际权威认可，持续领跑市场，树立统一终端安全管理新标杆
## Recognized by Authoritative International Institutions, It Continues to Lead the Market and Sets a New Benchmark for Unified Endpoint Security Management

本成果在多项国际权威测评中表现优异：在国际知名机构 VB100 认证中获样本检测能力 Grade A 级评定；在全球顶级独立安全测试机构 AV-TEST 测评中，以查杀率、性能、可用性三项核心指标满分通过，技术实力与微软、卡巴斯基等全球巨头处于同一梯队。成果支撑中国终端安全市场连续 8 年市场占有率第一，“天擎”在 IDC《中国统一终端安全技术评估，2025》中获评重点推荐的统一终端安全技术厂商，并被列为优秀安全工作空间解决方案，为行业树立统一终端安全管理新标杆。

This achievement has excelled in multiple authoritative international evaluations: it earned a Grade A rating for sample detection in the internationally renowned VB100 certification; in assessments by AV-TEST, a world-leading independent security testing agency, it passed with full marks on three core indicators—detection rate, performance, and usability—placing its technical strength on par with global giants such as Microsoft and Kaspersky. The achievement supports a top market share in the Chinese endpoint security market for eight consecutive years; "Tianqing" was recognized as a key recommended unified endpoint security technology vendor in IDC's "China Unified Endpoint Security Technology Assessment, 2025," and listed as an excellent secure workspace solution, setting a new benchmark for unified endpoint security management in the industry.




## 通过国家科技查新，引领行业规范化发展
## Verified Through the National Sci-Tech Novelty Search, It Spearheads Standardized Development in the Industry

本成果通过权威机构科技查新，并获得优秀解决方案奖、国家标准优秀实践案例一等奖，通过确立行业标准与推广最佳实践，促进终端安全市场规范化发展与整体升级。

Having passed the scientific and technological novelty search conducted by authoritative institutions, this work has been honored with the Outstanding Solution Award and the First Prize for National Standard Benchmark Practices. By establishing industry standards and promoting best practices, it fosters the standardized development and holistic advancement of the endpoint security market.


荣誉证书
CERTIFICATE OF HONOR
2022年度首届安全可信优秀解决方案
奇安信科技集团股份有限公司
金融行业信创过渡期终端安全建设方案


荣誉证书
2023年网络安全国家标准优秀实践案例
一等奖


荣誉证书
2023 Outstanding Practice Case of National Cybersecurity Standards
FIRST PRIZE


荣誉证书
CERTIFICATE OF HONOR
2022 Inaugural Outstanding Secure and Trustworthy Solution
Qi An Xin Technology Group Inc.
Financial Industry IT Application Innovation Transition Endpoint Security Solution

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世界互联网大会
World Internet
Conference