Translation

The following white paper issued by a PRC state-run think tank provides an extensive overview of Chinese government standards-setting related to AI. Appendices list all of China's current and planned AI standards and include case studies of recent PRC applications of AI in fields such as mass surveillance and smart logistics.

Title
Artificial Intelligence Standardization White Paper (2021 Edition)
人工智能标准化白皮书（2021版）

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The China Electronics Standardization Institute (CESI; 中国电子技术标准化研究院; 电子标准院) is the "compiling unit" (编写单位) for this white paper. CESI is a think tank subordinate to the PRC Ministry of Industry and Information Technology (MIIT; 工业和信息化部; 工信部); CESI is also known as the 4th Electronics Research Institute (电子第四研究院; 电子四院) of MIIT.

The National Artificial Intelligence Standardization General Working Group (国家人工智能标准化总体组) and the Artificial Intelligence Subcommittee (人工智能分委会) of the National Information Technology Standardization Technical Committee (SAC/TC 28; 全国信息技术标准化委员会; 全国信标委) are the "guidance units" (指导单位) for this white paper. The Standardization Administration of China (国家标准化管理委员会) stood up the National Artificial Intelligence Standardization General Working Group in 2018.

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Artificial Intelligence Standardization White Paper

(2021 Edition)

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Contents

1. Preface

The Party Central Committee and the State Council attach great importance to the development of new generation artificial intelligence (AI). General Secretary Xi Jinping noted that: "AI is a strategic technology heralding this round of S&T revolution and industrial transformation, and has a "lead goose" (“头雁”) effect with a strong stimulating nature... Accelerating the development of new generation AI is an important strategic handhold for China to gain the initiative in global science and technology competition." In response to the impact of the COVID-19 pandemic, the Party Central Committee and the State Council have upgraded the construction of new infrastructure, one of which is AI, to the level of national strategy. The State Council issued and implemented the *New Generation Artificial Intelligence Development Plan*[1] and other documents, focusing on the industrialization and integrated application of new generation AI technology to accelerate the integration of AI into the real economy and to strive to promote the comprehensive and healthy development of AI technology and the industry.

With the joint efforts of government, industry, academia, research institutes, and users (政产学研用), the development of China's AI industry has achieved remarkable results. First, our innovation capability continues to increase. Technologies such as image recognition and intelligent speech have reached a leading level globally, and the country's number of AI papers and patents ranks among the top in the world. Second, the scale of the industry continues to grow, and a complete AI industry chain has been formed in Beijing-Tianjin-Hebei, the Yangtze River Delta, the Pearl River Delta, and elsewhere. Third is the continuous deepening of integrated applications and the continuous emergence of new business formats and models, such as smart manufacturing, smart transportation, and intelligent healthcare, which further highlights the enabling role of industry development.

While China's AI industry has achieved remarkable results, it is facing many difficulties and challenges, such as large deficiencies in the underlying technology, fewer applications that can achieve commercial success, and high thresholds for integration with the real economy. The *Decision of the Central Committee of the Communist Party of China on Certain Important Issues Concerning Upholding and Improving the System of Socialism with Chinese Characteristics and Promoting the Modernization of the National Governance System and Governance Capacity*[2] notes that it is necessary to "strengthen standards guidance and enhance the industrial basic capabilities and the modernization level of the production chain." The development of the AI industry is inseparable from the guidance of standards, and a solid implementation of AI standardization is of great significance for making breakthroughs in core technologies, accelerating the implementation of applications, and improving the industrial ecosystem.

On the basis of the *Artificial Intelligence Standardization White Paper (2018 Edition)*,[3] this white paper further proposes the following contents: First, an analysis of the current state and

[1] Translator's note: For an English translation of this document, see: https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/
[2] Translator's note: The *Decision* is the document that the Chinese Communist Party (CCP) issued on November 5, 2019 following the Fourth Plenum of the 19th CCP Central Committee.
[3] Translator's note: For CSET's English translation of the 2018 edition of this white paper, see: https://cset.georgetown.edu/publication/artificial-intelligence-standardization-white-paper/

development trend of the AI industry from the perspective of the production chain; second, an introduction to the current internationally recognized system life cycle model, AI ecosystem framework, and machine learning technology framework; third, a sorting of the key work of major AI standardization organizations at home and abroad; fourth, the implementation of the *Guidelines for the Construction of the National New Generation Artificial Intelligence Standard System* (GBL [2020] No. 35) and the formation of the framework of the AI standards system and the list of standards systems; and fifth, the combination of the progress of standardization work and the construction of the standards system, with proposed recommendations for China's key tasks of AI standardization.

2. Current state and development trend of AI

AI is an important driving force for the new round of science and technology (S&T) revolution and industrial transformation. Data from McKinsey & Company shows that AI can create U.S. $3.5 trillion to $5.8 trillion in business value each year, increasing the business value of traditional industries by more than 60%.

China's AI market is huge, and enterprises are eager to invest. According to data from Accenture, half (49%) of Chinese AI companies have invested more than $50 million in research and development (R&D) in the past three years. International Data Corporation (IDC) predicts that China's AI market will reach $97.9 billion by 2023. In order to achieve the high-quality development of the AI industry and improve the modernization of the production chain and supply chain, the *Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035*[4] has proposed: "developing algorithmic reasoning training scenarios and promoting the construction of generalized and industry-oriented AI open platforms," and requires the implementation of a number of forward-thinking and strategic national major S&T projects in cutting-edge fields such as cutting-edge basic theories, special-purpose microchips, and deep learning frameworks.

The AI production chain includes a base layer, a technology layer, and an application layer: The base layer provides data and computing resources, including key links such as chips, development and compilation environments, data resources, cloud computing, and big data support platforms, which support the development of the industry. The technology layer includes various algorithms and deep learning technologies. Through the deep learning framework and open platform, the technology and algorithms are encapsulated, commercialization is quickly realized, and the AI industry is spurred to develop rapidly. The application layer embodies the deep integration of AI technology in various industries. There are many niche fields and strong cross-field integration, resulting in a trend of mutual promotion and prosperity.

2.1 Foundation layer

2.1.1 Development status

(1) The demand for computing power continues to increase, and AI chips have become the focus of the industry

[4] Translator's note: For CSET's English translation of the 14th Five-Year Plan, see: https://cset.georgetown.edu/publication/china-14th-five-year-plan/

As computing power infrastructure, chips are the source of power to promote the development of the AI industry. With the development of AI algorithms, the demand for computing power in niche fields such as video image analysis and speech recognition has exploded, and general purpose chips can no longer meet demand. The introduction of dedicated chips for different fields can not only provide sufficient computing power but also fulfills the requirements of low power consumption and high reliability. The inference chip (推理芯片) products launched by companies such as Huawei, Cambricon, and Vimicro are used in fields such as smart terminals, smart security, and autonomous driving to accelerate large-scale computing and meet higher computing power requirements.

(2) The explosive growth of the total amount of data supports an improved level of intelligentization (智能化) in products and services

Various domestic industries have generally achieved informatization (信息化), and a large amount of data has been gained. According to a National Information Center forecast, by 2025, China's total data will account for 27% of the world's total, becoming the world's number one country in terms of data resources. There is no lack of data with potential value in finance, marketing, and consumption among these data. AI can discover business value points and customer needs from data and help companies provide better business services.

2.1.2 Problems and challenges

(1) Hardware

First, the utilization rate is low, and the traditional hardware architecture cannot fully meet the requirements of AI for intensive computing. The second is poor compatibility. The AI computing hardware instruction sets and micro-architecture designs for different scenarios are different, and they lack uniform standards such that they cannot be compatible.

(2) Enabling software

First, the degree of tool integration needs to be improved. AI compiler tools are provided by different hardware and software manufacturers, and there is no unified measurement standard for tool integrity, integration, and efficiency. The second is the difficulty of coordination between devices. Different smart devices have different protocols and cannot achieve interconnection or intercommunication.

(3) Data

First, the collection and use of data must be regulated. AI is a "data-intensive" industry. The safe and effective collection, management, and use of data to support the practice of AI has become a bottleneck restricting the construction of AI application systems. The second is that data poses security risks. Efficient preventive measures need to be formulated to ensure the safe, reliable, and controllable development of data security and AI to prevent abuse by criminals.

2.1.3 Development trend analysis

(1) Chips form an industry ecosystem

The development of AI poses new challenges to the computing architecture, computing power, and algorithm applicability of chips. At the same time, only when a chip is together with the application scenario can it be implemented, forming an industry ecosystem in which the chip and the scenario are bound to one another.

(2) Data utilization is more efficient

After entering the era of big data, the data resources that can be used by AI systems have changed from sample data to large-scale multi-source heterogeneous data. Massive high-value data has continuously improved the accuracy of AI predictions and promoted the in-depth use of AI technology in multiple scenarios.

2.2 Technology layer

2.2.1 Development status

The AI deep learning framework has achieved algorithm encapsulation. With the development of AI, various deep learning frameworks have continued to emerge. Giants such as Google, Microsoft, Amazon, and Facebook have launched deep learning frameworks such as TensorFlow, CNTK, MXNet, PyTorch, and Caffe2, all of which are widely used. In addition, Google, Open AI Lab, and Facebook have also launched lightweight deep learning frameworks such as TensorFlow TFLite, Tengine, and QNNPACK.

In recent years, a number of deep learning frameworks have also emerged in China. Baidu and Huawei have launched PaddlePaddle and MindSpore, and the Institute of Computing Technology of the Chinese Academy of Sciences (CAS) and Fudan University have developed Seetaface and FudanNLP. Xiaomi, Tencent, Baidu, and Alibaba have launched lightweight deep learning frameworks such as MACE, NCNN, Paddle Lite, and MNN. Domestic deep learning frameworks occupy a place in the world, but the United States' TensorFlow and PyTorch still account for the mainstream.

2.2.2 Problems and challenges

Bottlenecks encountered by AI algorithms

One is weak generalizability. After the AI model is trained, ideal performance can be achieved, but when the application scenario is significantly different from the training environment scenario, the performance will be significantly reduced. The second is vulnerability to adversarial sample attacks. Perturbations that are not perceivable by human vision or hearing may cause the model to output incorrect results.

(2) The deep learning framework relies on ecosystem construction

In terms of applications, general purpose deep learning frameworks such as TensorFlow and PyTorch are used in fields such as natural language processing, computer vision, speech processing, and industries such as machine translation, smart finance, smart healthcare, and autonomous driving. A large number of professional deep learning frameworks have also emerged in various niche fields, such as ROS for writing robotic software, OpenCV for computer vision, NLTK for natural language processing, and ARToolKit for augmented reality.

China's deep learning frameworks started late, and they rely on foreign deep learning framework ecosystems in terms of algorithms, chips, terminals, and scenario applications.

(3) The AI test system is not comprehensive enough

First is the high test repeatability. The test content and model of the existing test benchmarks are highly repetitive, though there are omissions. Second, the systematic design and establishment thereof must be strengthened, and there is not yet a benchmark for mature

functionality and performance testing. Third, the AI testing standards system has not yet been formed, and fairness and authoritativeness must be improved.

2.2.3 Development trend analysis

(1) From perceptual intelligence to intelligent cognition

The development stages of AI include perceptual intelligence, cognitive intelligence, and decision-making intelligence. With the development of S&T, AI is moving towards cognitive intelligence, that is, it is applied to high-complexity scenarios and achieves analysis and decision-making through technologies such as multi-modal AI and big data.

(2) Development from specialized intelligence to general intelligence

Specialized intelligence has domain limitations. Artificial general intelligence (AGI) reduces the dependence on specific domain knowledge and improves the universality of processing tasks, which is the future development direction of AI.

(3) Building an ecosystem through open source

The open source deep learning framework provides developers with algorithm tools that can be used directly, reducing secondary development and improving efficiency. Domestic and foreign giants have promoted deep learning frameworks through open source, have laid out open source AI ecosystems, and have seized the commanding heights of the industry.

2.3 Application Layer

2.3.1 Development status

(1) Deep integration of application scenarios

First is the increasing diversification of computer vision technology industry applications. At present, computer vision technology has been successfully applied to dozens of fields, such as public security. According to data from MEMS Consulting, it is estimated that by 2023, the global image perception market will reach $17.38 billion. Second is the gradual expansion of intelligent voice technology application scenarios. With the improvement of dialog generation and speech recognition algorithm performance, the market scale of intelligent speech continues to expand. According to ASKCI Consulting Co., Ltd. (中商产业研究院) statistics, between 2016 and 2019, the shipment of smart speakers in China increased by 17 times. Voice technology products such as voice transcription and voiceprint recognition have been widely used in all manner of industries.

(2) Integrated development of AI and the real economy

The integration of AI and traditional industries not only improves the efficiency of industrial development but also realizes the upgrading of industries, the formation of new business formats, the establishment of new innovation ecosystems, and the birth of new economic growth points.

The application of AI in the fields of smart manufacturing, smart home, smart transportation, smart healthcare, education, and finance has resulted in an all-round explosive trend. First is smart manufacturing, with the optimization of operations management, predictive maintenance, and logistics optimization of manufacturing processes. Second, in the field of smart home, the penetration of AI technology is more balanced across different links such as smart

software, smart platforms, and smart hardware. However, there are many types of industry products and platforms, and compatibility issues are prominent. Third is the field of smart transportation, which is deeply integrated with infrastructure, transportation equipment, transportation services, and industrial governance, allowing for intelligent perception, enhancing the visual perception of smart transportation, and providing accurate and timely traffic index data. Fourth is the field of smart healthcare, empowering AI-assisted diagnosis systems and equipment, treatment and monitoring, management and risk prevention and control, and intelligent epidemic service platforms to improve the efficiency of medical diagnosis and improve the efficiency and accuracy of workflow management. Fifth is the field of education, which is enabling education service platforms, virtual laboratories, and interactive museums (体验馆) with teaching effectiveness analysis and feedback, improving education implementation scenarios and supply levels, realizing information sharing, data integration, work collaboration, and smart services, and thereby forming a personalized and diverse complementary educational ecosystem. Sixth is the financial sector, which is empowering financial risk control, data processing, and cybersecurity and promoting a new round of changes in financial products, services, and management.

2.3.2 Problems and challenges

(1) Outstanding characteristics of unbalanced industry development

In the field of AI in China, there is a serious phenomenon of emphasizing application while neglecting the basics. On the one hand, the development of specialized AI chip and hardware technology began late, and there is an urgent need to improve the relevant upstream and downstream production chains and establish de facto standards for industry applications. On the other hand, the dependence on foreign open source deep learning system platforms is high, and there is a lack of similar domestic mature open source platforms. At the application level, the structural imbalance of development is still prominent. Due to industry regulation and the restrictions imposed by profitability requirements, there are significant differences in the degree of application and development prospects of AI in industry. With reference to exemplary applications in finance, healthcare, logistics, and security, enhance innovation and breakthroughs in AI in traditional fields such as retail and manufacturing.

(2) System development and maintenance are time-consuming and inefficient

On the one hand, in practice, commercial AI products lack secondary application capabilities for development and operations and maintenance (O&M). On the other hand, the lack of experience of practitioners in the design and implementation of large-scale AI systems has forced industry organizations to make additional investments to support technical teams and hinders the application and practice of smart technologies. Smart application scenarios usually require cloud-end collaborative intelligent processing capabilities, but the cloud-side components are numerous, the configuration is complicated, and the deployment cost is high.

(3) AI ethics challenges

First, limited by historical conditions and development stages, human beings have a lagging cognition of the moral hazards of AI products. The second is that AI products lack robust ethical controls, and at the same time, they are given more autonomous decision-making powers, which will give rise to more ethical and moral issues.

2.3.3 Development trend analysis

(1) Relatively stable development momentum

In recent years, investment and financing in AI has become more rational, and the number of new companies has slowed down. The industry has grown steadily, the number of investment and financing events has noticeably decreased, and investment and financing amounts have increased. The industry pays more attention to the construction of underlying infrastructure, core technology innovation, and upper-level application empowerment, and the industrial chain is clearer.

With the strong support of the Chinese government and the demand for economic transformation and upgrading, the relevance and synergy of the AI production chain will be further enhanced.

(2) Accelerating integration into the real economy

The accelerated integration of AI into the real economy has brought about the practical effects of improving efficiency, reducing costs, and transforming and upgrading the retail, transportation, medical, manufacturing, and finance industries. New products and services such as unmanned stores, unmanned delivery vehicles, cell screening for medical diagnosis, digital twins, smart factories, 3D printing, and robo-advisors have emerged in large numbers, accelerating the cultivation of new industry momentum and opening up new growth points for the real economy, thereby promoting the optimization and upgrading of China's economic structure.

China's AI market has huge potential and broad room for applications, especially in terms of data scale and product innovation capabilities. In addition, after the commercialization of 5G, AI will be deeply integrated into industry and will gradually deepen into complex scenarios, pushing more industries into intelligence.

(3) Policy dividends are becoming increasingly prominent

Since 2017, AI has appeared in the government work report and the 19th Party Congress report. The Ministry of Industry and Information Technology (MIIT) has announced two batches of national AI innovation application pilot zones, and the Ministry of Science and Technology (MOST) has supported Suzhou, Changsha, and other places as they build national new generation AI innovation development pilot zones. All localities are combining their own advantages and industrial foundations to actively lay out AI development plans and vigorously develop AI. In the future, capital will be more concentrated in leading companies in the application layer sector, and the investment focus will gradually move down from the application layer with AI chips and deep learning frameworks receiving greater attention from the capital market.

2.4 Reference architecture

2.4.1 AI System Life Cycle Model

The Artificial Intelligence Subcommittee of the First ISO/IEC Joint Technical Committee (ISO/IEC JTC 1 /SC 42) proposed an AI system life cycle model in ISO/IEC 22989, *Artificial Intelligence Concepts and Terminology*, including initial phase, design and development, verification and validation, deployment, operation and monitoring, re-evaluation and exit phases. The life cycle model is derived from the system and software engineering system life cycle, and on this basis, it emphasizes the characteristics of AI, including development and operations,

traceability, transparency and explainability, security and privacy, risk management, and governance, as shown in Figure 1.

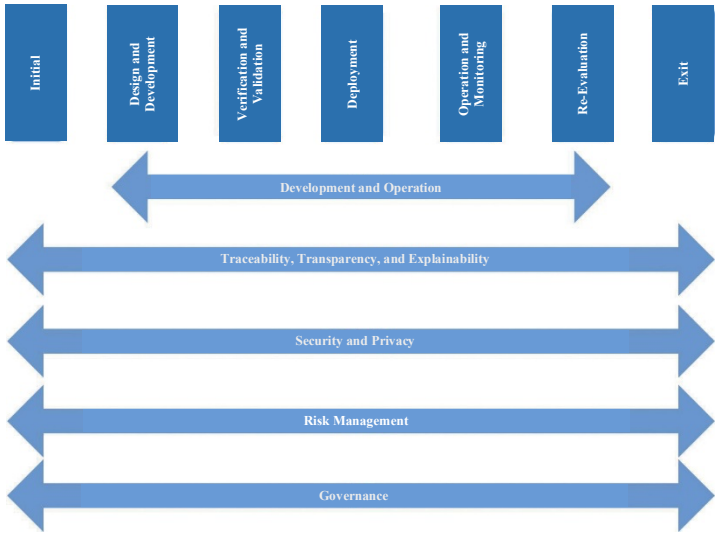


Figure 1 AI System Life Cycle Model

2.4.2 AI Ecosystem Framework

ISO/IEC JTC 1 /SC 42 proposes a framework for an AI ecosystem in the international standard ISO/IEC 22989 *Artificial Intelligence Concepts and Terminology* which includes, from top to bottom: The application layer of vertical industries and research, the core technology layer of AI systems, AI services, and machine learning technology frameworks and engineering systems, and the base layer of management and configurations that relies on cloud computing, edge computing, big data, and other computing environments and computing resource pools, as shown in Figure 2.

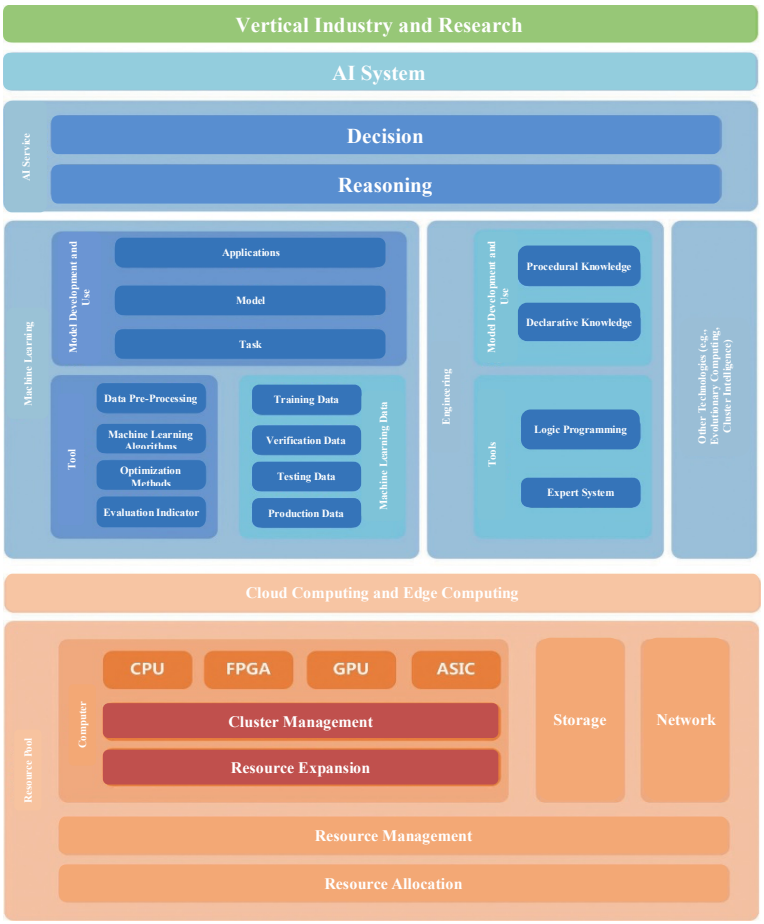


Figure 2 AI Ecosystem Framework

The machine learning technology framework section of the AI ecosystem framework is detailed in ISO/IEC 23053 *Framework for Artificial Intelligence Systems Using Machine Learning*, as shown in Figure 3. The machine learning technology framework embodies the new technical routes of recent years in the academic and industrial application branches of machine learning.

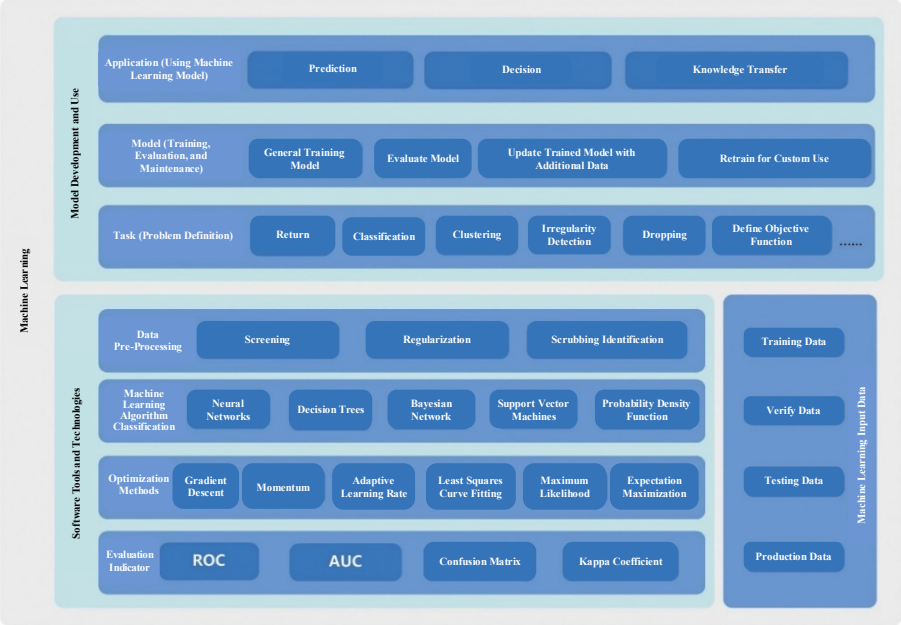


Figure 3 Machine Learning Technology Framework

3. The work of AI standardization

3.1 The necessity of AI standardization

Standards are the technical support for economic activities and social development and are an important aspect of a country's foundational systems. Standardization plays a fundamental and leading role in the modernization of the national governance system and governance capabilities. China's AI industry has made breakthrough progress but still faces problems such as a lack of underlying technology, few applications that can realize commercial value, and thresholds for integration with the real economy. As such, there is an urgent need to strengthen AI standardization work to support the healthy and sustainable development of the AI industry.

The standardization of AI is of great significance for accelerating technological innovation. On the one hand, it will promote the conversion of S&T achievements into practical applications (科技成果转化), promote the popularization and application of S&T innovation achievements, and promote industrial upgrading and technological innovation. On the other hand, it can solidify global advanced technological achievements, eliminate outdated production capacity, and release more resources and space for industrial development.

AI standardization promotes the healthy and sustainable development of industries. On the one hand, it supports governance and promotes more scientific and orderly government management and market supervision. On the other hand, an open AI industry ecosystem will be formed to promote the coordinated development of the upstream and downstream of the production chain, as well as large, medium, small, and micro enterprises.

AI standardization provides a guarantee for the quality of products and services. On the one hand, AI enterprises actively participate in the formulation of standards and create more high-quality products and services in the pursuit of high standards. On the other hand, compliance testing is carried out according to standards to ensure the quality of products and services.

AI standardization is a solid guarantee for information security. On the one hand, it can effectively reduce information security and personal privacy problems caused by AI technology. On the other hand, it can address the tendency of application ethics and safety standards to lag behind technological development.

3.2 AI standardization-related policies

3.2.1 Situation overseas

(1) The United States: Continuously strengthening policy guidance to standards

In February 2019, U.S. President Trump signed the American Artificial Intelligence Initiative, focusing on AI R&D and standards formulation. In June 2019, the White House issued the *National Artificial Intelligence Research and Development Strategic Plan*, focusing on basic research, ethics, trustworthiness, and related standards for AI and proposing the development of standards and benchmarks to measure and evaluate AI technology. In January 2021, the American National Standards Institute (ANSI) released the *United States Standards Strategy 2020* to further focus on AI standards.

(2) European Union: Strengthening supervision through standards and legislation

From 2019 to 2020, the European Commission issued the *Guidelines on Ethics in Artificial Intelligence*, *White Paper on Artificial Intelligence*, *Assessment List for Trustworthy Artificial Intelligence*, *Digital Services Act*, *Digital Market Act*, and other documents to promote AI legislation and strengthen AI supervision. In February 2021, the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) issued the *CEN and CENELEC Strategy 2030* and proposed the formulation of advanced and innovative standards in the field of AI. In April 2021, the European Commission Joint Research Centre issued *Artificial Intelligence Standardization — Progress and Its Relationship with the Proposals for the Artificial Intelligence Regulatory Framework* to support AI supervision through the formulation of international and European standards.

(3) Japan: Paying attention to top-level design and strategic guidance

In December 2018, the Japanese Cabinet issued *Social Principles of Human-Centric AI*, which comprehensively considers the impact of AI on humans, social systems, industrial structures, and governments and helps to understand the relationship between humans and machines, standards, and codes of conduct. In June 2019, the Japanese government issued its *AI Strategy 2019*, proposing building [Japan into] an AI powerhouse (人工智能强国),[5] setting goals such as laying a foundation for development, building a foundation for social applications and industrialization, formulating and applying AI ethics, and promoting the development of AI technology and industries.

3.2.2 Domestic situation

China has issued a series of AI policies, strengthened the top-level design of AI, and

[5] Translator's note: This translation renders the Chinese word 强国 qiángguó—which literally means "strong nation"—as "powerhouse," as in the phrase "AI powerhouse" (人工智能强国). For a more thorough discussion in English of the Chinese word qiángguó, see: https://www.newamerica.org/cybersecurity-initiative/digichina/blog/lexicon-wangluo-qiangguo/

vigorously promoted AI technology, industry, and standards-related work. In July 2017, the State Council issued the *New Generation Artificial Intelligence Development Plan*, putting forward the important task of conducting research on the AI standard framework system. In December 2017, MIIT issued the *Three-Year Action Plan to Promote the Development of a New Generation Artificial Intelligence Industry (2018-2020)*,[6] proposing the establishment of a system of standards and norms for the AI industry and the construction of an evaluation system for AI products. In July 2020, the Standardization Administration of China, the Office of the Central Cyberspace Affairs Commission,[7] the National Development and Reform Commission (NDRC), MOST, and MIIT jointly issued the *Guidelines for the Construction of a National New Generation Artificial Intelligence Standards System*, forming a new pattern in which standards lead the development of the AI industry.

3.3 International standardization work

3.3.1 ISO/IEC JTC 1

The Joint Technical Committee 1 (JTC 1) of the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC JTC 1) takes information technology as the core and relies on the AI Subcommittee (SC 42) to carry out AI standardization work, focusing on the development of standards around the basic commonality of artificial intelligence, key general use technologies, trustworthiness, and ethics. At the same time, ISO/IEC JTC 1 has also carried out standardization work such as AI security and applications in key industries.

(1) ISO/IEC JTC 1/SC 42

In October 2017, ISO/IEC JTC 1 held its 32nd plenary meeting and established the SC 42 AI technical subcommittee, whose research scope is AI standardization. SC 42 has undertaken most of the AI standardization projects of JTC 1 and has guided JTC 1, IEC, and ISO in developing AI applications. ISO/IEC JTC 1/SC 42 mainly conducts international standardization research on AI foundations, data, trustworthiness, use cases, algorithms, and governance, with a Foundational Standards Working Group (WG 1), Data Working Group (WG 2), Trustworthiness Working Group (WG 3), Use Cases and Applications Working Group (WG 4), Computational Approaches and Computational Characteristics of AI Systems Working Group (WG 5), Governance Implications of AI (with SC40) Joint Working Group (JWG 1), AI Systems Engineering Advisory Group (AG 2), Dissemination and Outreach Group (AHG 1), Liaison Group with SC 38 (AHG 2), Liaison Group with SC 27 (AHG 4), AI Standardization Landscape and Roadmap Group (AHG 5), and other organizations.

Of these groups, WG 1 is responsible for the development of foundational standards for AI. At present, it is mainly developing three standards, including *Information Technology — Artificial Intelligence — Artificial Intelligence Concepts and Terminology*, *Framework for Artificial Intelligence Systems Using Machine Learning*, and *Information Technology —*

[6] For an English translation of this document, see: https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-chinese-government-outlines-ai-ambitions-through-2020/

[7] Translator's note: The Office of the Central Cyberspace Affairs Commission (中央网络安全和信息化委员会办公室; 中央网信办) is effectively the same organization as the Cyberspace Administration of China (CAC; 国家互联网信息办公室; 国家网信办), as they share the same personnel and the same offices.

Artificial Intelligence — Management Systems, with details as follows:

ISO/IEC 22989 *Information Technology — Artificial Intelligence — Artificial Intelligence Concepts and Terminology* explains the AI terms and concepts formed in response to the characteristics of the third AI technology development and describes the AI system life cycle model, AI system function model, and AI reference architectures, such as the ecosystem framework.

ISO/IEC 23053 *Framework for Artificial Intelligence Systems Using Machine Learning* proposes a machine learning technology framework, has sorted out machine learning methods such as supervised learning, unsupervised learning, semi-supervised learning, transfer learning, and reinforcement learning, and defines the entire process of machine learning.

ISO/IEC 42001 *Information Technology — Artificial Intelligence — Management System*, as a management system standard, specifies the requirements and guidelines for the establishment, implementation, maintenance, and continuous improvement of AI management systems within an organization.

WG 2 is responsible for data standardization research in the context of AI, big data, and other data analytics. It is developing *Information Technology — Artificial Intelligence — Data Quality for Analytics and Machine Learning — Part 1: Overview, Terminology, and Examples* and other series of standards around the data quality of AI systems.

WG 3 is responsible for the research and standardization of AI credibility, and its research results have attracted much attention. At present, two standards have been released: *Information Technology — Artificial Intelligence – Overview of Trustworthiness in Artificial Intelligence* and *Artificial Intelligence — Assessment of the Robustness of Neural Networks — Part 1: Overview*, while *Information Technology — Artificial Intelligence — Bias in AI Systems and AI-Aided Decision Making*, *Information Technology — Artificial Intelligence — Overview of Ethical and Societal Concerns*, and other standards are being developed. WG 3 has published and is researching standards including but not limited to:

ISO/IEC TR 24028 *Information Technology — Artificial Intelligence – Overview of Trustworthiness in Artificial Intelligence* raises the issue of trustworthiness of AI systems from a macro perspective, analyzes the influencing factors of the technological vulnerability of AI systems and the methods to alleviate these factors to improve the credibility of AI systems, specific measures for which include improving the transparency and controllability of AI systems.

In the ISO/IEC TR 24029 series of standards, *Artificial Intelligence — Assessment of the Robustness of Neural Networks — Part 1: Overview* can be used to evaluate the robustness of neural networks and provides statistical methods, formal methods, and empirical methods for evaluating the robustness of neural networks while *Part 2: Methodology for the Use of Formal Methods* stipulates the technology, use conditions, and stages covered by the robustness evaluation as well as how to use the evaluated data.

ISO/IEC TR 24027 *Information Technology — Artificial Intelligence — Bias in AI Systems and AI-Aided Decision Making* discusses the relationship between fairness and algorithmic bias, explains the reasons and types of bias in AI system decision-making, and then discusses assessment and mitigation methods for bias generated in AI systems.

ISO/IEC 23894 *Information Technology — Artificial Intelligence — Risk Management* is a

management guide for the development and application process of AI technology and systems constructed under the guidance of the ISO 31000 General Risk Management standard, which describes risk assessment elements and risk response measures for AI systems.

ISO/IEC TR 24368 *Information Technology — Artificial Intelligence — Overview of Ethical and Societal Concerns* defines AI ethics and social principles, and on this basis gives examples of practices related to ethics and social concerns in the development and use of AI.

WG 4 is responsible for collecting AI use cases and conducting standardized research on AI applications. It has released one standard of *Information Technology — Artificial Intelligence — Use Cases* and is developing the two standards *Information Technology — Artificial Intelligence — Application Guidelines* and *Information Technology — Artificial Intelligence — Artificial Intelligence System Life Cycle Processes*.

WG 5 is responsible for the research and standardization of AI system calculation methods and system characteristics. It is currently developing three standards, including *Information Technology — Artificial Intelligence — Overview of Computational Approaches for AI Systems* and *Information Technology — Artificial Intelligence — Assessment of Machine Learning Classification Performance*.

JWG 1 was jointly established by the ISO/IEC JTC 1 /SC 42 and ISO/IEC JTC 1 /SC 40 IT Service Management and IT Governance Technical Subcommittee. It is currently responsible for development work for the standard ISO/IEC 38507 *Information Technology — Governance of IT — Governance Implications of the Use of Artificial Intelligence by Organizations*.

See Appendix 1 for the development list of specific standards of ISO/IEC JTC 1 /SC 42.

(2) Other subcommittees of ISO/IEC JTC 1

In ISO/IEC JTC 1, in addition to SC 42, SC 6, SC 7, SC 27, SC 29, SC 35, and other subcommittees are also carrying out AI-related standardization work.

ISO/IEC JTC 1/SC 6 Telecommunications and Information Exchange Between Systems Technical Subcommittee's pre-research project *AI-Empowered Networks* is related to the application of AI in the field of communications. ISO/IEC JTC 1/SC 7 Software and Systems Engineering subcommittee issued the technical report ISO/IEC TR 29119-11:2020 *Guidelines on the Testing of AI-based Systems*. ISO/IEC JTC 1/SC 27 Information Security, Cybersecurity, and Privacy Protection Technical Subcommittee's pre-research work projects PWI 7769 *AI Security Threats and Troubleshooting Guidelines* and PWI 6089 *Impact of AI on Security and Privacy* are related to AI security. ISO/IEC JTC 1/SC 29 Coding of Audio, Picture, Multimedia, and Hypermedia Information Technical Subcommittee developed the international standard ISO/IEC 6048 *JPEG AI Learning-Based Image Coding System* and promoted the establishment of a machine-oriented video coding research group.

The ISO/IEC JTC 1/SC 35 User Interface technical committee focuses on the development of international standards for full-duplex voice interaction, cross-device interaction, and affective computing in the field of AI. In July 2020, China promoted the establishment of the WG 10 Affective Computing Working Group under SC 35. The main AI standards developed by SC 35 include: the ISO/IEC 30150 *Information Technology — Affective Computing User Interface* series of standards, ISO/IEC CD 24661 *Information Technology — User Interfaces — Full Duplex Speech Interaction User Interfaces*, and ISO/IEC NP 4933 *Information Technology — User Interfaces — Mapping Framework of Interface Events Across Devices*.

3.3.2 ISO

The International Organization for Standardization (ISO) promotes the standardization of AI for applications such as smart manufacturing, machinery safety, smart transportation, health information, and robotics.

The ISO/TMB/SMCC Smart Manufacturing Coordinating Committee, in conjunction with the chairs of ISO and ISO/IEC JTC 1 related technical committees and sub-committees, compiled a white paper on the topic of smart manufacturing. The white paper defines the concept of smart manufacturing, identifies relevant parties in smart manufacturing, sorts out related technologies, proposes development principles, and analyzes future impacts.

The ISO/TC 199 Safety of Machinery Technical Committee carried out standardization work on machinery safety and issued a technical report ISO/TR 22100-5:2021 *Relationship between Machinery Safety and ISO 12100 Part 5: Application of AI Machine Learning*.

The ISO/TC 204 Intelligent Transport Systems Technical Committee focuses on the field of public transportation and promotes the pre-research project *Intelligent Transport Systems — Public Transport — Machine Learning/Artificial Intelligence for Public Transport Route Design and Update*.

ISO/TC 215 Health Informatics Technical Committee issued the technical report ISO/TR 24291:2021 *Health Informatics — Applications of Machine Learning Technologies in Imaging and other Medical Applications*.

The ISO/TC 299 Robotics Technical Committee promotes the standardization of robots in fields other than toys and military and promotes the development of 31 international standards related to AI, 22 of which have been released, including robot terminology, industrial robot safety, collaborative robots, service robot performance testing, and other such directions.

3.3.3 IEC

The International Electrotechnical Commission (IEC) has carried out AI-related standardization work in vertical fields such as smart manufacturing, smart devices, smart homes, smart cities, and smart energy and has explored AI ethics.

The IEC/MSB Market Strategy Bureau is mainly responsible for identifying future technology development trends in fields associated with IEC and providing strategic guidance. In October 2018, the white paper *Cross-Industry Application of AI* was released, expounding on key AI technologies such as language recognition, image recognition, and machine learning and their integration with vertical industries, providing guidance for more innovative applications, the implementation of business models, and the construction of standardized systems.

The IEC/TC 65 Industrial Process Measurement, Control and Automation Technical Committee is mainly responsible for formulating international standards for systems and components used in industrial process measurement and control in the field of continuous and batch control, and coordinating standardization work related to system integration. IEC/TC 65 has been developing international standards for digital factories since 2012 and is the core technology organization for "AI + smart manufacturing."

The IEC/SyC AAL Active Assisted Living System Committee provides standardized solutions in the field of smart homes and smart living environments for the elderly. Standards under development include IEC 63168 *Cooperative Multiple Systems in Connected Home*

Environments, IEC 63204 *Active Assisted Living (AAL) Reference Architecture and Architecture Model*, IEC TS 63234 *Economic Evaluation of AAL Services*, and other standards.

The IEC/SEG 10 Ethics in Autonomous and Artificial Intelligence Applications System Evaluation Group was established in 2018, and its main tasks are to identify ethical and social issues related to IEC technical activities, make appropriate recommendations to SMB, and formulate relevant independent and broadly applicable guidelines on the ethics of AI applications, ensuring the consistency of work between IEC committees and promoting cooperation with JTC 1/SC 42.

3.3.4 ITU

ITU-T is established under the International Telecommunications Union (ITU) to study the use of AI to improve telecommunications automation, performance, and service quality and to focus on promoting standardization in the fields of communication, multimedia technology and applications, healthcare, self-service, and assisted driving. In recent years, ITU-T has developed AI standards such as *Metrics and Evaluation Methods for a Deep Neural Network Processor Benchmark*, *Deep Learning Software Framework Evaluation Methodology*, and *Technical Framework for Shared Machine Learning*.

3.4 Standardization work overseas

3.4.1 IEEE

The Institute of Electrical and Electronics Engineers (IEEE) mainly focuses on ethical standards in the field of AI. In March 2017, it published *the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems*, establishing the design principles and standards of AI ethics to help people avoid fear of and blind devotion to AI technology.

As of June 2021, IEEE has approved more than 20 AI standards, including *Framework and Process for Deep Learning Evaluation*, *Framework of Knowledge Graphs*, *Well-being Standard for Ethical Artificial Intelligence and Autonomous Systems*, and *Guide for Application of Knowledge Graphs for Financial Services*.

3.4.2 NIST

The National Institute of Standards and Technology (NIST) is affiliated with the U.S. Department of Commerce and, with the support of the U.S. government, promotes the work of AI standards.

In August 2019, NIST released the report *U.S. AI Leadership: Plan for Federal Engagement in AI Standards and Related Tools*, which listed "actively participating in the development of AI standards" as an important task. The report puts forward guiding opinions for federal government agencies to develop AI technology and related standards, believing that AI should be prioritized in terms of inclusiveness and accessibility, openness and transparency, consensus-based, global, and non-discriminatory standards. The report also proposes nine key areas of AI standards: Concepts and terminology, data and knowledge, human interaction, indicators, networks, performance testing and reporting methods, security, risk management, and trustworthiness.

In August 2020, NIST released the *Four Principles of Explainable Artificial Intelligence*, which introduced the four principles of explainable AI, including the principle of explanation,

the principle of meaningfulness, the principle of explanation accuracy, and the principle of knowledge limits.

In March 2021, NIST released *Trust and Artificial Intelligence* (NISTIR 8332 draft), which proposed a method for evaluating users' trust in AI systems. The method holds that only by understanding the user's trust in AI can we benefit from it and minimize the risk.

In June 2021, NIST issued *A Proposal for Identifying and Managing Bias in Artificial Intelligence* (NIST Special Publication 1270), proposing ideas based on risk management, establishing a trustworthy and responsible AI framework, and forming a supporting AI credibility standard.

3.4.3 EU

European countries are more concerned about the ethical risks of security, privacy, and dignity brought about by AI. Since 2016, the European Union has issued a series of documents, hoping to reduce the ethical risks brought by AI through policies and standards.

The *Report with Recommendations to the Commission on Civil Law Rules on Robotics*, *European Civil Law Rules in Robotics*, and other documents give legal status to self-service robots. The *Draft Ethics Guidelines for Artificial Intelligence* provides guidance for the implementation and operation of AI systems, and the *Ethical Guidelines for Trustworthy Artificial Intelligence*, which proposes a framework for realizing the full life cycle of trustworthy AI. The *White Paper on Artificial Intelligence: a European Approach to Excellence and Trust* proposes the establishment of a "trustworthy AI framework," the research and development of people-oriented technology, the creation of a fair and competitive digital economy, and the establishment of an open, democratic, and sustainable society. In April 2021, the EU proposed the *Artificial Intelligence Act* to finely classify the risk levels of AI application scenarios and formulate targeted regulatory measures to resolve AI risks and ensure the unity and trustworthiness of the EU's AI market.

3.4.4 Other

In 2017, leading companies such as Microsoft, Facebook, and Amazon jointly released the Open Neural Network Exchange (ONNX) format standard, which provides an open source format for AI models.

Under ONNX, models can be switched between different frameworks, and developers can adopt other more suitable tools during project development. At present, domestic and foreign hardware manufacturers such as Intel, AMD, IBM, ARM, Nvidia, and Huawei all support this standard. Deep learning frameworks such as TensorFlow, Caffe2, PyTorch, MXNet, ML.NET, TensorRT, and Microsoft CNTK also support loading ONNX models for reasoning.

3.5 Domestic standardization work

3.5.1 National Information Technology Standardization Technical Committee

The National Information Technology Standardization Technical Committee (SAC/TC 28) is a counterpart to the International Organization for Standardization ISO/IEC JTC 1. Of these, the AI Technical Subcommittee (SAC/TC 28/SC 42) was established in March 2020. The international counterpart, ISO/IEC JTC 1/SC 42, is responsible for the formulation and revision

of national standards in AI fields such as AI foundations, technology, risk management, trustworthiness, governance, products, and applications.

In addition to the AI Technical Subcommittee, SAC/TC 28 has also carried out standardization work in AI related fields such as human-machine interaction, biometric feature recognition, and computer vision. The User Interface Technical Subcommittee (SAC/TC 28/SC 35) was established in the field of human-machine interaction to develop standards for intelligent voice and somatosensory interaction. The Biometric Recognition Technical Subcommittee (SAC/TC 28/SC37) has carried out the development of standards for fingerprint recognition, facial recognition, and biometric feature sampling in the area of biometric feature recognition. The Computer Graphics Image Processing and Environmental Data Technical Subcommittee (SAC/TC 28/SC 24) has developed standards in the fields of computer graphics and image processing and augmented reality.

In addition, under the leadership of SAC/TC 28, standardization organizations such as the Big Data Standards Working Group, the Cloud Computing Standards Working Group, the Internet of Things Standards Working Group, and the National Sensor Network Standards Working Group of the National Information Technology Standardization Technical Committee have also developed basic standards in related fields with research and development to provide support for AI technology and applications.

3.5.2 China National Technical Committee for Automation Systems and Integration Standardization

The China National Technical Committee for Automation Systems and Integration Standardization (SAC/TC 159) is mainly responsible for the standardization of automation systems and integration fields for product design, procurement, manufacturing and transportation, support, maintenance, sales processes and related services, and automation systems and integration. It is a counterpart to the Automation Systems and Integration Technical Committee (ISO/TC 184) and the Robotics Technical Committee (ISO/TC 299).

The Robot and Robot Equipment Technical Subcommittee (SAC/TC 159 /SC 2) under TC 159 is responsible for standardization work related to the field of AI. Its scope of work involves three aspects: The first is a robot that can be automatically controlled and is programmable and operable for industrial and non-industrial specific environments. Representative standards are *Robot controller open communication interface specifications*, *Industrial robot user programming instructions*, and *Multi-core processor-oriented robot real-time operating system application framework*. The second is a robot that is programmable in multi-axis, fixed, or mobile situations. Representative standards are *Industrial robot coordinate system and motion naming principles*, *General technical conditions for assembly robots*, and *Industrial robot mechanical interface Part 2: Axes*. The third is robotic equipment. Representative standards are *Robots and robotic equipment terminology*, *Robot design platform system integration architecture*, and *Specifications for modular functional components of robot mechanisms*.

3.5.3 National Audio, Video and Multimedia Standardization Technical Committee

The National Audio, Video and Multimedia Standardization Technical Committee (SAC/TC 242) is mainly responsible for the standardization of the national audio, video, and multimedia technology professional fields. At present, the development of standards related to AI such as *Smart television — Interactive application interface specification*, *Smart television —*

Speech recognition testing methods, *Smart television — Speech recognition general technical requirements*, and other standards are being developed.

3.5.4 National Information Security Standardization Technical Committee

The National Information Security Standardization Technical Committee (SAC/TC 260) is mainly responsible for standardization work in the field of national information security and promotes the revision of *Information security technology — Biometric identity authentication protocol framework based on trusted environments*, *Information security technology — Fingerprint identification system technical requirements*, and *Information technology — information security technology — biometric information protection requirements*, and other biometrics standards.

3.5.5 National Technical Committee 268 on Intelligent Transport Systems

The National Intelligent Transportation System Standardization Technical Committee (SAC/TC 268) is mainly responsible for standardization in the field of intelligent transportation systems across the country. TC 268 has issued standards such as *Intelligent transportation systems — Lane change decision aid system performance requirements and testing methods* and *Intelligent transportation systems — Vehicle forward collision warning system performance requirements and test procedures* around the field of intelligent transportation and has promoted *Intelligent transportation systems — Intelligent driving electronic map data model and exchange format Part 1: Highways*, *Intelligent transportation systems — Intelligent driving electronic map data model and exchange format Part 2: Urban roads*, and other standards.

3.5.6 Other groups

In response to the rapid development of the AI industry, rapid technological updates, and multiple application fields, social organizations such as the China Electronics Standardization Association, China Computer Users Association, and Shenzhen Artificial Intelligence Industry Association have quickly launched a number of AI group standards. AI group standards include but are not limited to those listed in Table 1.

Table 1 AI Group Standards

No.	Standard number/ plan number	Name of standard	Status
1	T/CESA 1026-2018	*Artificial intelligence — Deep learning algorithm evaluation specifications*	Issued
2	T/CESA 1034-2019	*Information technology — Artificial intelligence — Small sample machine learning sample size and algorithm requirements*	Issued
3	T/CESA 1037-2019	*Information technology — Artificial intelligence — Machine learning-oriented system framework and functional requirements*	Issued
4	T/CESA 1040-2019	*Information technology — Artificial intelligence — Machine learning-oriented data labeling procedures*	Issued
5	T/CESA 1041-2019	*Information technology — Artificial intelligence — Service capacity maturity evaluation reference models*	Issued

No.	Standard number/ plan number	Name of standard	Status
6	CESA-2020-3-009	*Information technology — Artificial intelligence — Server system performance test specifications*	Under study
7	CESA-2021-2-006	*Information technology — Artificial intelligence — Risk assessment models*	Under study
8	T/CCUA 009-2020	*Professional skill requirements and evaluation of artificial intelligence engineers Part 1: Computer vision*	Issued
9	T/SIOT 606-2021	*Intelligent voice and visual interaction software interface requirements*	Issued
10	T/GDPHA 022-2021	*Specifications for intelligent processing of medical images*	Issued
11	T/GDPHA 023-2021	*Specifications for intelligent processing of medical record text*	Issued
12	T/AI T/AI110.1-2020	*Artificial intelligence — Visual privacy protection Part 1: General technical requirements*	Issued
13	T/TMAC 025-2020	*Technical requirements for intelligent construction of digital twin workshops*	Issued
14	T/AIIA 001-2020	*Mobile robot positioning and navigation performance evaluation specifications*	Issued
15	T/CMAX 116-01-2020	*Content and methods of road test capability assessment for autonomous vehicles*	Issued

4. Construction of an AI standards system

In July 2020, the National Standards Committee, the Central Cyberspace Administration of China, the Development and Reform Commission, MOST, and MIIT jointly issued the *Guidelines for the Construction of a National New Generation Artificial Intelligence Standards System* (GJWL [2020] No. 35) (hereinafter referred to as the *Guidelines*). The *Guidelines* propose an AI standards system suitable for the current stage of development.

The AI standards system is led by the China Electronics Standardization Institute (CESI) and relies on the National Artificial Intelligence Standardization General Working Group to bring together China's mainstream industrial, academic, research, and user entities in the AI domain to support its preparation. The standards system is a top-level design for AI standardization, is used to guide AI standardization work, and supports AI technology research and development and industrial development.

4.1 Principles of Standards System Compilation

The compilation of the standards system adheres to the following principles:

(1) Guiding principles: To provide a basis for the establishment of national standard projects and comprehensive standardization projects in the next two years, guide the development of AI standards, and channel enterprises to participate in and put forward key standards.

(2) Usability principles: While guiding the development of standards, attention must be paid to standards verification and application and to building an advanced and applicable AI

standards system that meets the needs of industry development.

(3) Principle of phases: Attention must be paid to the actual needs of the development of AI in China, the development and application level of AI technology must be comprehensively considered, and the needs of China's AI standards system construction in the next two years must be met.

4.2 Standard architecture

The AI standard architecture includes "A Basic commonality," "B Supporting technology and products," "C Basic software and hardware platform," "D Key general purpose technology," "E Key field technology," "F Products and services," "G Industry applications," and "H Safety and ethics" are shown in Figure 4.

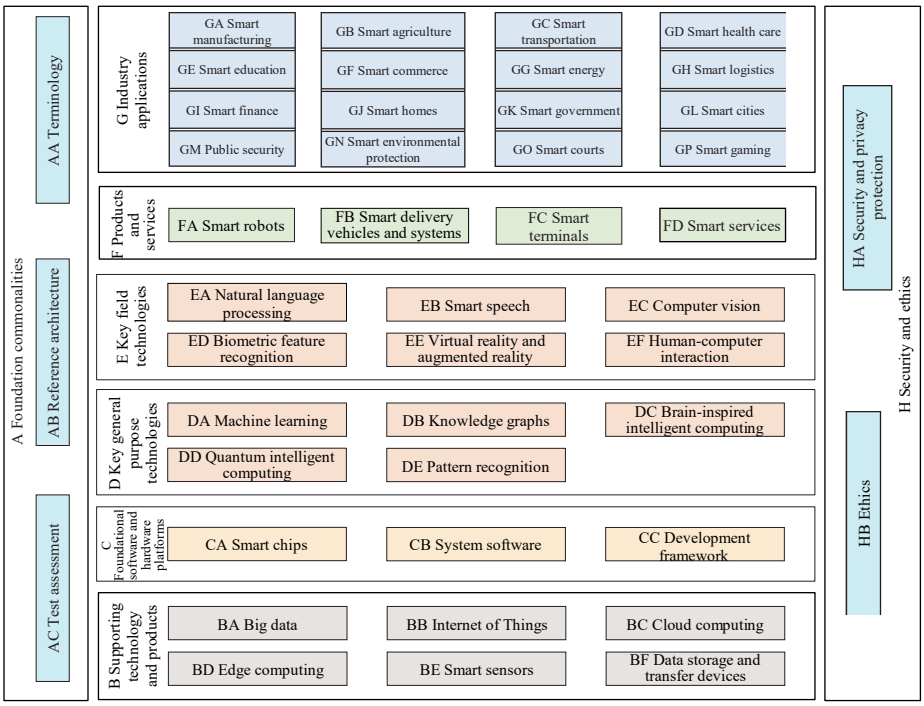


Figure 4 AI Standard Architecture

(1) Basic commonality standards: AI is a complex system engineering project involving many fundamental issues. Standardizing these fundamental issues is the prerequisite for the comprehensive application of AI science. This part focuses on the development of standards such as AI terminology, reference architecture, and universal testing and evaluation and provides basic support for other parts of the standard architecture.

(2) Supporting technology and product standards: AI is based on the massive data resources generated by the Internet of Things and stored on cloud platforms. Through big data analysis technology, it uses computing storage resource pools and intelligent algorithms to provide intelligent services for various industry applications. This part focuses on supporting the development of AI and the standardization of intelligent computing resource application services that are strongly related to AI.

(3) Basic software and hardware platform standards: As the foundational hardware and software facilities that are essential for the implementation of AI, smart chips, system

software, and development frameworks provide a collection of tools needed for AI application development and achieve a collaborative optimization of algorithms, chips, software, and systems under the integrated mindset of software and hardware. This part focuses on the development of standards around the requirements of AI chips, hardware infrastructure, computing power, and functions of the development framework.

(4) Key common technical standards: Machine learning, knowledge graphs, brain-inspired intelligent computing, quantum intelligent computing, and pattern recognition are the key general purpose technologies of AI, and they are the basis for the application of AI in key areas. Taking machine learning as an example, it has achieved certain results in the fields of intelligent speech recognition, natural language processing, object detection, and video classification. This part focuses on the characteristics of key common technologies and develops standards around models, systems, and performance evaluations.

(5) Technical standards in key areas: Natural language processing, intelligent speech, computer vision, biometric feature recognition, virtual reality and augmented reality, human-computer interaction, and other key technologies are important driving forces for the application of AI to the real economy. This part mainly carries out language information extraction, text processing, semantic processing, speech recognition and processing, image recognition synthesis, image recognition and processing, human physiological or behavioral feature recognition, virtual reality and augmented reality, intelligent perception, multimodal interaction, and other standard development work.

(6) Product and service standards: Aiming at the intelligentized product and service model formed by AI technology, this refers to the integration of and the creation of products and services related to smart robots, smart vehicles, smart terminals, and smart services in the field of AI. This part focuses on improving the quality of AI products and services and mainly develops related standards such as service robots, industrial robots, driving environment fusion perception, mobile intelligent terminals, and intelligent services.

(7) Industry application standards: Located at the top of the AI standards system structure, the industry applications referred to in the standards system are based on the *New Generation Artificial Intelligence Development Plan* issued by the State Council and are combined with the current development trends of AI applications. This part is mainly for the specific needs of industry related to AI and carries out standardization work to support the development of AI in industry.

(8) Safety and ethics standards: Located on the far right side of the AI standard architecture, it runs through other sections, including the foundational AI, data, algorithms and models, technology and systems, management and services, security testing and evaluation, products and applications, and other information security related standards, as well as ethical standards involving traditional morality and legal order. Support is provided for the establishment of an AI compliance system to ensure the healthy and orderly development of the AI industry.

4.3 Standards system framework

The framework of the AI standards system is mainly composed of eight parts: Basic commonality, supporting technologies and products, basic software and hardware platforms, key general purpose technologies, key niche technologies, products and services, industry

applications, and safety and ethics, as shown in Figure 5.

The AI standards system is a top-level design of AI standardization work, and domestic standardization organizations and institutions carry out standardization work in accordance with the AI standards system. According to the analysis, the domestic standardization organizations involved in section 3.5 of this white paper have issued, approved, researched, and planned a total of 215 AI standards. See Appendix 2 for details.

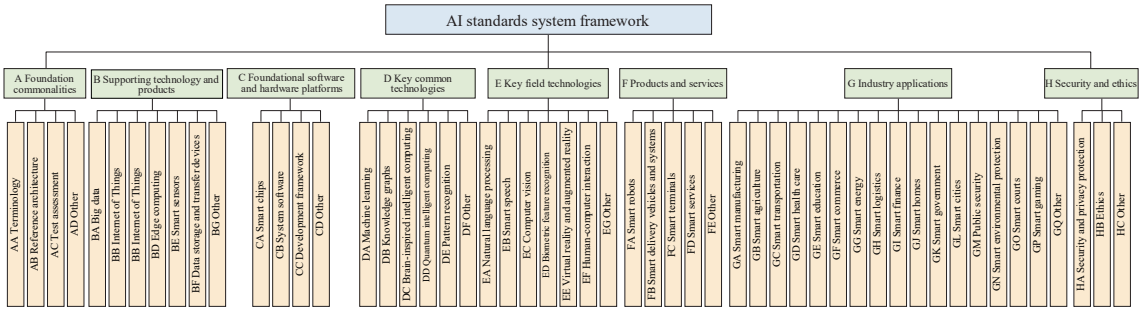


Figure 5 AI Standards System Framework

4.4 Key points of standards system establishment

(1) Avoid conflicts across multiple fields: The application of AI in various industries involves various technologies such as big data and cloud computing. The AI standards system overlaps with supporting technologies such as big data and cloud computing, robots, intelligent delivery vehicles, and other related standards systems in industries such as smart manufacturing, smart city, and smart government affairs, but they are not included or covered. During the preparation of the AI standards system, the *Guidelines for the Establishment of a Smart Manufacturing Standards System*, *Guidelines for the Establishment of a National Robot Standards System*, and *Guidelines for the Establishment of a National Vehicle Networking Industry Standards System (Smart Networked Vehicles)*, and other guidelines were fully reviewed, and intersections involved here all refer to the parts or links that are strongly related to AI. To avoid contradictions, relevant content directly refers to existing guidelines.

(2) Establish a dynamic updating and improvement mechanism: With the development of AI, new models for the application of AI in various vertical fields will continue to emerge, "AI+" will blossom in an all-round way, and the standards system for new generation AI will be further updated and improved. Taking this standards system as a starting point, attention must continue to be paid to the actual AI needs of China in transformation and upgrading, to give comprehensive consideration of new technologies and new applications arising from S&T development, and to meet China's needs for AI standards system establishment through the establishment of a dynamic mechanism for updates and improvements.

(3) Correctly grasp the relationship between technology and industrial development: It should be noted that there is a gap between the focus of standardization construction in this standards system and the uncertainty, unknown nature, and suddenness of the standard requirements in the development process of AI. It should be noted that in the process of AI technology and industrial development, the market environment and industrial demand are constantly changing, and its standard requirements may also change rapidly. The standard construction mentioned in this standards system is only for guiding and supporting industrial

development purposes and does not represent the trend or goal of AI technology or industrial development.

4.5 Key standard development

In the near future, the field of AI will focus on promoting the formulation, testing and validation, and pilot application of the following standards.

(1) Information technology — Artificial intelligence — Deep learning framework multi-hardware platform adaptation technical requirements

Information technology — Artificial intelligence — Deep learning framework multi-hardware platform adaptation technical requirements provides a technical solution for the deep learning framework to adapt to multiple hardware platforms, including cloud-side and end-side scenarios adapting different combinations of operating systems, training chips, and inference chips. Moreover, based on different adaptation solutions, it defines a deep learning framework index system, standardizes key technologies such as the compatibility, adaptation, and optimization of the deep learning framework and the hardware platform. This standard provides a basis for the establishment of domestic AI software and hardware coordination capabilities. The overall architecture of the multi-hardware platform adaptation of the deep learning framework is shown in Figure 6. The standard technical solution includes the equipment management layer access interface, the operator adaptation layer access interface, and the multi-hardware adaptation index of the training framework and the inference framework. The system includes installation and deployment, compatible adaptation, operator support, model support, training performance, stability, and easy scalability.

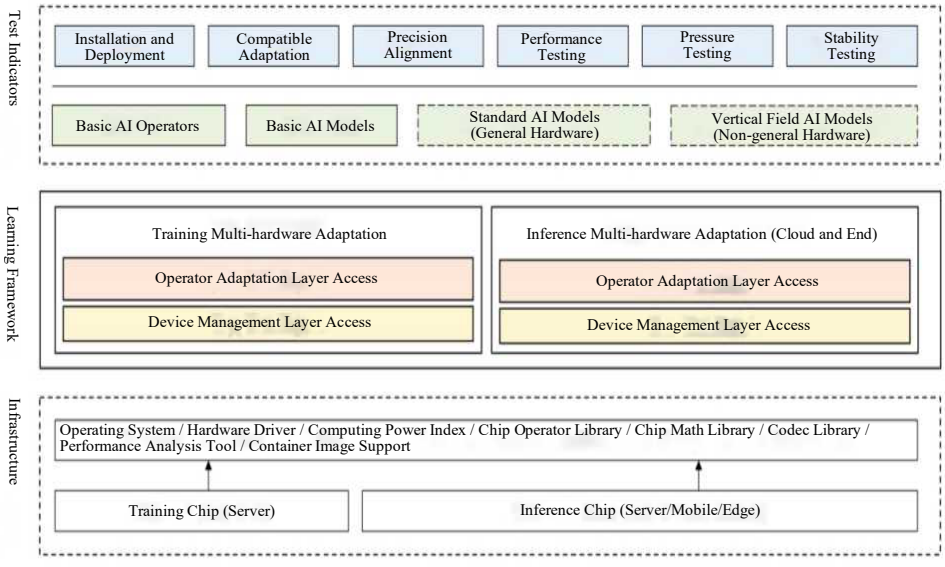


Figure 6 Overall Architecture of Multi-Hardware Platform Adaptation of Deep Learning Framework

(2) Information technology — Artificial intelligence — Resource management specifications Part 1: Computing virtualization

Information technology — Artificial intelligence — Resource management specifications Part 1: Computing virtualization stipulates the technical framework of AI virtualization and

related interface requirements, as well as the indicators of virtualization capabilities and scheduling capabilities required in AI computing tasks. This standard can be used to guide the design, development, and testing of AI computing virtualization systems. The AI computing resource management system is shown in Figure 7. The algorithm application layer is designed by developers and users on the basis of the deep learning framework and then sent to the resource scheduling layer for computing and execution of the algorithm. The resource scheduling layer completes task allocation according to the distributed computing tasks and resource pool conditions and then flexibly selects virtualized AI computing instances. The virtualization solution virtualizes physical AI accelerator cards (CPU, GPU, FPGA, NPU), obtains AI computing instances of different specifications, forms a resource pool, and accesses a unified interface provided by the resource scheduling layer.

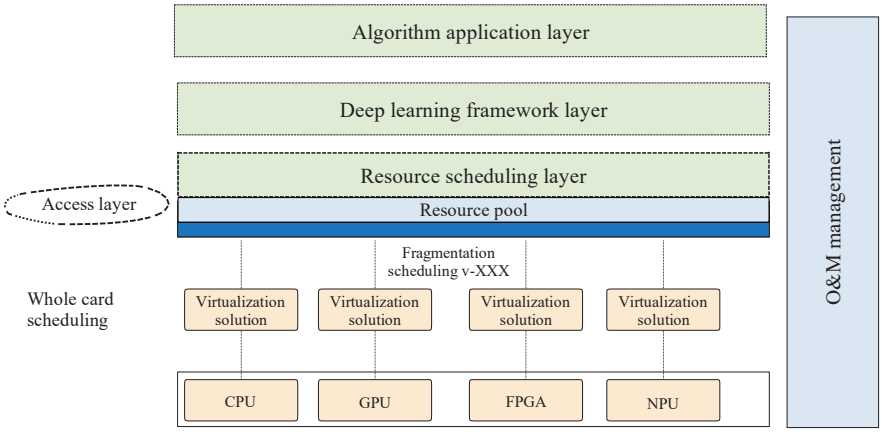


Figure 7 AI Computing Resource Management System

(3) Information technology — Artificial intelligence — Server system performance test specifications

Information technology — Artificial intelligence — Server system performance test specifications stipulates the performance test methods of AI server systems (including servers, server clusters, high-performance computing clusters, etc.). The AI server performance test framework is shown in Figure 8. Under the two working modes of AI server training and reasoning, the standard has standardized the test processes, test rules, and test scenarios of performance testing to ensure the fairness and science of data sets, testing tools, test indicators, and test results.

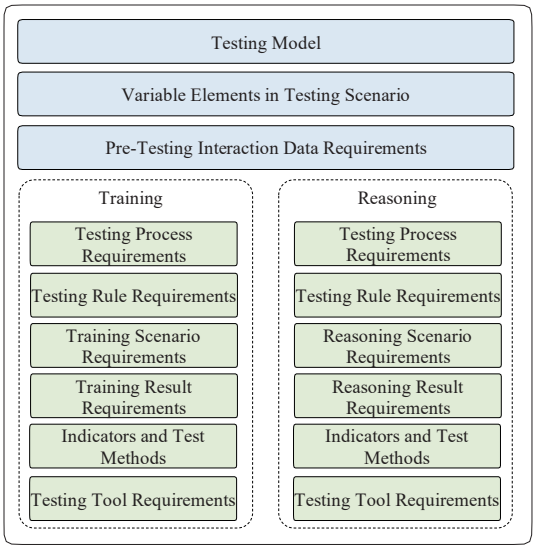


Figure 8 AI Server Performance Testing Framework

(4) Information technology — Artificial intelligence — Risk assessment models

Information technology — Artificial intelligence — Risk assessment models specifies the risk assessment models for products in the field of AI, including risk capacity levels, risk elements, and risk capacity requirements and provides methods for judging the risk assessment levels of AI products. The overall framework of the AI risk assessment model is shown in Figure 9. This standard can guide AI product developers, users, and third parties and other related organizations to conduct risk assessments of AI products.

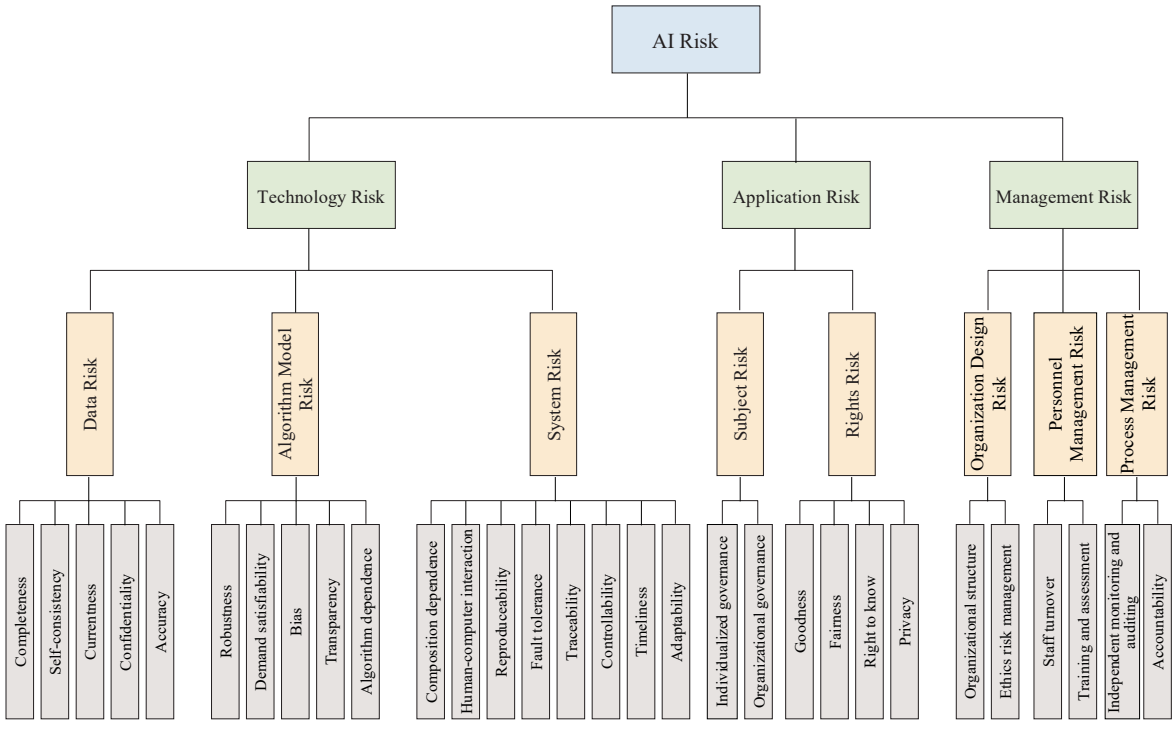


Figure 9 Risk Assessment Model

(5) Machine Learning AI System Specifications

Machine Learning AI System Specifications specifies the technical requirements and testing methods for machine learning systems. This standard is used in the planning and design of machine learning-oriented systems and solutions in various fields and can be used as a basis for evaluation, selection, and acceptance.

(6) Information technology — Artificial intelligence — Platform computing resource requirements

Information technology — Artificial intelligence — Platform computing resource requirements stipulates the technical requirements for AI computing resources and their scheduling and is used to guide the design, development, and evaluation of AI computing resource combinations, scheduling systems, or subsystems.

(7) Artificial intelligence — Service capability maturity assessment specifications

Artificial intelligence — Service capability maturity assessment specifications stipulates the maturity evaluation criterion of AI service capability, as well as the maturity level, capability framework, and evaluation methods. This standard is used to evaluate the maturity of the AI service capabilities provided by service providers, as well as the individual evaluation of a certain capability main domain and capability sub-domain in the service capability maturity model.

(8) Information technology — Artificial intelligence — Machine learning-oriented data labeling procedures

Information technology — Artificial intelligence — Machine learning-oriented data labeling procedures stipulates machine learning-oriented data labeling process framework and specific labeling processes. This standard is used to guide the implementation of data labeling for enterprises, universities, scientific research institutes, and government agencies that face AI research or development and applications.

(9) Artificial intelligence — Privacy protection machine learning technical requirements

Artificial intelligence - Privacy protection machine learning technical requirements stipulates the technical requirements of the privacy protection machine learning system to regulate the technical framework and process, functional requirements, non-functional requirements, and security requirements of the privacy protection machine learning system. This standard is used to guide technology companies, user organizations, and third-party organizations in the design, development, testing, use, operation, and maintenance management of privacy protection machine learning systems.

(10) Information technology — Neural network representation and model compression Part 1: Convolutional neural networks

Information technology - Neural network representation and model compression Part 1: Convolutional neural networks specifies the basic representation and compression methods of convolutional neural network models, which are used to guide the research, development, testing, evaluation, and application of neural network models.

5. Key recommendations for AI standardization work

Based on the current state of AI technology and industry development, together with the progress of standardization work and the establishment of the standards system, we propose key work recommendations for China's AI standardization.

(1) Improve the working mechanism and help industry to achieve healthy and sustainable development

AI is deeply integrated into the real economy, and the standardization of AI is exhibiting a trend of collaborative participation in multiple fields. First, through the National Information Technology Standardization Technical Committee's AI Technical Subcommittee (SAC/TC 28/SC 42), the standardization of new generation information technology fields such as AI, the Internet of Things (IoT), cloud computing, and big data should be coordinated and promoted to strengthen the application of AI in vertical fields. Second, the role of the national AI standardization working group platform should be given full play to coordinate the development of AI standards in the real economy and related fields, and to absorb the energy of government, industry, academia, research institutes, and users to jointly promote AI standardization.

(2) Develop key standards and improve the AI standards system

The development of key AI standards must be promoted based on the principles of "advantages first, maturity first, lead with basics, and be application-driven." The first is to consolidate the industrial foundation with a focus on the development of standards such as performance benchmarks, hardware virtual interfaces, and development framework compatibility specifications. The second is to support industrial applications and develop a number of industrial application standards around areas with a certain industrial scale, such as intelligent speech and computer vision. The third is to promote integrated development with the goal of supporting the deep integration of AI into the real economy and to develop a batch of industry application standards for applications such as smart transportation, smart healthcare, and smart classrooms.

(3) Carry out pilot demonstrations to improve industrial service capabilities

China's AI standardization work is progressing steadily, and relevant standards are being successively released. Governments and relevant departments at all levels must play a guiding role to strengthen the promotion of AI standardization. The first is to carry out propaganda and promotion activities around key standards such as machine learning models and machine translation capability evaluations, combining the application of standards with the development of the AI industry. The second is to promote the construction of a standard compliance assessment system, focusing on selecting national AI innovation application pilot zones and national new generation AI innovation development test zones to carry out standard application demonstrations. The third is to build an AI standardization public technology service platform, improve the service capability of standardization for industry, and support basic and general purpose technology research and development, third-party evaluations, and other such work.

(4) Create de facto standards (事实标准) and enhance industry competitiveness

A de facto standard is the assassin's mace (杀手锏) of industry competition. By summarizing the outreach experience of information technology standards such as DCMM, ITSS, and CMMI, a cultivation model should be explored for China's de facto AI standards. By combining major works and major projects around the open-source community and new infrastructure construction, and through consulting on training, testing and evaluation, product

certification, and other means, standards should be promoted with large-scale promotion and applications to create a batch of de facto AI standards.

(5) Strengthen international exchanges and promote the global promotion of Chinese wisdom

The first is to actively connect with international standards organizations such as ISO/IEC JTC 1 and continue to strengthen participation in AI international standards. The second is to rely on the National Artificial Intelligence Standardization General Working Group and the National Information Technology Standardization Technical Committee Artificial Intelligence Technical Subcommittee to organize the participation of domestic standardization institutions and enterprises in the formulation and revision of international standards and to contribute Chinese wisdom to international standard proposals. The third is to support domestic experts in assuming the positions of secretary and convener in the International Organization for Standardization to enhance the right to speak internationally. The fourth is to actively host international conferences and forums related to AI, deepen bilateral and multilateral cooperation in the field of AI, and achieve mutual benefits.

Appendix 1 Development of ISO/IEC JTC 1/SC 42 Standards

No.	Working group	Standard number/ plan number	Name of standard	Status
1	WG 1 (Foundational Standards Working Group)	ISO/IEC 22989	*Information Technology - Artificial Intelligence - Concepts and Terminology*	Under study
2		ISO/IEC 23053	*Information Technology - Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)*	Under study
3		ISO/IEC 42001	*Information Technology - Artificial Intelligence - Management System*	Under study
4	WG 2 (Data Working Group)	ISO/IEC 20546:2019	*Information Technology - Big data - Overview and vocabulary*	Issued
5		ISO/IEC TR 20547-1:2020	*Information Technology - Big data reference architecture - Part 1: Framework and application process*	Issued
6		ISO/IEC TR 20547-2:2018	*Information Technology - Big data reference architecture - Part 2: Use cases and derived requirements*	Issued
7		ISO/IEC 20547-3:2020	*Information Technology - Big data reference architecture - Part 3: Reference architecture*	Issued
8	WG 2 (Data Working Group)	ISO/IEC TR 20547-5:2018	*Information Technology - Big data reference architecture - Part 5: Standards roadmap*	Issued
9		ISO/IEC 5259-1	*Information technology - Artificial intelligence - Data quality for analytics and machine learning - Part 1: Overview, terminology, and examples*	Under study
10		ISO/IEC 5259-2	*Information Technology - Artificial Intelligence - Data quality for analytics and machine learning (ML) - Part 2: Data quality measures*	Under study
11		ISO/IEC 5259-3	*Information Technology - Artificial Intelligence - Data quality for analytics and machine learning (ML) - Part 3: Data quality management requirements and guidelines*	Under study

No.	Working group	Standard number/ plan number	Name of standard	Status
12		ISO/IEC 5259-4	*Information Technology - Artificial Intelligence - Data quality for analytics and machine learning (ML) - Part 4: Data quality process framework*	Under study
13		ISO/IEC 24668	*Information Technology - Artificial Intelligence - Process management framework for big data analytics*	Under study
14		ISO/IEC PWI 8183	*Information Technology - Artificial Intelligence - Data life cycle framework*	Under study
15	WG 3 (Trustworthiness Working Group)	ISO/IEC TR 24027	*Information Technology - Artificial Intelligence (AI) - Bias in AI systems and AI aided decision making*	Under study
16		ISO/IEC TR 24028: 2020	*Information technology - Artificial Intelligence - Overview of trustworthiness in Artificial Intelligence*	Issued
17		ISO/IEC TR 24029-1: 2021	*Artificial Intelligence (AI) - Assessment of the robustness of neural networks - Part 1: Overview*	Issued
18		ISO/IEC 24029-2	*Artificial Intelligence - Assessment of the robustness of neural networks - Part 2: Methodology for the use of formal methods*	Under study
19		ISO/IEC TR 24368	*Information Technology - Artificial Intelligence - Overview of ethical and societal concerns*	Under study
20		ISO/IEC 23894	*Information Technology - Artificial Intelligence - Risk Management*	Under study
21		ISO/IEC 25059	*Software Engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - Quality Model for AI-based systems*	Under study
22		ISO/IEC TR 5469	*Artificial Intelligence - Functional safety and AI systems*	Under study
23		ISO/IEC TS 6254	*Information Technology - Artificial Intelligence - Objectives and methods for explainability of ML models and AI systems*	Under study

No.	Working group	Standard number/ plan number	Name of standard	Status
24		ISO/IEC TS 5471	*Artificial Intelligence - Quality evaluation guidelines for AI systems*	Under study
25	WG 4 (Use Cases and Applications Working Group)	ISO/IEC TR 24030: 2021	*Information Technology - Artificial Intelligence (AI) - Use cases*	Issued
26		ISO/IEC 5339	*Information Technology - Artificial Intelligence - Guidelines for AI applications*	Under study
27		ISO/IEC 5338	*Information Technology - Artificial Intelligence - AI system life cycle processes*	Under study
28	WG 5 (Computational Approaches and Computational Characteristics of AI Systems Working Group)	ISO/IEC TR 24372	*Information Technology - Artificial Intelligence - Overview of computational approaches for AI systems*	Under study
29		ISO/IEC TS 4213	*Information Technology - Artificial Intelligence - Assessment of machine learning classification performance*	Under study
30		ISO/IEC 5394	*Information Technology - Artificial Intelligence - Reference Architecture of Knowledge Engineering*	Under study
31	JWG 1 (Joint Working Group on Governance Implications of AI (with SC 40))	ISO/IEC 38507	*Information Technology - Governance of IT - Governance implications of the use of artificial intelligence by organizations*	Under study

Appendix 2 Detailed list of AI standards

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
A Foundations and General Purpose	AA Terminology	GB/T 5271.28-2001	*Information technology - Vocabulary - Part 28: Basic AI concepts and expert systems*	Issued
		GB/T 5271.29-2006	*Information technology - Vocabulary - Part 29: AI speech recognition and synthesis*	Issued
		GB/T 5271.31-2006	*Information technology — Vocabulary — Part 31: AI machine learning*	Issued
		GB/T 5271.34-2006	*Information technology — Vocabulary — Part 34: AI neural networks*	Issued
		GB/T 26238-2010	*Information Technology — Biometric terminology*	Issued
		GB/T 38247-2019	*Information technology — Augmented reality terminology*	Issued
		20190851-T-469	*Information technology — Artificial intelligence — Terminology*	Under study
	AC Test assessment	T/CESA 1026-2018	*Artificial intelligence — Deep learning algorithm evaluation specifications*	Issued
		T/CESA 1038-2019	*Information technology — Artificial intelligence — Assistance capacity level evaluation*	Issued
		T/CESA 1039-2019	*Information technology — Artificial intelligence — Machine translation capacity level evaluation*	Issued
		T/CESA 1041-2019	*Information technology — Artificial intelligence — Service capacity maturity evaluation reference models*	Issued
		T/CESA 1043-2019	*Server specifications for deep learning*	Issued
		CESA-2020-3-009	*Information technology — Artificial intelligence — Server system performance test specifications*	Under study
		——	*Artificial intelligence — Service capability maturity assessment specifications*	To be developed
B Supporting technology	BB Internet of Things	GB/T 37976-2019	*Internet of Things (IoT) — General technical requirements for the interface of smart hotel application platforms*	Issued
	BC Cloud computing	GB/T 38554-2020	*General requirements for cloud manufacturing simulation services*	Issued
	BF Data storage and transfer devices	GB/T 37743-2019	*Information technology — Smart device operating system identity recognition service interface*	Issued
C Foundational software and hardware platforms	CA Smart chips	T/CESA 1119-2020	*Artificial intelligence — Cloud-oriented deep learning chip test indicators and test methods*	Issued
		T/CESA 1120-2020	*Artificial intelligence — Edge-oriented deep learning chip test indicators and test methods*	Issued
		T/CESA 1121-2020	*Artificial intelligence — Terminal-oriented deep learning chip test indicators and test methods*	Issued
	CD Other	20192139-T-469	*Information technology — Artificial intelligence — Platform computing resource requirements*	Under study
		——	*Information technology — Artificial intelligence — Deep learning framework multi-hardware platform adaptation technical requirements*	To be developed
		——	*Artificial intelligence — Resource management specifications Part 1: Computing virtualization*	To be developed
D Key general purpose	DA Machine learning	T/CESA 1034-2019	*Information technology — Artificial intelligence — Small sample machine learning sample size and algorithm requirements*	Issued

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
technologies		T/CESA 1036-2019	*Information technology — Artificial intelligence — Machine learning model and system quality factors and test methods*	Issued
		T/CESA 1037-2019	*Information technology — Artificial intelligence — Machine learning-oriented system framework and functional requirements*	Issued
		T/CESA 1040-2019	*Information technology — Artificial intelligence — Machine learning-oriented data labeling procedures*	Issued
		20192138-T-469	*Information technology — Neural network representation and model compression Part 1: Convolutional neural networks*	Under study
D Key general purpose technologies	DA Machine learning	20201611-T-469	*Artificial intelligence — Machine learning-oriented data labeling procedures*	Under study
		20203869-T-469	*Machine Learning AI System Specifications*	Under study
		——	*Technical specifications for computer vision system trustworthiness*	To be developed
	DB Knowledge graphs	CESA-2020-2-019	*Artificial intelligence — Knowledge graph classification and grading specifications*	Under study
		CESA-2020-2-020	*Artificial intelligence — Knowledge graph performance evaluation and test specifications*	Under study
		20192139-T-469	*Information technology — Artificial intelligence — Knowledge graph technology framework*	Under study
E Key niche technologies	EA Natural language understanding	——	*Information technology — Artificial intelligence — Technical specifications for speech machine translation*	To be developed
	EB Smart speech	GB/T 21023-2007	*General technical specifications for Chinese-language speech recognition systems*	Issued
		GB/T 21024-2007	*General technical specification for Chinese-language speech synthesis systems*	Issued
		GB/T 34083-2017	*Specification of programming interface for Chinese-language speech recognition Internet service*	Issued
		GB/T 34145-2017	*Specification of programming interface for Chinese-language speech synthesis Internet service*	Issued
		GB/T 35312-2017	*Specification of programming interface for Chinese-language speech recognition terminal service*	Issued
		GB/T 36339-2018	*Technological requirements of intelligent customer service semantic library*	Issued
		GB/T 36464.1-2020	*Information technology — Intelligent speech interaction system — Part 1: General specifications*	Issued
		GB/T 36464.2-2018	*Information technology — Intelligent speech interaction system — Part 2: Intelligent home appliances*	Issued
		GB/T 36464.3-2018	*Information technology — Intelligent speech interaction system — Part 3: Intelligent customer service*	Issued
		GB/T 36464.4-2018	*Information technology — Intelligent speech interaction system — Part 4: Mobile terminals*	Issued
		GB/T 36464.5-2018	*Information technology — Intelligent speech interaction system — Part 5: In-vehicle*	Issued
E Key niche technologies	EB Smart speech	SJ/T 11380-2008	*Technical specifications for automatic voiceprint recognition (speaker recognition)*	Issued
		20194128-T-469	*Information technology — Intelligent speech interaction testing Part 1: Speech recognition*	Under study

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
		20194129-T-469	*Information technology — Intelligent speech interaction testing Part 2: Semantic understanding*	Under study
	EC Computer vision	T/CESA 1035-2019	*Information technology — Artificial intelligence — Audio, video, and image analysis algorithm interfaces*	Issued
		20190805-T-469	*Information technology — Computer vision — Terminology*	In review
		CESA-2021-2-007	*Information technology — Artificial intelligence — Deep learning-based computer vision algorithm interface technology requirements*	Under study
		——	*Technical specifications for the reliability of computer vision systems*	To be developed
		——	*Technical specifications for video- and image-based human tracking system technology*	To be developed
	ED Biometric feature recognition	GB/T 26237.1-2010	*Information technology — Biometric data interchange formats — Part 1: Framework*	Issued
		GB/T 26237.4-2014	*Information technology — Biometric data interchange formats — Part 4: Finger image data*	Issued
		GB/T 26237.5-2014	*Information technology — Biometric data interchange formats — Part 5: Face image data*	Issued
		GB/T 26237.6-2014	*Information technology — Biometric data interchange formats — Part 6: Iris image data*	Issued
		GB/T 26237.7-2013	*Information technology — Biometric data interchange formats — Part 7: Signature/sign time series data*	Issued
		GB/T 26237.8-2014	*Information technology — Biometric data interchange formats — Part 8: Finger skeletal data*	Issued
		GB/T 26237.9-2014	*Information technology — Biometric data interchange formats — Part 9: Vascular image data*	Issued
		GB/T 26237.10-2014	*Information technology — Biometric data interchange formats — Part 10: Hand silhouette data*	Issued
E Key niche technologies	ED Biometric feature recognition	GB/T 26237.14-2019	*Information technology — Biometric data interchange formats — Part 14: DNA data*	Issued
		GB/T 28826.1-2012	*Information technology — Public biometrics interchange format framework Part 1: Data element specifications*	Issued
		GB/T 28826.2-2014	*Information technology — Common biometric exchange formats framework — Part 2: Procedures for the operation of the biometric feature registration authority*	Issued
		GB/T 29268.1-2012	*Information technology — Biometrics performance tests and reporting Part 1: Principles and framework*	Issued
		GB/T 29268.2-2012	*Information technology — Biometrics performance tests and reporting Part 2: Technology and scenario evaluation test methods*	Issued
		GB/T 29268.3-2012	*Information technology — Biometrics performance tests and reporting Part 3: Modal specificity testing*	Issued
		GB/T 29268.4-2012	*Information technology — Biometrics performance tests and reporting Part 4: Interoperability performance testing*	Issued
		GB/T 30266-2013	*Information technology — Recognition cards — Comparison of biometric features in cards*	Issued
		GB/T 30267.1-2013	*Information technology — Biometric application program interface Part 1: BioAPI specifications*	Issued
		GB/T 30268.1-2013	*Information technology — Biometric application programming interface (BioAPI) conformance testing Part 1: Methods and procedures*	Issued

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
		GB/T 30268.2-2013	*Information technology — Biometric application programming interface (BioAPI) conformance testing Part 2: Biometric identification service provider test breaks*	Issued
		GB/T 32629-2016	*Information technology — BioAPI interworking protocol*	Issued
		GB/T 33767.5-2018	*Information technology — Biometric sample quality — Part 5: Face image data*	Issued
E Key niche technologies	ED Biometric feature recognition	GB/T 33767.6-2018	*Information technology — Biometric sample quality — Part 6: Iris image data*	Issued
		GB/T 36460-2018	*Information technology — Biometric feature recognition — Multimodal and other multibiometric fusion*	Issued
		GB/T 37036.1-2018	*Information technology — Biometric feature recognition used with mobile devices — Part 1: General requirements*	Issued
		GB/T 37036.2-2019	*Information technology — Mobile device biometric recognition Part 2: Fingerprints*	Issued
		GB/T 37036.3-2019	*Information technology — Mobile device biometric recognition Part 3: Faces*	Issued
		GB/T 37045-2018	*Information technology — Biometric fingerprint processing chip technical requirements*	Issued
		GB/T 37742-2019	*Information technology — General specifications for fingerprint recognition devices*	Issued
		20173821-T-469	*Information technology — Mobile device biometric recognition Part 4: Iris*	Under study
		20193149-T-469	*Information technology — Biometric fingerprint modules general specifications*	Under study
		20193150-T-469	*Information technology — Biometric feature recognition attack detection Part 1: Framework*	Under study
		20190843-T-469	*Information technology — Biometric calibration, enhancement, and fusion data Part 1: Fusion information format*	Under study
	EE Virtual reality and augmented reality	GB/T 38258-2019	*Information technology — Virtual reality application software basic requirements and testing methods*	Issued
		GB/T 38259-2019	*Information technology — Virtual reality — Head-mounted display device — General specifications*	Issued
		20190776-T-469	*Information technology — Virtual reality content representation coding Part 1: System*	Under study
		20192086-T-469	*Information technology — Virtual reality expression Part 2: Video*	Under study
E Key niche technologies	EF Human-computer interaction	GB/T 38665.1-2020	*Information technology — Gesture interaction system — Part 1: General technical requirements*	Issued
		GB/T 38665.2-2020	*Information technology — Gesture interaction system Part 2: System external interface*	Issued
		20184719-T-469	*Technical requirements for the semantic library of smart manufacturing human-computer interaction systems*	Under study
		20190836-T-469	*Artificial intelligence — Affective computing user interface framework*	Under study
F Products and services	FA Smart robots	GB/T 12643-2013	*Robots and robot equipment terminology*	Issued
		GB/T 16977-2019	*Robots and robot equipment coordinate system and motion naming principles*	Issued
		GB/T 29825-2013	*Robot general bus communication protocol*	Issued
		GB/T 32197-2015	*Robot controller open communication interface specifications*	Issued

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
		GB/T 33263-2016	*Robot design software functional component specifications*	Issued
		GB/T 33264-2016	*Application framework of robot real-time operating system for multi-core processors*	Issued
		GB/T 33266-2016	*General high-speed communication general bus performance for modular robot*	Issued
		GB/T 33267-2016	*The interface of robot simulation environment*	Issued
		GB/T 35116-2017	*Robot design platform system integration architecture*	Issued
		GB/T 35127-2017	*Robot design platform integrated data exchange specifications*	Issued
		GB/T 35144-2017	*Robot mechanism modular functional component specifications*	Issued
		GB/T 36008-2018	*Robots and robot equipment — Collaborative robots*	Issued
		GB/T 36530-2018	*Robots and robot equipment — Safety requirements for personal assistant robots*	Issued
		GB/T 37416-2019	*General technical requirements for cleaning robots*	Issued
F Products and services	FC Smart terminals	GB/T 26766-2019	*Urban bus and tram car smart terminals*	Issued
		GB/T 36464.4-2018	*Information technology — Intelligent speech interaction system — Part 4: Mobile terminal*	Issued
		SJ/T 11592-2016	*Conceptual model for smart TV*	Issued
		SJ/T 11597-2016	*Digital television interactive application interface specifications*	Issued
		SJ/T 11573-2016	*Technical requirements and test methods for networked smart set-top boxes*	Issued
		SJ/T 11688-2017	*Smart television — Intelligentization technology evaluation methods*	Issued
		SJ/T 11712-2018	*Speech recognition for smart television — Measurement methods*	Issued
		SJ/T 11713-2018	*Speech recognition for smart television — Measurement methods — General technical requirements*	Issued
		T/CESA 1131-2020	*Information technology — Mobile device augmented reality system application interface*	Issued
		T/CESA 1160-2021	*Specifications for child protection of mobile smart terminals*	Issued
		20184715-T-339	*Smart television — Interactive application interface specifications*	Under study
		CESA-2020-3-009	*Information technology — Artificial intelligence — Server system performance test specifications*	Under study
	FD Smart services	GB/T 33261-2016	*General specifications for modular design of service robots*	Issued
		GB/T 36464.3-2018	*Information technology — Intelligent speech interaction system — Part 3: Intelligent customer service*	Issued
		20191925-T-604	*Entertainment robot safety requirements and test methods*	Under study

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
		20201447-T-604	*General technical requirements for guiding service robots*	Under study
G Industry applications	GA Smart manufacturing	GB/T 29824-2013	*Industrial robots — User programming commands*	Issued
		GB/T 33262-2016	*Design specification of modularity for industrial robot*	Issued
		GB/T 37392-2019	*General technical requirements for stamping robots*	Issued
		GB/T 37394-2019	*General technical conditions for forging robots*	Issued
		GB/T 37415-2019	*General technical conditions for truss robots*	Issued
G Industry applications	GA Smart manufacturing	GB/T 38559-2020	*Industrial robots — Technical specification for force control*	Issued
		GB/T 38560-2020	*Industrial robots — Universal drive module interface*	Issued
		20191926-T-604	*General technical requirements for electronic glue spray robot systems*	Under study
		20193006-T-604	*Industrial robots — Guidelines for energy efficiency evaluation*	Under study
		20194034-T-604	*Industrial robots — Cloud service platform categorization and reference architecture*	Under study
		20194035-T-604	*Industrial robots — Operational efficiency evaluation methods*	Under study
	GB Smart agriculture	GB/T 36007-2018	*Weeding robots — General technical requirements*	Issued
		GB/T 36012-2018	*Weeding robots — Performance specifications and test methods*	Issued
		GB/T 36013-2018	*Weeding robots — Safety requirements*	Issued
	GC Smart transportation	GB/T 31024.1-2014	*Cooperative intelligent transportation systems — Dedicated short range communications — Part 1: General technical requirements*	Issued
		GB/T 31024.2-2014	*Cooperative intelligent transportation systems — Dedicated short range communications — Part 2: Specification of medium access control layer and physical layer*	Issued
		GB/T 31024.3-2019	*Special short-range communication for cooperative intelligent transportation systems Part 3: Network layer and application layer specifications*	Issued
		GB/T 31024.4-2019	*Special short-range communication for cooperative intelligent transportation systems Part 4: Equipment application specifications*	Issued
		GB/T 33577-2017	*Intelligent transportation systems — Vehicle forward collision warning system performance requirements and test procedures*	Issued
		GB/T 36464.5-2018	*Information technology — Intelligent speech interaction system — Part 5: In-vehicle*	Issued
		GB/T 37373-2019	*Intelligent traffic data security services*	Issued
		GB/T 37374-2019	*Intelligent transportation — Digital certificate application interface specifications*	Issued
		GB/T 37380-2019	*Personal mobile portable terminal intelligent transportation information service application data exchange protocol*	Issued

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
G Industry applications	GC Smart transportation	GB/T 37436-2019	*Intelligent transportation systems — Extended reversing assist system performance requirements and testing methods*	Issued
		GB/T 37471-2019	*Intelligent transportation systems — Lane change decision aid system performance requirements and testing methods*	Issued
		T/CESA 1044-2019	*Information technology — Artificial intelligence — Motor vehicle driver driving status video acquisition system specifications*	Issued
		20192188-T-469	*Intelligent transportation systems — Intelligent driving electronic map data model and exchange format Part 2: Urban roads*	Under study
		20192189-T-469	*Intelligent transportation systems — Intelligent driving electronic map data model and exchange format Part 1: Highways*	Under study
	GD Smart health care	T/CESA 1107-2020	*Technical requirements and test evaluation methods for personnel tracking systems based on video images*	Issued
		T/CESA 1108-2020	*Technical requirements and test evaluation methods for intelligent human body temperature detection and recognition systems*	Issued
		T/CESA 1109-2020	*Technical requirements and test evaluation methods for smart medical imaging aided diagnosis systems*	Issued
		——	*Intelligent human body temperature detection and recognition system technology*	To be developed
		——	*Smart medical imaging aided diagnosis system technology*	To be developed
	GH Smart logistics	20192969-T-604	*General technical specifications for logistics robot information systems*	Under study
	GJ Smart homes	GB/T 36464.2-2018	*Information technology — Intelligent speech interaction system — Part 2: Smart home appliances*	Issued
	GL Smart cities	GB/T 33356-2016	*Evaluation indicators for new-type smart cities*	Issued
		GB/T 34678-2017	*Smart city — Technical reference model*	Issued
		GB/T 34679-2017	*General technical specifications for smart mine information systems*	Issued
		GB/T 34680.1-2017	*Evaluation model and general evaluation indicator system for smart cities — Part 1: General framework and requirements for developing evaluation sub-indicators*	Issued
G Industry applications	GL Smart cities	GB/T 34680.3-2017	*Evaluation model and general evaluation indicator system for smart cities — Part 3: Information resources*	Issued
		GB/T 36332-2018	*Smart city — Core conceptual model of knowledge models*	Issued
		GB/T 36333-2018	*Smart city — Top-level design guide*	Issued
		GB/T 36334-2018	*Smart city — Specification for software service budget management*	Issued
		GB/T 36342-2018	*Smart campus overall framework*	Issued
		GB/T 36445-2018	*Smart city — SOA standard application guidelines*	Issued

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
		GB/T 36620-2018	*IoT-based technical application guide for smart cities*	Issued
		GB/T 36621-2018	*Smart city — Information technology operations guide*	Issued
		GB/T 36622.1-2018	*Smart city — Public information and service support platform Part 1: General requirements*	Issued
		GB/T 36625.2-2018	*Smart city — Data fusion — Part 2: Specification of data encoding*	Issued
		GB/T 36622.2-2018	*Smart city — Support platform for public information and services — Part 2: Directory management and service requirements*	Issued
		GB/T 36622.3-2018	*Smart city — Public information and service support platform Part 3: Test requirements*	Issued
		GB/T 36625.1-2018	*Smart city — Data fusion Part 1: Conceptual model*	Issued
		GB/T 36625.5-2019	*Smart city — Data fusion Part 5: Municipal infrastructure data elements*	Issued
		GB/T 37043-2018	*Smart city — Terminology*	Issued
		T/CESA 1042-2019	*Information technology — Smart city — Technical requirements for intelligent early warning of urban sewage treatment processes*	Issued
		20181813-T-469	*Smart city — Technical requirements for equipment connection management and service platforms*	Under study
G Industry applications	GL Smart cities	20194200-T-469	*Smart city — Evaluation model and basic evaluation index systems Part 5: Transportation*	Under study
		20194205-T-469	*Evaluation indicators for new-type smart cities*	Under study
H Security and ethics	HA Security and privacy protection	GB/T 20979-2019	*Information security technology — Iris recognition system technical requirements*	Issued
		GB/T 32927-2016	*Information security technology — Security architecture of mobile smart terminals*	Issued
		GB/T 34975-2017	*Information security technology — Mobile smart terminal application software security technical requirements and test evaluation methods*	Issued
		GB/T 34976-2017	*Information security technology — Mobile smart terminal operating system security technical requirements and test evaluation methods*	Issued
		GB/T 34977-2017	*Information security technology — Mobile smart terminal data storage security technical requirements and test evaluation methods*	Issued
		GB/T 34978-2017	*Information security technology — Mobile smart terminal personal information protection technical requirements*	Issued
		GB/T 35101-2017	*Information security technology — Smart card reading and writing equipment security technical requirements (EAL4 enhanced)*	Issued

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
		GB/T 35281-2017	*Information security technology — Mobile internet application server security technical requirements*	Issued
		GB/T 35290-2017	*Information security technology — Radio frequency identification (RFID) system general security technical requirements*	Issued
		GB/T 35291-2017	*Information security technology — Smart cipher key application interface specifications*	Issued
		GB/T 36651-2018	*Information security technology — Biometric identity authentication protocol framework based on trusted environments*	Issued
		GB/T 36951-2018	*Information security technology — IoT perception terminal application security technical requirements*	Issued
		GB/T 37033.1-2018	*Information security technology — RFID system password application technical requirements Part 1: Password security protection framework and security levels*	Issued
H Security and ethics	HA Security and privacy protection	GB/T 37033.2-2018	*Information security technology — RFID system password application technical requirements Part 2: Electronic tags and readers and communication password application technical requirements*	Issued
		GB/T 37033.3-2018	*Information security technology — RFID system password application technical requirements Part 3: Key management technical requirements*	Issued
		GB/T 37044-2018	*Information security technology — Security reference model and generic requirements for IoT*	Issued
		GB/T 37076-2018	*Information security technology — Fingerprint identification system technical requirements*	Issued
		GB/T 37933-2019	*Information security technology — Industrial control system special firewall technical requirements*	Issued
		GB/T 37934-2019	*Information security technology — Industrial control network security isolation and information exchange system security technical requirements*	Issued
		GB/T 37952-2019	*Information security technology — Mobile terminal security management platform technical requirements*	Issued
		GB/T 37953-2019	*Information security technology — Industrial control network monitoring security technical requirements and test evaluation methods*	Issued
		GB/T 37954-2019	*Information security technology — Industrial control system vulnerability detection product technical requirements and test evaluation methods*	Issued
		GB/T 37971-2019	*Information security technology — Smart city security system framework*	Issued
		GB/T 38542-2020	*Information security technology — Mobile smart terminal identification technology framework based on biometric recognition*	Issued
		20173583-T-469	*Information security technology — Industrial control system information security protection capability evaluation methods*	Under study

Level 1	Level 2	Standard number/ plan number	Name of standard	Status
		20173862-T-469	*Information security technology — Mobile smart terminal security technical requirements and testing and evaluation methods*	Under study
		20173865-T-469	*Information security technology — Smart audio and video collection equipment application security requirements*	Under study
H Security and ethics	HA Security and privacy protection	20173867-T-469	*Information security technology — Smart networking device password protection guidelines*	Under study
		20173870-T-469	*Information security technology — Industrial control system security inspection guidelines*	Under study
		20190901-T-469	*Information technology — Information security technology — Biometric information protection requirements*	Under study
		20194266-T-469	*Information security technology — Smart home information security general technical specifications*	Under study
		——	*Artificial intelligence — Privacy protection machine learning technical requirements*	To be developed
	HB Ethics	CESA-2021-2-006	*Information technology — Artificial intelligence — Risk assessment models*	Under study

Appendix 3 Examples of applications

Based on AI application scenarios, this white paper has selected 9 typical application cases. Owing to space limitations, each case is only a brief introduction, but interested readers may contact the relevant organizations to obtain further information.

Case 1: Smart city AI middle-ground (中台) solution

Application area: AI + City

Application scenario: Smart city "Unified Online Management" ("一网统管")

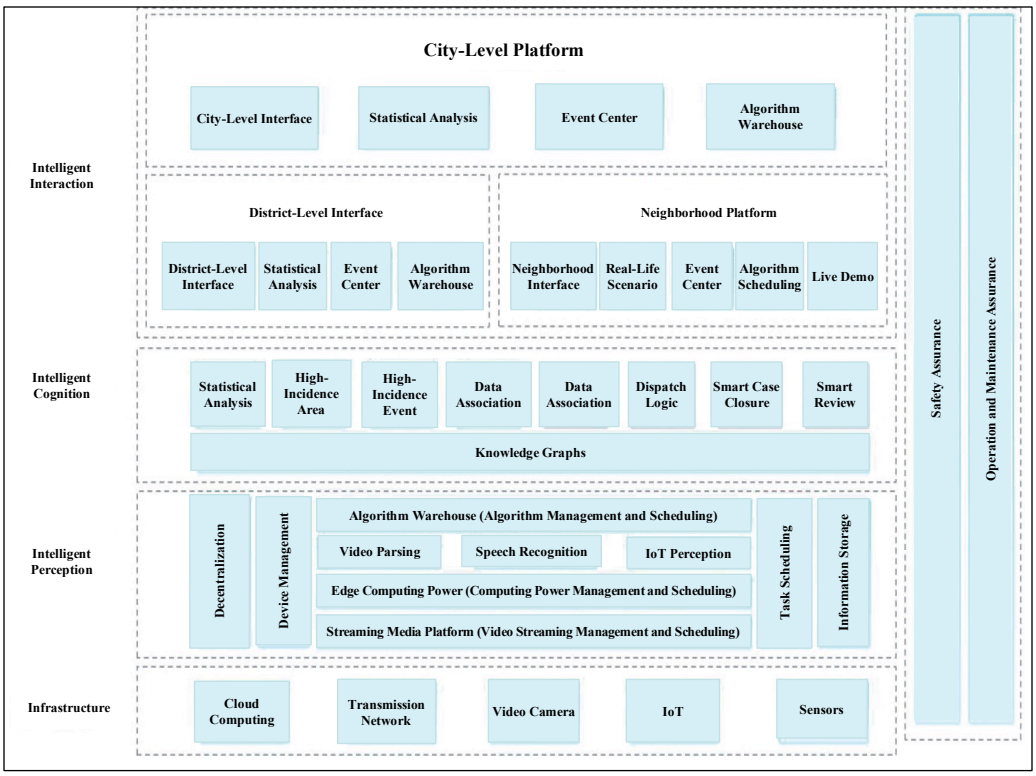
Case provider: Shanghai YITU Network Technology Co., Ltd.

(1) Customer needs and project outline

Under the new smart city governance and management model, YITU Technology has built a computing power platform and AI middle ground that supports distributed orchestration based on the "cloud-edge-terminal" technical architecture, which has become an innovative technology solution for smart cities. For instance, a certain city has introduced unified online government service and unified online management to coordinate resolution of urban management, social governance, and corporate and people's livelihood problems. The city's digital construction has been implemented through modern information methods such as AI, IoT, big data, and computing power infrastructure, such as video analysis all-in-one machines, based on domestic AI deep learning chips, achieving successful promotion through cross-departmental collaboration. This has enhanced the scientific decision-making capabilities of grassroots personnel and management organizations. Intelligentized means have been utilized to achieve machine awareness, automatic order dispatches, and business closed-loops so that applications are key and efficiency is king.

(2) Specific solution brief

The technical architecture of the YITU AI middle ground is shown in the figure below. Specifically, the infrastructure consists of various computing facilities and network facilities used to support the development of AI middle-ground business, including cloud computing equipment, edge computing equipment, terminal-side sensors and computing equipment, and network communication facilities.



The intelligent awareness layer maps real-world physical quantities into digital quantities through sensor devices. With the use of AI reasoning technologies such as video analysis, speech recognition, and IoT awareness, it can be transformed into computer structured perception data to realize various algorithm management and algorithm scheduling through algorithm warehousing. Together with a training engine, it can realize the iterative upgrading of algorithm training and self-evolution.

The intelligent cognition layer is based on information from the awareness layer and the understanding of semantic information, together with common sense and domain knowledge, to perform a higher degree of intelligent operations. Knowledge graph technologies such as knowledge inference, knowledge calculation, and fusion are then used for the upper application of smart cities to provide decision-making support to realize the overall planning and management of all aspects of city functions.

The intelligent interaction layer mainly provides services for the applications of the "neighborhood-district-city" three-level platform, including visual interface, statistical analysis, event centers, algorithm warehousing, algorithm scheduling, and real-time demonstrations.

(3) Value and results after project implementation

In practical applications, a district urban transportation center unites various commissions, offices, and bureaus to break through data and resource barriers. By integrating urban governance pain points and the actual needs of various departments, with the use of YITU's AI middle ground, cities can achieve intelligent discovery, intelligent awareness, and smart promotion to minimize the impact of human interference and ultimately achieve closed-loop processing for each work department.

This project uses the domestic integrated video analysis machine independently developed by YITU to access and analyze 650 video streams and 3,511 image streams. In the future, as demand increases, computing power can be increased through parallel expansion. In this way, they have realized nearly 300 algorithms, such as crowd gathering, regional intrusion, loitering detection (徘徊检测), stagnant water detection, illegal parking, helmet detection, garbage recognition, the prevention of eavesdropping photography in public, and knowledge graphs of people (人物知识图谱). At the same time, corresponding configurations and adjustments can be made according to the business scenario needs. The system has been implemented in many scenarios, including street public safety management, campus periphery security management, elder care wellbeing service management, community civilized governance, and illegal ship mooring management, and has achieved ideal results.

Case 2: Highway AI audit system

Application area: AI + Transportation

Application scenario: Highway auditing

Case provider: CloudWalk Technology

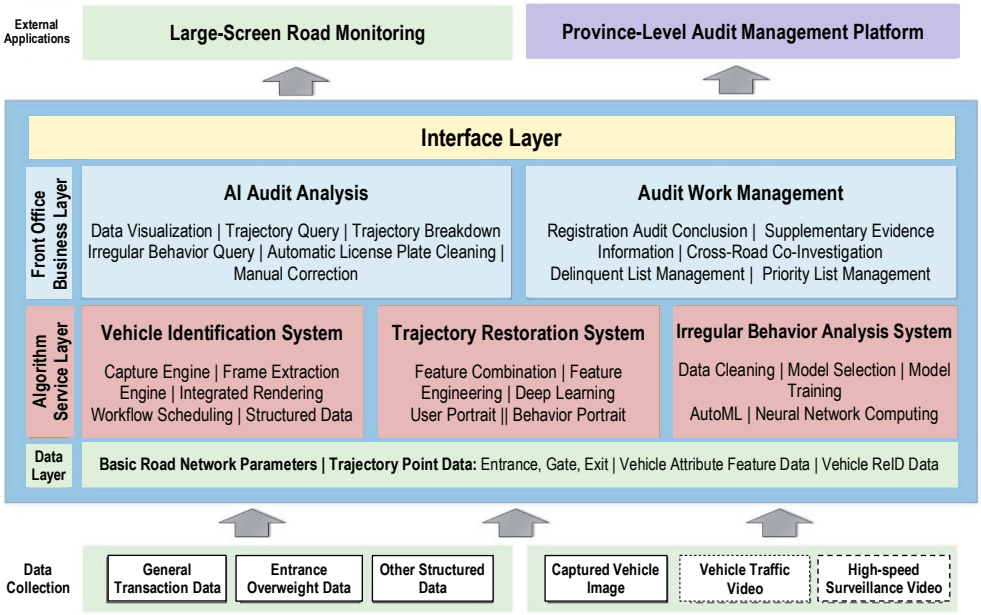
(1) Customer needs and project outline

China formally abolished provincial toll stations on January 1, 2020, achieving a true national network for toll collection. After the abolition of provincial border stations, expressway network tolls have broken past geographical restrictions. As single toll fees are high, the temptation to evade tolls is great, which induces more drivers to evade tolls, such as by using fake plates or blocking on-board units (OBUs). With the expansion of road networks, the rapid increase in high-speed traffic data has made it more difficult to audit and recover tolls, and the traditional manual-based auditing method has proven unsustainable.

CloudWalk Technology's high-speed auditing human-computer collaboration platform uses intelligent analysis to discover highway toll evasion problems, forming an effective audit of "stealing, evading, and missing" tolls, purifying the highway traffic environment, and maintaining orderly highway traffic.

(2) Specific solution brief

The solution is based on the CloudWalk Technology's AI recognition engine human-computer collaboration platform, which integrates multi-source data such as highway traffic transactions and video images, restores the trajectory of the vehicle road network, and builds an efficient highway inspection program with global collaborative deployment and control. The main functions are as follows:



1） Vehicle analysis

Vehicle ReID utilizes deep learning methods to extract vehicle panoramic photo features to perform vehicle attribute analysis for vehicle license plates, brands, models, and body colors and vehicle feature analysis for license plate positioning, body text, front decorations, annual inspection labels, and the like.

2） Abnormal behavior analysis

Analysis and identification of larger-size vehicles with sub-standard electronic toll collection (ETC) cards, missing cards and drop-and-pull transport, OBU/Certificate of Professional Competence (CPC) obfuscation, multiple cards per vehicle/multiple vehicles per card, entries without exits, u-turns and loop driving, ETC inversion, and rushing through checkpoints is performed.

3） Full trajectory and point combination trajectory

Through the integration of OBU/ETC media records and AI recognition records, the system intuitively discovers abnormalities in path fitting.

(3) Value and results after project implementation

1） The big data analysis platform connects real road section data with data on 4 million pass-throughs per day and 300,000 vehicle trajectories for data analysis that shows that abnormal vehicle trajectories account for 0.3%. In this way, many toll evasions were promptly discovered.

2） The restoration accuracy of the vehicle trajectories path-fitted by images and time nodes has achieved 85%, and it provides a variety of trajectory decomposition and combination display methods.

3） This then provides a rich library for audit-oriented technical warfare (技战法). At the

same time, by combining the business needs of various provinces and cities, new audit types can be quickly customized.

Case 3: Atlas Infectious Disease Screening, Diagnosis, and Early Warning Solution for Fever Clinics

Application area: AI + Medical

Application scenario: Design and optimization of the new smart COVID-19 diagnosis system

Case provider: Huawei Technologies Co., Ltd. (Partner: BioMind)

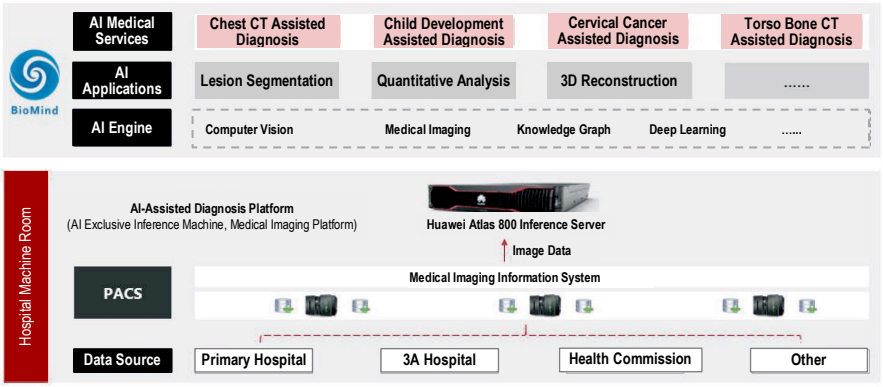
(1) Customer needs and project outline

Since the outbreak of COVID-19 in late 2019, fever clinics have become one of the important institutions for the prevention and early warning of acute infectious respiratory diseases. With nosocomial infections in many hospitals, the State Council and the National Health Commission have issued the following deployment requirements: "The prevention and control of nosocomial infection in medical institutions has always been the focus of management. It is also an unbreakable bottom line and red line. In the future, the grid (网格化) layout experience of fever clinics in Wuhan, Hubei will be promoted nationwide." In order to reduce the risk of nosocomial infection in fever clinics in 62 designated hospitals in Wuhan, all were equipped with independent computerized tomography (CT) and rescue equipment. However, there have been several problems with the early rapid detection and accurate reporting of COVID-19 in fever clinics: 1) Signs are not obvious in early patient imaging, leading to missed diagnosis and false alarms, and resulting in aggravation of the disease and spread of the pandemic; 2) COVID-19 is easily confused with other forms of infectious pneumonia; 3) The detection cycle takes a long time; 4) Patients gather to wait for reporting, resulting in cross-infection; 5) Medical staff are prone to misdiagnose when they are extremely tired; 6) The equipment negatively impacts timeliness and accuracy of pandemic control.

Huawei Technologies Co., Ltd., together with partners such as BioMind, formed the Atlas infectious disease screening and early warning program for fever clinics, providing intelligent auxiliary diagnosis of 11 types of lung diseases such as COVID-19 pneumonia and human avian influenza virus pneumonia for hospital fever clinics.

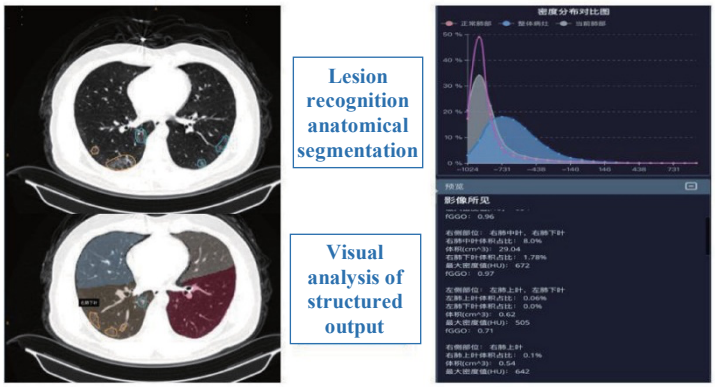
(2) Specific solution brief

The Atlas infectious disease screening and diagnosis early warning program for fever clinics deploys an AI-assisted diagnosis all-in-one machine for infectious diseases at outpatient clinics. By combining Huawei Atlas basic software and hardware with medical image diagnosis algorithms and picture archiving and communication system (PACS)/CT equipment, the edge-based solution can intelligently provide auxiliary diagnosis capabilities for 11 types of lung diseases, such as COVID-19 pneumonia.



1） In AI medical services, the system has functions such as quantitative analysis of pathological markers of lung diseases, comprehensive analysis of accurate assessment, dynamic analysis, intelligent follow-up, and qualitative early warning for screening and triage.

2） In terms of AI applications, the system performs operations such as lesion segmentation, quantitative analysis, and three-dimensional reconstruction of images and visualizes results (as shown in the figure below).

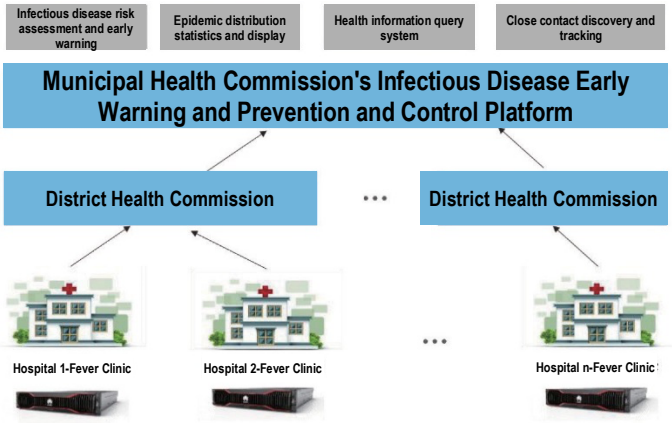


3） AI-assisted diagnosis platform: In order to make AI services and applications more quickly deployed and applied to fever clinics, the system uses the Huawei Atlas 800 server with edge inferencing, which has the following characteristics: 1) High computing power, low energy consumption, and can support 620 TOPS INT8 computing power with power consumption of only 480W; 2) Agile deployment: Docking and debugging can be completed in half a day; 3) Localized deployment at the edge to ensure data security.

(3) Value and results after project implementation

The implementation of this solution has effectively provided diagnostic speed, accuracy, and improved curative effect evaluation, which is reflected in: 1) The speed of screening patients has been greatly increased, reducing a doctor's 15-minute workload to 10 seconds; 2) Effectively guarantees the accuracy of diagnosis: Improved accuracy rate from a traditional 70% to 90%; 3) Effectively evaluates therapeutic effect: Through a cross-checking of the therapeutic effect of AI and manual evaluation, the solution has been shown to deliver efficient patient therapeutic effect evaluations. Compared with Nvidia's similar solutions, this solution effectively reduces costs by about 20%.

The solution also adopts a hierarchical deployment. Through the joint deployment of AI all-in-one machines and fever clinic CT equipment, the solution realizes the real-time reporting of diagnostic data, enabling the command centers of higher-level health commissions to obtain timely and accurate information about the current state of the pandemic.



Case 4: Visual AI smart diagnosis and treatment system

Application area: AI + Medical

Application scenario: Provides tissue-level and cell-level pathological diagnosis, covering multiple organs with high risk of malignant diseases such as the chest and digestive tract, covering 95% of common cancer focus regions and high-risk abnormal cells.

Case provider: SenseTime

(1) Customer needs and project outline

Pathological diagnosis is of great significance in the diagnosis and treatment process, but there is an extreme shortage of pathologists in China. As of 2020, there were only 20,000 registered pathologists in China, and the number of current pathologists is far from meeting the clinical needs of domestic hospitals. Under such circumstances, through supply-side reforms, in addition to increasing the supply of medical resources, using AI technology to empower and improve the efficiency of medical resources is an effective way to quickly alleviate the current shortage of medical resources.

The use of AI algorithms can assist doctors in diagnosis and treatment to greatly reduce the burden on doctors so that they can use the energy and time released to deal with more pressing events, to diagnose and treat more patients, and to make more focused communication with patients. This also reduces pressure on the medical system and is conducive to the healthy development of the doctor-patient relationship.

The AI algorithms realize the digitization and standardization of expert experience and knowledge graphs and can copy and output them, thereby increasing the overall supply of medical resources, rapidly improving the medical level of primary hospitals. As such, whether the patient is in a developed area or a remote area, they can still see a physician nearby and enjoy basic and homogeneous medical services, thereby promoting the balanced development of medical and health resources.

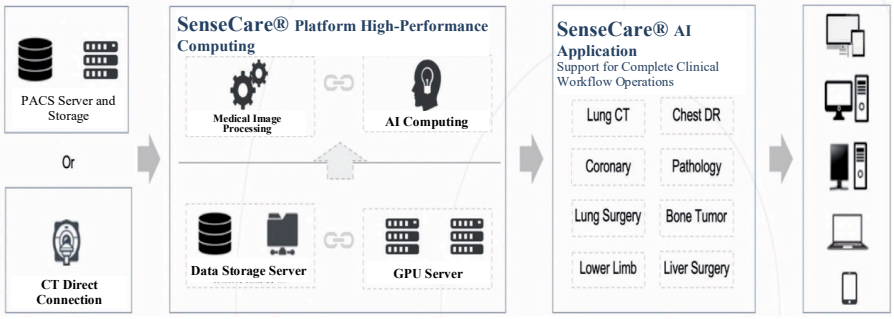
(2) Specific solution brief

Aiming at the main pain points of pathological diagnosis and screening, SenseTime built upon the accumulation of visual AI technology to develop the SenseCare smart diagnosis and treatment platform. By seamlessly connecting digital pathology scanners, the "intelligent pathology AI application" mounted on the scanners provides tissue-level and cell-level pathological assistance diagnosis for many organs with high incidence of malignant diseases, including the digestive tract, covering 95% of common cancer focus regions and high-risk abnormal cells.

The SenseCare smart diagnosis and treatment platform is an efficient tool independently developed by SenseTime to provide smart diagnosis and treatment assistance to entire hospitals. The platform is based on medical big data, and with SenseTime's deep technical accumulation in visual AI and advanced post-processing technology for medical images and by integrating the two engines of high-concurrency 3D rendering and scalable clinical AI applications, the platform provides hospitals with AI support covering the entire process of diagnosis, treatment, and rehabilitation. The full stack operation of diagnosis and healing is carried out with a high degree of convenience, meeting the needs of physicians throughout the entire process from clinical diagnosis and surgical planning to preoperative simulation.

The SenseCare smart diagnosis and treatment platform uses efficient visual AI to greatly improve pathological diagnosis in two ways, thereby reducing the workload of pathologists: First, the platform can utilize digital pathological slices to process image data quickly and in large quantities through visual AI algorithms and can directly highlight and locate lesions, greatly shortening the reading time for a single pathological section. Second, the algorithms can conduct a preliminary screening of slices so as to further optimize the resource allocation of pathologists. If the algorithm determines malignancy in a slice, a senior physician can perform diagnosis to determine the type and stage of cancer; if the algorithm determines that a slice is benign, physicians can then quickly confirm the AI results.

The SenseCare platform is in an early stage of development and works together with Shanghai General Hospital and SenseTime Medical Partners to face a variety of technical quality and evaluation standards. The platform's modeling is trained with the real data of tens of thousands of patients, including follow-up data covering common malignant lesions of the digestive tract with over 1 million+ items of cancer region data and 100,000+ items of malignant cell data, to improve the accuracy of the algorithms. In addition, the developers of the platform combine the weekly feedback and needs of physicians to periodically iterate and optimize algorithms to continuously improve the accuracy and speed of the SenseCare smart pathology AI application in actual use.



By adhering to the concept of "serving clinical diagnosis and healing through medical big

data," the SenseCare smart diagnosis and treatment platform has launched a variety of product solutions including chest CT, chest X-ray, coronary artery, pathology, and bone tumor diagnosis based on the flexible scalability of the platform. The platform currently covers more than 13 body parts and organs and provides AI assistance for the clinical diagnosis and treatment needs of multiple departments, helping clinicians perform multi-dimensional analysis such as high-precision disease detection, categorization, and benignancy and malignancy prediction. The platform also has designed a 3D preoperative planning and simulation treatment solution.

(3) Value and results after project implementation

In terms of screening accuracy, the platform can detect high-risk cases of related diseases with a detection rate of 100% and a negative rejection rate of over 80%. In addition, the platform integrates SenseTime's OCR technology to associate the AI computing results of digital slices with pathological numbers, simplify the search and matching process for physicians, and systematically create an AI-based digital pathology-assisted reading platform.

During the COVID-19 pandemic, the SenseCare chest CT smart clinical solution rushed to assist key COVID-19 screening hospitals in many provinces and cities including Beijing, Shanghai, Tianjin, Shandong, Hebei, and Fujian, providing an effective and accurate decision-making basis for frontline medical workers. "By introducing SenseTime's SenseCare lung AI analysis product, we can realize the smart diagnosis and quantitative evaluation of CT images of COVID-19. Quantitative analysis can be completed in a few seconds, and suspected patients can be automatically screened," noted the director of the radiology department of a hospital in Qingdao, suggesting that his team can issue an inspection report within the shortest possible time to avoid long-term personnel delays and reduce the risk of cross-infection. The secret behind these results is AI-assisted diagnosis.

Case 5: Construction of a monitoring and early warning system for wild Asian elephants in Xishuangbanna Biosphere Reserve, Yunnan

Application area: AI + Agriculture

Application scenario: Asian elephant monitoring and early warning, AI recognition of night/fractured images

Case provider: Inspur Software Co., Ltd.

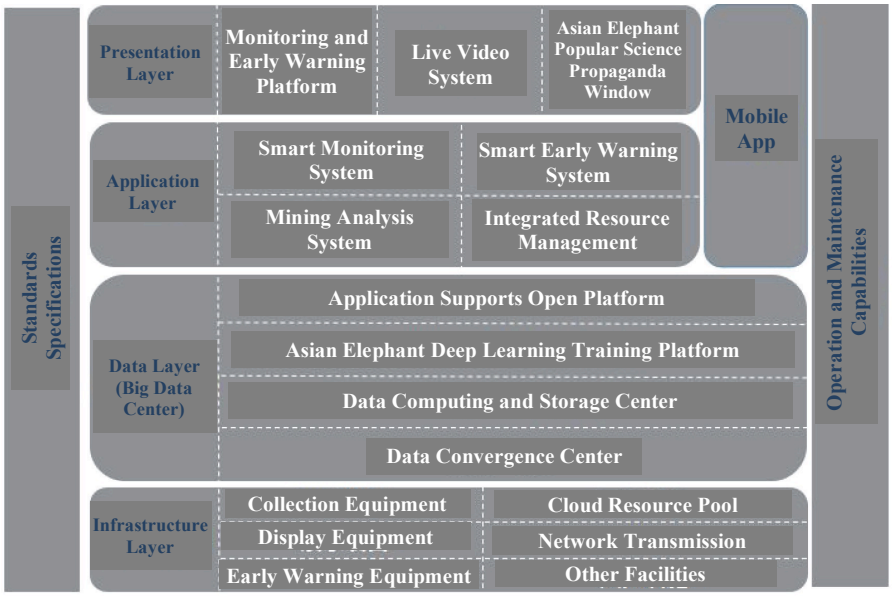
(1) Customer needs and project outline

The customer proposed that, based on the results of surveys of the Asian elephant resources

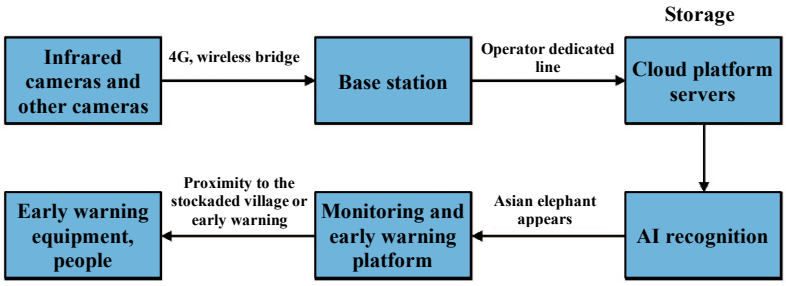
in Yunnan Province over the years in terms of population size, distribution, habitat, and accidents, a solution was needed carefully analyze the main problems in the Asian elephant monitoring system with an in-depth analysis of the core problems and solutions to human-elephant conflicts. Inspur proposed multiple methods such as ground personnel patrols, drone data collection, intelligent video monitoring, infrared camera monitoring, and other methods and connections to data from other systems to achieve rapid transmission through wired and wireless networks and the collection of air-to-ground multi-channel data. By building an efficient multi-organization collaborative flat monitoring and early warning system, a monitoring and early warning platform could be created with comprehensive perception and responsiveness so as to establish a social linkage mechanism that responds promptly and provides comprehensive services. To provide effective scientific basis for future development of better, more reasonable, and more scientific protection and management measures, to provide real, reliable, timely, accurate, and complete information support for leaders at all levels to grasp the monitoring and early warning status of Asian elephants and implement decisive decision-making.

(2) Specific solution brief

Through ground personnel patrols, drone data collection, intelligent video monitoring, infrared camera monitoring, and other methods and connections to data from other systems, the solution is able to achieve rapid transmission through wired and wireless networks and the collection of air-to-ground multi-channel data. By relying on information technology such as AI and big data, the solution establishes an information sharing mechanism, reduces the workload of human identification, establishes a sound early warning mechanism and an external services system. The overall structure of the solution is shown in the figure below:



Through monitoring by infrared cameras and other cameras, it can effectively release a large amount of human resources and make up for the deficiencies of manual monitoring. By installing infrared and other cameras in the surrounding areas of the stockaded villages along the migration route of Asian elephants, it can monitor Asian elephant activities continuously, 24 hours a day. The data flow and early warning process of the infrared cameras and other cameras is shown in Figure 2:



The front end can monitor Asian elephants through infrared and other cameras, drones, and monitoring personnel. Depending on actual circumstances, the monitoring and early warning platform can intelligently issue early warning information through smart broadcasting equipment, mobile terminal applications, SMS messaging, and other such channels.

(3) Value and results after project implementation

Since the implementation of the solution, 605 infrared cameras and 21 street cameras have been deployed, and more than 1.08 million photos have been taken. The algorithm recognition accuracy is as high as 99%, breaking through the technical barriers of night and incomplete image recognition. As such, even under extremely poor visual conditions, it can still accurately identify Asian elephants and successfully warn of their presence. The solution has effectively identified Asian elephants and issued warnings more than 5,100 times and has successfully avoided more than 500 "human-elephant conflicts." The early warning center system is shown in the figure below:

After the completion of the solution, there has not been a single casualty incident in the jurisdiction, effectively alleviating human-elephant conflicts and avoiding economic losses to the country and our people. The solution has provided a large volume of precious scientific research

image data for Asian elephant scientific research. The solution also offers scientific and effective monitoring methods for Asian elephant full-time monitors to improve the effectiveness of Asian elephant daily monitoring work.

Case 6: Smart home system based on AI smart speaker Bluetooth mesh

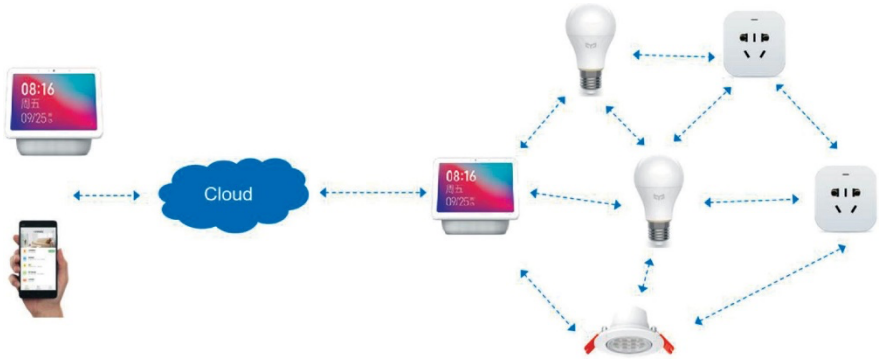
Application area: AI + Home

Application scenario: Voice-based smart home control

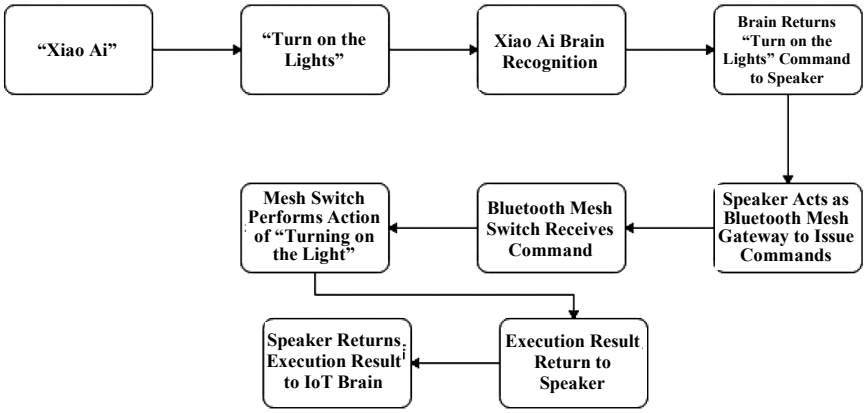
Case provider: Beijing Xiaomi Mobile Software Co., Ltd.

(1) Customer needs and project outline

At present, the integration of AI technology into the smart home is growing ever deeper. AI technology can be embedded in more life scenarios to create an ecosystem of smart life scenarios. In this case, smart speakers are connected to smart home devices based on a Bluetooth mesh, and a smart home Bluetooth network topology with smart speakers at the center is constructed. The user can control the device through the smart speaker closest to the device, or through the bridge of the smart speaker to achieve remote control of the device across the speaker. With the help of smart speakers, the Bluetooth mesh solution can achieve a Wi-Fi-like user experience in terms of obtaining the actual status of smart home devices. Users can easily view the device online or offline on a mobile app, control the device, and quickly understand functions such as success or failure.



In the actual use process, the user only needs to use voice commands to complete the operation and control of a device. The following figure uses the voice control to turn on the lights in the same room as an example to illustrate the voice interaction process:



(2) Specific solution brief

This solution provides two solutions for connecting devices to the network: When the mobile app is close to the distribution network and the speaker voice distribution network. The user can choose to use the mobile app to configure the network with a single click or choose to use the speaker to perform voice operation to configure the network. Both network access methods support batch operations where one batch of devices can be connected to the network at a time. The theoretical upper limit of the number of devices in a mesh network is 32,767, which can be flexibly expanded through a rational layout. In addition, this solution has been continuously optimized in terms of network access speeds and security; a single device can access the network in as fast as 2 seconds, greatly reducing device network access times. Two-way verification has been carried out between the cloud and Bluetooth mesh devices, completely eliminating access from counterfeit devices.

A major user experience improvement brought about by large-scale device access is that devices can be controlled in groups, that is, one control message can be used to control a group of devices at the same time, and the devices in the group can execute control commands synchronously. Users can group any number of Bluetooth mesh devices or even Bluetooth mesh devices in different spaces into a group according to their individual needs to easily achieve scenarios such as “turning on the light at home” and “turning on the reading light.” At the same time, a single device can also belong to multiple different groups. In addition, this solution can also be automatically linked with other devices in the smart home ecosystem such that it is easy to achieve experiences of convenience such as automatically turning on the lights when entering and automatically turning off the lights when exiting.

(3) Value and results after project implementation

The smart home system solution based on a smart speaker Bluetooth mesh has five unique innovative features:

1） Convenient access to the network that does not rely on Wi-Fi routers, making it simple and easy to use.

2） Batch access of smart home devices is fast and convenient.

3） Utilization of a complete closed-loop voice control system which can control smart home devices across speaker device levels with an industry-leading interactive experience.

4） Low power consumption throughout the entire scenario; compared with similar products in the industry, it has obvious advantages in terms of battery life.

5） Two-way authentication of cloud devices makes smart home safer.

The technical thinking behind the smart home system based on the smart speaker Bluetooth mesh described in the case study have been widely used in industry. This has not only reduced use costs for users but has also improved the user experience. This solution is highly competitive and has great promotional prospects in the industry, as proven in full by the series of massively popular products, such as smart switches and smart lights, in Xiaomi’s smart home ecosystem.

Case 7: Tencent Smart Model Platform Solution

Application area: AI + Finance

Application scenario: Modeling of business scenarios related to bank marketing, risk control, and operations

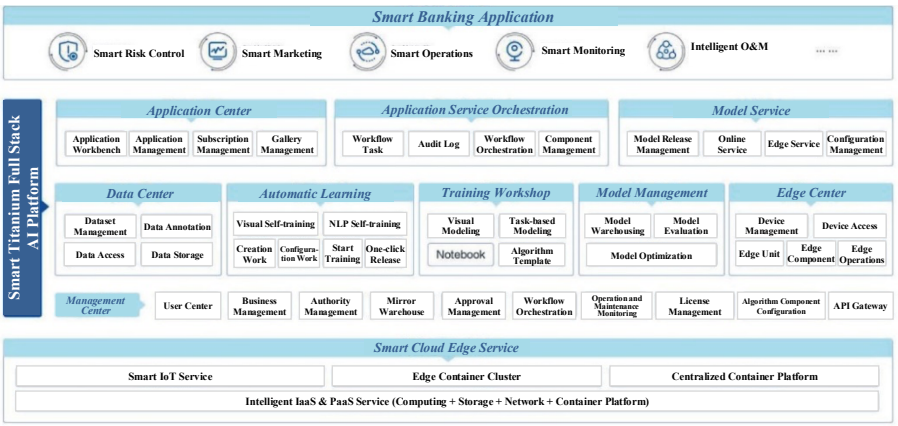
Case provider: Tencent

(1) Customer needs and project outline

The model platform project is a project planned and constructed by the customer in order to make up for the shortcomings of the existing data analysis and modeling capabilities in the industry. The project unifies the development and operation of the management model to form a platform-level AI service capability center. The project uses the Tencent cloud intelligent titanium TI-ONE platform (智能钛TI平台) to establish a machine learning platform based on big data, machine learning algorithms, deep learning algorithms, and other technologies, integrating data processing, model training, offline and online reasoning, and system management. The project is based on the intelligent titanium TI-ONE platform. When combined with banking-related business scenarios for business modeling, the solution fully taps into the value of existing data in the banking industry.

(2) Specific solution brief

With the help of the Tencent cloud intelligent titanium AI platform (智能钛人工智能平台), the entire process of business AI landing, including data acquisition, data processing, algorithm construction, model training, model evaluation, model deployment, and AI application development is opened up to the public, helping users to quickly create, deploy, and manage AI applications. The intelligent titanium AI platform includes nine capability centers, namely, the application center, application service orchestration, model services, the edge center, the data center, automatic learning, the training workshop, model management, and the management center. The solution provides users with full-process AI model production and application release services, allowing users to quickly obtain training data from multiple sources. The solution also provides a variety of tools for data annotation and feature extraction, allowing users to make use of simplified or specialized algorithm modeling tools as needed and dispatch computing resources for model production and effect evaluation. With one-click deployment of models to production services, users can quickly connect to cloud-edge-end data, algorithms, and smart devices, and with component orchestration tools, the solution supports the management and scheduling of services and resources. In addition, through the continuous integration of AI service components and the opening up of standardized interfaces, internal and external algorithms, data, and equipment resources are integrated into the solution to meet the needs of complex AI business scenarios for AI services.

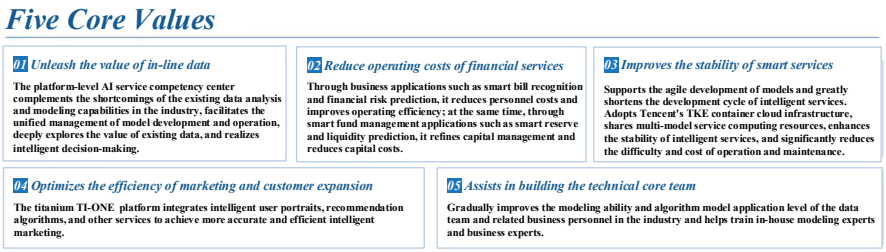


(3) Value and results after project implementation

1） The solution provides smart data support services for risk control, marketing, and operations in the industry to enhance the depth and breadth of data applications.

2） The solution improves the modeling capabilities and level of algorithm model applications for data teams and related business personnel in the industry, cultivates modeling experts and business experts, and improves the level of independent controllability (自主可控) of machine learning modeling in the industry.

3） The solution also provides capacity support for the customer's comprehensive transformation to digital and intelligent banking.



Case 8: Smart warehousing logistics system

Application area: AI + Logistics

Application scenario: Automated factory supporting smart warehousing logistics solutions

Case provider: Beijing Megvii Technology Co., Ltd.

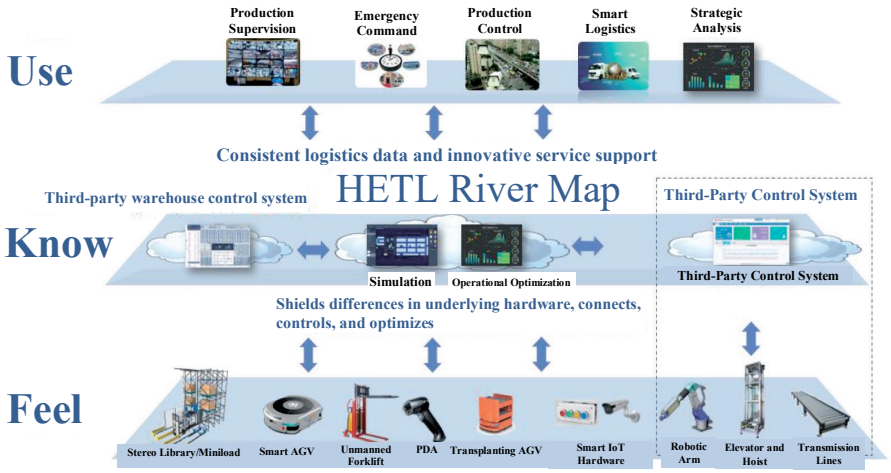
(1) Customer needs and project outline

China is the world's largest logistics market. As a key link in the deep integration of modern manufacturing and logistics, "building a modern logistics system" was included in the Central Economic Work Conference as one of the key tasks of economic work in 2021. One of the important components is modern warehousing and logistics. Through the introduction of advanced information technologies such as AI, IoT, and big data, a smart warehousing and logistics system plan was constructed to greatly improve the efficiency of production and manufacturing.

Under this industry trend, in order to further enhance the overall competitiveness of its products, after thorough investigation and analysis, leading home electronics company A decided to plan the automation transformation of the production plant. The project was required to build a highly automated, information-based smart warehousing logistics system that integrates a receiving platform, three-dimensional warehousing, smart handling, automatic distribution, automatic connection, and other automated equipment. The smart manufacturing capabilities would also need to serve automatic and continuous production to shorten the production cycle, reduce manufacturing costs, and respond quickly to market demand.

(2) Specific solution brief

The overall system architecture for the solution was built around the Megvii Hetu (河图) system. As shown in the figure, it bridges the industrial gap between software and hardware, promotes the integration of software and hardware, and can provide multi-device access capabilities and a wealth of smart robotic management solutions to help companies create a new smart IoT model of "human-computer collaboration with group intelligence and openness" to reduce costs and increase efficiency.



The solution establishes a full-process management and control mechanism, creates a digital management platform with a manufacturing execution system (MES) at its core, and builds a digitalization scheme through SAP, product lifecycle management (PLM), a warehouse management system (WMS), supplier relationship management (SRM), electronic billboards, production lines, and other systems and tools for an unmanned factory that integrates efficient manufacturing, data interconnection, and lean management.

The solution establishes a rapid product traceability system to quickly trace raw materials, production processes, materials and parts, and quality control to improve analysis capabilities and information management.

The solution establishes complete workshop control of raw materials, semi-finished products, and finished products to realize precise material demand distribution and inventory control and reduce the amount of manufacturing and raw materials at production sites.

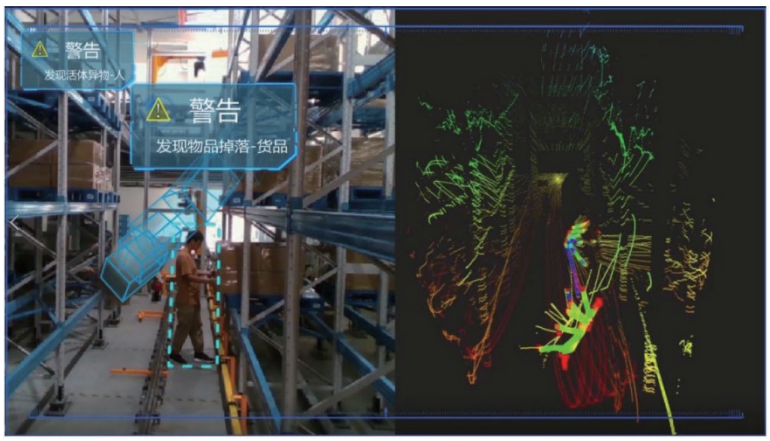
The solution establishes a data platform to realize the centralized storage and analysis of production process information data for the establishment of an information platform.

(3) Value and results after project implementation

After adopting the smart warehousing and logistics solution, the safety and efficiency of enterprise A's intelligentized production has been significantly improved, for example:

1） Significant improvement in storage capacity: Key performance indicators such as cargo flow, three-dimensional storage in storage, sorting, and outflow, and material distribution have been greatly improved, exceeding the predetermined target, with an increase to the material storage cycle of 30%.

2） Improved safety: In the field of industrial production, safety is always one of the core elements. In the smart warehousing logistics solution, the world's first AI stacker with stack shape recognition, foreign body tracking detection, and visual inventory functions are also deployed, greatly reducing the possibility of accidents.



1） Flexible guarantee: The picking modules in different regions are interchangeable, and the unbalanced production capacity results in the extrusion of semi-finished products on the line, which can be returned to the warehouse for processing.

2） Low expansion cost: The river map system in the center is self-learning and self-adapting, such that it is easy to increase management capacity. The automated guided vehicle (AGV) map can also be expanded flexibly, and the construction is convenient.

Case Study 9: Smart Policing System

Application area: AI + Public Security

Application scenarios: Scenarios such as public safety and community management

Case provider: Intellifusion

(1) Customer needs and project outline

The customer intended to analyze the key target elements of humans, human bodies, vehicles, non-motor vehicles, and the like in the regional and city-level captured videos through the video big data platform in the hopes of automatically extracting information such as what cars, which people dressed in what kinds of clothes, what features of faces, and what features of non-motorized vehicles appear in the region during what time periods. At the same time, the

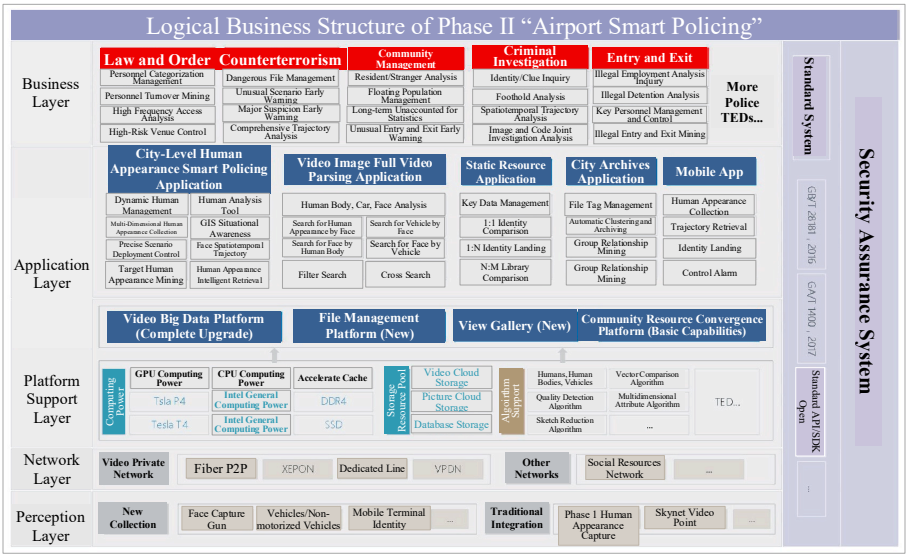
customer intended to integrate multi-dimensional data sources to realize multi-dimensional information association with targets of analysis at the core so as to form a knowledge map. With the use of efficient multi-dimensional information retrieval, related information for corresponding times, spaces, and identification dimensions can be quickly discovered, improving the accuracy of target analysis, reducing the scope of investigation, and improving the ability of police research and judgment.

Through its DeepEye (深海) multidimensional big data system, Intellifusion addressed the independence of various systems and the isolation of various data to realize the integration and analysis of various data such as human image data, vehicle data, mobile phone data, electronic fencing, and Wi-Fi data. The system archives massive amounts of data to form a human-centered (以人为核心) multi-dimensional data holographic archive and combines work requirements to analyze and apply target characteristics so as to realize applications such as pre-warning, in-event management and control, and post-event traceability in the region.

(2) Specific solution brief

In 2019, Intellifusion delivered a set of DeepEye multidimensional big data systems to the Shuangliu Branch of the Chengdu City Public Security Bureau. The system is "human appearance-centered" (以“人像为核心”) and while creating a new sensing source, it also integrates existing data from Skynet,[8] intelligent transportation, and other sectors. The system then integrates all the elements of videos of “people and cars” and combines data such as communication, traffic, and identity information. With the help of Intellifusion’s underlying clustering and archiving Tiantu (天图) engine and the multi-billion-level relationship mapping capabilities of the Tianpu (天谱) engine and other AI big data analysis capabilities, a smart policing application system has been created that integrates geographic information system (GIS) regional trajectory analysis, global deployment, and early warning, city-level human and vehicle case files, surveillance that integrates images and code (图码联侦), holographic relationship mapping, and multiple management and control techniques and tactics. This system has comprehensively improved the policing performance of the Shuangliu Branch and also promotes the derivation of smart policing mechanisms under the new AI capabilities, providing an effective policing guarantee for regional "law enforcement, crime prevention, management, control, and service" (“打防管控服”).

[8] Translator's note: Skynet (天网) is an interconnected system of video surveillance camera data from a vast expanse of venues and locations in China.



(3) Value and results after project implementation

Since 2019, the Shuangliu Branch of the Chengdu Public Security Bureau has firmly grasped the favorable opportunities in its district to vigorously promote the development of the AI industry and has used the construction of "Smart Airport Policing" as a vehicle for improving the level of urban smart governance and to build the first "regional" human appearance tracking system in southwestern China. Since the official operation of the "Smart Airport Policing" application platform in August 2019, a total of more than 3.2 billion dynamic pictures of humans were collected, and the various police systems of the sub-bureaus have logged in and used it more than 35,020 times with more than 231,750 face searches, assisting in the arrest of more than 950 suspected criminals of all types (including more than 200 online fugitives) and assisting in the recovery of more than 200 people who had been missing under various categories. The platform has also assisted in the cracking of the "January 9, 2020 Jewelry Store Heist," "February 11, 2020 Baiyun West Street Intentional Homicide," the "Intentional Assault and Murder of Du Moufang (杜某芳)," the "June 14 Intentional Homicide," and other major cases.