Translation

The following government-issued white paper describes China's approach to standards-setting for artificial intelligence. Appendices list all of China's current (as of January 2018) and planned AI standardization protocols, and provide examples of applications of AI by China's leading tech companies.

Title
Artificial Intelligence Standardization White Paper (2018 Edition)
人工智能标准化白皮书（2018版）

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China Electronics Standardization Institute (CESI; 中国电子技术标准化研究院; 电子标准元) is the "compiling unit" (编写单位) for this white paper. The 2nd Industrial Department (工业二部) of the Standardization Administration of China (SAC; 国家标准化管理委员会) is the "guidance unit" (指导单位) for this white paper.

Source
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Contents

1 Preface

1.1 Research background

The concept of artificial intelligence (AI) was born in 1956. Over the course of more than a half century of development, AI technology and applications have experienced many ups and downs due to the influence of intelligent algorithms, computing speeds, data storage levels, and other factors. Since 2006, tremendous success has been achieved in fields like machine vision and speech recognition using machine learning algorithms represented by deep learning. The great improvements in recognition accuracy have once again made AI the object of widespread attention across academia and industry. At the same time that technologies like cloud computing and big data are boosting calculation speeds and lowering computing costs, they are also providing rich data resources for AI development, helping to train more intelligentized (智能化) algorithm models. The AI development model has also undergone a gradual transformation from seeking to "use computers to simulate artificial intelligence" to enhanced hybrid intelligent systems combining machines and humans. These use combinations of machines, humans, and networks to form collective intelligence systems, and use combinations of machines, humans, networks, and things to form more complex intelligent systems.

As the core driving force behind a new round of industrial transformation, AI is spawning new technologies and new products. At the same time, AI is also playing a powerful empowering role for traditional industries. It has the potential to induce major changes in the industrial structure and to bring about an overall leap in social productive forces. AI can free humans from monotonous labor, as more and more simple, repetitive and dangerous tasks are being completed by AI systems. While reducing labor inputs and increasing work efficiency, AI systems can also do things faster and more accurately than humans. AI can find broad applications in such fields as education, medical treatment, eldercare, environmental protection, city operation, and justice services, and it is able to greatly improve the precision level of public services and increase the quality of people's lives across the board. AI can also help humanity accurately perceive, predict, and warn of major situations in the operation of infrastructure and public security, promptly grasp changes in collective consciousness and psychology, take the initiative to make decisions in reaction to events, and significantly improve social governance capabilities while safeguarding public security.

Since AI is a future-shaping strategic technology, the world's developed nations are all striving for dominance in a new round of international competition, and issuing plans and policies centered around AI. They are making deployments for core AI technologies, top AI talents, and AI standards and norms, and are accelerating the development of AI technologies and industries. The major technology companies are constantly enlarging their investments of money and manpower to seize the high ground in AI development. In 2017, China released the New Generation Artificial Intelligence Development Plan (Guo Fa [2017] No. 35), the *Three Year Action Plan to Promote the Development of the New Generation Artificial Intelligence Industry, 2018-2020* (No. 231 [2018] of the Ministry of Industry and Information Technology) and other policy documents to promote the R&D and industrialized development of AI technology. Currently, there is a certain technological and industrial foundation for AI development in China, with an array of AI companies concentrated in the microchip, data, platform, and applications fields. They have achieved good initial results in some directions and moved towards commercialized development. For example, applications have been achieved in such fields as the financial, security, and service industries; and in specific tasks, the degree of accuracy and effectiveness of semantic recognition, speech recognition, facial recognition, image recognition technologies already far exceed those of humans.

Standardization work plays fundamental, supportive, and guiding roles for AI and its industrial development. It represents both a key lever for promoting the development of industry innovation, as well as the commanding heights of industry competition. At present, while AI-related products and services in China are growing increasingly abundant, problems with inadequate degrees of standardization are also surfacing. AI involves numerous fields. Although some fields already have a certain foundation of standardization, these scattered standardization efforts are insufficient to fully support the entire AI field. In addition, AI is an emerging field that is just beginning to take off. On a global scale, standardization work is still in its infancy, and a complete system of standards has yet to take shape. With China and the rest of the world basically on the same starting line, a window of opportunity exists for breakthroughs. As long as we take aim at that opportunity and deploy rapidly, it will be entirely possible to seize the commanding heights of standards innovation. Otherwise, a good opportunity may be lost. Consequently, there is an urgent need to take advantage of the opportunity at hand, accelerate research on AI technology and industry development, systematically sort through and develop systems of standards for various AI fields, clarify the relationships of dependency and constraint between standards, establish unified and complete systems of standards, and use standards as a means to promote the booming development of AI technologies and industries in China.

1.2 Research objectives and significance

Prior to this white paper, under the guidance of the 2nd Industrial Department of the Standardization Administration of China (SAC) and the Science and Technology Department of the Ministry of Industry and Information Technology (MIIT), by sorting through the evolving circumstances of AI technologies, applications and industries, and analyzing the technology hot spots (热点), industry dynamics, and future trends of AI, standards systems were researched and formulated that are capable of adapting to and guiding the development the AI industry, starting from the perspective of supporting the overall development of the industry. Then, the fundamental and key standards projects that are urgently needed in the short term were further proposed.

This white paper is not intended to be a comprehensive review of technologies and industries in AI fields, nor does it go into extensive detail. It merely analyzes the current technology hot spots and industry circumstances covered within AI fields, so as to investigate and propose systems of AI standards. AI standardization is still in its infancy, and this white paper only serves as an initial link connecting AI technologies, AI industries, and standardization. It will be revised constantly in the future based on the developing requirements of technologies, industries, and standardization. This white paper gives only a moderate amount of opinion-based statements, and strives to use relatively simple and easy-to-understand language and methods for exposition purposes.

The significance of this white paper lies in sharing research results and practical experiences in the AI field with those involved in the industry, as well as calling on different segments of society to jointly strengthen AI-related technology research, industry investment, service applications, and building up of standards, for the joint promotion of AI and its industrial development.

2 Outline of Artificial Intelligence (AI)

2.1 History and concept of AI

2.1.1 Origins and history of AI

AI began in the 1950s, and thus far its development can be divided roughly into three stages. First stage (1950s to the 1980s): This stage saw the birth of AI. The programmable digital computer had already appeared, based on abstract mathematical inference, and symbolism was developing rapidly, but because many things could not be expressed in a formalized fashion, the models built had certain limitations. Also, given the increasing complexity of computational tasks, AI encountered bottlenecks for a time. Second stage (1980s to the end of the 1990s): In this stage, expert systems achieved rapid development, and there were significant breakthroughs in mathematical models, but due to the inadequacies of expert systems in terms of knowledge acquisition and reasoning ability, as well as high development costs, the development of AI again entered a lull. Third stage (beginning of the 21st century to the present): With the amassing of large amounts of data, innovations in theoretical algorithms, and increasing computing power, AI has made breakthrough advances in many application fields, ushering in a flourishing period. The specific course of AI's development is as shown in Figure 1.

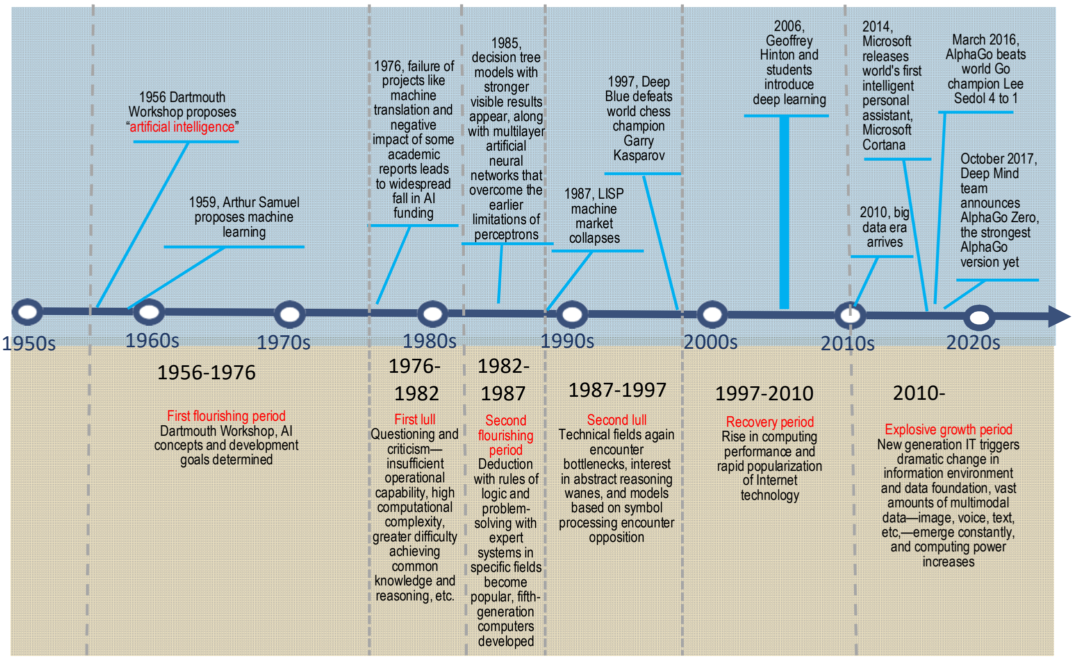


Figure 1. History of AI development

Making intelligent machines has long been a major dream of humans. As early as 1950, Alan Turing set forth his thinking on AI in *Computing Machinery and Intelligence*. The Turing test he proposed is an important measure of machine intelligence, and it later gave rise to the visual Turing test and other measurement methods. The term "artificial intelligence" appeared for the first time at the Dartmouth Workshop in 1956, marking it as the formal birth of AI as a field of research. Over the past 60 years, while AI development has had its ups and downs, the basic thinking can be roughly divided into four schools: symbolism, connectionism, behaviorism, and statisticism. This white paper will not attempt to elaborate on these four schools. The four schools grasp some of the characteristics of AI from different aspects, but in terms of "producing" AI, they have all made landmark achievements.

Arthur Samuel proposed machine learning in 1959. With machine learning, producing intelligence evolved into gaining intelligence through the ability to learn, and this pushed AI to enter the first flourishing period. With the emergence of expert systems in the late 1970s, AI achieved a major breakthrough, moving from theoretical research into the realm of practical applications, from exploration of general rules of thinking to the application of specialized knowledge. This propelled AI research to a new peak. However, machine learning models remained "artificial" and had significant limitations. Deepening application of expert systems exposed their inherent problems in terms of knowledge acquisition difficulty, narrow fields of knowledge, weak reasoning capability, poor applicability and so on. Beginning in 1976, AI research entered a 6-year-long bleak period.

In the mid-1980s, with AI research project initiation support from the US and Japan, as well as the development of knowledge engineering-oriented machine learning methods, there emerged decision tree models with stronger visible results and multilayer artificial neural networks that overcame the earlier limitations of perceptrons. This led to another flourishing period for AI. At that time, however, it was difficult for computers to simulate highly complex and large-scale neural networks, so certain limitations remained. In 1987, due to the collapse of the LISP machine market, the US cancelled AI funding, Japan's Fifth Generation Computer Project failed and it exited the market, the progress of expert systems slowed, and AI again entered a bleak period.

In 1997, IBM's Deep Blue defeated world chess champion Garry Kasparov. This success had landmark significance, as it represented a victory for rule-based AI. In 2006, with promotion from Geoffrey Hinton and his students, deep learning began to attract attention. This had a significant influence on the subsequent development of AI. Starting in 2010, AI entered an explosive development phase, driven mainly by the advent of the big data era, as well as gains in cloud computing capabilities and machine learning algorithms. With the swift development of AI, the industry also began continuously churning out new R&D achievements: In 2011, on the *Jeopardy* game show, IBM Watson prevailed against the record-holders for highest earnings and longest winning streak; in 2012, Google Brain, by imitating the human brain and without human guidance, used unsupervised deep learning methods to successfully learn from large amounts of videos how to identify cats; in 2014, Microsoft unveiled a real-time translation system which could mimic speakers' voices and save their accents; the same year, Microsoft released the world's first intelligent personal assistant, Microsoft Cortana; also in 2014, Amazon released the most successful smart speaker product to date, the Echo, and the Alexa personal assistant; in 2016, Google's AlphaGo robot defeated world champion Lee Sedol in a Go competition; and in 2017, Apple launched the Siri intelligent personal assistant and HomePod, based on its original Siri personal assistant.

At present, countries around the world have all begun emphasizing AI development. On June 29, 2017, the first World Intelligence Congress opened in Tianjin. At the main forum of the Congress, Pan Yunhe, an academician of Chinese Academy of Engineering, delivered a keynote address on the theme of "China's new generation AI." His address covered the AI research strategies of different countries around the world: In May 2016, in the United States, the White House published *Preparing for the Future of Artificial Intelligence*; in December

2016, the United Kingdom released *Artificial Intelligence: Artificial intelligence: opportunities and implications for the future of decision making*; in April 2017, France formulated the *National Strategy for Artificial Intelligence*; Germany enacted its first nationwide self-driving cars law in May 2017; according to incomplete statistics, there were upwards of 400 Chinese AI companies operating in China in 2017, and industry giants like Baidu, Tencent, and Alibaba were all ramping up efforts in AI fields. Viewed in terms of quantity and investment, natural language processing, robots, and computer vision have become AI's three hottest areas of industry focus.

2.1.2 **Concept of AI**

AI being an interdisciplinary field, there have always been different viewpoints as to its definition. In ***Artificial Intelligence: A Modern Approach***, some of the existing definitions of AI are divided into four categories: systems that think the same as humans, systems that act the same as humans, systems that think rationally, and systems that act rationally. According to the **Wikipedia** definition, "artificial intelligence is intelligence demonstrated by machines," that is, anything, as long as it is some kind of machine and has the characteristics or appearance of some kind or kinds of "intelligence," should be counted as "artificial intelligence." **The Encyclopedia Britannica**, meanwhile, defines AI as the ability of a digital computer or digital computer-controlled robot to perform certain tasks that only intelligent beings have the ability to do. **Baidu Baike** defines AI as "a new technological science that studies and develops theories, methods, technologies, and application systems used in the simulation, extension and expansion of human intelligence." It regards AI as a branch of computer science, noting that its research includes robots, speech recognition, image recognition, natural language processing, and expert systems.

In the view of this white paper, AI is the theories, technologies, methods, and application systems for using digital computers or digital computer-controlled machines to simulate, extend, and expand human intelligence, perceive environments and acquire knowledge, and use knowledge to obtain the best results.

Definitions of AI explain the basic idea and content of the AI discipline, that is, the man-made systems constructed around intelligent activities. AI is the engineering of knowledge. It is the process of simulating human use of knowledge to complete certain actions. AI can be divided into weak AI and strong AI based on whether the AI can truly achieve reasoning, thinking, and problem-solving.

Weak AI refers to intelligent machines that are unable to truly achieve reasoning and problem-solving. These machines superficially seem intelligent, but do not truly possess intelligence, nor do they have independent consciousness. So far, AI systems are all still specialized intelligence that achieves specific functions, and are not able, as humans are, to constantly adapt to complex new environments and constantly come up with new functions. Hence, they are all weak AI. Mainstream research at present remains centered on weak artificial intelligence, and remarkable progress has been made. For example, major breakthroughs have been made in areas such as speech recognition, image processing, object segmentation, and machine translation, in which the levels are near or even beyond human ones.

Strong AI refers to intelligent machines that truly think, and these kinds of machines are considered to have perception and self-awareness. This class of machines can be divided into two main categories: humanoid (the machine's thinking and reasoning is similar to human thinking) and non-humanoid (the machine generates perceptions and awareness that are entirely different from those of humans, and use reasoning methods that are entirely different from those of humans). In terms of general significance, AI that achieves human levels, can respond adaptively to challenges in the external environment, and has self-awareness is called "artificial general intelligence," "strong artificial intelligence," or "human-like intelligence." With strong AI, not only are there enormous philosophical debates (involving discussion of fundamental questions about thinking and consciousness), but the research also has huge technological challenges. Progress on strong AI is currently rare. The view more supported by experts in the U.S. private sector and the U.S. National Science and Technology Council (NSTC) is that it is unattainable, at least within the next few decades.

Can strong AI be designed and produced relying on the classical routes of the four schools—symbolism, connectionism, behaviorism, and statisticism? One mainstream view among them is: Even if there were higher-performance computing platforms and big data support on a larger scale, it would still only be a change of quantity, not quality. Humans' understanding of their own intelligence is still in its infancy. Until humans really understand the mechanisms of intelligence, it will be impossible to produce strong AI. Understanding the mechanisms by which the brain generates intelligence is the ultimate question in neuroscience. The vast majority of neuroscience experts believe that this is a question which will take hundreds or thousands of years to solve, or will remain forever unsolvable.

There is also a "new" route that leads to strong AI, which we will call "simulationism." In this new route, the brain is analyzed structurally through the manufacturing of advanced brain detection tools, then engineering technology and methods are used to construct brain-inspired devices that mimic the brain's neural network elements and structure, and finally, through environmental stimuli and interactive training, the brain is emulated to achieve human-like intelligence. Although this feat of engineering is also very difficult, the engineering technical problems can all be solved in a matter of decades, instead of being in the remote distance like the scientific problem of "understanding the brain."

Simulationism could be called a fifth school after symbolism, connectionism, behaviorism, and statisticism. It is linked in countless ways to those earlier four schools, and it is also a key link between the previous four schools leading toward strong artificial intelligence. Classical computers are achieved with mathematical logic-based switching circuits, employ a Von Neumann architecture, and can serve as the vehicles for achieving a specialized intelligence such as logical reasoning. However, strong AI cannot be achieved relying on classical computers. For the simulationism route to "brain emulation," it is necessary to design and manufacture an entirely new software-hardware system, and that is "brain-inspired computers," or more accurately, "brain emulators" (“仿脑机”). "Brain-based devices" are an iconic achievement of simulation engineering, and they are also an important milestone on the path toward strong AI.

2.2 Features of AI

（1） **Designed by humans for the service of humans, computational in essence, and data-based**. Fundamentally speaking, AI systems must be people-centered. These systems are human-designed machines, running or working by means of human-invented microchips and other hardware according to human-designed program logic or software algorithms.

Their nature is manifested as computation, and through the collection, processing, handling, analysis, and mining of data, they form valuable information streams and knowledge models, provide people services that extend their human abilities, and achieve simulation of some of the "intelligent behaviors" expected of humans. Ideally, they must be characterized by service to humans. They should not harm humans, and in particular, they should not have behavior that intentionally does harm to humans.

（2） **Able to perceive environments, generate reactions, interact with humans, and be complementary to humans**. By means of sensors and other devices, AI systems should have the ability to perceive the external environment (including humans), be able to receive various kinds of information from the environment, as humans do, through the senses—hearing, sight, smell, touch, etc., enter/produce text, speech, expressions, actions (control actuators) and other necessary reactions, and even influence environments or humans. By means of pushbuttons, keyboards, mice, screens, gestures, postures, expressions, force feedback, virtual/augmented reality and other methods, interaction between people and machines can be produced, such that machinery and equipment increasingly "comprehend" humans, or even collaborate with them, with each complementing the other's strengths. In this way, AI systems can help humans do work that humans are not good at or do not like, but which can be completed by machines, whereas humans are suited to doing jobs that require greater creativity, insight, imagination, flexibility, variety, or careful comprehension, or that require emotion.

（3） **Able to adapt, learn, evolve iteratively, connect, and expand**. Under ideal conditions, AI systems possess a certain adaptability and ability to learn, that is, they can adaptively adjust parameters or update and optimize models following changes in the environment, data or tasks; moreover, on this basis, they are able to achieve iterative evolution with machines or even humans as objects through increasingly broad and in-depth digital connection/expansion to clouds, terminals, people, and things. This makes the systems adaptive, robust, flexible, and expandable, in order to respond to constantly changing real environments, thereby allowing AI systems to generate an abundance of applications in all fields of endeavor.

2.3 AI reference architecture

At present, the AI field has yet to form well-developed reference architectures. Therefore, one kind of reference architecture is proposed in this chapter (as shown in Figure 2) based on AI's state of development and application characteristics, starting from the standpoint of the flow of information. We strive to build a relatively well-developed AI agent architecture, describing the overall workflow of the AI system, without being limited to specific applications, so that it is suitable to the needs of general AI fields.

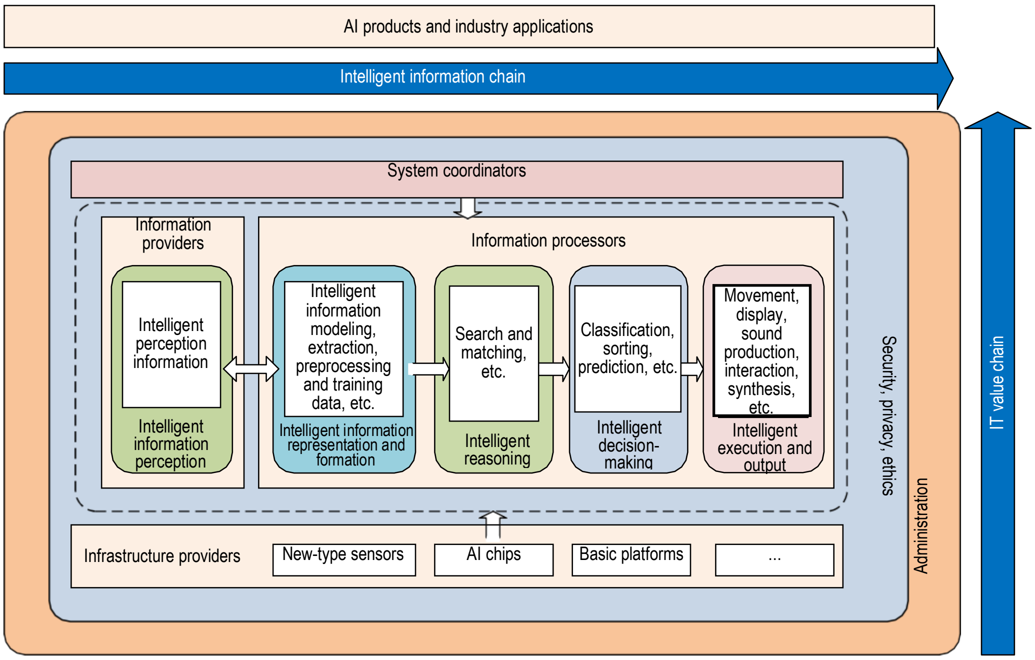


Figure 2. Diagram of AI reference architecture

The AI reference architecture provides a hierarchical classification system based on "roles—activities—functions," and elaborates the framework of the AI system from the two dimensions of "intelligent information chain" (horizontal axis) and "IT value chain" (vertical axis). The "intelligent information chain" reflects the general process from intelligent information perception to intelligent information representation and formation, intelligent reasoning, intelligent decision-making, and intelligent execution and output. In this process, intelligent information is a flowing carrier, undergoing a condensation process of "data—information—knowledge—wisdom." The "IT value chain," from the underlying AI infrastructure and information (provision and processing of technical realizations) to the system's industry ecosystem, reflects the value that AI contributes to the IT industry. In addition, AI systems also have other very important framework construction elements: security, privacy, ethics, and administration. AI systems are composed primarily of infrastructure providers, information providers, information processors, and system coordinators.

(1) Infrastructure providers

Infrastructure providers provide AI systems computing power support, achieve communication with the outside world, and achieve support through basic platforms. Computing power is provided by developers of smart chips (CPU, GPU, ASIC, FPGA, and other hardware acceleration chips, as well as other smart chips). Communication with the outside world is through new-type sensors provided by manufacturers. Basic platforms include the platform protection and support provided by distributed computing framework providers and network providers.

(2) Information providers

In AI fields, information providers are the sources of information. Intelligent perception information is provided by data providers through the knowledge and information perception process, and includes original data sources and data collection. Original data source perception involves graphical, image, voice, and text recognition. It also involves the Internet of Things (IoT) data of traditional equipment, including the business data of existing systems as well as such perception data such as force, displacement, liquid level, temperature, and humidity.

(3) Information processors

Information processors are providers of technology and services in AI fields. The main activities of information processors include intelligent information representation and formation, intelligent reasoning, intelligent decision-making, and intelligent execution and output. Intelligent information processors are usually algorithm engineers and providers of technical services, and they carry out support by means of computing frameworks, models, and general-purpose technology, such as certain deep learning frameworks and machine learning algorithm models.

Intelligent information representation and formation refers to a set of conventions made in order to describe the surrounding world, and the symbolization and formalization of intelligent information in stages with intelligent information modeling, extraction, preprocessing, training data, etc.

Intelligent information reasoning, in computers or intelligent systems, refers to the process of simulating human intelligent reasoning methods and, based on an inference control strategy, using formalized information to carry out machine thinking and problem-solving, with search and matching being typical functions.

Intelligent information decision-making refers to the decision-making process carried out after reasoning is applied to intelligent information, usually providing such functions as classification, sorting, and prediction.

Intelligent execution and output serves as the intelligent information output link, and is the response to the input. The output is the result of the entire intelligent information flow process, and its functions include movement, display, sound production, interaction, and synthesis.

(4) System coordinators

System coordinators provide the overall requirements that the AI system must satisfy, including policy, legal, resource, and business requirements, as well as the supervisory control and audit activities carried out to ensure that the system meets those requirements. Because AI is an interdisciplinary field, it is necessary for system coordinators to define and integrate the required application activities, so that they will run in the vertical systems of AI fields. One of the functions of system coordinators is to configure and manage other roles within the AI reference architecture as they execute one or more functions, and to maintain the operation of the AI system.

(5) Security, privacy, and ethics

Security, privacy and ethics cover the other 4 main roles in the AI field, and have significant influence over each role. At the same time, security, privacy, and ethics fall within the administrative role's scope of coverage, and relevant connections are established between them and all roles and activities. In security, privacy, and ethics modules, it is necessary to construct comprehensive and solid security protection systems through different technical means and security measures, so as to protect the security and privacy of AI field participants.

(6) Administration

The administrative role is responsible for system administration activities, including software deployment, resource management, and so on. The function of administration is to monitor the operational status of various kinds of resources, and respond to performance or malfunction incidents, so that each system component is transparent and observable.

(7) AI products and industry applications

AI products and industry applications are the products and applications of AI systems. They are the encapsulation of overall AI solutions, wherein intelligent information decision-making is commercialized in products and realized in applications. Their main application areas include the smart manufacturing, smart transportation, smart home, smart health care, and smart security areas.

3 Current AI situation and trends

Based on the AI-related technology that is involved in the reference architecture, the focus of this section is on introducing the state of development of key technologies in the AI field over the last twenty years, including such key technologies as machine learning, knowledge graphs, natural language processing, computer vision, human-computer interaction, Biometric feature recognition, and virtual/augmented reality.

3.1 Key AI technologies

3.1.1 Machine learning

Machine learning is an interdisciplinary field involving many areas—statistics, system identification, approximation theory, neural networks, optimization theory, computer science, brain science, etc. It studies how machines can simulate or achieve human learning behavior to acquire new knowledge or skills, and how they reorganize the structure of existing knowledge so that their own performance is constantly improving. It is the core of AI technology. Data-based machine learning is an important method in modern intelligence technology. Research involves searching for rules starting from observational data (samples), and using those rules to predict future data or unobservable data. There are different classification methods in machine learning based on different learning styles, learning methods, and algorithms.

(1) Based on learning styles, machine learning is classified into supervised learning, unsupervised learning, and reinforcement learning.

Supervised learning

Supervised learning is the use of a labeled training dataset, and a model established through a certain learning strategy/method, to achieve a labeling (classification)/mapping of new data/instances. The most typical supervised learning algorithms include regression and classification. Supervised learning requires that the classification labels of the training sample are known. The more precise the classification labels are, and the more representative the sample is, the more accurate the machine learning will be. Supervised learning has been extensively applied in areas such as natural language processing, information retrieval, text mining, handwriting recognition, and spam detection.

Unsupervised learning

Unsupervised learning is using unlabeled limited data to describe the structure/rules in unlabeled data. The most typical unsupervised learning algorithms include one-class density estimation, one-class dimensionality reduction, and clustering. Unsupervised learning, which does not require training samples or human-annotated data, facilitates compressing data for storage, reducing the amount of calculations, and increasing algorithm speeds, and it can also avoid classification error problems caused by positively or negatively biased samples. It is mainly used in fields like economic forecasting, anomaly detection, data mining, image processing, and pattern recognition, for purposes such as assembling large-scale computer clusters, social network analysis, market segmentation, and astronomical data analysis.

Reinforcement learning

Reinforcement learning is where intelligent systems learn from the environment-to-behavior mapping, such that the function value of the reinforced signal is maximized. Because very little information is provided by the external environment, the reinforcement learning system must learn by relying on its own experience. The goal of reinforcement learning is to learn from the mapping from environmental states to behaviors, so that the behavior chosen by the intelligent agent obtains the environment's maximum reward, and the external environment evaluates the learning system to be in some sense the best. It has been successfully applied in such fields as robot control, self-driving cars, chess, and industrial control.

(2) Machine learning can be divided into traditional machine learning and deep learning based on the learning approach.

Traditional machine learning

Traditional machine learning starts with some observational (training) samples and attempts to discover rules that cannot be obtained through analysis of principles, then achieve accurate prediction of future data behavior or trends. Relevant algorithms include logical regression, the hidden Markov method, support vector machines, k-nearest neighbor, three-level artificial neural networks, the Adaptive Boosting (AdaBoost) algorithm, Bayesian methods, and decision tree methods. Traditional machine learning weighs the effectiveness of learning results and the explainability of learning models, and provides a kind of framework for solving problems of learning with limited samples. It is mainly used in pattern classification, regression analysis, and probability density estimation, under limited sample conditions. An important theoretical basis that traditional machine learning methods have in common is statistics, and these methods have found broad applications in many computer fields, such as natural language processing, speech recognition, image recognition, information retrieval, and biological information.

Deep learning

Deep learning is a learning method in which deep-level structural models are built. Typical deep learning algorithms include deep belief networks, convolutional neural networks, restricted Boltzmann machines, and recurrent neural networks. Deep learning is also called deep neural networks (referring to neural networks with more than 3 layers). An emerging field within machine learning research, deep learning was proposed by Geoffrey Hinton and others in 2006. Deep learning originated in multilayer neural networks. In essence, it provides a method that combines feature representation with learning. Deep learning characteristically abandons explainability, pursuing only the effectiveness of learning. Following many years of trial and error and study, numerous deep learning models have appeared, among which convolutional neural networks and recurrent neural networks are typical models. Convolutional neural networks are often applied to spatially distributed data; recurrent neural networks, which incorporate memory and feedback, are frequently applied to temporally distributed data. Deep learning frameworks are the basic underlying frameworks for carrying out deep learning. They generally include a mainstream neural network algorithm model, and support distributed learning of the training model among servers, GPUs, and TPUs. Some frameworks also have the ability to run on multiple platforms, including mobile devices and cloud platforms, and migrate from one to another. Mainstream open source platforms currently include TensorFlow, Caffe/Caffe2, CNTK, MXNet, Paddle-paddle, Torch/PyTorch, and Theano.

(3) In addition, common machine learning algorithms also include transfer learning, active learning, and evolutionary learning.

Transfer learning

Transfer learning refers to when, in certain fields, it is impossible to obtain enough data to conduct model training, and relationships obtained with data from another field are used to conduct learning. Transfer learning can transfer parameters from well-trained models to new models to guide the training of the new models, and can make learning underlying rules more efficient and reduce the quantity of data. Transfer learning at present is mainly used in small-scale applications with limited numbers of variables, such as positioning based on sensor networks, text classification, and image classification. In the future, transfer learning will be widely applied in solving more challenging problems like video classification, social network analysis, and logical reasoning.

Active learning

Active learning searches for the most useful unlabeled samples by means of a particular algorithm, then uses the samples found to train a classification model and increase the model's precision. Active learning is able to selectively acquire knowledge, and to obtain high-performance models with relatively few training samples. The most frequently used strategy is to select effective samples by means of uncertainty and diversity criteria.

Evolutionary learning

Evolutionary learning has very few requirements as to the nature of optimization problems, requiring only that the quality of the solution can be assessed. It is applicable to solving complex optimization problems, and can also be used directly in multi-objective optimization. Evolutionary algorithms include particle swarm optimization algorithms and multi-objective optimization algorithms. Currently, research on evolutionary learning is mainly focused on evolutionary data clustering, classifying evolutionary data more effectively, and providing certain kinds of adaptive mechanisms to determine the effects of evolutionary mechanisms.

3.1.2 Knowledge graphs

Knowledge graphs are essentially structured semantic knowledge bases. They are a type of graphical data structure consisting of nodes and edges, used to symbolically describe physical world concepts and their interrelationships. Their basic building blocks are "entity-relationship-entity" triples, as well as entities and their related "attribute-value" pairs. Different entities are interconnected through relationships to form a network knowledge structure. In knowledge graphs, each node represents a real-world "entity," and each edge is a "relationship" between one entity and another. More colloquially, a knowledge graph is a network of relationships obtained by taking all different kinds of information and linking them together, offering the ability to analyze problems from a "relationships" perspective.

Knowledge graphs can be used in anti-fraud, inconsistency verification, anti-organized fraud, and other public security protection fields where it is necessary to use anomaly analysis, static analysis, dynamic analysis, and other data mining methods. In particular, knowledge graphs have great advantages in the areas of search engines, visualization, and precision marketing, and they have become popular industry tools. However, there are still major challenges for the development of knowledge graphs, such as the problem of noisy data, i.e., where the data itself has errors or there is redundancy in the data. With the progressive deepening of knowledge graph applications, there remain a series of key technologies that require breakthroughs.

3.1.3 **Natural language processing**

Natural language processing is an important direction in the fields of computer science and artificial intelligence that investigates various theories and methods to achieve effective communication between people and machines using natural language. It involves many other fields, including primarily machine translation, machine reading comprehension, and question answering systems.

(1) Machine translation

Machine translation refers to the process of using computer technology to achieve translation from one natural language to another natural language. Statistics-based machine translation methods have overcome the previous limitations of translation methods based on rules and examples, and translation performance has made huge gains. The success of machine translation based on deep neural networks in certain scenarios, like everyday spoken language, has shown enormous potential. With the development of contextual representation of data in context and knowledge-based logical reasoning, and the continuous extension of knowledge graphs, machine translation will make greater progress in areas like dialog translation and text translation.

At present, one type of machine translation with relatively good performance in unrestricted domains is statistics-based translation, which includes training and decoding stages. The goal of the training stage is to obtain model parameters, while that of the decoding stage is to use the estimated parameters and a given optimization goal to obtain the best translation results for the sentences to be translated. The main steps in statistics-based translation include corpus preprocessing, word alignment, phrase extraction, phrase probability calculation, and maximum entropy ordering. For end-to-end translation methods based on neural networks, it is not necessary to design feature models specially for bilingual sentences. Instead, word strings are entered directly into a neural network model, and then translation results for the target sentences are obtained following operation by the neural network. In systems based on end-to-end machine translation, adopting a recursive neural network or convolutional neural network is usually adopted to carry out representation and modeling of sentences, and semantic information is extracted from vast amounts of training data. Compared to phrase-based statistical translation, its translation results are more fluent and natural, and relatively good results have been obtained in practical applications.

(2) Semantic understanding

Semantic understanding technology refers to the process of using computing technology to achieve understanding of text, and to answer questions regarding text. Semantic understanding places more emphasis on understanding context and controlling the accuracy of answers. Semantic understanding received greater attention following the release of the MCTest dataset, and rapid development was achieved as related datasets and associated neural network models emerged one after the other. Semantic understanding technology is poised to play an important role in relevant fields such as intelligent customer service, automated product question answering, etc., further improving the precision of question answering and dialog systems.

In terms of data acquisition, semantic understanding effectively expands data resources through automatic data generation and automatic fill-in-the-blank (cloze) question generation methods. In order to understand cloze-type questions, a series of deep learning-based methods have been proposed, such as the attention-based neural network method. Current mainstream models use neural network techniques to model texts and questions, predict the beginnings and ends of answers, and extract text segments. For more generalized answers, the processing difficulty rises further, and current semantic understanding technology still leaves considerable room for improvement.

(3) Question answering systems

Question answering systems are divided into open-domain dialog systems and specific domain question answering systems. Question answering system technology refers to technology that allows computers to communicate with humans using natural language just as humans do. People can pose questions to a question answering system using natural language representation, and the system responds with highly relevant answers. Although a good number of question answering system application products have now appeared, most are applications in areas like actual information service systems and mobile phone assistants, and in terms of robustness, question answering systems still have problems and challenges.

Natural language processing faces four big challenges: First, there is uncertainty with respect to different layers—lexical, syntactic, semantic, pragmatic, and phonetic; second, new vocabulary, terminology, semantics, and grammar lead to the unpredictability of new language phenomena; third, data inadequacies make coverage of complex language phenomena difficult; and fourth, semantic ambiguities and intricately complex relevance are difficult to describe using simple mathematical models, and semantic calculations require non-linear calculations with huge numbers of parameters.

3.1.4 **Human-computer interaction**

Human-computer interaction (HCI) mainly investigates the exchange of information between people and computers. It mainly includes the exchange of information in two directions, from people to computers and from computers to people, and is an important peripheral technology in the field of artificial intelligence. HCI is a comprehensive subject closely related to cognitive psychology, ergonomics, multimedia technology, and virtual reality technology. Traditional information exchange between people and computers mainly depends on interactive devices, including primarily keyboards, mice, joysticks, data clothing (数据服装), eye trackers, position trackers, data gloves, pressure pens, and other input devices, as well as printers, plotters, displays, helmet-mounted displays, speakers, and other output devices. In addition to the traditional basic interaction and graphic interaction, HCI technology includes speech interaction, affective interaction, somatosensory interaction, and brain-computer interaction. These four typical means of interaction are all closely associated with HCI, and each is introduced below.

(1) Voice interaction

Voice interaction is a highly effective interaction method. It is a comprehensive technology that uses natural language or machine-synthesized speech together with computers to carry out interaction, combining knowledge from linguistics, psychology, engineering, and computer technology fields. Voice interaction must not only study speech recognition and speech synthesis, but must also study people's interaction mechanisms and behavioral methods in voice-based channels. The voice interaction process includes four parts: speech acquisition, speech recognition, semantic understanding, and speech synthesis. Speech acquisition completes the recording, sampling, and encoding of audio; speech recognition completes the conversion of voice information into text information that machines can recognize; semantic understanding completes corresponding operations based on text characters or commands following conversion by speech recognition; and speech synthesis completes the conversion of text information into voice information. As the most natural and easiest way for humans to communicate and obtain information, voice interaction has more advantages than other interaction methods. It could potentially bring about a fundamental revolution in HCI, representing the pinnacle of future development in the era of big data and cognitive computing, and its prospects for development and application are vast.

(2) Affective interaction (情感交互)

Emotions are a high-level form of information transmission, whereas emotional ("affective") interaction is a kind of interactive state. It conveys emotions while expressing functions and information, and arouses people's memories or inner sentiments. Traditional HCI is unable to understand or apply people's feelings or moods. Lacking the ability to understand and express emotions, it is difficult for computers to have human-like intelligence, and it is difficult to achieve true harmony and naturalness through HCI. Affective interaction just means endowing computers with the same abilities to observe, understand, and produce emotions as people, and ultimately have computers be able to engage in natural, friendly, and lively interaction just as people can. Affective interaction has become a hot topic within the AI field, with the aim being to make human-computer interaction more natural. At present, there are still many technical challenges in such aspects as information processing methods for affective interaction, affective description methods, affective data acquisition procedures, and affective representation methods.

(3) Somatosensory interaction (体感交互)

Somatosensory interaction is where entities do not require the aid of any complex control systems, and, based on somatosensory technology, natural interaction with surrounding digital equipment and the environment is carried out directly by means of physical movements. Somatosensory technologies are divided mainly into three categories according to differences in somatosensory methods and principles: inertial sensing, optical sensing, and opto-inertial sensing (光学联合感测). Somatosensory interaction is usually supported by a series of technologies such as motion tracking, gesture recognition, motion capture, and facial expression recognition. In comparison with other means of interaction, somatosensory interaction technology has seen greater improvements in both hardware and software. Interaction equipment has developed in terms of miniaturization, portability, and ease of use, greatly reducing constraints on users and making the interaction process more natural. Currently, somatosensory interaction has found comparatively broad application in the gaming and entertainment, medical assistance and rehabilitation, fully automated three-dimensional modeling, assisted shopping, and eye tracking fields.

(4) Brain-computer interaction

Brain-computer interaction, also known as a brain-computer interface (BCI), refers to pathways for achieving direct transmission of information between the brain and the external world without relying on neural pathways of nerves, muscles, etc. BCI systems detect central nervous system activity and convert it into manual output commands. They can replace, restore, strengthen, supplement, or improve the normal output of the central nervous system, thereby changing the central nervous system's interaction with the internal and external environment. Brain-computer interaction converts brain signals into machine commands through nerve signal decoding. It generally includes three modules—signal acquisition, feature extraction, and command output. From the perspective of brain signal acquisition, BCIs are generally divided into invasive and non-invasive types. In addition, there are other common ways of differentiating BCIs: based on the direction of brain signal transmission, they can be divided into brain-computer, computer-brain, and bidirectional BCI; based on the type of signal generation, BCIs can be classified as spontaneous type and evoked type; based on different signal sources, they can be classified as brain electrical activity-based BCI, functional magnetic resonance-based BCI, and near infrared spectroscopy analysis-based BCI.

3.1.5 **Computer vision**

Computer vision is the science of using computers to mimic the human visual system, endowing computers with the ability to extract, process, comprehend, and analyze images, as well as with the ability to sequence images. Fields such as self-driving cars, robots, and smart health care all need to extract and process information from visual signals using computer vision technology. Recently, with the development of deep learning, there has been a gradual fusing of preprocessing, feature extraction, and algorithm processing to form end-to-end AI algorithm technology. Computer vision can be divided into five major categories based on the problems solved: computational imaging, image understanding, 3D vision, dynamic vision, and video coding/decoding.

(1) Computational imaging

Computational imaging is a science that explores the structure of the human eye, and the principles and extended applications of camera imaging. In terms of camera imaging principles, computational imaging constantly promotes improvement of visible light cameras, making modern cameras more portable and able to be applied in different scenarios. At the same time, computational imaging is also continually driving the generation of new types of cameras, so that cameras transcend the limitations of visible light. In terms of the applied science of cameras, computational imaging can improve camera capabilities, thereby improving images taken under restrictive conditions through subsequent algorithmic processing.

(2) Image understanding

Image understanding is a branch of science that uses computers to understand images in order to achieve understanding of the external world similar to that of the human visual system. It can generally be divided into three levels based on the degree of abstraction of the information understood: low-level understanding, including image boundaries, image feature points, and texture elements; intermediate-level understanding, including object boundaries, regions, and planes; and high-level understanding, which can be divided roughly into recognition, detection, segmentation, pose estimation, and image text description, based on the high-level semantic information that needs to be extracted. Application of high-level image understanding algorithms has gradually expanded to AI systems, such as those for face-based payment, smart security, and image search.

(3) 3D vision

3D vision is a science that studies how to obtain three-dimensional information through vision (3D reconstruction), as well as how to understand the 3D information thus obtained. 3D reconstruction can be divided according to the source of reconstruction information into single-view image reconstruction, multi-view image reconstruction, and deep image reconstruction. Three-dimensional information understanding means using three-dimensional information to assist in image understanding, or directly understanding three-dimensional information. Three-dimensional information understanding can be divided into low-level (corners, edges, normal vectors, etc.), mid-level (planes, cubes, etc.), and high-level (object detection, recognition, segmentation, etc.), Application of 3D vision technology can expand in robots, self-driving cars, smart factories, virtual/augmented reality, and other directions.

(4) Dynamic vision

Dynamic vision is a science that analyzes videos or series of images, and simulates the ordering of images during human processing. In general, dynamic vision problems can be defined as problems of searching for the correspondence of image elements (pixels, regions, objects) in time series, and extracting the semantic information. Dynamic vision research is widely applied in such areas as video analysis and human-computer interaction.

(5) Video coding/decoding

Video coding/decoding refers to the compression of video streams by means of specific compression techniques. In video stream transmission, the most important coding/decoding standards (codecs) are the International Telecommunication Union's series of standards: H.261, H.263, H.264, H.265, M-JPEG, and MPEG. Video compression is mainly divided into two categories: lossless compression and lossy compression. Lossless compression refers to when the data reconstructed after using compression is completely the same as the original data, like compression of disk files. Lossy compression, also called irreversible coding, refers to when the data reconstructed after using compression differs from the original data, but without resulting in people misunderstanding the information that the original data expressed. Lossy compression has a wide scope of application, including for example video conferencing, video broadcasting, and video surveillance.

Computer vision technology is developing rapidly, and has attained an initial industrial scale. The future development of computer vision technology mainly faces the following challenges: (a) Better integration with other technologies in different application fields. Computer vision can make wide use of big data to solve some problems, and it has matured and can surpass humans, but it cannot achieve high precision in some problems. (b) Reducing the development time and labor cost of computer vision algorithms. At present, computer vision algorithms need large amounts of data and manual annotation, and long R&D cycles are required to achieve the precision and time required by application fields. (c) Accelerating the design and development of new algorithms. With the emergence of new imaging hardware and AI chips, the design and development of computer vision algorithms for different chips and data acquisition devices is also a challenge.

3.1.6 **Biometric feature recognition**

Biometric feature recognition technology refers to technology for identifying and authenticating the identities of individuals using individuals' physiological or behavioral features. With regard to the process in applications, Biometric feature recognition is typically divided into registration and identification stages. In the registration stage, information on the biometric features of the human body are collected by means of sensors—for example, fingerprint, face, and other optical information is collected using image sensors, and audio information on speaking voices, etc., is collected with microphones—then data preprocessing and feature extraction technology are used to process the collected data, and the corresponding features thus obtained are stored. In the identification process, information collection methods consistent with those in the registration process are adopted to carry out information collection, data preprocessing, and feature extraction for the people to be identified, then a comparative analysis is performed on the extracted features and the stored features to complete identification. With regard to application tasks, biometric feature recognition is generally divided into the two tasks of identification and confirmation. Identification refers to the process of determining the identities of people from a repository, and is a one-to-many problem. Confirmation refers to the process of determining identity by comparing the information of the person to be identified with that of a particular individual in the repository, which is a one-to-one problem.

Biometric feature recognition technology involves a very wide range of content, including fingerprints, palm prints, human faces, irises, finger veins, voiceprints, gaits and other biological characteristics. The recognition process involves image processing, computer vision, speech recognition, machine learning, and other technologies. Biometric feature recognition is currently an important intelligentized identity authentication technology with broad application in the financial, public security, education, transportation, and other fields. The technologies for fingerprint, facial, iris, finger vein, voiceprint, and gait recognition are introduced below.

(1) Fingerprint recognition

The fingerprint recognition process usually includes three processes: data acquisition, data processing, and analysis and judgment. In data acquisition, fingerprint images are obtained by means of optical, electrical, mechanical, thermal, or other physical sensors. Data processing includes preprocessing, distortion correction, and feature extraction. Analysis and judgment is the process of conducting analysis and judgment on the extracted features.

(2) Facial recognition

Facial recognition is a typical computer vision application. From the perspective of application processes, facial recognition technologies can be divided into detection positioning, facial feature extraction, and facial confirmation. Facial recognition technology applications are mainly affected by such factors as light, shooting angle, image occlusion (图像遮挡), and age. Under restrictive conditions, face recognition technology is relatively mature, while for unrestricted conditions, the technology is continuing to improve.

(3) Iris recognition

The theoretical framework of iris recognition primarily includes four parts—iris image segmentation, iris-region normalization, feature extraction, and recognition. Most research work has been developed based on this theoretical framework. The main difficulties in applying iris recognition technology include sensors and lighting effects: On one hand, since the dimensions of the iris are occluded by melanin, it is necessary to use high-resolution sensors under a near-infrared light source to get clear imaging, and the sensor quality and stability requirements are relatively high. On the other hand, changes in the brightness of lighting can trigger pupil dilation, leading to complex deformations in the texture of the iris, and this increases the difficulty of matching.

(4) Finger vein recognition

Finger vein recognition is a technology that uses a feature of deoxygenated hemoglobin in the veins of the human body—good absorption of near-infrared rays in a specific wavelength range—and employs near-infrared light to carry out vein imaging and recognition. Due to the highly random manner in which finger veins are distributed, the features of their networks offer good uniqueness, and being an internal feature of the human body, they are not subject to external influences, so their modal characteristics are very stable. The main difficulties facing finger vein recognition technology stem from the imaging component.

(5) Voiceprint recognition

Voiceprint recognition is a technology for recognizing speakers based on the voiceprint features of the voices to be recognized. Voiceprint recognition can be divided two stages: front-end processing and modeling analysis. In the voiceprint recognition process, a speech sample from a certain individual is taken, and after feature extraction, it is matched with a voiceprint model in a multi-composite voiceprint model library. The common recognition methods can be divided into template matching methods and probability model methods.

(6) Gait recognition

One's gait is the only biometric feature that can be clearly imaged from long distances in complex scenes. Gait recognition refers to the recognition of people's identity by means of body shape and walking posture. The technical challenges of gait recognition are greater than those of the several kinds of biometric feature recognition described above, as seen in the need to extract features from video, as well as the need for more demanding preprocessing algorithms, but gait recognition has the advantages of being remote, view-invariant, and light-insensitive.

3.1.7 **Virtual reality/augmented reality**

Virtual reality (VR)/augmented reality (AR) is a new kind of audiovisual technology with computers at its core. Combined with related science and technology, it generates, within a certain range, digital environments that are highly similar to real-world environments in terms of visual, auditory, tactile, and other aspects. Using the required equipment, users interact with objects in a digitalized environment, with each affecting the other, and get feelings and experiences similar to those of real-world environments.

From a technology features perspective, VR/AR can be divided based on different processing stages into five areas: acquisition and modeling technology, analysis and utilization technology, exchange and distribution technology, display and interaction technology, and technical standards and assessment systems. (1) Acquisition and modeling technology studies how to digitize and model the physical world or human creativity, the main difficulty being the technology to digitize and model the three-dimensional physical world. (2) For analysis and utilization technology, the focus of research is on methods for analyzing, understanding and searching digital content and turning it into knowledge, the main difficulty being the semantic representation and analysis of content. (3) In exchange and distribution technology, the main emphasis is on the large-scale circulation, conversion, and integration of digitized content in various kinds of network environments, and on personalized services aimed at different end users, with the core technologies being those for open content exchange and rights management. (4) In display and interaction technology, the focus of research is on various digital content display techniques and interaction methods that conform to human habits, in order to improve people's cognitive abilities for complex information, and the main challenge lies in building natural and harmonious human-computer interaction environments. (5) The focus of standards and assessment systems research is on specification standards and corresponding assessment techniques for virtual/augmented reality basic resources, content cataloging, source coding, etc.

The challenges facing VR/AR at present lie mainly in intelligent acquisition, ubiquitous devices, free interaction, and perceptual integration. A series of scientific and technical problems exists with regard to hardware platforms and equipment, core microchips and devices, software platforms and tools, and relevant standards and norms. On the whole, VR/AR shows trends toward VR system intelligentization, seamless integration of VR environment objects, and natural interaction that is omnidirectional and comfortable.

3.1.8 **Trends in AI technology development**

In summary, AI technology has remarkable characteristics in the following areas of development, which are the focus of further research on AI trends.

(1) Technology platforms becoming open source

Open source learning frameworks have made excellent achievements in the development of AI fields, and their influence on the deep learning field has been enormous. Open source deep learning frameworks allow researchers to make direct use of already developed deep learning tools, reducing duplication of development, increasing efficiency, and promoting close cooperation and exchanges in the industry. Industry giants at home and abroad have realized that building an industry ecosystem through open source technology is an important means of seizing dominant industry positions. Making technology platforms open source can expand the scale of technologies, integrate technologies and applications, and effectively lay out entire AI production chains. Google, Baidu, and other leading foreign and domestic firms have all deployed out open source AI ecosystems, and in the future more software and hardware companies will participate in open source ecosystems.

(2) Development from special-purpose AI toward general-purpose AI

Currently, AI development is concentrated mainly in special-purpose intelligence areas, with domain-specific limitations. As S&T develops, various fields are merging and influencing each other. What is needed is a general-purpose intelligence—broad in scope, highly integrated, with strong applicability—that will provide upgrading for everything from helpful decision-making tools to specialized decision-making solutions. General-purpose AI has the ability to perform general intelligent behaviors, and can form interconnections between AI and such human characteristics as perception, knowledge, awareness, and intuition, reducing reliance on domain-specific knowledge and increasing universality in the handling of tasks. This will be a future development direction for artificial intelligence. AI in the future will broadly cover all fields, eliminating the barriers between applications in different fields.

(3) Major advances in going from intelligent perception toward intelligent awareness

A point of view that has gained broad acceptance in the industry is that the main stages in AI's development will include: computational intelligence, perceptual intelligence, and cognitive intelligence. The early stage of AI was computational intelligence, where machines had rapid computing and memory storage abilities. AI in the current big data era is perceptual intelligence, where machines have visual, auditory, tactile, and other perception abilities. With the development of brain-inspired S&T, AI will inevitably make strides toward the era of cognitive intelligence; that is, machines will be made able to understand and to think.

3.2 Current situation and trends of the AI industry

As the core driving force behind new rounds of industrial transformation, AI will spawn new technologies, products, industries, business formats, and patterns, thereby bringing about major changes in industrial structure and triggering an overall upgrade of social productive forces. McKinsey has predicted that the total value of the global AI application market will reach US$127 billion by 2025, and AI will provide the breakthrough points in the development of a host of intelligent product industries.

By sorting through the distribution of AI industries, a diagram is proposed for the AI industry ecosystem, mainly divided into three layers—core business forms, associated business forms, and derived business forms—as shown in Figure 3.

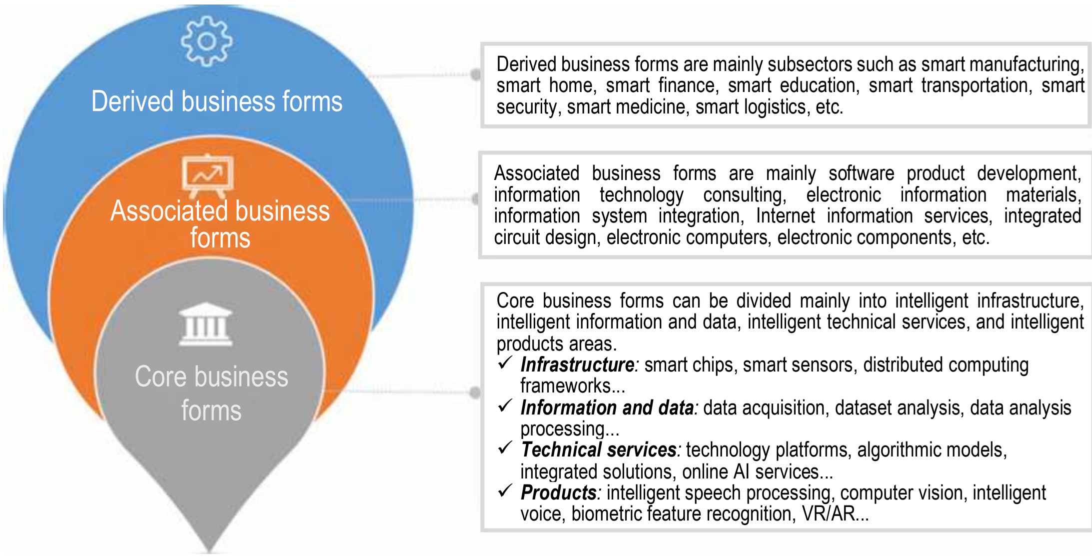


Figure 3. AI industry business forms

Below, we focus on four core business forms—intelligent infrastructure construction, intelligent information and data, intelligent technical services, and intelligent products—to expand their description, and summarize the trends in AI industrial applications and industrial development.

3.2.1 **Intelligent infrastructure**

Intelligent infrastructure provides computing power support for the AI industry. Its scope includes smart sensors, smart chips, and distributed computing frameworks, and it is an important underpinning of AI industry development.

(1) AI chips

From an applications perspective, AI chips can be categorized into either training or inference types. In terms of deployment scenarios, they can be divided into two broad categories: cloud-based and device-based. Because training processes involve vast amounts of training data and complex deep neural network structures, requiring computing on a huge scale, smart chip clusters are mainly used to complete them. The amount of data for inference is less than that for training, but it still involves large amounts of matrix operations. At present, training and inference are both usually realized at the cloud end, and it is only for devices with very high real-time requirements that they are handed over to devices to handle.

Smart chips can be divided according to technical architecture into general-use chips (CPU, GPU, FPGA), FPGA-based semi-custom chips, fully customized ASIC chips, and brain-inspired computing chips (IBM's TrueNorth). In addition, among the main AI processors, there are also DPU, BPU, NPU, EPU, and other AI chips suited to different scenarios and functions.

With the rapid growth in Internet user numbers and the scale of data, AI development requirements in terms of computing performance have grown urgently, and demand for CPU computing performance improvement has outpaced Moore's Law. At the same time, due to technical limitations, the performance of traditional processors cannot continue to grow according to Moore's Law, so developing a new generation of smart chips is imperative. Development of future smart chips is proceeding in two main directions. The first is chips that emulate the structure of the human brain; the second is quantum chips. Smart chips are the strategic high ground in the AI era. It is estimated that the global market for AI chips will have surpassed US$10 billion by 2020.

(2) Smart sensors

Smart sensors are sensors with information processing functionality. Smart sensors equipped with microprocessors have information collection, processing and exchange functionality, and are the product of sensor integration combined with microprocessors. Smart sensors are the nerve endings of artificial intelligence, used to fully perceive the external environment. The large-scale deployment and application of all kinds of sensors creates the necessary conditions for achieving artificial intelligence. Different application scenarios, such as smart security, smart home, and smart health care, present different requirements for sensor applications. In the future, with constant expansion of AI application fields, market demand for sensors will continue to grow, and by 2020, the market is expected to exceed US$460 billion. High sensitivity, high precision, high reliability, miniaturization, and integration will become important trends in smart sensor development in the future.

(3) Distributed computing frameworks

The conventional stand-alone computer model has proven incapable of supporting vast quantities of data processing and complex knowledge reasoning. Therefore, computing models have had to divide enormous computing tasks into small tasks that stand-alone computers can bear, and hence cloud computing, edge computing, and big data technology have provided the basic computing frameworks. Popular distributed computing frameworks at present include OpenStack, Hadoop, Storm, Spark, Samza, and Bigflow. A succession of open source deep learning frameworks have also emerged, including TensorFlow, Caffe, Keras, CNTK, Torch7, MXNet, Leaf, Theano, DeepLearning4, Lasagne, Neon, etc.

3.2.2 **Intelligent information and data**

Information and data are among the key elements in AI value creation. China's huge population and industrial base bring inherent advantages in terms of data. Improvements in algorithms and computing power technology have given rise to a multitude of enterprises. At present, companies in the data collection, analysis, and processing areas are mainly of two kinds. One is dataset providers whose main business is the provision of data. They provide datasets in different domains to firms on the demand side that require them for machine learning and other technologies. The other is integrated data collection, analysis, and processing firms that have their own data acquisition channels and perform analysis on the data collected, and ultimately provide the results after processing to firms on the demand side for their use. Some large corporations are themselves on the demand side for data analysis and processing results.

3.2.3 **Intelligent technology services**

Intelligent technology services are mainly concerned with how to build AI technology platforms, and provide AI-related services externally. Firms of this type occupy a key position in the AI production chain. Relying on infrastructure and large amounts of data, they provide critical platforms, solutions, and services for various types of AI. In terms of the kinds of services provided, technology service providers currently include the following kinds:

(1) Providers of AI technology platforms and algorithmic models. Companies of this kind are mainly oriented toward the needs of users or industries, and provide AI technology

platforms and algorithmic models. Users can carry out AI application development on AI platforms using a series of algorithmic models. Companies of this kind focus mainly on such key areas as general-use AI frameworks, algorithmic models, and general-use technology.

(2) Providers of comprehensive AI solutions. Firms of this type are mainly oriented toward the needs of users or industries. They design and provide industry AI solutions combining both software and hardware. Multiple kinds of AI algorithm models, as well as software and hardware environments, are integrated into comprehensive solutions, helping users or industries solve specific problems. This type of firm focuses on AI applications in specific fields or specific industries.

(3) Providers of online AI services. Firms of this type are generally providers of traditional cloud services. Relying mainly on the user resources of their existing cloud computing and big data applications, they gather together users' demands and industry attributes, and provide users many kinds of AI services; from specific application platforms featuring APIs with all kinds of model algorithms and computing frameworks, to comprehensive solutions for specific industries, they further attract use by large numbers of users, thereby further perfecting the AI services they offer. This type of firm mainly provides relatively general-use AI services, while also focusing on a number of key industries and fields.

It needs to be pointed out that the above three roles are not strictly separated, and overlap appears under many circumstances. With the increasing development and maturity of the technology, there are now many firms in the AI production chain that have features of two or three of the above roles at the same time.

3.2.4 **Intelligent products**

Intelligent products refer to where the technological accomplishments in AI fields are integrated and commercialized. Specific categories are as shown in Table 1.

Table 1. Artificial intelligence products

Classification	Examples of typical products	
Smart robots	Industrial robots	Welding robots, painting robots, material handling robots, processing robots, assembly robots, cleaning robots, and other industrial robots
	Personal/household service robots	Housekeeping robots, education and entertainment robots, assistive robots for the elderly and people with disabilities, personal transportation services robots, security surveillance services robots
	Public service robots	Hotel service robots, bank service robots, venue service robots, and food service robots
	Specialized robots	Special extreme robots, rehabilitation assistance robots, agricultural industry (including farming, forestry, animal husbandry, and fishery) robots, underwater robots, military and police robots, electric power industry robots, petrochemical industry robots, mining robots, construction robots, logistics robots, security robots, cleaning robots, medical service robots, and other unstructured and non-household robots
Intelligent delivery vehicles and systems	Self-driving cars	
	Rail transit systems	
	UAVs	Unmanned helicopters, fixed-wing aircraft, multi-rotor aircraft, unmanned airships, unmanned parawings
	Unmanned surface vessels	

Intelligent terminals		Smartphones
Intelligent terminals		On-board intelligent terminals
Intelligent terminals	Wearable terminals	Smart watches, smart earphones, smart glasses
Natural language processing		Machine translation
Natural language processing		Machine reading comprehension
Natural language processing		Question answering systems
Natural language processing		Intelligent search
Computer vision		Image analyzers, video surveillance systems
Biometric feature recognition		Fingerprint recognition systems
Biometric feature recognition		Facial recognition systems
Biometric feature recognition		Iris recognition systems
Biometric feature recognition		Finger vein recognition systems
Biometric feature recognition		DNA, gait, palm print, voiceprint and other biometric feature recognition systems
VR/AR		PC terminal VR, all-in-one VR, mobile VR headsets
Human-computer interaction	Voice interaction	Personal assistants
Human-computer interaction	Voice interaction	Voice assistants
Human-computer interaction	Voice interaction	Intelligent customer service
Human-computer interaction		Affective interaction
Human-computer interaction		Somatosensory interaction
Human-computer interaction		Brain-computer interaction

As progress on making China a manufacturing superpower (制造强国) and a network superpower (网络强国) and building a digital China accelerates, demand for AI technologies and products will grow further in the manufacturing, home furnishings, finance, education, transportation, security, health care, logistics, and other areas.

3.2.5 **Industrial applications of AI**

The deep integration of artificial intelligence in industrial sectors will change and even refashion traditional industries. This chapter will focus on presenting the applications of AI in the manufacturing, home furnishings, finance, transportation, security, health care, and logistics industries. Due to space limitations, discussion of many other important industry applications will not be presented here.

(1) Smart manufacturing

Smart manufacturing is a new type of production approach based on the deep integration of new generation information and communication technologies with advanced manufacturing technology. Running through every step of manufacturing activity, from design and production to management and services, its functions include self-sensing, self-learning, self-decision-making, self-execution, and self-adaptation. Demand for AI in smart manufacturing is manifested primarily in the following three areas: The first is intelligent equipment, including identification equipment, human-computer interaction systems, industrial robots, and CNC machines, and involving such key technologies as cross-media analysis and reasoning, natural language processing, virtual reality intelligent modeling, and autonomous unmanned systems. The second is smart factories, including specific content such as intelligent design, production, and management, as well as integrated optimization, and involving cross-media analysis and reasoning, big data intelligence, machine learning, and other key technologies. The third is intelligent services, including large-scale personalized customization, and remote operations and maintenance (remote O&M), as well as predictive maintenance, and including key technologies such as cross-media analysis and reasoning, natural language processing, big data intelligence, and high-level machine learning. For example, existing paper documents relating to intelligent equipment failures can be turned into digitalized data through natural language processing, then training data needed for deep learning can be formed by converting the unstructured data into structured data. One can thereby construct a neural network for equipment failure analysis, providing the basis for further failure analysis and optimized parameter-setting.

(2) Smart home

According to the *Guide to the Construction of a Comprehensive Home Automation Standardization System* published by the Ministry of Industry and Information Technology (MIIT), smart homes are one of eight major home automation application scenarios. Influenced by factors such as industry environment, prices, and consumer acceptance, China's smart home industry has experienced a lengthy exploration period. By 2010, with the development of Internet technology and the emergence of the smart cities concept, the smart home concept had gradually gained a clearer definition and an outpouring of all kinds of products ensued. Software systems also underwent several cycles of upgrading.

Smart homes take residences as the platforms, and, based on Internet of things (IoT) technology, construct home ecosystems from hardware (smart appliances, intelligent hardware, security control equipment, furniture, etc.), software systems, and cloud computing platforms to achieve such functions as remote device control, device interconnection and intercommunication, and device self-learning. By collecting and analyzing user behavior, moreover, they provide users personalized services for their daily lives, making home living safe, energy-efficient, and convenient. For example, with the help of intelligent speech technology, users can use natural language to operate different home system devices, such as to open and close curtains (or windows), operate household appliances and lighting systems, clean and sanitize, etc. Drawing on robotics technology, smart televisions can analyze users' interests and preferences from their viewing histories, and recommend relevant programs for them. Locks are opened by means of voiceprint recognition, facial recognition, fingerprint recognition, and other technologies; and through big data technology, self-perception by smart appliances of their own status and environment can be achieved, so that they possess fault diagnosis capability. Product abnormalities are discovered through collection of product operation data, and service is provided proactively, lowering failure rates. Using big data analysis, remote monitoring, and diagnosis, it is also possible to quickly discover and resolve problems and improve efficiency.

(3) Smart finance

AI's rapid development will also have profound effects on the finance industry at the high end of the service value chain, and AI is gradually becoming an important factor in determining how the financial industry communicates with customers and discovers their financial needs. In the financial industry, AI technology can be used in customer service, and to support decision-making for credit extension, various financial transactions, and financial analysis. It can also be used in risk prevention and control. It will greatly alter existing patterns in the financial industry, and the industry will become more personalized and intelligentized. For financial institutions' sales departments, AI can help win customers, serve customers with precision, and boost efficiency; for their risk control departments, it can improve risk control and increase efficiency; and for their customers, it can achieve optimized asset allocations and better experiences with financial institution services. AI applications in financial areas include: (a) intelligent customer acquisition—financial users are profiled relying on big data, and customer acquisition efficiency is greatly increased through demand-response models; (b) identity authentication—taking AI as the kernel, users' identities are verified through facial recognition, voiceprint recognition, finger vein recognition, or other biometric means, together with recognition of various vouchers, ID cards, bank cards, and other certificates using optical character recognition (OCR) and other technologies, thereby greatly lowering verification costs and helping to improve security; (c) big data risk control—anti-fraud, credit risk and other models are built by combining big data with computing power and algorithms, giving financial institutions multi-dimensional control of credit and operational risks, while also avoiding asset losses; (d) intelligent investment consulting—based on big data and algorithm capabilities, information on users and assets is tagged for precise matching of users and assets; (e) intelligent services—the depth and breadth of customer service are expanded based on natural language processing and speech recognition capabilities, greatly reducing service costs and improving the customer experience; and (f) financial cloud—cloud computing capability and financial technology are used to provide financial institutions comprehensive financial solutions for greater security and efficiency.

(4) Intelligent transportation

An intelligent transportation system (ITS) is an application product that integrates communication, information, and control technologies into transportation systems. Drawing on modern S&T methods and equipment, ITS connects each of the core transportation elements together to achieve mutual information exchange and sharing, as well as the mutual coordination, optimum configuration, and efficient use of all transportation elements, forming a highly efficient collaborative environment and laying the foundation for safe, efficient, convenient, and low-carbon transportation. For example, information on vehicle traffic flows and driving speed on roads is collected using transportation information collection systems, the real-time traffic conditions are formed after the information is analyzed and processed, and the decision-making system then adjusts the duration of traffic lights accordingly, and the adjustment can change the direction of traffic in variable lanes or reversible lanes. Traffic conditions are sent to navigation software and broadcasts through information distribution systems, allowing people to plan their routes rationally. By means of electronic toll collection (ETC), vehicles going through ETC entrances have their identities and information automatically collected and processed, get charged and are let through, effectively improving capacity, simplifying toll collection, and reducing environmental pollution.

ITS applications are most widespread in Japan, followed by the United States, Europe, and other regions. China's ITS have developed rapidly in the last several years, and advanced ITS have been set up in Beijing, Shanghai, Guangzhou, Hangzhou, and other large cities. Beijing in particular has established four major ITS, for road traffic control, public transit command and scheduling, highway management, and emergency management; and Hangzhou has established three major ITS—a shared main platform for traffic information, a logistics information platform, and a static traffic management system.

(5) Smart security

Smart security technology is technology that uses AI to save and analyze videos and images, and then identifies and handles security threats in them. The biggest difference between smart security and traditional security is that traditional security is heavily reliant on people and very labor intensive, while smart security can make judgments using computers, thereby achieving security precautions and handling as close to real-time as possible.

At present, the development of high-definition video, intelligent analysis, and other technologies is making the security industry develop away from the traditional passive approach and toward active judgment and early warning. The industry is also developing away from security for single fields and toward multi-industry applications. This is further improving production efficiency and increasing the degree of intelligentization in daily life, and providing visualized and intelligentized solutions for yet more industries and groups of people. Faced with vast amounts of video data, users can no longer carry out search and analysis by simply using a human wave attack. Expert systems or assistants that use AI technology must be adopted to analyze video content and detect abnormal information in real time, and perform early warning of risks. In terms of technology aspects, smart security analysis in China at present is concentrated mainly in two main types. One uses field separation and foreground extraction methods to perform detection and extraction of targets in video frames, and differentiates between different things by means of various rules, thereby achieving different judgments and producing corresponding alarms. Examples include area intrusion analysis, fight detection, crowd analysis, traffic incident detection, etc. The other uses pattern recognition technology, models specific objects within frames, and performs training using large-scale sampling, and is thereby able to achieve recognition of specific objects in frames of video. Application examples include vehicle detection, face detection, head detection (for crowd flow statistics), etc.

Smart security currently covers a great many fields, such as monitoring of neighborhoods, roads, buildings, and motor vehicles, detection of moving objects, etc. Smart security still needs to solve the problem of analyzing, storing/controlling, and transmitting massive amounts of video data, combining video analysis technology with cloud computing and cloud storage technology, and constructing security systems within smart cities.

(6) Smart health care

The rapid development of AI has provided very favorable technological conditions for the medical and health fields to develop toward greater intelligentization. In the last few years, smart health care has played important roles in areas like assisted diagnosis and treatment, disease prediction, medical imaging-assisted diagnosis, and drug development.

In the assisted diagnosis and treatment area, AI technology can be used to increase the work efficiency of medical personnel effectively, and improve the diagnostic and treatment levels of primary care physicians on the front lines. For example, intelligent speech technology can be used to achieve intelligent voice entry of electronic case histories; intelligent image recognition technology can be used to achieve automated medical image reading; and AI technology and big data platforms are being used to construct assisted diagnosis and treatment systems.

In the disease prediction area, AI can leverage big data technology to carry out epidemic detection, so as to promptly and effectively predict and prevent epidemics from further spreading and developing. Taking influenza for example, many countries have stipulated that when doctors discover new flu cases, they must notify a disease control and prevention center. However, there are often delays in the notification of new flu cases because people may get sick and not promptly seek medical attention, and it may also take time for information to be transmitted back to the disease control and prevention center. AI can shorten response times effectively through epidemic detection.

In the area of medical imaging-assisted diagnosis, the development of image interpretation systems is the product of AI technology. Early image interpretation systems relied mainly on people manually writing decision rules, which was very time-consuming, and clinical application was difficult, so they failed to gain widespread clinical application. Radiomics is the extraction and analysis of features through medical imaging, which provides assessment methods, diagnosis/treatment, and accurate decision-making, for the predictive and prognostic diagnosis and treatment of patients. This has simplified the AI technology application process to a great extent, cutting labor costs.

(7) Smart logistics

Traditional logistics enterprises are using barcodes, RFID technology, sensors, GPS, etc., to improve and optimize shipping, warehousing, distribution handling, and other logistics activities. At the same time, they are also trying to use technologies like intelligent search, inference-based planning, computer vision, and intelligent robots to automate operations in freight transportation processes, to achieve high-efficiency optimized management, and to increase logistics efficiency. In warehousing, for example, by analyzing large amounts of historical inventory data, big data intelligence is being used to create related prediction models and achieve dynamic adjustment of logistics inventory merchandise. Big data intelligence can also support merchandise distribution planning, and thereby achieve logistics supply-demand matching, optimization and allocation of logistics resources, etc. In material handling, intelligent handling robots (e.g., handling robots, storage rack shuttles, sorting robots, etc.), equipped with computer vision, dynamic route planning, and other technologies, have found wide application, greatly reducing the time required to ship orders, and greatly increasing logistics warehouse storage density, material handling speed, and picking accuracy.

3.2.6 **AI industry trends**

Looking at the course of progress in the AI industry, technological breakthroughs are the core force that drives industrial upgrading. The joint development of data resources, computing power, and core algorithms has unleashed a third new wave in artificial intelligence. The AI industry is now in the advanced stages of going from perceptual intelligence to cognitive intelligence. The former involves technologies like intelligent speech, computer vision, and natural language processing, and there is already a large-scale foundation of applications, but the requirement for the latter, that "machines must think and take the initiative just as people do," still awaits breakthroughs. Self-driving cars, fully automatic intelligent robots, and so on, remain in development, and large-scale application is still a certain distance away.

(1) Seamlessly combined online and offline AI services are emerging

Widespread deployment and application of distributed computing platforms has enlarged the scope of application for online services. At the same time, the development of AI technologies and continuous emergence of products, such as smart homes, intelligent robots, autonomous vehicles, etc., is creating new channels and new modes of transmission for AI services, accelerating the process of fusing online and offline services, and promoting the upgrading of many industries.

(2) Intelligentized application scenarios are becoming less single-faceted, more multifaceted

AI applications in most fields at present are still in the special purpose stage, such as facial recognition, video surveillance, speech recognition, etc. They are all used mainly to complete specific tasks, their scope of coverage is limited, and the degree of industrialization remains low. With the launch of products for smart homes, intelligent logistics, etc., AI applications have finally entered a new stage, with more complex scenarios and complex problems to handle, thereby improving society's productive efficiency and the quality of life.

(3) The deep integration of AI in the real economy is accelerating further

The 19th Party Congress report proposed "promoting the in-depth integration of the Internet, big data, artificial intelligence and the real economy." On one hand, this will jump-start the transformation and upgrading of traditional industries, and promote the achievement of overall breakthroughs in strategic emerging industries. On the other hand, with the open source trend in AI's underlying technologies, traditional industries will likely grasp basic AI technologies at a faster pace, and rely on their accumulated industry data resources to achieve innovation in the deep integration of AI with the real economy.

3.3 Safety,[1] ethical, and privacy issues

Historical experience makes clear that new technologies can often raise production efficiency and promote social progress. At the same time, however, because AI is still in the initial stage of development, issues regarding the field's safety, ethics, and privacy-related policies, laws, and standards merit attention. In the case of AI technology, the safety, ethics, and privacy issues directly affect people's trust in AI technology during their experiences interacting with AI tools. In order for AI to be able to develop, the general public must trust that the safety benefits AI technology can bring to humanity are far greater than the harm. To guarantee safety, AI technology itself and applications in various fields must abide by ethical principles agreed upon by human societies, among which are privacy issues requiring particular attention. Because AI's development is accompanied by the recording and analysis of more and more personal data, the safeguarding of personal privacy is thus an important requirement for society's trust to be able to grow. In sum, establishing an environment of policies, laws, and standards to make AI technology serve society and to protect the public interest is an important prerequisite for the sustainable and healthy development of AI technology. Toward that end, this chapter discusses the policy and legal issues regarding AI technology-related safety, ethics, and privacy.

3.3.1 **AI safety issues**

The biggest feature of AI is its ability to achieve, without human intervention, automated operation that is knowledge-based and capable of self-correction. After an AI system is turned on, the system's decision-making no longer requires further commands from operators, and this kind of decision-making can generate results that are unanticipated by humans. In the course of developing AI products, designers and producers may or may not accurately foresee the possible risks of the products. As a result, AI safety issues must not be

[1] Translator's note: The Chinese word 安全 can mean both "safety" and "security." The translator judges that in section 3.3, "safety" is the appropriate translation.

ignored.

Unlike traditional public safety (as with nuclear technology) that requires the support of strong infrastructure, AI relies on computers and the Internet, and does not need expensive infrastructure to create threats to safety. People who have mastered the relevant technology can make AI products anytime, anywhere, without expensive infrastructure. AI programs do not run in an open and traceable fashion, and their diffusion pathways and speeds are hard to control precisely. Under circumstances where existing traditional regulatory techniques cannot be used, other ways must be found to regulate AI technologies. In other words, to truly achieve the goal of safeguarding public safety, regulators must consider ethical issues at a deeper level, and ensure that AI technologies and their applications all conform to ethical requirements.

Since the goals achieved for AI technologies are influenced by their initial designs, it is necessary to guarantee that the goals of AI designs are consistent with the interests of most humans and with ethics, so even if different environments are encountered in the decision-making process, AI can make relatively safe decisions. In terms of AI technology applications, issues of responsibility and fault in the AI development and deployment process must be fully considered. The goal of putting safety assurance requirements in place can be achieved by establishing the specific content of rights and responsibilities for AI technology developers, product makers/service providers, and end users.

In addition, considering that the AI management provisions of countries around the world remain disjointed, and relevant standards are lacking as well, participants in the same AI technology may come from different countries, but those countries have yet to sign a common agreement on artificial intelligence. For this reason, China should strengthen international cooperation, and push for the establishment of a set of universal principles and standards to ensure the safety of AI technology.

3.3.2 **AI ethical issues**

Artificial intelligence is the extension of human intelligence (人类智能), and it is an extension of human value systems as well. Correct consideration of human ethical values should be included in its development process. The establishment of ethical requirements for AI technology must rely on in-depth thinking and broad consensus by society and the public on artificial intelligence ethics, and abide by some consensus principles:

One is the principle of human interests, that is, AI must take the realization of human interests as the ultimate objective. This principle is manifested in respect for human rights, maximizing benefits for humanity and the natural environment, and decreasing technological risks and negative impacts on society. Under this principle, policies and laws should be aimed at constructing the external social environment for AI development, and promoting AI ethics and safety awareness education for individuals in the society, so that the society is alert to the risks of abusing AI technology. In addition, it is also necessary to be vigilant against AI systems making ethically biased decisions. For example, where colleges use machine learning algorithms to assess entrance applications, if the historical admissions data used to train the algorithms reflect (intentionally or unintentionally) certain biases in past admission procedures (such as gender discrimination), then the machine learning may exacerbate those biases in the repetitive and accumulative calculation process, creating a vicious cycle. If they are not corrected, the biases may in this way exist perpetually in society.

A second principle is that of accountability, that is, establishing a clearly defined accountability system for both the technology development and application aspects. This will facilitate, at the technical level, holding the personnel or departments that develop AI technology accountable, and at the application level, will facilitate the establishment of a rational liability and compensation system. Under the accountability principle, it is necessary to adhere to the principle of transparency in technology development aspects; and in technology application aspects, the principle of consistency in rights and responsibilities should be followed.

The principle of transparency, in particular, requires understanding a system's working principles and thereby predicting future development; that is, humans should know how and why AI makes specific decisions. This is critical for assigning responsibility. For instance, in the important AI topic of neural networks, people need to know why particular output results are produced. Additionally, the transparency of data sources is similarly very important as well. Even when handling datasets without problems, it is also possible to encounter bias issues hidden in the data. The transparency principle also requires that attention be paid, during technology development, to dangers generated from the collaboration of multiple AI systems.

The principle of consistency in rights and responsibilities means that future policies and laws must expressly stipulate: On one hand, necessary business data must be reasonably recorded, relevant algorithms must be supervised, and business applications must be subject to reasonable review; on the other hand, business entities should still be able to use reasonable intellectual property rights or trade secrets to protect their core parameters. In AI application fields, the principle of consistency in rights and responsibilities has yet to be fully realized in the ethics practices of the business community and governments. This is mainly because engineers and design teams often ignore ethical issues in the process of developing and producing AI products and services. Also, the AI industry as a whole is not yet accustomed to workflows that give overall consideration to the needs of various stakeholders, and AI-related companies have yet to find a balance between trade secret protection and transparency.

3.3.3 **AI privacy issues**

AI's recent development has been built on information technology applications with large amounts of data, and issues involving the reasonable use of personal data are inevitable. Therefore, an explicit and operational definition of privacy is necessary. The development of AI technology also makes personal privacy violation (behavior) easier. Consequently, relevant laws and standards must provide stronger protections for personal privacy. Existing regulations on private information include two types of handling: collection of personal information without users' express consent, and collection of personal information with users' express consent. The development of AI technology poses new challenges for the existing regulatory framework. This is because the scope of personal information collection to which users give consent no longer has definite boundaries. Using AI technology, it is very easy to deduce private information that citizens are unwilling to disclose, such as deducing private information from public data, or deducing information (online behavior, interpersonal relationships, etc.) about other people connected to an individual (such as friends, relatives, and colleagues) from the individual's information. This kind of information exceeds the scope of personal information that individuals have agreed to disclose.

In addition, the development of AI technology makes it easier for governments to collect and use citizens' personal data and information. Large quantities of data/information can help various government agencies better understand the situations of the groups of people they serve, ensuring personalized service opportunities and quality. But with this comes the risk of improper use of personal data/information by government agencies and individual government personnel, and the potential hazards should receive sufficient attention.

In the context of artificial intelligence, personal data acquisition and informed consent must be redefined. First, relevant policies, laws, and standards should directly regulate the collection and use of data, and not merely obtain the consent of data owners; next, standard processes that are practical and implementable, and suitable for different usage scenarios, should be established and provided to designers and developers to protect the privacy of data sources; also, behaviors that use AI to deduce information beyond what citizens initially agree to disclose should be regulated. Finally, policies, laws and standards should adopt extended protection with regard to personal data management, encourage the development of related technology, and explore having algorithmic tools act as individuals' agents in the digital and real worlds. Such an approach allows control and usage to coexist, because algorithmic agents can set different usage permissions according to different circumstances, while managing the information that individuals agree and refuse to share.

The safety, ethical, and privacy issues touched on in this section are challenges facing AI development. Addressing safety issues is a prerequisite for making technology development sustainable. The technology's development brings with it risks to social trust. A problem urgently in need of a solution is how to increase social trust, have technology development meet ethical requirements, and in particular, guarantee that privacy is not violated. Therefore, it is necessary (to formulate) a rational foundation of policies, laws and standards, and to collaborate with the international community. When formulating policies, laws, and standards, one must set aside superficial news hype and advertising-style hot topic promotion, promote deeper-level understanding of AI technology products, and concentrate on the enormous challenges this new technology also brings as it generates significant benefits for society. As an important member of the international community, China shoulders important responsibilities for ensuring that the application of AI technology is on the right track, and that healthy development is obtained for the right reasons.

3.4 The important role of AI standardization

With today's deepening economic globalization and market internationalization, standards serve as an important technical basis for economic and social activities, and they have become important indicators for gauging the technology development levels of countries and regions, as well as the basic rules for products to enter markets, and the concrete manifestations of the market competitiveness of enterprises. Standardization work plays fundamental, supportive, and guiding roles for AI and its industrial development. It represents both a key lever for promoting the development of industry innovation, as well as the commanding heights of industry competition. The industry's healthy development, as well as the strength of competition in international product markets, depends on the advancement and perfection of AI standards.

The United States, the EU, Japan, and other developed nations attach great importance to the task of AI standardization. The *National Artificial Intelligence Research and Development Strategic Plan* issued by the United States, the "Human Brain Project" issued by the EU, and the "Integrated Project of Artificial Intelligence/Big Data/IoT/Cybersecurity" implemented by Japan all propose enhanced deployments centered around core technologies, top talents, and standards/specifications, and strive to seize dominance in a new round of S&T competition.

China attaches great importance to the task of AI standardization. In the State Council's *New Generation Artificial Intelligence Development Plan*, AI standardization serves as an important support, and the plan proposes to: "Strengthen research on the AI standards framework system. Adhere to the principles of security, availability, interoperability, and traceability, and gradually establish and improve AI technical standards on basic universality, connectivity, industry applications, cybersecurity, privacy protection, etc. Accelerate promotion of relevant standards development by industry associations and alliances for self-driving cars, service robots, and other application sectors." In the *Three-Year Action Plan to Promote the Development of New Generation Artificial Intelligence Industry, 2018-2020*, the Ministry of Industry and Information Technology pointed out the need to build a system of AI industry standards and norms, establish and improve technical standards on basic universality, connectivity, security/privacy, industry applications, etc.; and at the same time, to construct an AI product assessment and evaluation system.

China has laid a good foundation in AI fields and made breakthroughs in core technologies such as speech recognition, visual recognition, and Chinese information processing. It also boasts a huge market environment for applications. However, the overall development level still lags behind that of developed nations, with relatively large disparities in areas such as key equipment, high-end chips, and major products and systems. Infrastructure, policies and regulations, and standards systems to accommodate AI development are in urgent need of improvement.

To summarize the foregoing analysis, greater emphasis must be placed on the important guiding role played by standardization work in promoting technology innovation and supporting industrial development.

(I) Standardization work facilitates the acceleration of AI technology innovation and the commercialization of AI achievements. With AI technology now in a rapid development phase, and products and applications that can be scaled up and commercialized gradually appearing in the market, standardization is needed as a means of solidifying technical achievements and realizing rapid popularization of innovations;

(II) Standardization work helps increase the quality of AI products and services. Some products that have appeared on the market, such as facial recognition systems, smart speakers, and service robots, have had defective or uneven quality. To improve the quality of products and services, standard, unified specifications are needed, accompanied by methods for conducting conformity testing and evaluation;

(III) Standardization work helps to effectively protect the safety of users. Difficult ethical issues such as the "trolley problem" in the field of self-driving cars, and problems such as the compromising of user privacy due to Apple mobile phone fingerprints, have aroused widespread concern. Protecting the rights of users is both difficult and key. This requires establishing people-centered (以人为本) principles and formulating relevant security standards and norms, to ensure that intelligent systems comply with and serve human ethics, and to ensure information security;

(IV) Standardization work contributes to the creation of fair and open AI industry ecosystems. At present, industry giants use methods such as open source algorithms and platform interface binding to create their own deep learning frameworks and other ecosystems, making user data more difficult to transfer. This requires unified standards to achieve interoperability and coordination between manufacturers, so as to prevent industry monopolies and user lock-in, and form virtuous industrial ecosystems.

4 Current state of AI standardization

In recent years, international, foreign, and domestic standards-setting organizations have all been studying AI issues and carrying out related standardization work on related technologies.

4.1 Current state of standardization internationally

4.1.1 ISO/IEC JTC 1

The ISO/IEC JTC 1 (Joint Technical Committee 1 of the International Organization for Standardization and the International Electrotechnical Commission) has a history of over 20 years of standardization work in the field of artificial intelligence. ISO/IEC JTC 1 has previously carried out relevant standardization work in such key areas as AI vocabulary, human-computer interaction, biometric feature recognition, and computer image processing, as well as AI technology-supporting fields like cloud computing, big data, and sensor networks.

In the vocabulary area, the ISO/IEC JTC 1 Vocabulary Working Group has issued four standards: ISO/IEC 2382-28:1995 "Information technology — Vocabulary — Part 28: Artificial intelligence — Basic concepts and expert systems," ISO/IEC 2382-29:1999 "Information technology — Vocabulary — Part 29: Artificial intelligence — Speech recognition and synthesis," ISO/IEC 2382-31:1997 "Information technology — Vocabulary — Part 31: Artificial intelligence — Machine learning," and ISO/IEC 2382-34:1999 "Information technology — Vocabulary — Part 34: Artificial intelligence — Neural networks." The above standards have now been withdrawn, and the relevant terminology has been included in the ISO/IEC 2382:2015 "Information technology — Vocabulary" standard.

In the human-computer interaction field, ISO/IEC JTC 1/SC 35 (User interface subcommittee) has launched standardization projects on voice interaction, gesture-based interaction, and affective interaction. In the voice interaction area, there are four standardization projects: ISO/IEC 30122-1 "Information technology — User interfaces — Voice commands — Part 1: Framework and general guidance," ISO/IEC 30122-2 "Information technology — User interfaces — Voice commands — Part 2: Constructing and testing," ISO/IEC 30122-3 "Information technology — User interfaces — Voice commands — Part 3: Translation and localization," and ISO/IEC 30122-4 "Information technology — User interfaces — Voice commands — Part 4: Management of voice command registration," of which parts 2 and 3 have already been published. In the gesture-based interaction area, three projects are ongoing, including ISO/IEC 30113-1 "Information technology — User interface — Gesture-based interfaces across devices and methods — Part 1: Framework." One affective interaction project is in progress: ISO/IEC 30150 "Information technology — Affective computing user interface — Framework."

In the biometric feature recognition area, ISO/IEC JTC 1/SC 37 (Biometrics subcommittee) has published a total of 121 standards, including those on data exchange formats, application program interfaces, sample quality, and performance testing. Some representative standards are ISO/IEC 19794-2:2005 "Information technology — Biometric data interchange formats — Part 2: Finger minutiae data," ISO/IEC 19784-1:2006 "Information technology — Biometric application programming interface — Part 1: BioAPI specification," ISO/IEC 29794-6:2015 "Information technology — Biometric sample quality — Part 6: Iris image data," and ISO/IEC 19795-1:2006 "Information technology — Biometric performance testing and reporting — Part 1: Principles and framework." The standards cover fingerprint, facial, iris, vein, digital signature, voiceprint, and other modalities, forming a relatively complete system of standards.

In the computer image processing area, ISO/IEC JTC 1/SC 24 (Computer graphics, image processing, and environmental data representation subcommittee) and ISO/IEC JTC 1/SC 29 (Coding of audio, picture, multimedia, and hypermedia information subcommittee) are carrying out standardization work. ISO/IEC JTC 1/SC 24 is now developing ISO/IEC 8632-1 "Information technology — Computer graphics — Metafile for the storage and transfer of picture description information — Part 1: Functional specification," ISO/IEC 8632-3 "Information technology — Computer graphics — Metafile for the storage and transfer of picture description information — Part 3: Binary encoding," ISO/IEC 18039 "Information technology — Computer graphics, image processing and environmental data representation — Mixed and augmented reality (MAR) reference model" and other standards. Standards being developed and published by ISO/IEC JTC 1/SC 29 include ISO/IEC 15938-13 "Information technology — Multimedia content description interface — Part 13: Compact descriptors for visual search" and ISO/IEC 24800-3 "Information technology — JPSearch — Part 3: Query format."

In the cloud computing area, ISO/IEC JTC 1/SC 38 (Cloud computing and distributed platforms subcommittee) has mainly developed cloud computing general-use foundational standards, interoperability standards, portability standards, and specifications for cloud services, application scenarios, case analysis, cloud security, etc. Among these international standards, those that play a supporting platform role for AI technology include ISO/IEC 19941 "Information technology — Cloud computing — Interoperability and portability," ISO/IEC 19944 "Information technology — Cloud computing — Data flow across devices and cloud services," etc.

In the big data area, ISO/IEC JTC 1/WG 9 (big data standards working group) mainly carries out development of general-use standards for the big data field. The standards that it is developing or has published include: ISO/IEC 20546 "Information technology — big data — Overview and vocabulary," ISO/IEC 20547-1 "Information technology — big data reference architecture — Part 1: Framework and application process," ISO/IEC 20547-2 "Information technology — big data reference architecture — Part 2: Use cases and derived requirements," ISO/IEC 20547-3 "Information technology — big data reference architecture — Part 3: Reference architecture," ISO/IEC 20547-4 "Information technology — big data reference architecture — Part 4: Security and privacy," and ISO/IEC 20547-5 "Information technology — big data reference architecture — Part 5: Standards roadmap."

In the sensor network area, ISO/IEC JTC 1/SC 41 has carried out research on such aspects as IoT architecture, IoT interoperability, IoT applications, IoT trustworthiness, industrial IoT, edge computing, and real-time IoT, and is carrying out development work on international standards such as ISO/IEC 29182-2:2013 "Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 2: Vocabulary and terminology," and ISO/IEC

20005:2013 "Information technology — Sensor networks — Services and interfaces supporting collaborative information processing in smart sensor networks."

In the security area, ISO/IEC JTC 1/SC 27 has carried out standards research on personal information security, big data security, IoT security, cloud computing security, etc., including ISO/IEC 29100 "Information technology — Security techniques — Privacy framework," ISO/IEC 29101 "Information technology — Security techniques — Privacy architecture framework," ISO/IEC 29190 "Information technology — Security techniques — Privacy capability assessment model," and ISO/IEC 29134 "Information technology — Security techniques — Guidelines for privacy impact assessment."

ISO/IEC JTC 1's scope of research covers many areas of AI technology, and the work of many subcommittees (SC) and working groups (WG) has been affected by artificial intelligence. Between July 29 and August 31, 2017, JTC 1 carried out an online survey to investigate the degree of association between the work carried out by some of its SC/WG and AI standardization. Details are as shown in Table 2:

Table 2. AI standardization-related SC and their degree association

JTC 1 Topic	SC 7	SC 17	SC 22	SC 24	SC 27	SC 28	SC 29	SC 36	SC 37	SC 40	SC 41	WG 9
Interoperability				◆		◆	◆			◆	◆	◆
Societal security		◆			◆			◆	◆	◆		◆
Availability				◆		◆		◆		◆	◆	◆
Privacy		◆			◆			◆		◆		◆
Scope and field				◆				◆		◆	◆	◆
System performance							◆	◆	◆	◆		◆
Software engineering	◆							◆	◆	◆		◆
Metrics								◆	◆	◆		◆
Production security								◆		◆		◆
Traceability								◆		◆		◆
Other			◆					◆		◆		
Risk analysis								◆		◆		
Ethics								◆		◆		

In regard to this, ISO/IEC JTC 1 believed it was necessary to establish a new standards organization to carry out AI standardization work In October 2017, the 32nd Meeting of ISO/IEC JTC 1 plenum approved and established the JTC 1/SC 42 Artificial Intelligence technical subcommittee, which will carry out international standardization work in such areas as foundational standards, computational methods, trustworthiness, and societal concerns. Two new work project proposals—"Artificial Intelligence Concepts and Terminology" (NP 22989) and "Framework for Artificial Intelligence Systems Using Machine Learning" (NP 23053)—have also passed international standards votes, and subsequently will be carried out by SC 42. SC 42's first plenum will be held April 18-20, 2018 in Beijing, China. At the meeting, there will be further discussion on defining the scope of work and standards projects for priority development.

4.1.2 **ISO**

The International Organization for Standardization (ISO) mainly carries out AI standardization research in the areas of industrial robots, smart finance, and intelligent driving.

In the field of robotics, ISO/TC 299 (Robotics technical committee) has carried out development of such standards as ISO 11593:1996 "Manipulating industrial robots — Automatic end effector exchange systems — Vocabulary and presentation of characteristics," ISO 9946:1999 "Manipulating industrial robots — Presentation of characteristics," ISO 9787:1999 "Manipulating industrial robots — Coordinate systems and motion nomenclatures," and ISO 8373:2012 "Robots and robotic devices — Vocabulary."

In the smart finance field, ISO/TC 68 (Financial services technical committee) engages in financial standardization work, and is mainly responsible for the development of standards relating to the banking, securities and financial services businesses. It has issued a total of 58 finance-related standards, of which those related to AI include ISO 19092:2008 "Financial services — Biometric feature recognition — Security framework," ISO 14742:2010 "Financial services — Recommendations on cryptographic algorithms and their use," and ISO 19038:2005 "Banking and related financial services — Triple DEA — Modes of operation — Implementation guidelines."

In the intelligent driving field, ISO/TC 22 (Road vehicles technical committee) is responsible for formulating foundational standards concerning road vehicles, and is carrying out standards research related to networked cars.

4.1.3 **IEC**

The International Electrotechnical Commission (IEC) has mainly carried out AI standardization work in the field of wearable devices.

IEC TC100 (Audio, video, and multimedia systems and equipment technical committee) has carried out standardization work in the field of wearable devices, and has established a "Wearable device usage scenarios" topic under the responsibility of the SS8 study group, to work on developing standards for wearable devices, including virtual reality. IEC TC 124 (Wearable electronic devices and technologies technical committee) is responsible for developing technical standards on wearables-related electrical engineering, materials, and personal safety.

The IEC Market Strategy Board (MSB) started work on preparing a "Artificial Intelligence Applications across Vertical Industries" white paper in August 2017, and plans to publish it in mid-2018.

4.1.4 **ITU**

The International Telecommunications Union (ITU) began carrying out AI standards research in 2016. In June 2017, with the XPRIZE Foundation, ITU co-organized the "AI for Good Global Summit." ITU-T has proposed draft recommendations on AI, including ITU-T Y.AI4SC on AI and IoT, and ITU-T Y.qos-ml on requirements for machine learning-based QoS assurance.

4.2 Current state of standardization overseas

4.2.1 **IEEE**

The Institute of Electrical and Electronics Engineers (IEEE) focuses mainly on the research of ethical standards in AI fields. In March 2017, the IEEE published an article in *IEEE Robotics and Automation Magazine* entitled "The IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems." It advocated the establishment of principles and standards for the ethical design of artificial intelligence to help keep AI from engendering in people either fear or blind worship, and thereby promote AI technology innovation. The IEEE has approved 7 IEEE standards projects: IEEE P7000 "Model Process for Addressing Ethical Concerns During System Design"; IEEE P7001 "Transparency of Autonomous Systems"; IEEE P7002 "Data Privacy Process"; IEEE P7003 "Algorithmic Bias Considerations"; IEEE P7004 "Standard for Child and Student Data Governance"; IEEE P7005 "Standard on Employer Data Governance"; and IEEE P7006 "Standard for Personal Data AI Agent."

4.2.2 **NIST**

The National Institute of Standards and Technology (NIST) in the United States has a certain foundation of research on AI data acquisition and analysis tools, future expert systems, AI-based quality control of aggregate production, and machine learning for high-throughput materials discovery and optimization applications, but so far it has not had any relevant standards under study or published.

4.2.3 **Other**

Also, the focus of the European Telecommunications Standards Institute (ETSI) in AI standardization is on cognitive technology, and on incorporating AI in ETSI's technology roadmap. At well-known overseas companies including Alphabet, Amazon, Facebook, IBM, and Microsoft, relevant research staff are carrying out research on AI ethics standards.

4.3 Current state of standardization in China

4.3.1 **National Information Technology Standardization Technical Committee**

The National Information Technology Standardization Technical Committee (SAC/TC 28) works as the counterpart to ISO/IEC JTC 1. In terms of AI aspects, it has mainly carried standardization work in the fields of terminology/vocabulary, human-computer interaction, biometric feature recognition, big data, and cloud computing.

In the vocabulary area, it has currently released four basic national standards: "Information technology — Vocabulary — Part 28: Artificial intelligence — Basic concepts and expert systems," "Information technology — Vocabulary — Part 29: Artificial intelligence — Speech recognition and synthesis," "Information technology — Vocabulary — Part 31: Artificial intelligence — Machine learning," and "Information technology — Vocabulary — Part 34: Artificial intelligence — Neural networks."

In the human-computer interaction field, the User Interfaces Technical Subcommittee of SAC/TC 28 has established working groups on voice interaction, somatosensory interaction, brain-computer interaction, etc., and carries out standards development on intelligent voice and somatosensory interaction, etc. The five currently issued voice interaction standards are "General specification for Chinese speech recognition system," "General specification for Chinese speech synthesis system," "Technical specification for automatic voiceprint recognition (speaker recognition)," "Specification of programming interface for Chinese speech recognition Internet service," and "Specification of programming interface for Chinese speech synthesis Internet service." Development is being carried out on "Specification of programming interface for Chinese speech recognition terminal service," "Information technology-Intelligent speech interaction system" and other series standards, as well as national standards such as "Technological requirements of intelligent customer service semantic library." At the same time, domestic research achievements are actively being contributed internationally. In 2017, "Information technology — affective computing user interface — framework" was submitted to ISO/IEC JTC 1/SC 35 as an international proposal, and a project was initiated.

In the biometric feature recognition field, the Biometric Feature Recognition Technical Subcommittee of SAC/TC 28 has carried out standards development on "General technical requirements for fingerprint recognition devices," "General technical requirements for facial recognition devices," "Information technology — Biometric sample quality — Part 4: Finger image data," "Information technology — Biometric sample quality — Part 5: Face image data," etc.

In the computer graphics/image processing and environmental data field, the Computer Graphics/Image Processing and Environmental Data Technical Subcommittee of SAC/TC 28 has carried out graphics/image-related foundational standard development on "Information technology — Augmented Reality Part 1: Vocabulary," etc.

In addition, SAC/TC 28's Big Data Standards Working Group, Cloud Computing Standards Working Group, IoT Standards Working Group, and National Sensor Network Standards Working Group are also carrying out foundational standards development in relevant fields, providing support for AI-related technologies and applications.

4.3.2 China National Technical Committee for Automation Systems and Integration Standardization

The scope of work of the Robotic Devices Technical Subcommittee of the China National Technical Committee for Automation Systems and Integration Standardization (SAC/TC 159) mainly involves such areas as whole industrial robots, system interfaces, parts, and controllers. It has developed such standards as "Industrial robots — Automatic end effector exchange systems — Vocabulary and presentation of characteristics," "Industrial robots — Presentation of characteristics," "Industrial robots — Object handling with grasp-type grippers — Vocabulary and presentation of characteristics," "Industrial robots — Coordinate systems and motion nomenclatures," and "Robots and robotic devices — Vocabulary."

4.3.3 National Audio, Video and Multimedia Standardization Technical Committee

The National Audio, Video and Multimedia Standardization Technical Committee (SAC/TC 242) mainly conducts relevant standards research centered around audio, video, and smart home health care products. Standards currently being developed include "Subjective Evaluation Methods for Virtual Reality Audio," "Technical Requirements for Wrist-Wearable Devices for Smart Home Health Management," "Categorization and Description of Smart Home Health Care Products for the Elderly," "Reference Model for Smart Home Health Care Service Platforms for the Elderly," and "Technical Specifications for Smart Home Wristbands (Watches) for the Elderly"

4.3.4 National Information Security Standardization Technical Committee

The National Information Security Standardization Technical Committee (SAC/TC 260) has carried out security-related standards research work in the areas of biometric feature recognition, smart cities, smart manufacturing, etc. In the biometric feature recognition field, it has carried out standards development on "Information security techniques — Biometric authentication protocol framework based on trusted environment," "Information security technology — Technical requirements for fingerprint identification system," "Information security technology — Technical requirements for online facial recognition system," and "Information security technology — Technical requirements for iris recognition system"; in the self-driving cars field, it has carried out standards development on "Information security technology — Cybersecurity guidebook for vehicle electronic systems"; in the smart manufacturing field, it has carried out standards development on "Information security technology — Security requirements and evaluation approaches for industrial control network monitor," "Information security technology — Security technical requirements of industrial control system security isolation and information exchange systems," and "Information security technology — General information security evaluation criteria for industrial control system products."

4.3.5 National Technical Committee 268 on Intelligent Transport Systems

The National Technical Committee 268 on Intelligent Transport Systems (SAC/TC 268) has carried out standards work mainly in the field of intelligent transportation, and has developed such standards as "Cooperative intelligent transportation systems — Dedicated short range communications — Part 1: General technical requirements," "Cooperation of roadside to vehicle — Dedicated short range communications — Part 2: Specifications of medium access control layer and physical layer," "Intelligent transport — Data security service," "Intelligent transport — Digital certificate application interface," "Cooperative intelligent transportation systems — Dedicated short range communications — Part 3: Technical requirements for network layer and application layer," and "Cooperative intelligent transportation systems — Dedicated short range communications — Part 4: Devices and applications."

4.4 Problems and challenges facing AI standardization

Although AI standardization work now has a certain foundation, it still faces a series of practical problems. The difficulties and challenges are as follows:

(1) While AI technologies and products are still developing rapidly, reaching a consensus in the industry on AI concepts, content, application modes, level of intelligentization, etc., remains difficult, and the existing foundation of standardization work is relatively weak;

(2) AI standards involve a rather large number of general-use technology fields, which involve different standardization technical committees. The boundaries of their classification work in AI fields need further clarification, and it is necessary to strengthen the top-level design of AI standardization to avoid overlapping and repetition of standardization work.

(3) With AI being a cutting-edge technology that has captured attention at home and abroad, and industry giants accelerating their layout plans, China needs to further improve its innovation capability in AI fields. Standardization work in machine learning,

natural language processing, etc., needs strong support from domestic technology R&D institutions and industries.

(4) As AI technologies of various kinds are integrated and applied in different fields, numerous agencies, fields, and companies are involved, and the difficulty of work coordination is great.

(5) Standards on ethics and safety often lag behind the development of technology, which can lead to more disagreements and disputes. This creates new challenges for standards development work.

4.5 Analysis of AI standardization requirements

By analyzing the state of AI development at home and abroad based on the foregoing content, the following preliminary analysis of standardization requirements can be obtained:

(1) Define the scope of research needed for AI. AI is showing fast-paced growth as it turns from laboratory research toward practical systems in various fields of application. This requires that definition be carried out, using uniform terminology, to clarify the core concepts of AI's content, extensions, and demands, so as to guide the industry toward a correct recognition and understanding of AI technology, and facilitate widespread use of AI technology by the public.

(2) Describe AI system frameworks. When users encounter the functions and implementation of AI systems, they generally regard them as a "black box," but it is necessary to enhance the transparency of AI systems through specification of the technology framework. Because AI systems have a broad range of applications, it may be very hard to provide a generic AI framework. A more practical approach is to provide specific frameworks for specific ranges and issues. For example, AI systems based on machine learning are now a mainstream technology, and they rely on technology resources that include cloud computing and big data. This can be used as the foundation for constructing a framework for machine learning-based AI systems, and defining the functions of their components.

(3) Evaluate the intelligence levels of AI systems. Controversy exists over differentiating between AI systems based on the degree of intelligentization, and providing benchmarks for judging their intelligence levels is a difficult and challenging task. As the need for different application venues for intelligence level evaluation becomes clearer, it is necessary for standardization work to gradually solve this problem.

(4) Promote interoperability of AI systems. AI systems and their components have a certain complexity, and different application scenarios involve different systems and components. The exchange and sharing of information between systems and between components needs to be ensured through interoperability. AI interoperability also involves interoperability between different modular products, and achieving intercommunication requires that different intelligent products have standardized interfaces. Standardization work ensures that the application program interfaces, services, and data formats of AI systems, by means of standard and compatible interfaces, define interchangeable components, data, and transaction models.

(5) Conduct AI product assessment. Where AI systems serve as industrial products, it is necessary to assess their function, performance, safety, compatibility, interoperability,

and other aspects, in order to ensure their quality and usability, and provide assurance for the sustainable development of the industry. Assessment work generally includes a series of testing and appraisal activities, and the object of assessment may be an automated driving system, service robot, or other product. Scientific assessment results are obtained, in accordance with regularized procedures and methods, by means of measurable indicators and quantifiable assessment systems. At the same time, standard implementation is promoted with the help of training, promotion, and other means.

(6) Standardize key technologies. For already formed patterns and widely used key technologies, standardization should be carried out in a timely fashion, so as to prevent the fragmentation and independence of versions, and to ensure interoperability and continuity. For instance, in the case of user data bound to deep learning frameworks, it is necessary to ensure, by means of explicit data representation and compression algorithms for neural networks, that data is exchangeable, and not bound by platforms, to safeguard users' rights to the data. Foundational standards also need to be formulated as soon as possible for human-computer interaction technology, sensor interfaces, basic algorithms, etc.

(7) Ensure security and ethics. AI collects large amounts of data on personal, biometric, or other characteristics. It is not certain that, starting from the system design, such data can be properly organized and handled, or that appropriate privacy protection measures will be adopted. In the case of AI systems that have a direct impact on the safety of humanity and the safety of life, and may constitute threats to humans, it is necessary to carry out regulation and assessment of such systems through standardization and other means, before such AI systems gain widespread application, in order to ensure safety.

(8) Standardization tailored to application industry characteristics. Apart from general-use technology, AI implemented in specific industries also has individualized requirements and special features. Typical examples are home applications, medical applications, transportation applications, etc., for which it is necessary to consider the functional performance characteristics of specific equipment, system composition and interrelationships, etc.

4.6 Construction of organizational mechanisms for AI standardization

In China at present, although key AI technology fields already have a certain foundation of standards, and specifications have been formulated for many products and technologies, top-level design from an AI perspective is still lacking. Among basic and supporting technologies, products, and industry applications, there are many technical committees, but the research work of each technical committee is limited to the scope of its own field. In standardization work, no mechanism for overall advancement has been formed, to the detriment of technology innovation and the coordinated advancement of industrialized applications. Therefore, there is an urgent need to establish a mechanism for overall coordination of standardization in AI fields.

In January 2018, the Standardization Administration of China (SAC) approved the establishment of the National Artificial Intelligence Standardization General Working Group and the National Artificial Intelligence Standardization Expert Advisory Group. The General Working Group serves in an overall coordination, planning and layout capacity, with responsibility for: carrying out international and domestic AI standardization work, and formulating China's plans, systems, and policy measures for AI standardization; coordinating the technical content and technical reporting of AI-related national standards, making overall plans for relevant standardization organizations, enterprises, and research institutes, and establishing transmission mechanisms for AI basic general-use standards and industry application standards; constructing a standards system with good compatibility and openness, centered around key technologies and guided by industry applications; carrying out national standards-related pilot demonstration, application implementation, and publicity/training work; and arranging participation in international AI standardization work, and carrying out international exchanges and cooperation on standardization. The General Working Group Secretariat is located at the China Electronics Standardization Institute (CESI). The General Working Group can establish special-topic groups under it, based on the needs of standardization work, responsible for specialized work on particular aspects.

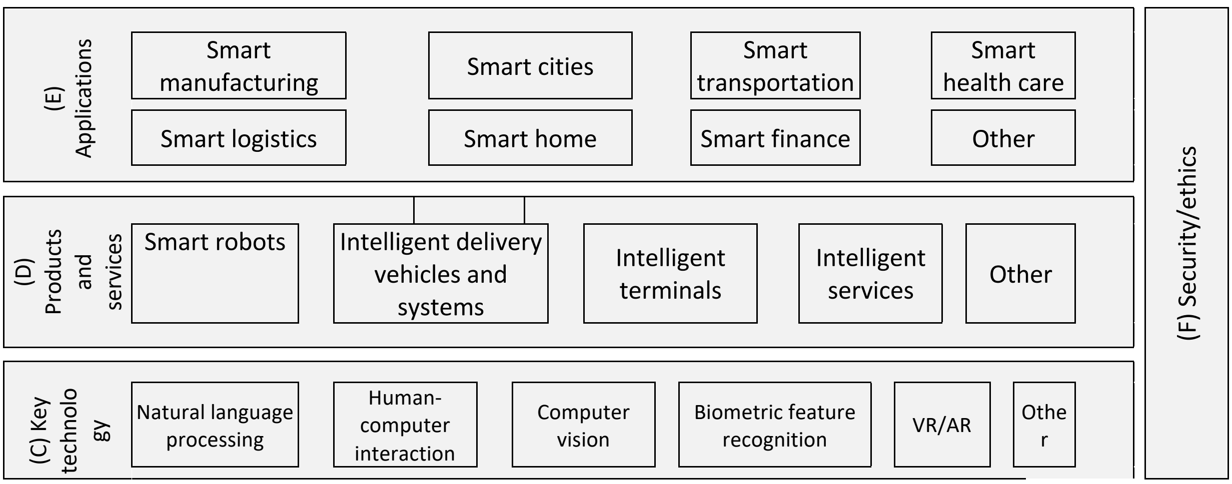
The Expert Advisory Group is composed of eminent experts and scholars in domestic AI fields, and is responsible for: providing advice to the General Working Group on the planning, systems, policy measures, and other aspects of China's AI standardization; offering opinions and recommendations on the development, piloting, application, and implementation of international and domestic AI standards, and on establishment of standards dissemination mechanisms; and guiding the work of the National AI Standardization General Working Group.

5 AI standardization systems

AI involves the integration of multiple technologies across different fields, and there are internal relationships of interdependence and mutual constraint among AI standards. As a result, AI standardization work requires overall planning and coordination, based on systematic and scientific theory and methods, and applying standardized work principles, to constantly optimize relationships between standards, and avoid disharmony, lack of coordination, irrational composition, and other problems between and among standards.

5.1 Structure of the AI standardization system

The structure of the AI standardization system include six parts: (A) foundation, (B) platforms/support, (C) key technology, (D) products and services, (E) applications, and (F) security/ethics. These mainly reflect the constitutive relationships of standards system components. The structure of the AI standards system is as shown in Figure 4.



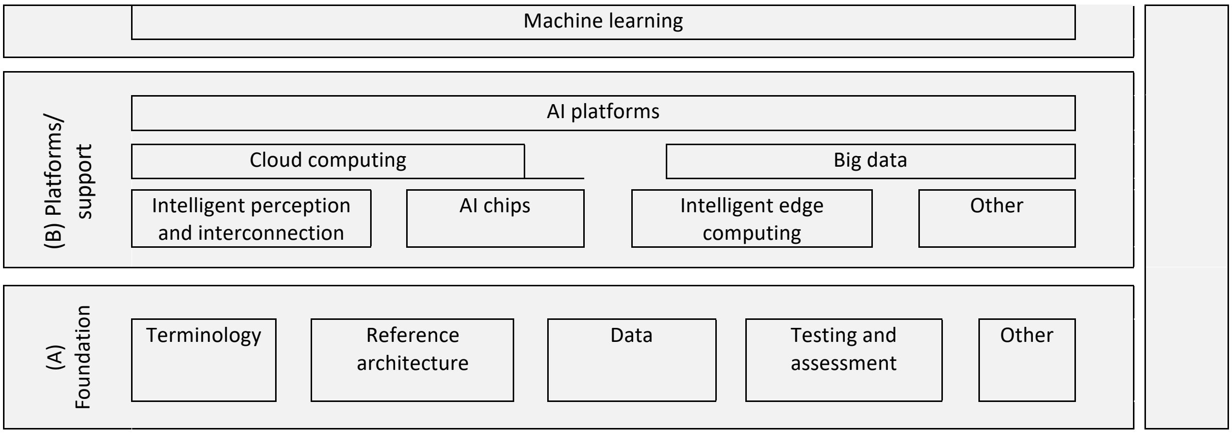


Figure 4. Structural diagram of the AI standards system

Specifically, (A) Foundational standards include the four main categories of terminology, reference architecture, data, and testing and assessment. Located at the lowest level of the AI standards system, it supports the other parts in the standards system structure. (B) Platforms/support is a general integration of AI hardware, software, networks, and data. It plays a vertical connection role within the standards system structure. (C) Key technology standards are directed mainly at fields like natural language processing, human-computer interaction, computer vision, biometric feature recognition, and VR/AR, and provide support for practical applications of AI. (D) Products/services standards include relevant standards on the intelligentized products and new service models formed in AI technology fields. (E) Application standards are at the top level of the AI standards system and are oriented towards the specific requirements of industries. They refine and implement the standard of the other parts, and support promotion of AI development by various industries. (F) Security/ethics standards are at the far right of the AI standards system structure and run through the other parts. They provide security standards and support AI development.

5.2 Standards system framework

The AI standards system framework is formed by combining the current state of AI technologies, industries, and standards at home and abroad. It is composed of six parts—foundation, platforms/support, key technology, products and services, applications, and security/ethics—as shown in Figure 5.

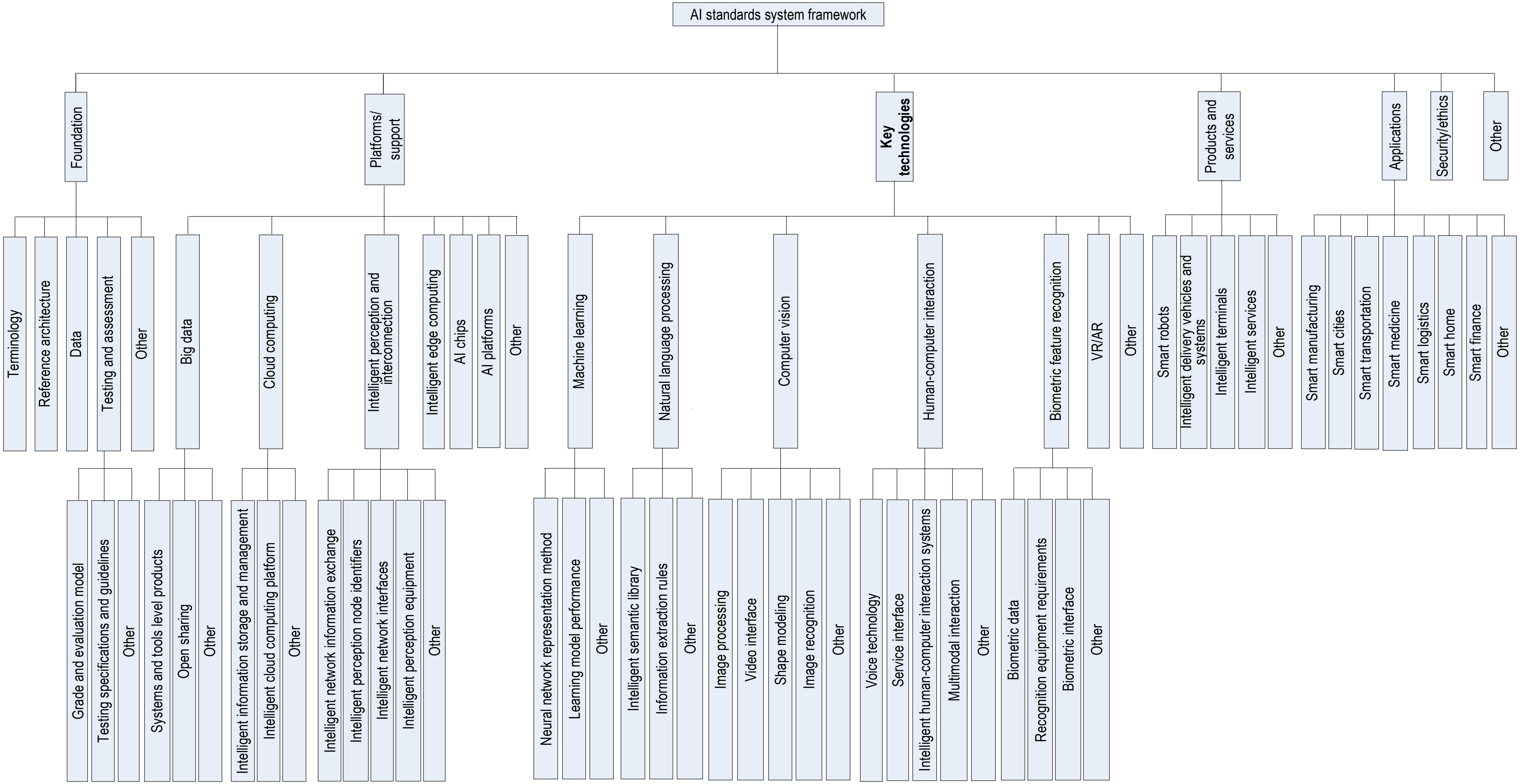


Figure 5. AI standards system framework

5.2.1 **Foundational standards**

Standards of this type are directed mainly at regularizing AI's fundamentals, including terminology, reference architecture, data, testing and assessment, etc.

With respect to standards on existing AI terminology, we must carry out standards formulation and revision work centered on current AI development conditions; deeply study AI-related technologies and production chains, and carry out standards development work on the AI reference architecture, etc.; taking into account the development requirements of AI fields, carry out development of data resource-related standards such as formats, labels, data models, and quality requirements, etc., for data used in data training; for fields in which AI technologies and industries are relatively mature, extract the common requirements for testing and assessment, and carry out standards development on general-use testing guidelines, assessment principles, intelligence level classification requirements, etc.

5.2.2 **Platform/support standards**

Standards of this type are mainly directed at regulating AI's underlying platforms and supports, including big data, cloud computing, intelligent perception and connection, edge computing, smart chips, AI platforms, etc.

A certain foundation of standardization work is already in place for big data, cloud computing, intelligent perception and connection, etc., used to support AI. For big data, the focus is on developing standards for systems-level and tools-level products, data openness and sharing, etc.; for cloud computing, the focus is on developing standards for the pooling, scheduling, and management of virtual and physical resources, such as heterogeneous computing for artificial intelligence; for intelligent perception and connection, the focus is on developing standards related to high-precision sensors, and new-type MEMS sensors, in order to provide standards support for AI hardware development; for edge computing, the focus is on developing standards for the reference architecture, lightweight operating environment requirements, etc.; for smart chips, standards development is on chip performance testing requirements, etc.; for AI platforms, the focus is on developing standards related to the general functional requirements AI computing frameworks, AI algorithm task scheduling, etc., as well as the general computing power requirements for supporting different modes of computing such as machine learning, knowledge graphs, etc.

5.2.3 **Key technical standards**

Standards of this type mainly regulate AI-related technologies, including key technologies like machine learning, natural language processing, computer vision, human-computer interaction, biometric feature recognition, and VR/AR.

In terms of machine learning, open source has an important influence in AI. Because of their experimental and flexible nature, open source software and the open source community are often one step ahead. Research needs to be conducted on the coordinated development of open source and standardization. At the same time, standards on neural network representation methods and model compression, machine learning algorithm performance assessment, etc., are also priority directions for subsequent standardization work.

In the natural language processing area, the development of technology and industries at home and abroad is in its infancy. For next steps, the following standardization work can be carried out: semantic library aspects, including semantic library structures, data specifications, interface specifications, etc.; information extraction specifications, etc.; textual content analysis aspects, including content relevance analysis guidelines and description, and methods of use, as well as guidelines for judging whether textual content is correct or not, and related performance assessment specifications.

In terms of computer vision, research on computer vision terminology standards has been conducted domestically. Because different application scenarios have different requirements with respect to acquisition devices, such devices have a major impact on the development of computer vision algorithms. Types of data acquisition devices and corresponding parameter requirements need to be regulated. Visual data acquisition and the output results of computer vision algorithms (metadata) are all highly varied, involving data formats, computer vision databases (using, e.g., single or multiple forms of data), multi-category forms of data, etc., hence definition of data formats, construction of computer vision databases (using, e.g., single or multiple forms of data), and associated multi-category forms of data, are all issues in urgent need of regulation. Different application scenarios pose different requirements for computer vision, and there is a great need for standardization, such as for quantifying and regulating the measurement methods for computer vision in different industries.

In terms of human-computer interaction, a certain amount of standardization achievement has been made at home and abroad, mainly concentrated in the voice interaction and gesture interaction directions. Going forward, we must continue development on testing standards related to speech synthesis, recognition, and other technologies and interfaces, and build a standards compliance assessment platform for intelligent voice interaction systems; develop technical specifications for gesture recognition, and service interface specifications; further augment intelligent human-computer interaction systems specifications, such as specifications and standards for multimodal interaction-based systems in the smart education field.

In terms of biometric feature recognition, standardization work mainly centers on four areas: image data, application interfaces, system applications, and performance testing. Domestically, standards development has been completed on general specifications for identification using typical modalities such as fingerprints, faces, irises, etc., as well as on data exchange formats and sample quality. A fingerprint testing platform has been established that can complete standards compliance testing of fingerprint identification products based on compliance testing methods already developed. With the development of identification technologies based on emerging modalities (DNA, gait, etc.), as well as the increase in application scenarios such as Internet finance, standards urgently need to be formulated for DNA data quality, emergence attack (呈现攻击) detection, security assessment, and security precautions, so as to support biometric feature recognition industry development.

As for VR/AR, the domestic VR/AR field currently has already carried general specifications on scenario modeling information representation, augmented reality terminology, and head-mounted display devices, as well as standards on comfort and safety aspects. However, some VR/AR technical requirements have exceeded currently existing technical requirements of some supporting industries. To address China's current problems in virtual reality content creation, device manufacturing, and applications in different fields, it is necessary to develop standards on frameworks, codecs, perception and interaction, devices, application, health and safety, comfort, etc., forming a hierarchical, structured, and harmonized standards system.

5.2.4 **Products and services standards**

Standards for products and services include standards for existing AI products and services such those for intelligent robots, intelligent delivery systems, smart terminals, and intelligent services.

With respect to intelligent robots, in combination with the work deployments under the "Guidelines for Construction of a National Robot Standardization System," centered around service robots, the focus is on technical standards for core components and specialized sensors, and improving standards for service robot hardware interfaces, safe usage and multimodal interaction models, feature sets, frameworks for service robot application operating systems, general requirements of service robot cloud computing platforms, etc.; centered around industrial robots, the focus is on carrying out standardization work on dynamic path planning for industrial robots, collaborative robot design specifications, and calibration of image recognition for industrial inspection.

In the area of intelligent delivery systems, the focus is on carrying out standardization work on connected vehicles. The main problems faced at present are related to high-performance collaborative sensor technology for vehicle intelligentization, in-vehicle connectivity technology, security technology for intelligentization and network connectivity of vehicles, etc. In combination with the work deployments under the "National Guidelines for Developing the Standards System of the Telematics Industry (Intelligent and Connected Vehicles)," the focus is on carrying out standards development work on definition of advanced driver assistance systems (ADAS) terminology, classification of vehicle driving automation, technical requirements for information security of in-vehicle information interaction systems, etc.

In the area of smart terminals, establishing a standardization and test validation platform for smart terminals is an effective way to improve the development specifications for the smart terminals industry. In order to meet the industry's development requirements, there is an urgent need to establish standards for device interconnection interfaces, content service interfaces, application development interfaces, system security technology, testing and evaluation, etc., so as to push forward the open sharing of data formats and standard protocols between devices, and promote interconnectivity between products and systems.

The area of intelligent services includes both (1) using Software as a Service (SaaS) delivery methods to provide industries integrated solutions that include image recognition, intelligent voice, natural language processing, machine learning algorithms, and other AI modules, and (2) using artificial intelligence technology to transform traditional IT services. Its corresponding standardization needs are growing. For example, large differences exist among different firms in the same kinds of services in terms of their feature sets, service interfaces, communication interaction protocols, and service acquisition methods. Standardized specifications and harmonization are urgently needed. The next steps are to focus on strengthening standards formulation work on AI service capabilities and maturity evaluation, AI services reference architecture, etc.

5.2.5 **Applications standards**

Application standards include the smart manufacturing, smart cities, smart transportation, smart health care, smart logistics, smart home, and smart finance fields.

In the smart manufacturing field, China's rapid promotion of smart manufacturing standardization work has provided a good foundation for exploring applications of AI in smart manufacturing. Centered around the requirements under the "National Intelligent Manufacturing Standards System Construction Guidelines," and incorporating applications of AI technology in manufacturing, the next step is to focus on conducting standards research on personalized customization, Supervisory Control and Data Acquisition (SCADA) data analysis, intelligent online monitoring, predictive maintenance, advanced planning and scheduling (APS) and process optimization, intelligent robots, VR/AR-based maintenance and repair, etc.

In the smart home field, in combination with the requirements of the "Guidelines for Constructing a Comprehensive Smart Home Standards System," we recommend uniting the smart home industry's upstream and downstream firms for joint participation in constructing/improving the smart home standards system, based on the current state of development of the industry and technology. The focus should be on formulating standards for key technologies, products and services in the main smart home application fields, and, in due course, initiating and participating in international standardization processes for several key standards.

In the smart finance field, in the future, smart finance will use AI technology to carry out information prediction, decision-making, and action, making financial investment and analysis more accurate. This will facilitate the creation of standardized, model-based and intelligentized risk control systems, thereby promoting financial development. Consequently, in conjunction with financial applications, using deep learning technology, and with financial knowledge graphs constructed based on machine learning, and automatic discovery of patterns from financial data, we recommend that research work be carried out on AI financial data standardization, financial credit standardization, financial risk control standardization, etc.

In the smart cities area, existing standardization work on new smart cities is concentrated on foundational and general types of standards, while standards relating to specific application fields are still in need of improvement. The next step is to strengthen research on technical standard to support the deep integration of AI with urban planning, construction, operations, services, management, and other aspects, and carry out work on dynamic assessment indicators of AI application results, while taking into account the circumstances of AI application at the level of smart city infrastructure intelligentization, facility management and operation, city operations and management, etc.

In the smart transportation area, there is already a certain foundation of standardization domestically. For next steps, the direction of standardization work will be information and data platforms and comprehensive management systems. The focus should be on developing standards for smart transportation data/information platforms, vehicle-to-road network communications, electronic license plate identification, etc., to form a multidimensional and integrated smart traffic control and management service system.

In the smart health care field, there is already a certain foundation of standardization domestically, but problems exist as well with regard to data quality, data and model privacy, difficulties building data models, etc. The next step is to focus on carrying out standards formulation work for physiological monitoring, intelligentization of medical supervision, medical information exchange, data platform interfaces, evaluation of medical data quality, etc.

In the smart logistics field, China is developing rapidly in the smart logistics technology and industry directions, and there is now a certain domestic foundation of standardization. The next steps will focus on carrying out standardization work on such aspects as specifications for logistics intelligentization planning within smart logistics, general requirements for intelligent recognition, intelligent warehouse dispatching specifications, requirements for logistics configuration in conjunction with the supply chain, etc.

In the intelligent agriculture area, the industry is becoming progressively more mature, and some sensor network standards have been formulated. Owing to the complexity and diversity of agricultural application scenarios, however, there remains an urgent need to formulate standards related to smart sensors, narrowband Internet of Things (NB-IoT), disease and pest forecasting data models, data platform interfaces, etc.

In the smart health and eldercare field, from a development planning perspective, the smart health and eldercare standards system prioritizes the development of standards for five categories of common physiological health indicators, intelligent testing equipment products and data services for individuals, families, and communities—blood pressure, blood glucose, blood oxygen, heart rhythm, and electrocardiograms—to improve the process specifications and evaluation indicator system for smart health and eldercare services, and promote regularization and standardization of smart health and eldercare services.

In the smart government area, there has been constant innovation in e-government technology and industry development, and emerging technologies are appearing continuously. Based on the development requirements under China's "Outline of the 13th Five-Year Plan for the National Informatization," the next steps will focus on standardization work directed at data sharing, business synergies, government information resource opening and other aspects.

In the case of smart environmental protection, the standards were already relatively comprehensive in traditional environmental protection fields. However, no environmental protection standards on AI have yet been released. The next steps should focus on: carrying out research and formulation of standards on AI combined with environmental protection fields; intelligent forecasting and data models for resource/energy consumption and environmental pollution emissions; and intelligent environmental monitoring networks with information sharing.

In the case of intelligent courts, development and applications need to rely on the support of multiple AI technologies, including intelligent big data, speech recognition, and image and video classification, in order to achieve functions such as case element analysis, courtroom speech recognition and automatic transcription, video analysis of courtroom behavior, and forwarding and scheduling of courtroom video streaming media. Therefore, to achieve the intelligentization of the court trial system and trial capacity, it is necessary to develop specifications such as those for harmonization of trial data formats and in-depth analysis of trial data, and utilize deep learning algorithms to mine and analyze diversified data, and thereby increase the efficiency of court hearings.

5.2.6 **Security[2]/ethics standards**

Security/ethics standards include standards and specifications relating to AI security, ethics and privacy protection. Broadly speaking, AI security/ethics standards involve security standards related to AI itself, and its platforms, technologies, products, and applications, as well as ethics and privacy protection-related specifications. At present, AI security and ethics standards are mostly security standards for some applications in fields such as biometric feature recognition and automated driving, as well as supportive types of security standards, such as big data security, privacy protection, and so on, whereas security standards for AI itself or of a foundational or general-use nature are relatively few.

Regarding AI security and ethics standards research, on the one hand, it is necessary to strengthen research on foundational standards for AI, with the focus on conducting standards research on AI security's reference architecture, security risks, ethical design, security assessment, etc., and propose security requirements and methodologies for AI algorithms, products, and systems. On the other hand, it is necessary to continue deepening standardization work in application fields, improving intelligent security requirements of existing standards, and continue conducting research on security fields such as the security of AI applications in the cybersecurity domain, intelligent robot security, automatic driving security, intelligent security, smart transportation security, smart logistics security, and smart city security.

For example, in the smart cities field, the focus is on carrying out standards research on public security, safety management systems, data security, security monitoring and warning, etc.; in the smart logistics field, the focus can be to conduct standards research on depth-sensing intelligent warehouse systems, intelligent logistics public information platforms and command systems, product quality certification and traceability systems, data security management and evaluation intelligent distribution and scheduling systems, etc.; and in the smart finance field, the focus can be to carry out standards development work on intelligent customer service, intelligent monitoring and other technologies and equipment in the financial industry, data security controls for financial risk intelligent early warning and control systems, and back-office data abuse.

5.3 Standards that urgently need to be formulated in the near term

A detailed list of standards that are urgently needed in the near future has been made, based on the analysis of the AI standards system and AI standardization requirements, as shown in Table 3:

Table 3. Detailed list of standards that are urgently needed in the near future

No.	Primary classification	Secondary classification	Name of standard	Adopted standard number and degree of adoption	Status
1.	Foundation	Terminology	Information technology — Artificial intelligence — Terminology	——	To be developed
2.		Reference architecture	Information technology — Artificial intelligence — Reference architecture	——	To be developed
3.		Testing and assessment	Information technology — Artificial intelligence — Assessment guidelines	——	To be developed

[2] Translator's note: The Chinese word 安全 can be translated as either "safety" or "security." The translator judges that in section 5.2.6, "security" is the appropriate English translation.

No.	Primary classification	Secondary classification	Name of standard	Adopted standard number and degree of adoption	Status
4.	Platforms/ support	AI platforms	Information technology — Artificial intelligence — Platforms — Capability requirements for task scheduling and resource management	——	To be developed
5.			Information technology — Artificial intelligence — Basic service interface specifications	——	To be developed
6.			Information technology — Artificial intelligence — Platforms — Capability requirements of computing framework	——	To be developed
7.			Information technology — Artificial intelligence — Platforms — General-use requirements	——	To be developed
8.		Intelligent edge computing	Edge computing reference architecture	——	To be developed
9.		AI chips	Smart chip performance assessment guidelines	——	To be developed
10.	Key technology	Machine learning	Information technology — Neural network representation and model compression	——	To be developed
11.			Information technology — Learning model performance assessment specifications	——	To be developed
12.		Computer vision	Information technology — Computer vision — Terminology	——	To be developed
13.			Intelligent surveillance — Structured video — Data exchange formats	——	To be developed
14.			Smart media — Specifications of metadata for intelligent analysis	——	To be developed
15.			Technical requirements of video image identification systems	——	To be developed
16.		Human-computer interaction	Information technology — Intelligent voice interaction system — Part 1: General specifications	——	To be developed
17.			Information technology — Intelligent speech interaction — Evaluation — Part 1: Speech processing	——	To be developed
18.			Information technology — Intelligent speech interaction — Evaluation — Part 2: Recognition	——	To be developed
19.			Information technology — Intelligent speech interaction — Evaluation — Part 3: Semantic understanding	——	To be developed
20.			Information technology — Artificial intelligence — Voice interaction — Evaluation — Part 4: Synthesis	——	To be developed
21.			Information technology — Artificial intelligence — Voice interaction — Evaluation — Part 5: Speech evaluation	——	To be developed
22.			Information technology — Artificial intelligence — Applications — Evaluation — Part 1: General system specifications	——	To be developed
23.			Information technology — Smart speaker assessment guidelines	——	To be developed
24.		VR/AR	Information technology — Virtual reality — Head-mounted display devices — Comfort testing methods	——	To be developed
25.			Information technology — Virtual reality — Head-mounted display devices — Safety testing methods	——	To be developed

No.	Primary classification	Secondary classification	Name of standard	Adopted standard number and degree of adoption	Status
26.			Augmented reality — Face structure location and special effects data format specifications	——	To be developed
27.	Products	Robots	Intelligent service robots — General technical specifications	——	To be developed
28.	Applications/ services	Smart home	Information technology — Smart home — Communication and interaction protocol specifications	——	To be developed
29.			Information technology — Smart home — human-computer interaction interface requirements	——	To be developed
30.		Smart medicine	Medical imaging — Computer-aided diagnosis system technical requirements	——	To be developed
31.	Security		Information technology — Artificial intelligence — Security situational awareness technical requirements	——	To be developed

6 Key recommendations for AI standardization work

AI standardization-building is a key factor in the development of China's AI industry, and is an important means for guaranteeing that China's AI industry will seize the lead and gain the advantage in global competition. Factoring in the current state of AI development and its requirements, and comparing against the existing standardization work situation, the following tasks are proposed for the focus of China's AI standardization in the near term:

(I) Strengthen top-level design of AI standardization

The scope of key AI technologies and industry applications involves a great many agencies and standardization technical organizations. We recommend gathering the resources of mainstream industry, academic, and research units under the overall planning of the National AI Standardization General Working Group and the Expert Advisory Group, to create an excellent standardization atmosphere. At the same time, sorting through the varied elements of the AI industry ecosystem, and with a good grasp of the key directions for the industry's future development, a sound standards system should be developed, under the principle of being "fundamentals-led and application-driven."

(II) Strengthen research on core and key AI technologies

To break through the bottlenecks in AI's basic theory and key/core technologies, we should: implement major projects on key technologies, with algorithms as the core and data/hardware as the foundation, and adopting a "safe and controlled AI" orientation; draw up a roadmap for general-use technology development, focusing on improving perceptual recognition, knowledge computing, cognitive reasoning, movement execution, and human-computer interaction capabilities; and form an open, compatible, stable, and mature technical system, sorting out the standardization needs, and using technological breakthroughs to drive breakthroughs in core technical standards.

(III) Drive forward development of key AI standards

While implementing the standardization deployments and requirements of policy documents such as the "New Generation Artificial Intelligence Development Plan" and the "Three Year Action Plan to Promote the Development of the New Generation Artificial Intelligence Industry," we should focus on AI standardization needs, in accordance with the principle of "giving priority to urgent needs, letting the mature go first," and carry out development of urgently needed standards for terminology, reference architectures, algorithmic models, technology platforms, etc.; and drive forward international AI standardization work, gathering together superior resources from domestic industry, academic, and research institutions to participate in international standard development work, to boost our international voice.

(IV) Build a public service platform for standards compliance testing

Accelerate construction of a compliance testing platform for key AI standards, carry out standardized application verification, harmonize testing assessment standards, strengthen construction of the public service platform for testing, and elevate the public service platform's testing and evaluation capabilities. Relying on standards, guide companies to try to develop AI solutions in typical industries, and join together investment and financing institutions to carry out incubation.

(V) Perfect security, ethics, and privacy-related standards, laws, and policies

AI development brings with it a variety of social issues. It is necessary to consider fully questions of responsibility and fault in the AI development and deployment process, and formulate/improve related security laws and regulations; relying on a broad consensus among the general public on AI ethics, set ethical requirements for AI technology; carry out regulation starting from the collection of data, and for the management of personal data, extended protection should be adopted to protect the public's privacy. During this process, improve security, ethics, and privacy-related standards, laws, and policies.

Appendix 1 Detailed list of AI standards

Based on the AI standards system framework, AI standards that have already been issued, or are under study or are to be developed, are arranged to form a detailed list of AI standards, as shown in Table 4.

Table 4. Detailed list of AI standards

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
1.	Foundation	Terminology	GB/T 5271.28-2001	Information technology — Vocabulary — Part 28: Basic AI concepts and expert systems	——	Already issued
2.			GB/T 5271.29-2006	Information technology — Vocabulary — Part 29: AI speech recognition and synthesis	——	Already issued
3.			GB/T 5271.31-2006	Information technology — Vocabulary — Part 31: AI machine learning	——	Already issued
4.			GB/T 5271.34-2006	Information technology — Vocabulary — Part 34: AI neural networks	——	Already issued
5.				Information technology — Artificial intelligence — Terminology	——	To be developed
6.		Data	GB/T 31916.5-2015	Information technology — Cloud data storage and management — Part 5: Cloud data management services based on Key-Value	——	Already issued
7.			20141179-T-469	Information technology — System and software engineering — systems and software quality requirements and evaluation (SQuaRE) — Part 12: Data quality models	——	Under study
8.			2010-2210T-SJ		——	Under study
9.		Reference architecture	20141190-T-469	Information technology — Big data — Technical reference model	——	Under study
10.			GB/T 32399-2015	Information technology — Cloud computing — Reference architecture	——	Already issued
11.			——	Information technology — Artificial intelligence — Reference architecture	——	To be developed
12.		Testing and assessment	——	Information technology — Artificial intelligence — Assessment guidelines	——	To be developed
13.	Platforms/ support	Big data	20160598-T-469	Information technology — Big data — Technical requirements for storage and processing platforms	——	Under study
14.			20171081-T-469	Information technology — Big data — Functional testing specifications for storage and processing systems	——	Under study
15.			20160597-T-469	Information technology — Big data — Basic functional requirements of analysis systems	——	Under study
16.			20171065-T-469	Information technology — Big data — Functional testing specifications for analysis systems	——	Under study

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
17.			20171067-T-469	Information technology — Big data — Openness and sharing — Part 1: General principles	——	Under study
18.			20171068-T-469	Information technology — Big data — Opening and sharing — Part 2: Basic requirements for government data opening and sharing	——	Under study
19.			20171069-T-469	Information technology — Big data — Openness and sharing — Part 3: Degree of openness evaluation	——	Under study
20.			20171066-T-469	Information technology — Big data — Basic performance requirements for application-oriented fundamental computation platforms	——	Under study
21.			20171084-T-469	Information technology — Big data — General specifications for Big data systems	——	Under study
22.		Intelligent sensors and networks	GB/T 33905.1-2017	Intelligent sensor — Part 1: General principles	——	Already issued
23.			GB/T 33905.2-2017	Intelligent sensor — Part 2: Application profile for Internet of things	——	Already issued
24.			GB/T 33905.3-2017	Intelligent sensor — Part 3: Terminology	——	Already issued
25.			GB/T 33905.4-2017	Intelligent sensor — Part 4: Performance evaluation methods	——	Already issued
26.			GB/T 33905.5-2017	Intelligent sensor — Part 5: Methods for inspection and routine testing	——	Already issued
27.			20120545-T-469	Sensor network identifier analysis and management specification	——	Under study
28.			20141553-T-469	Information technology — Sensor networks — Part 903: Gateway: Logical interface technical specification	——	Under study
29.			20171073-T-469	Internet of things — Access of sensing and controlling device — Part 1: General requirements	——	Under study
30.			20150049-T-469	Internet of things — Sensing object information fusion model	——	Under study
31.		Cloud computing	GB/T 31915-2015	Information technology — Elastic computing application interface	——	Already issued
32.			GB/T 31916.1-2015	Information technology — Cloud data storage and management — Part 1: General principles	——	Already issued
33.			GB/T 31916.2-2015	Information technology — Cloud data storage and management — Part 2: Object-based cloud storage application interface	——	Already issued
34.			20153697-T-469	Information technology — Cloud data storage and management — Part 3: Distributed file storage application interface	——	Under study
35.			20153674-T-469	Information Technology — Cloud computing — Cloud storage resource management technical	——	Under study

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
				specification		
36.			20153703-T-469	Information technology — Cloud computing — Distributed block storage system general technical requirements	——	Under study
37.			20153698-T-469	Information technology — Cloud computing — General requirements of virtual machine management	——	Under study
38.			20153707-T-469	Information technology — Cloud computing — Cloud service operation general requirements	——	Under study
39.			20120544-T-469	Platform as a Service (PaaS) reference architecture	——	Under study
40.		AI platforms	——	Information technology — AI Platforms — Capability requirements for task scheduling and resource management	——	To be developed
41.		AI platforms	——	Information technology — Artificial intelligence — Basic service interface specifications	——	To be developed
42.		AI platforms	——	Information technology — Artificial intelligence — Platforms — Capability requirements of computing framework	——	To be developed
43.		AI platforms	——	Information technology — Artificial intelligence — Platforms — General-use requirements	——	To be developed
44.		Intelligent edge computing	——	Edge computing reference architecture	——	To be developed
45.		AI chips	——	Smart chip performance assessment guidelines	——	To be developed
46.	Key technology	Machine learning	——	Information technology — Neural network representation and model compression	——	To be developed
47.	Key technology	Machine learning	——	Information technology — Learning model performance assessment specifications	——	To be developed
48.	Key technology	Computer vision	——	Information technology — Computer vision — Terminology	——	To be developed
49.	Key technology	Computer vision	20141209-T-469	Information technology — Information representation of shape modeling — Part 1: Framework and basic components	——	Under study
50.	Key technology	Computer vision	20141210-T-469	Information technology — Information representation of shape modeling — Part 2: Feature constraints	——	Under study
51.	Key technology	Computer vision	20141203-T-469	Information technology — Information representation of shape modeling — Part 3: Streaming transmission	——	Under study
52.	Key technology	Computer vision	20141204-T-469	Information technology — Information representation of shape modeling — Part 4: Storage format	——	Under study

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
53.			——	Intelligent surveillance — Structured video — Data exchange formats	——	To be developed
54.			——	Smart media — Specifications of metadata for intelligent analysis	——	To be developed
55.			——	Technical requirements of video image identification systems	——	To be developed
56.		Natural language processing	20151549-T-469	Technological requirements of intelligent customer service semantic library	——	Under study
57.		Human-computer interaction	20171072-T-469	Information technology — Gesture interaction system — Part 1: General technical requirements	——	Under study
58.			20171075-T-469	Information technology — Gesture interaction system — Part 2: System interface	——	Under study
59.			20141231-T-469	Information technology — Specification of programming interface for Chinese speech recognition terminal service	——	Under study
60.			GB/T 21023-2007	General specifications for Chinese speech recognition system	——	Already issued
61.			GB/T 21024-2007	General specifications for Chinese speech synthesis system	——	Already issued
62.			SJ/T 11380-2008	Technical specifications for automatic voiceprint recognition (speaker recognition)	——	Already issued
63.			GB/T 34145-2017	Specification of programming interface for Chinese speech synthesis Internet service	——	Already issued
64.			GB/T 34083-2017	Specification of programming interface for Chinese speech recognition Internet service	——	Already issued
65.			——	Information technology — Intelligent voice interaction system — Part 1: General specifications	——	To be developed
66.			20153685-T-469	Information technology — Intelligent speech interaction system — Part 2: Intelligent home appliances	——	Under study
67.			20153686-T-469	Information technology — Intelligent speech interaction system — Part 3: Intelligent customer service	——	Under study
68.			20153687-T-469	Information technology — Intelligent speech interaction system — Part 4: Mobile terminal	——	Under study
69.			20153688-T-469	Information technology — Intelligent speech interaction system — Part 5: In-vehicle terminal	——	Under study
70.			2014-0419T-SJ	Information technology — Speech recognition for smart television — Measurement method	——	Under study
71.			2014-0420T-SJ	Information technology — Speech recognition for smart television — Measurement method — General technical requirements	——	Under study

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
72.			——	Information technology — Intelligent speech interaction — Evaluation — Part 1: Speech processing	——	To be developed
73.			——	Information technology — Intelligent speech interaction — Evaluation — Part 2: Recognition	——	To be developed
74.			——	Information technology — Intelligent speech interaction — Evaluation — Part 3: Semantic understanding	——	To be developed
75.			——	Information technology — Intelligent speech interaction — Evaluation — Part 4: Synthesis	——	To be developed
76.			——	Information technology — Artificial intelligence — Voice interaction — Evaluation — Part 5: Speech evaluation	——	To be developed
77.			——	Information technology — Artificial intelligence — Applications — Evaluation — Part 1: General system specifications	——	To be developed
78.			——	Information technology — Smart speaker assessment guidelines	——	To be developed
79.		Biometric feature recognition	GB/T 26237.1-2010	Information technology — Biometric data interchange formats — Part 1: Framework	ISO/IEC 19794-1: 2006 Revised	Already issued
80.			GB/T 26237.2-2011	Information technology — Biometric data interchange formats — Part 2: Finger minutiae data	ISO/IEC 19794-2: 2005 Revised	Already issued
81.			GB/T 26237.3-2011	Information technology — Biometric data interchange formats — Part 3: Finger pattern spectral data	ISO/IEC 19794-3: 2006 Revised	Already issued
82.			GB/T 26237.4-2014	Information technology — Biometric data interchange formats — Part 4: Finger image data	ISO/IEC 19794-4: 2005 Revised	Already issued
83.			GB/T 26237.5-2014	Information technology — Biometric data interchange formats — Part 5: Face image data	ISO/IEC 19794-5: 2005 Revised	Already issued
84.			GB/T 26237.6-2014	Information technology — Biometric data interchange formats — Part 6: Iris image data	ISO/IEC 19794-6: 2005 Revised	Already issued
85.			GB/T 26237.7-2013	Information technology — Biometric data interchange formats — Part 7: Signature/sign time series data	ISO/IEC 19794-7: 2007 Revised	Already issued
86.			GB/T 26237.8-2014	Information technology — Biometric data interchange formats — Part 8: Finger pattern skeletal data	ISO/IEC 19794-8: 2006 Equivalent	Already issued

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
87.			GB/T 26237.9-2014	Information technology — Biometric data interchange formats — Part 9: Vascular image data	ISO/IEC 19794-9: 2007 Revised	Already issued
88.			GB/T 26237.10-2014	Information technology — Biometric data interchange formats — Part 10: Hand geometry silhouette data	ISO/IEC 19794-10: 2007 Equivalent	Already issued
89.			20080532-T-469	Information technology — Biometric data interchange formats — Part 14: DNA data	——	Under study
90.			SJ/T 11607-2016	General specifications for fingerprint recognition devices	——	Already issued
91.			SJ/T 11608-2016	General specifications for facial recognition devices	——	Already issued
92.			20151546-T-469	Information technology — General specifications for fingerprint processing chip	——	Under study
93.			20160129-T-469	Information technology — General specifications for fingerprint recognition devices	——	Under study
94.			20152000-T-469	Information technology — General specifications for iris recognition devices	——	Under study
95.			GB/T 33767.1-2017	Information technology — Biometric sample quality — Part 1: Framework	ISO/IEC 29794-1: 2009 Equivalent	Already issued
96.			20141198-T-469	Information technology — Biometric sample quality — Part 4: Finger image data	ISO/IEC 29794-4: 2010 Equivalent	Under study
97.			20141199-T-469	Information technology — Biometric sample quality — Part 5: Face image data	ISO/IEC 29794-5: 2010 Equivalent	Under study
98.			20153692-T-469	Information technology — Biometric sample quality — Part 6: Iris image data	ISO/IEC 29794-6: 2015 Equivalent	Under study
99.			GB/T 28826.2-2014	Information technology — Common biometric exchange formats framework — Part 2: Procedures for the operation of the biometric registration authority	ISO/IEC 19785-2: 2006 Revised	Already issued
100.			GB/T 33844-2017	Information technology — Biometric feature recognition — Ten-fingerprint capture using biometric application programming interface (BioAPI)	ISO/IEC 29141: 2009 Equivalent	Already issued
101.			GB/T 32629-2016	Information technology —BioAPI interworking protocol	ISO/IEC 24708: 2008 Equivalent	Already issued
102.			GB/T 33842.2-2017	Information technology — Conformance testing methodology for biometric data interchange formats defined in GB/T 26237 —	——	Already issued

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
				Part 2: Finger minutiae data		
103.			GB/T 33842.4-2017	Information technology — Conformance testing methodology for biometric data interchange formats defined in GB/T 26237 — Part 4: Finger image data	——	Already issued
104.			20151550-T-469	Information technology — Conformance testing methodology for biometric data interchange formats defined in GB/T 26237 — Part 5: Face image data	ISO/IEC 29109-5: 2014 Revised	Under study
105.			20141196-T-469	Information technology — Biometric feature recognition — Multimodal and other multibiometric fusion	ISO/IEC 24722: 2007 Revised	Under study
106.			20153999-T-469	Information technology — Biometric feature recognition used with mobile devices — Part 1: General requirements	——	Under study
107.		VR/AR	20130388-T-469	Information technology — Augmented reality — Part 1: Terminology	——	Under study
108.			20171076-T-469	Information technology — Virtual reality — Head-mounted display device — General specifications	——	Under study
109.			20172574-T-469	Information technology — Virtual reality application software basic requirements and testing methods	——	Under study
110.			——	Information technology — Virtual reality — Head-mounted display devices — Comfort testing methods	——	To be developed
111.			——	Information technology — Virtual reality — Head-mounted display device — Safety testing methods	——	To be developed
112.			——	Augmented reality — Specifications for face structure location and special effects data formats	——	To be developed
113.	Products	Robots	GB/T 33267-2016	The interface of robot simulation environment	——	Already issued
114.			GB/T 29825-2013	Robot general bus (通用总线) communication protocol	——	Already issued
115.			GB/T 33266-2016	General high-speed communication general bus performance for modular robot	——	Already issued
116.			GB/T 33262-2016	Design specification of modularity for industrial robot	——	Already issued
117.			GB 11291.2-2013	Robots and robotic devices — Safety requirements for industrial robots — Part 2: Robot systems and integration	ISO/IEC 10218-2: 2011 Equivalent	Already issued
118.			GB/T 29824-2013	Industrial robot — User program instruction	——	Already issued

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
119.			GB/T 12642-2013	Industrial robots — Performance criteria and related test methods	——	Already issued
120.			GB/T 20868-2007	Industrial robots — Detailed implementation specifications for performance and related tests	——	Already issued
121.			GB/T 33261-2016	General specifications for modular design of service robots	——	Already issued
122.			GB/T 34454-2017	Dry cleaning robots for household use — methods of measuring performance	——	Already issued
123.			GB/T 33265-2016	Education robot safety requirements	——	Already issued
124.			——	Intelligent service robots — General technical specifications	——	To be developed
125.		Intelligent terminals	GB/T 30284-2013	Technical requirements of security for operating system in smart mobile terminal (EAL2)	——	Already issued
126.		Intelligent terminals	GB/T 32927-2016	Information security technology — Security architecture of mobile smart terminal	——	Already issued
127.		Intelligent terminals	GB/T 33776.4-2017	Forestry Internet of Things (IoT) — Part 4: General specification of hand-held intelligent terminal	——	Already issued
128.		Intelligent terminals	GB/T 34132-2017	General specification for smart terminal in smart substation	——	Already issued
129.		Intelligent terminals	SJ/T 11592-2016	Conceptual model for smart TV	——	Under study
130.		Intelligent terminals	2014-0421T-SJ	Evaluation method of intelligentization technology for smart TV	——	Under study
131.		Intelligent terminals	2014-0418T-SJ	Technical requirements and testing methods for smart TV gesture recognition	——	Under study
132.		Intelligent terminals	2015-1604T-SJ	Control coding and measurement methods for smart TV entertainment device	——	Under study
133.		Intelligent delivery vehicles and systems	JB/T 5063-2014	Handling robot — General specification	——	Already issued
134.		Intelligent delivery vehicles and systems	SJ 20569-1996	General specification for integrated radio system of unmanned aerial reconnaissance vehicle	——	Already issued
135.		Intelligent delivery vehicles and systems	GB 10827.1-2014	Industrial trucks — Safety requirements and verification — Part 1: Self-propelled industrial trucks, other than driverless trucks, variable-reach trucks, and burden-carrier trucks	——	Already issued
136.	Applications/ services	Smart home	GB/T 30246.1-2013	Home network — Part 1: System architecture and reference model	——	Already issued
137.	Applications/ services	Smart home	GB/T 30246.2-2013	Home network — Part 2: Control terminal specification	——	Already issued
138.	Applications/ services	Smart home	GB/T 30246.3-2013	Home network — Part 3: Internal gateway specification	——	Already issued

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
139.			GB/T 30246.4-2013	Home network — Part 4: Terminal device specification — Audio video and multimedia device	——	Already issued
140.			GB/T 30246.5-2014	Home network — Part 5: Terminal device specification — Home appliances and similar electrical appliances	——	Already issued
141.			GB/T 30246.6-2013	Home network — Part 6: Multimedia and data network communication protocol	——	Already issued
142.			GB/T 30246.7-2013	Home network — Part 7: Control network communication protocol	——	Already issued
143.			GB/T 30246.8-2013	Home network — Part 8: Device description file specification — XML format	——	Already issued
144.			GB/T 30246.9-2013	Home network — Part 9: Device description file specification — Binary format	——	Already issued
145.			GB/T 30246.11-2013	Home network — Part 11: Specification for conformance test of interfaces in control network	——	Already issued
146.			——	Information technology — Smart home — Communication and interaction protocol specifications	——	To be developed
147.			——	Information technology — Smart home — Human-computer interaction interface requirements	——	To be developed
148.		Smart logistics	GB/T 32404-2015	General technological framework for logistic information service in mobile network based on machine to machine (M2M) technology	——	Already issued
149.			GB/T 32405-2015	M2M protocol for logistic information service in mobile network	——	Already issued
150.			GB/T 32406-2015	Technical requirements of M2M platform for logistic information service in mobile network	——	Already issued
151.			GB/T 32407-2015	Technical requirements of M2M communication module for logistic informatization service in mobile network	——	Already issued
152.		Smart manufacturing	20170053-T-339	Industrial Internet — General Network Framework	——	Under study
153.			20170057-T-469	Intelligent manufacturing — Object identification requirements	——	Under study
154.			20170054-T-339	Intelligent manufacturing — Identification and resolution system requirements	——	Under study
155.			20170039-T-604	Digital factory — General technical requirements	——	Under study
156.			20170038-T-604	Digital factory — Machine tools manufacturing — Information model	——	Under study
157.		Smart cities	GB/T 33356-2016	Evaluation indicators for new-type smart cities	——	Already issued
158.			GB/T 34678-2017	Smart city — Technical reference model	——	Already issued

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
159.			20151993-T-469	Smart city — Domain knowledge model — Part 1: Core conceptual model	——	Under study
160.			20151994-T-469	Smart city — Data fusion — Part 2: Specification of data encoding	——	Under study
161.			20151995-T-469	Smart city — Data fusion — Part 1: Data concept model and description specification	——	Under study
162.			20151996-T-469	Smart city — Support platform for public information and services — Part 2: Directory management and service requirements	——	Under study
163.			20151997-T-469	Smart city — Guide for information system operation and maintenance	——	Under study
164.			20151998-T-469	Smart city — Top-level design guide	——	Under study
165.			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	——	Already issued
166.			20130390-T-469	Evaluation model and general evaluation indicator system for smart cities — Part 2: Information applications and services	——	Under study
167.			GB/T 34680.3-2017	Evaluation model and general evaluation indicator system for smart cities — Part 3: Information resources	——	Already issued
168.		Smart transportation	GB/T 31024.1-2014	Cooperative intelligent transportation systems — Dedicated short range communications — Part 1: General technical requirements	——	Already issued
169.			GB/T 31024.2-2014	Cooperative intelligent transportation systems — Dedicated short range communications — Part 2: Specification of medium access control layer and physical layer	——	Already issued
170.			20130075-T-469	Dedicated short range communications — Part 3: Network layer and application layer	——	Under study
171.			20130076-T-469	Dedicated short range communications — Part 4: Equipment application	——	Under study
172.		Smart health care	GB/T 24466-2009	Requirements for an electronic health record architecture	——	Already issued
173.			20161920-T-469	Smart city — Smart health care — Part1: Framework and general requirements	——	Under study
174.			20152350-T-339	Smart city — Smart health care — Part2: Mobile health	——	Under study

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
175.			20150079-T-361	Medical and health IoT — Nomenclature codes — sensing device — Part 1: General specification	——	Under study
176.			20150081-T-361	Medical and health IoT — Nomenclature codes — sensing device — Part 2: Thermometer	——	Under study
177.			20150076-T-361	Medical and Health IoT — Nomenclature Codes — sensing device — Part 3: Pulse Oximeter	——	Under study
178.			20150074-T-361	Medical and Health IoT — Nomenclature Codes — sensing device — Part 4: Electrocardiogram	——	Under study
179.			20150075-T-361	Medical and Health IoT — Nomenclature Codes — sensing device — Part 5: Blood pressure monitor	——	Under study
180.			20150073-T-361	Medical and Health IoT — Nomenclature Codes — sensing device — Part 6: Blood glucose meter	——	Under study
181.			20150077-T-361	Medical and Health IoT — Nomenclature Codes — sensing device — Part 7: Energy monitor	——	Under study
182.			20150078-T-361	Medical and health IoT — Nomenclature codes — sensing device — Part 8: Location identity	——	Under study
183.			2017-0289T-SJ	Technical requirements for wrist-wearable devices for smart home health management	——	Under study
184.			2017-0290T-SJ	Categorization and description of smart home health care products for the elderly	——	Under study
185.			2017-0291T-SJ	Reference model for smart home health care service platforms for the elderly	——	Under study
186.			2017-0292T-SJ	Technical specifications for smart home wristbands (watches) for the elderly	——	Under study
187.			——	Medical imaging — Computer-aided diagnosis system technical requirements	——	To be developed
188.		Smart finance	JR/T0093.1-2012	China financial mobile payment — Remote payment applications — Part 1: Data elements	——	Already issued
189.			JR/T0093.2-2012	China financial mobile payment — Remote payment applications — Part 2: Specification for transaction model and processing	——	Already issued
190.			GB/T27912-2011	Biometric feature recognition security framework for financial services	——	Already issued
191.	Security		20141145-T-469	Information security technology — Security requirements for IoT sensing layer access to communication network	——	Under study
192.			20151593-T-469	Information security technology — Security reference model and generic requirements for IoT	——	Under study

No.	Primary classification	Secondary classification	National/industry standard number/ plan number	Name of standard	Adopted standard number and degree of adoption	Status
193.			20152012-T-469	Information security technology — Security technical requirements of data transmission for IoT	——	Under study
194.			20152014-T-469	Information security technology — Security technical requirements of gateway in sensing layer of IoT	——	Under study
195.			20152007-T-469	Information security technology — Security technical requirements of gateway in sensing layer of IoT	——	Under study
196.			20171113-T-469	Information security technology — Technical requirements of security design for information system classified protection — Part 4: IoT	——	Under study
197.			GB/T 31167-2014	Information security technology — Security guide for cloud computing services	——	Already issued
198.			GB/T 31168-2014	Information security technology — Security capability requirements of cloud computing services	——	Already issued
199.			20170565-T-469	Information security technology — Biometric authentication protocol framework based on trusted environment	——	Under study
200.			——	Information technology — Artificial intelligence — Security situational awareness technical requirements	——	To be developed

Appendix 2 Examples of applications

Based on AI application scenarios, this white paper has selected 10 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: City Brain (城市大脑) —Innovative practices and applications for optimal allocation of public resources in cities

Field of application: urban governance

Application scenarios: traffic situation evaluation and traffic light control optimization, urban event perception and intelligent processing, public travel and operational vehicle scheduling, social governance and public security

Case provider: Alibaba Cloud Computing Ltd.

（1） Customer need and project outline

With China's progress toward informatization having reached a certain stage, vast quantities of data have been accumulated. In the current situation, however, the different traffic management informatization systems and platforms operated by various agencies were all built using traditional IT models. The underlying standards and modes of operation are different, and each operates independently, unable to interoperate or coordinate. Traditional approaches to informatization lead to the creation of information silos, with different data resources cut off from each other, and low levels of data sharing and openness. And as to the vast quantities of data for storage and computation, it is difficult to mine the data's value and put it to good use without cutting-edge big data, cloud computing, and AI capabilities.

City Brain is a new infrastructure for supporting the future sustainable development of cities. Its core function is to use a comprehensive range of real-time data resources to optimize a city's public resources operations and promptly correct its operating deficiencies, thereby achieving the following three breakthroughs:

① Urban governance model breakthrough

Urban data is used as the resource for improving government's administrative capabilities, solving prominent issues in urban governance, and achieving the intelligentization, intensification, and personalization of urban governance

② City services model breakthrough

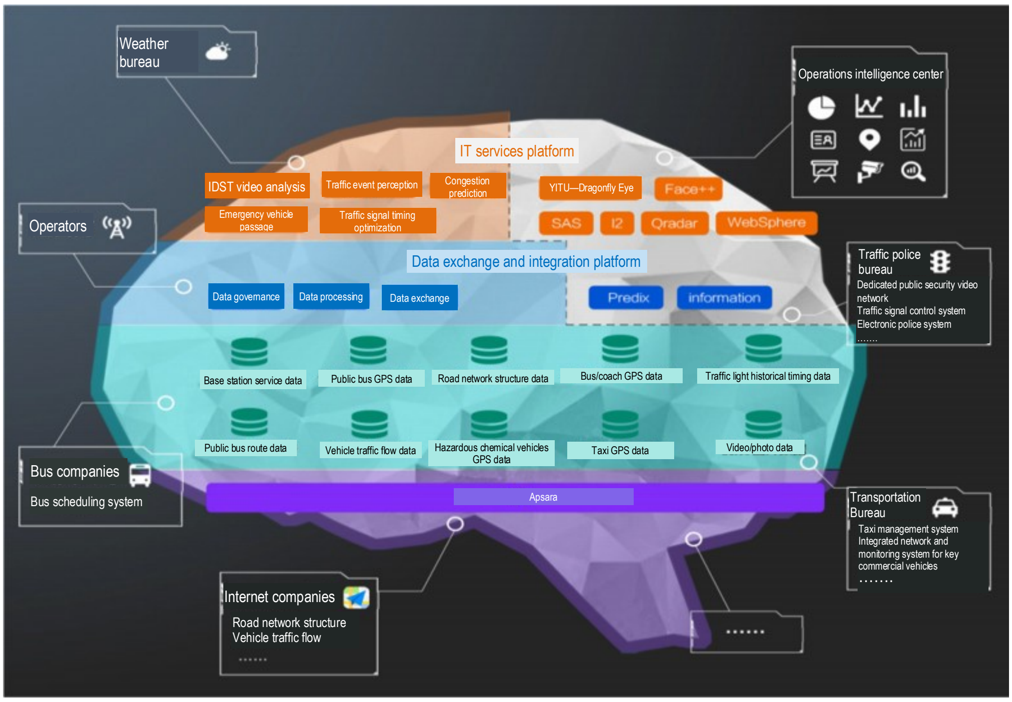
By delivering services to enterprises and individuals more accurately, anytime, anywhere, the city's public services are more effective, and public resources are used more economically.

③ Urban industry development breakthrough

Open urban data resources are important basic resources, playing a catalytic role in driving industrial development and promoting the transformation and upgrading of traditional industries.

（2） Specific solution brief

ET City Brain (ET城市大脑) is a data intelligence product built to address urban governance issues. Relying on Alibaba's Aliyun integrated big data computing platform as the foundation, it uses Aliyun's data resource platform to aggregate urban data of multiple types, including enterprise data, public security data, government data, and data from various operators, and leverages machine learning and AI algorithms. With ET City Brain's comprehensive, real-time perspective, urban problems can be uncovered and given corresponding optimized solutions for handling, while simultaneously linking to various resources in the city for scheduling, thereby increasing the efficiency of city operations across the board.

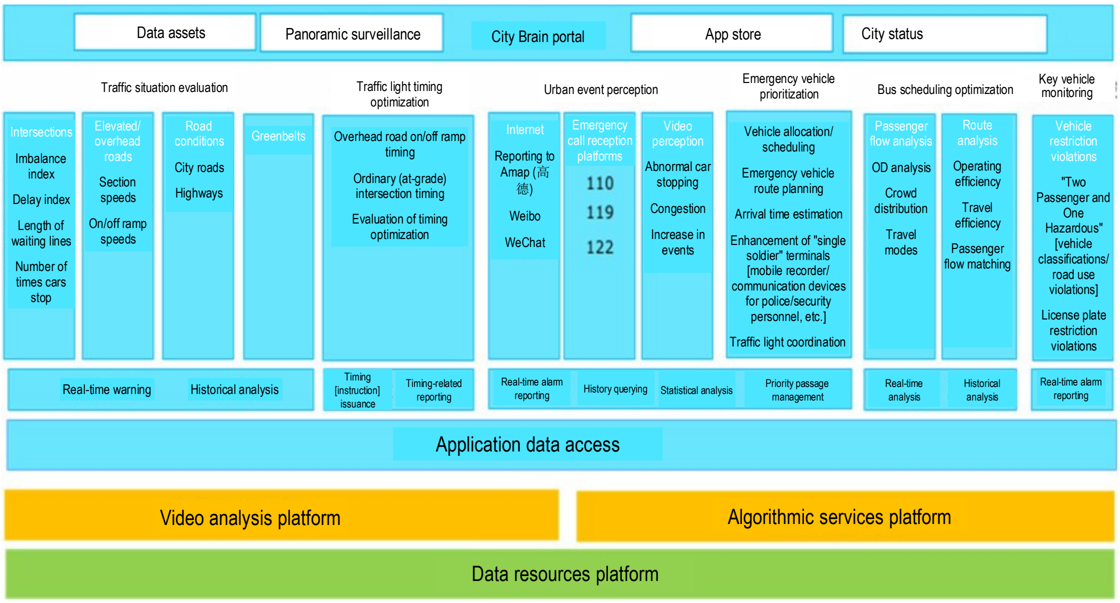


As can be seen from the above diagram of City Brain's overall structure, City Brain is divided into three layers. The bottom layer is the Aliyun Apsara (飞天) computing platform, the middle layer is the Aliyun City Brain data resource platform, and the top layer is the Aliyun City Brain IT service platform. The data resource platform and IT service platform are open platforms that can carry other firm's products.

Integrated computing platform: Provides City Brain sufficient computing power, is extremely flexible, and supports real-time computing for the full amount of urban data. Exabyte (EB)-level storage capacity, petabyte (PB)-level processing capacity, and real-time analytics capacity for millions of video channels.

Data resource platform: Full-network real-time data aggregation allows data to truly become a resource. Safeguarded data security, improved data quality, data value realized through data scheduling.

IT service platform: Open IT service platform, thriving industry ecosystem. Conservation through consumption of data resources instead of natural resources.



The diagram of the City Brain product's subsystems shows the content of each of the intelligent data application's subsystem modules, consisting specifically of the following subsystems: traffic situation evaluation, traffic light control strategy optimization, urban event perception, priority passage for emergency vehicles, bus scheduling optimization, and key vehicle supervision.

(3) Value and results after project implementation

In the transportation field, the world's first "Internet + connected traffic lights" platform was successfully rolled out in Hangzhou and achieved practical results (among pilot intersections, the imbalance index fell 26%, and the congestion index fell 19%); in Hangzhou, automatic inspection of traffic abnormalities was achieved for the first time through analysis of dome camera video, with real-time traffic accident alarms given in seconds and a recognition accuracy rate over 92%. At the same time, areas with intelligent control of connected traffic lights saw travel times cut by 15.3%; in Xiaoshan District, ambulance response times shrank by 50%, turning on green lights for the lives of all those awaiting rescue. City Brain, with its forward-looking city governance practices, has been successfully introduced in medium, large, and extremely large cities, including Suzhou, Quzhou, and Macau. Through data aggregation, real-time data analysis and judgment for entire cities is achieved, for effective allocation and optimization of public resources, constant correction of deficiencies in city operations, and a breakthrough in urban governance service models.

Case 2: Successful application of medical imaging AI

Field of application: medical imaging

Application scenario: image-assisted diagnosis in clinical practice

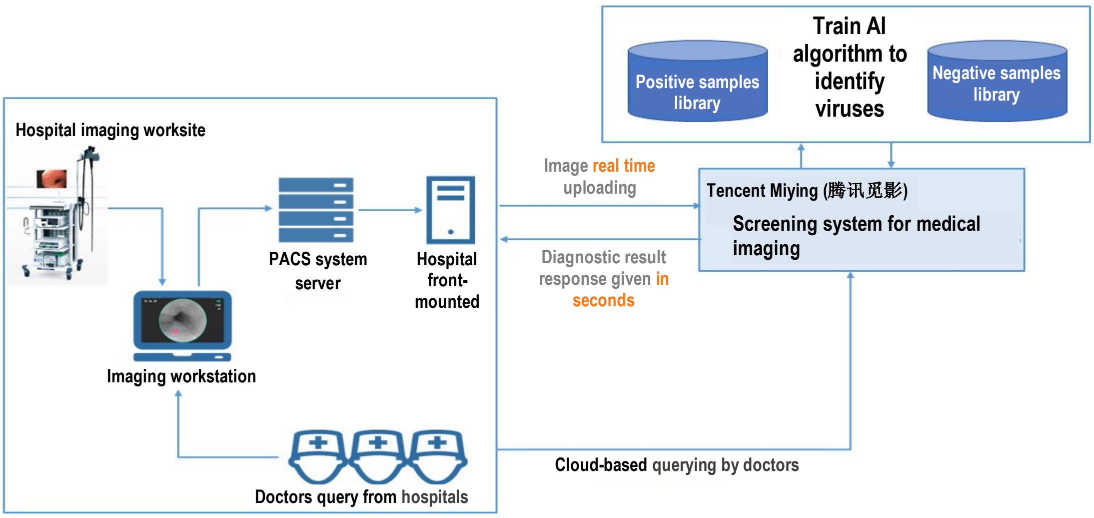
Case provider: Tencent Internet Plus (Shenzhen) Co., Ltd.

（1） Customer need and project outline

With continuous progress in medical imaging technology, medical imaging technologies such as X-rays, ultrasound, computed tomography (CT) scanning, magnetic resonance (MR) imaging, digital pathology imaging, and gastrointestinal endoscopy have advanced by leaps and bounds over the last few decades. In traditional clinical fields, interpretation of medical images has been done primarily by medical imaging experts and clinical physicians, but the ever-growing amount of image data has brought enormous challenges and pressures for the doctors who read them. Following constant breakthroughs in computer technology, computer-assisted medical image analysis has become possible, and it accounts for a growing share of clinical auxiliary diagnosis. Compared to manual image interpretation, computer-aided diagnosis can significantly increase interpretation efficiency, avoid human errors, and lower physician workloads and pressures.

（2） Specific solution brief

Relying on its world-leading image recognition technology Tencent developed an intelligent medical image screening system that has achieved intelligent screening and identification of early-stage esophageal cancer, early-stage lung cancer, early-stage breast cancer, diabetic retinopathy, and other diseases, to aid in clinical diagnosis. Tencent's intelligent medical image screening system consists of subsystems for esophageal cancer early screening, lung cancer early screening, intelligent staged identification of diabetic retinopathy, and breast cancer early screening, and serves needs such as identification of benign/malignant esophageal tumors, lung nodule location detection, benignancy/malignancy identification in lung cancer, diabetic retinopathy identification, diabetic retinopathy stage identification, calcification and mass detection in breast cancer, breast cancer benignancy/malignancy identification, etc.



（3） Value and results after project implementation

Tencent's intelligent medical image screening system has already been widely applied at dozens of 3A-level hospitals in provinces nationwide, and has received high recognition by physicians. For example, in two weeks at Wenzhou Central Hospital in Zhejiang, the online esophageal cancer early screening system discovered 2 early esophageal cancer patients that doctors had not discovered. Those two patients ultimately had early cancer surgery after diagnosis was confirmed. Early discovery and early treatment greatly increases patient survival rates, lowers the cost of treatment, and helps ensure postoperative quality of life.

Region	Hospitals	Applications
Guangdong	Sun Yat-sen University Cancer Center	Esophageal cancer early screening system
Guangdong	Nanshan People's Hospital	Esophageal cancer early screening system Lung cancer early screening system Fundus diabetic retinopathy screening system
Guangdong	Guangdong Second Provincial General Hospital	Lung cancer early screening system Esophageal cancer early screening system
Zhejiang	Zhejiang Provincial People's Hospital	Esophageal cancer early screening system
Zhejiang	Wenzhou Central Hospital	Esophageal cancer early screening system
Guangxi	People's Hospital of Guangxi Zhuang Autonomous Region	Fundus diabetic retinopathy screening system Esophageal cancer early screening system
Jiangsu	The Affiliated Suzhou Science & Technology Town Hospital of Nanjing Medical University	Lung cancer early screening system
Sichuan	Second Hospital of Traditional Chinese Medicine of Sichuan Province	Lung cancer early screening system
Shaanxi	Xi'an No.4 Hospital	Fundus diabetic retinopathy screening system

Compared to independent manual diagnosis by a doctor, carrying out assisted medical image diagnosis using Tencent's AI-based intelligent medical image screening system has significant advantages: owing to uniformity issues, it makes image diagnosis more objective; AI diagnosis can greatly increase manual image reading speeds, lower doctors' workloads, and improve efficiency; compared to manual image reading, AI diagnosis can more quickly and accurately identify lesions, prevent under-diagnosis and misdiagnosis by doctors, and add a layer of security to doctors' diagnoses, so it represents the trend of the future; AI diagnosis can assist in early screening for major diseases, reduce manual screening labor costs and workloads, and greatly increase the prevalence and accuracy of early screening for major diseases in China; by helping grassroots doctors make diagnoses, AI diagnosis allows relatively inexperienced doctors to quickly accumulate diagnostic experience, decreasing learning costs, hence it can greatly ease the situation in China, where patients are many and doctor resources are inadequate.

Case 3: Successful application of speech evaluation in English listening and speaking tests

Field of application: educational testing

Application scenario: English listening and speaking tests for high school and college entrance exams

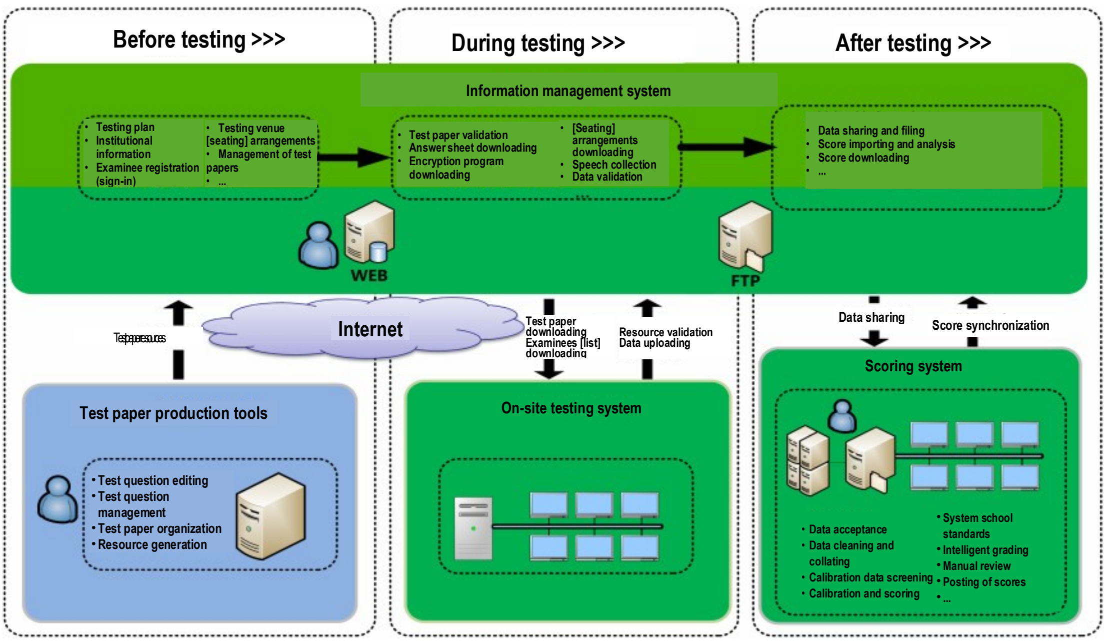
Case provider: iFLYTEK Co., Ltd.

(1) Customer needs and project outline

With international exchanges growing by the day, English communication skills are increasingly important. The nation, society, and schools all attach much importance to the task of teaching English. However, due to a lack of effective evaluation and teaching methods, phenomena such as "mute English" and "pidgin English" are still pervasive. According to *China Youth Daily* statistics, 56% of students spend "most" of their time studying English, but only 10% truly have the ability to communicate. The vast majority of provinces nationwide have implemented English listening and (additional) speaking tests for high school entrance exams, and a growing number of cities and provinces, such as Guangdong and Jiangsu, are incorporating English speaking test results in the absolute scores of high school and college entrance exams. It has been shown in practice that English listening and speaking tests can significantly promote the development of English teaching. English speaking and listening tests for high school and college entrance exams have become a major trend.

(2) Specific solution brief

Drawing on its world-leading intelligent speech evaluation technology, iFLYTEK developed an English speaking and listening intelligent testing system that achieves automation and intelligentization of the entire English speaking/listening testing process. iFLYTEK's English speaking/listening testing system is composed of a test question/exam paper generation subsystem, exam management subsystem, on-site testing subsystem, and exam scoring subsystem, and supports all mainstream question forms, including short text reading aloud, situational response, role-playing, oral expression, and topic rephrasing.



(3) Value and results after project implementation

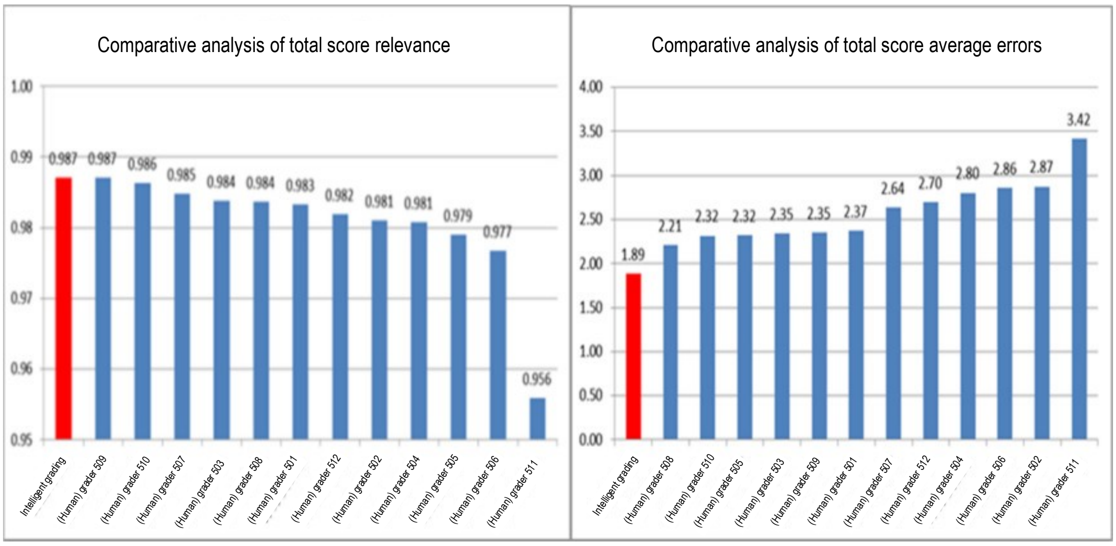
The iFLYTEK English speaking/listening testing system has been widely applied in high school and college entrance exams in 23 provinces, cities, and regions nationwide, including in Beijing high school and college entrance exams, Shanghai college entrance exams, Guangdong college entrance exams, Jiangsu high school entrance exams, and Shenzhen high school entrance exams, with annual testing of 2.3 million person-times, and a cumulative total testing of over 19 million person-times.

Specific application circumstances of the iFLYTEK English speaking/listening testing system are as shown below:

Region	Test type	Role of test scores
Guangdong	College entrance exam	English speaking/listening test has a total score of 15 points, included directly in total score on college entrance exam
	High school entrance exam	Carried out in 9 cities, including Guangzhou, Shenzhen, Dongguan, Jiangmen, and Zhongshan; scores included directly in total score on high school entrance exams
Beijing	High school entrance exam	For Beijing high school entrance exams beginning in 2018, out of a total English score of 100 points, 60 points are for on-paper test scores and 40 points are for listening and speaking tests, separate from unified examination written tests; students given two chances to take the test.
	College entrance exam	Since 2017, the English listing portion of the Beijing college entrance exam has counted 30 points, for which computerized testing is adopted, and it is scored separately from the written test. The test is administered twice per year, and the highest score on the listening test and the written test score are combined to form the English subject score that is added to the total score. Beginning in 2021, a speaking test will be added to the English section, with the speaking and listening tests together counting a total of 50 points, and the English section having a full score of 150 points.
Shanghai	High School Academic Proficiency Test	Serves as a reference score in admissions for foreign language-related majors
	College entrance exam	In January 2017, English listening and speaking tests were launched across the board for Shanghai college entrance exams, with tests administered twice per year. Test scores are added to the total college entrance test score and count a total of 10 points.
Chongqing	Single enrollment in higher vocational colleges	English subject paper-and-pencil exams are no longer administered. Listening/speaking test scores serve directly as scores for admission to higher vocational colleges.
	High school entrance exam	Carried out in districts and counties such as Qijiang, Jiangjin and Qianjiang, with a total of 30 points, added directly to the total high school entrance test score.
Jiangsu	High school entrance exam	Has a total score of 30 points, included directly in total score on high school entrance exam
Zhejiang	High school entrance exam	Wenzhou began testing officially in 2010; total score is 30 points, included directly in total score on high school entrance exam
Anhui	High school entrance exam	Total score of 30 points, included directly in total score on high school entrance exam, currently administered in Hefei
Shandong	High school entrance exam	Speaking has a total score of 30 points, included directly in total score on high school entrance exam, currently administered in Qingdao, Zibo, and Weihai
Qinghai	High school entrance exam	Total score of 30 points, included directly in total score on high school entrance exam, currently administered in Xining
Guizhou	College entrance exam	College entrance (additional) exam, applied province-wide in 2014
Hubei	College entrance exam	College entrance (additional) exam
Fujian	High school entrance exam	Speaking test counts 10 points, used as reference score for high school admissions, currently administered officially in Sanming
Shenyang	High school entrance exam	Total score of 20 points, included directly in total score on high school entrance exam; testing officially began in 2015, with scores added directly to total high school entrance exam scores beginning in 2016

With the rapid development of AI technology, intelligent speech technology based on natural language understanding and machine learning has made great strides, and has now been widely applied in multiple industries.

In a 2012 science and technology assessment by Guangdong Province, computer grading using iFLYTEK's intelligent speech evaluation technology surpassed that of all experts in terms of relevance, with a lower error average than that of all experts, and the overall results were better than manual results.



Note: "Relevance" is an indicator that measures the reasonableness of a grader's ranking of candidates' scores. Ranging between 0-1, the closer to 1 the better; "error average" is an indicator that measures the accuracy of a grader's scores, and the smaller the average error is, the more accurate the scores are.

English listening/speaking testing carried out using AI-based technology has significant advantages over traditional manual testing:

① Intelligent speech evaluation technology can thoroughly address manual test grading's problems of high subjectivity and inconsistent grading criteria, making English speaking tests fairer and more equitable.

② Intelligent speech evaluation technology can greatly speed up large-scale speaking test grading, lower the cost and implementation difficulty associated with grading speaking tests, and promote the development of speaking tests.

③ Intelligent speech evaluation technology can carry out detailed assessment of multiple dimensions, including standard pronunciation assessment, pronunciation problem detection, and applied speaking ability assessment, and can objectively and comprehensively reflect students' speaking ability.

④ Test site application of AI technology to perform online, real-time grading makes adaptive testing possible. Because adaptive testing assesses students' levels more accurately, it is a future trend in testing.

⑤ When intelligent speech quality assessment technology is used on the testing end, it can avoid recording failures during the student speech acquisition stage due to faulty equipment or human factors, greatly improving the success rate of speaking tests.

Case 4: Intelligent supply chain design system

Field of application: manufacturing

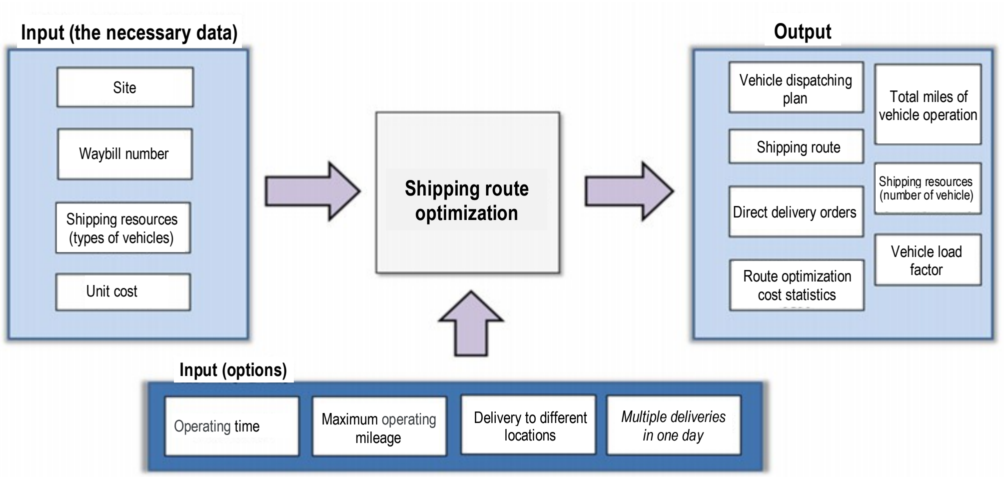
Application scenario: supply chain route optimization

Case provider: Huawei Technologies Co., Ltd.

(1) User needs and project outline

Every time a logistics service provider in Huawei's supply chain adds a delivery/pick-up point for single-vehicle delivery, one more exceptional cost is added, contributing to high multi-point delivery costs, and manual splitting among carriers before delivery, based on the shipping documents, is required. As a result, annual exceptional costs have reached over RMB 12 million.

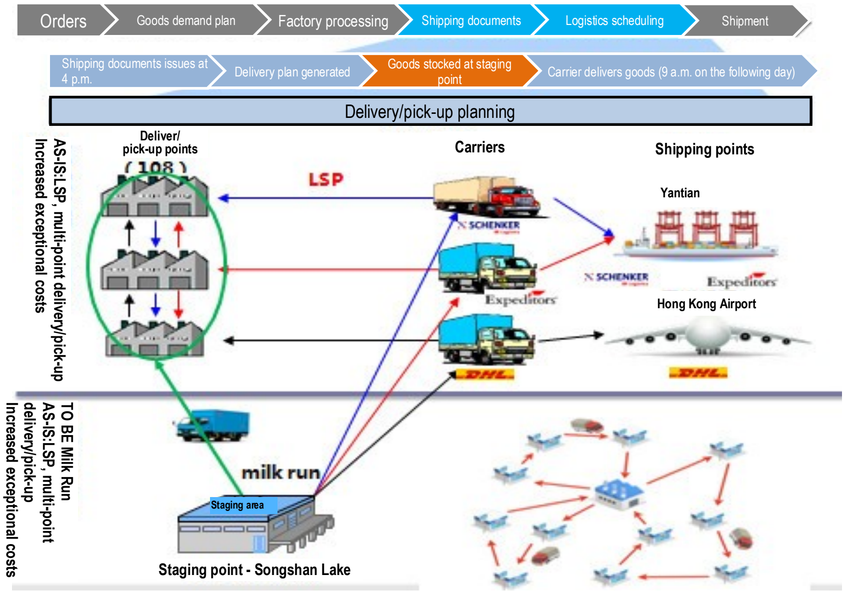
Previous manual methods were inefficient, expensive, and unable to achieve real-time, rapid designing of the most suitable supply chain logistics solutions, but after an intelligent supply chain design system was adopted, it enabled a large-scale reduction in labor inputs, and rapid optimization of supply chain routes.



(2) Specific solution brief

The intelligent system automatically identifies whether to choose the direct delivery logistics mode or choose the milk run[3] mode, and automatically optimizes and recommends the number of vehicles to give the customer. The daily output dispatching plan solves a combined paths optimization problem subject to mapping relationships involving multiple orders and multiple factories, with the objective being to minimize monthly transportation costs. A logistics dispatching and route plan is produced within 10 minutes.

[3] Translator's note: A "milk run" (中转仓) is a delivery mode for mixed loads from different suppliers. Rather than each supplier sending its own vehicle to the same customer, one vehicle visits each supplier on a daily basis and picks up deliveries for that customer. The method gets its name from the dairy industry practice of sending one tanker to collect milk each day from several dairy farmers for delivery to a milk processing firm.



The route optimization solutions from Huawei's AI system focus on reducing logistics transportation costs, and include three modules:

Automatic transportation solution identification	Suppose there are M orders, form orders of which the milk run method is adopted, and for the remainder the original direct delivery transportation method is adopted. By means of 0-1 dynamic programming technology, using automatic identification, the m number of orders going via milk run is determined.
Intelligent route optimization technology	By means of a k-nearest neighbor (KNN) clustering model, clustering of factories corresponding to *m* orders is carried out to find the nodes with the smallest adjacent distances. Then, based on the clustering results, the Dijkstra algorithm is adopted to calculate the shortest path visiting all nodes and calculate the dispatching plan, together with the transportation route.
Cost optimization statistics	Based on the daily optimum dispatching plans, monthly statistics are generated on the total transportation cost savings, total vehicle operation mileage, number of vehicles required for transportation, vehicle loading rates, etc.

An intelligent distributed optimization algorithm library is constructed, which includes a business model layer, mathematical model layer/various programming problems, and a basic optimization algorithm layer; by means of 0-1 dynamic planning technology, the number of transportation vehicles going via milk run is automatically identified and determined; and by means of the clustering k-nearest neighbor (KNN) model, clustering of factories corresponding to the orders is carried out to find the nodes with the smallest adjacent distances. Then, based on the clustering results, the dispatching plan is further calculated, together with the transportation routes.

(3) Value and results after project implementation

Using delivery point planning reduces exceptional costs and increases delivery efficiency. Taking days as the units, rental vehicles are rationally allocated and delivery routes are optimized, and the milk run approach is used to maximize vehicle load factors while reducing the number of trips and delivery-related exceptional expenses. According to historical data on optimization carried out during January-June 2016, monthly shipping costs fell by over 30%. Based on the platform's capabilities, the optimization algorithm is highly efficient, requiring only about 10 seconds to generate the daily dispatching plan.

Case 5: Baidu machine translation

Field of application: machine translation

Application scenario: conversion between different languages

Case provider: Baidu Netcom Science and Technology Co., Ltd.

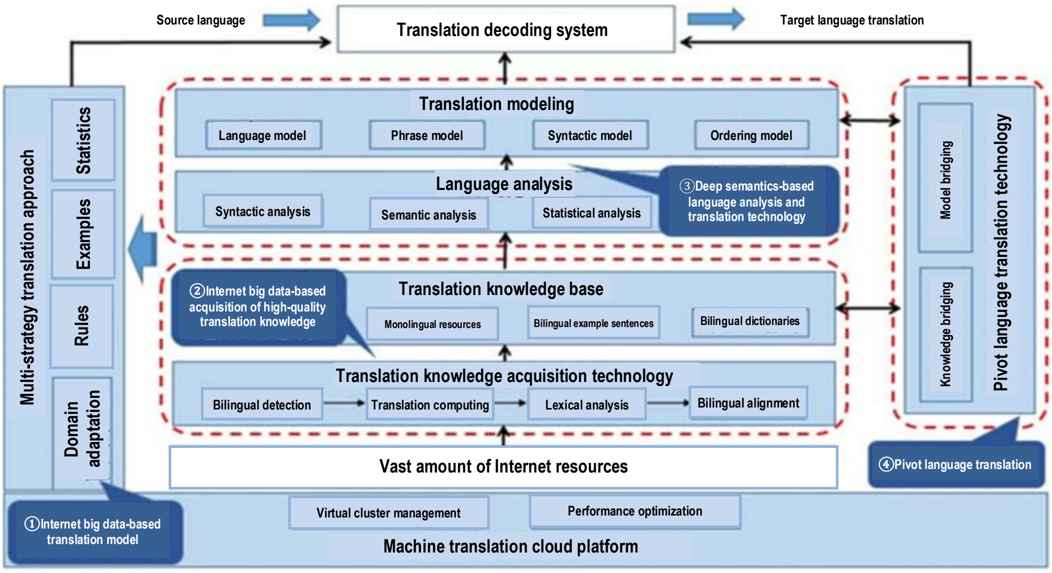
（1） Customer needs and project outline

Machine translation is the use of computers to automatically translate one language into another language. As early as 1946, at the dawn of the first modern computers, U.S. scientist Warren Weaver proposed the idea of machine translation. Machine translation involves disciplines such as computers, cognitive science, linguistics, and information theory. It is one of the ultimate goals of artificial intelligence, and machine translation research has important academic significance.

Against a backdrop of the Internet and globalization, and with cyber games (网络博弈) among great powers (大国) heating up, network information security faces unprecedented challenges. An important foundational safeguard for China's information security is the research and development of machine translation systems, with fully independent intellectual property rights, for real-time and accurate access to political, economic, cultural, military, and other information in multiple languages. This will have important significance in terms of safeguarding national security, developing the national economy, and implementing the strategy of internationalization.

（2） Specific solution brief

The internet and big data bring new opportunities and challenges for machine translation, making possible the automatic acquisition and real-time updating of translation knowledge, for which traditional translation models and methods are in urgent need of innovation. This project has made major breakthroughs in the acquisition of vast amounts of translation knowledge, as well as in translation models and multilingual translation technology, having solved the problems of traditional methods in terms of high R&D costs, long R&D cycles, and low quality. With accurate and real-time response to the Internet's massive amounts of complex translation requests, it has enabled China to master the core technology of Internet machine translation and seize the technological high ground in the field. The core technologies of big data-based Internet machine translation are as follows:



① An Internet big data-based translation model was proposed. Guided by this model, adaptive training and multi-strategy decoding algorithms were proposed, which broke through the bottlenecks in translating multiple types of writing in multiple domains; full optimization and integration of translation cloud platforms and algorithms was achieved, with real-time response to over 100 million complex and varied translation requests coming from all over the world each day.

② High-quality translation knowledge acquisition technology, based on Internet big data, was developed. This broke through the bottlenecks of traditional translation with respect to small-scale knowledge acquisition and high cost. International standards in the field of language content processing were formulated. The scale of high-quality translation knowledge accumulated by the project is 100 times the scale of that published by the authoritative international institution NIST.

③ Deep semantics-based language analysis and translation technology was proposed. This overcame one of the world's widely recognized problems in machine translation, that of disambiguation and ordering. The world's first statistical translation model based on tree-to-string syntax was proposed, making effective use of source language syntax information to solve the problems of phrase generalization and long-distance translation ordering.

④ A pivot language-based translation knowledge-bridging and model-bridging technology was proposed. The bottleneck in machine translation of limited language coverage was overcome, making possible translation of small languages with scarce resources, and rapid deployment of multilingual translation was achieved, with the ability to deploy 1 new language in 11 days. The system currently supports 28 languages and 756 translation directions.

(3) Value and results after project implementation

The above technology is applied in numerous important national agencies and in over 7,000 enterprises (including Baidu, Huawei, and Kingsoft [金山]) and third-party applications. In addition, Baidu's machine translation project won the 2015 National Science and Technology Progress Award—Second Prize. Typical applications of Baidu's machine translation include the following:

① Based on the above research accomplishments, a "multilingual information collection, processing and analysis system" was achieved. The system supports automatic collection, translation, and analysis of text in 10 languages, including foreign languages (English, Japanese, German, French, Korean, Arabic, and Turkish) and languages of China's minority nationalities (Tibetan, Uyghur, and Mongolian). The system's results are applied in important national agencies and departments, such as the 55th Research Institute of the Chinese People's Liberation Army (PLA) General Staff Department, effectively supporting development of such organizations' core businesses, and playing an important role in promoting the development of multilingual intelligence (情报) translation and analysis undertakings.

② The research accomplishments are applied in Baidu Translate, which supports 28 languages such as Chinese, English, Japanese, Korean, and Thai, and 756 translation directions, creating market competitive advantage in the form of support for high-quality multilingual translation, covering over 500 million users worldwide, and responding to more than 100 million translation requests each day. According to a third-party evaluation, out of the 32 translation directions Baidu Translate had online at the time, it was superior to Google in 28 translation directions. In a technical assessment of S&T achievements by the Chinese Institute of Electronics, the unanimous opinion of the institute's experts was that it had "achieved world-leading levels in three indicators—translation quality, translation language directions, and response time."

③ The translation technology is applied in Baidu Search, helping users more easily obtain multilingual information and find what they are after. In July 2014, General Secretary Xi Jinping and Baidu CEO Li Yanhong jointly launched a Portuguese search engine, providing users cross-language search service. The technology is also applied in Baidu's Arabic and Thai search engines. Over the last three years, it has achieved RMB 1.094 billion in direct economic benefits.

④ Baidu Translate's open platform provides free services to over 7,000 third-party applications, which has promoted the national economy and assisted in the internationalization of Chinese enterprises; and by providing large numbers of small and medium-sized enterprises translation platform services, it has lowered barriers to entrepreneurship and innovation, driving the prosperity and development of related industries. Huawei has integrated translation service into its Ascend Mate smartphone's camera translation app, boosting the phone's market competitiveness. Phones with the translation function have been sold in 30 countries and regions, including France, Germany, Russia, Spain, and the United Kingdom. Kingsoft PowerWord (“金山次吧”) uses the above technology to achieve the leap from word searches to automatic sentence translation. This has boosted the value of its products, having been installed on some 46.6 million devices with a total output value of RMB 45.61 million. Cross-border B2B e-commerce platform DHgate.com (敦煌网) uses Baidu Translate to carry out cross-border trade. Serving over a million domestic suppliers, it helps them sell merchandise to 224 countries and regions around the world, which has promoted the development of China's foreign trade.

Case 6: Xiao-i's (小i) intelligent service robot system

Field of application: intelligent human-computer interaction

Application scenarios: automated customer service, call centers, and intelligent human-computer interaction

Case provider: Shanghai Xiao-i Robot Technology Co., Ltd. (Xiao-i)

（1）**Customer needs and project outline**

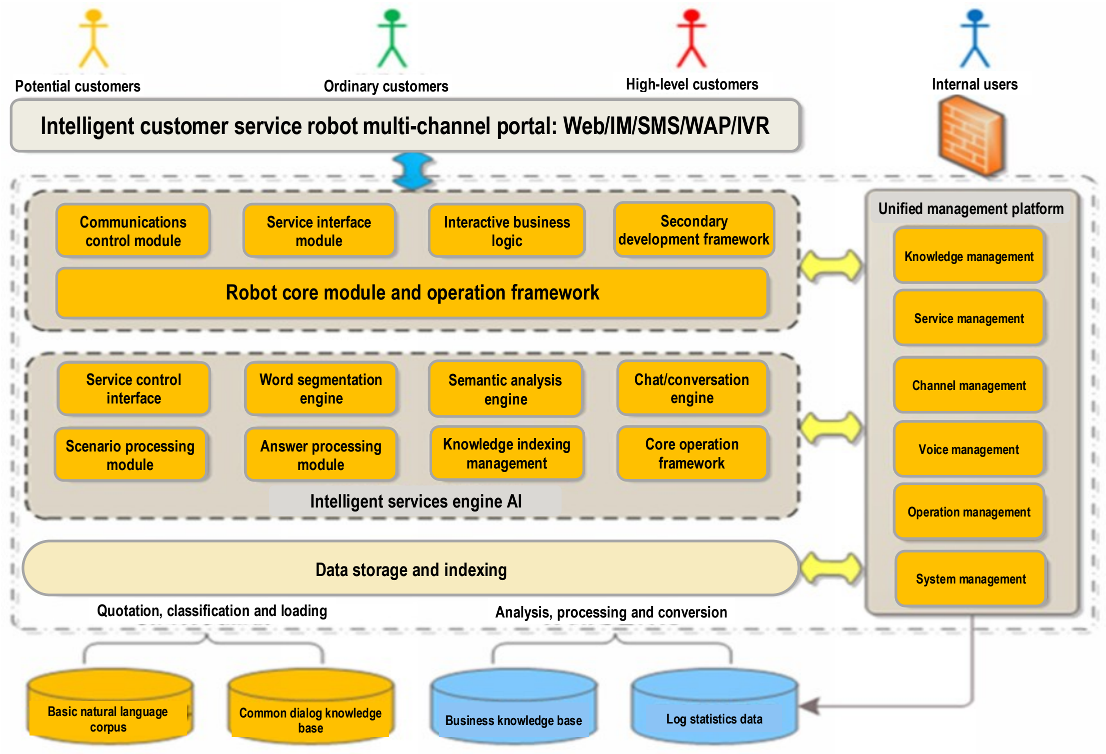
Customer service robots are an entirely new kind of intelligent tool, able to answer users' questions online in real time 24 hours a day. Therefore, when manual customer service is supplemented by customer service robots, the ability to serve the public is significantly greater than with traditional customer service that is purely manual.

Intelligent customer service robots can combine images, text, and even audio and video to give users the most complete answers through a carrier such as the Internet, IM, or WAP/SMS, allowing users to resolve issues through interaction. In the United States and in European countries where customer service centers are already highly developed, a considerable portion of companies have implemented service systems with intelligent customer service robots, using AI technology to provide convenient, accurate, and high-quality services to corporate and government customers. They cooperate effectively with customer service centers and increase customer satisfaction levels.

To apply AI technology in the field of Internet real-time communications and wireless communications, after carrying out deep research for enterprises with large-scale intelligence needs, such those in the telecommunications, financial, electricity, and government call center markets, various intelligent customer service robots and solutions for businesses and governments were launched, based on a robot intelligent engine system, which could provide enterprises and customers high-quality and efficient services on a low-cost basis.

（2） **Specific solution brief**

A basic architectural diagram of the intelligent service robot is shown below.



The basic architectural diagram mainly includes the following modules:

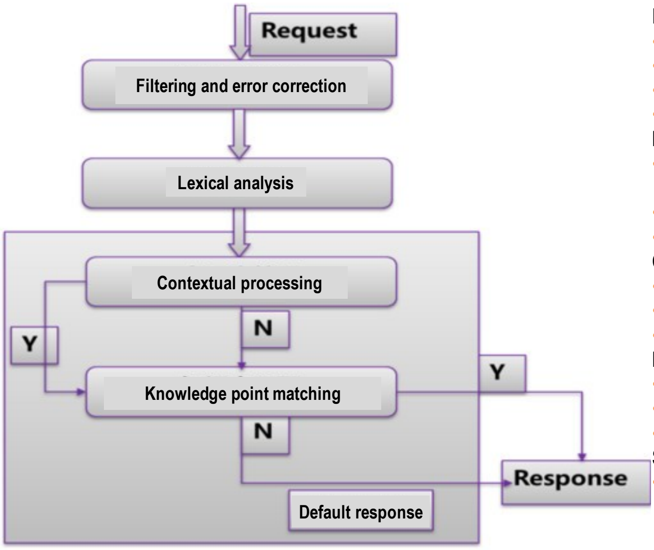
Robot core modules and operational framework:

Components include a communication control module, business interface module, business logic switching and secondary development framework, etc. The platform primarily achieves a communication interface service between third-party service systems (such as manual customer service systems) and omnichannel terminals and back-end intelligent service engines, and it can also provide secondary development interfaces for the different business logics of various channels. Includes all front-end user interaction and representation functions for users using the intelligent robot system, as well as responsibility for the login verification, response scheduling, and load balancing of robots.

Intelligent service engine AI

The intelligent service engine is a basic platform for processing natural language and integrating various kinds of specialized processing engines. It includes engine core modules, an intelligent word segmentation engine, a semantic analysis engine, and a chat/conversation engine, as well as a scenario context processing module and knowledge indexing and management module. The intelligent service engine is like the robot's brain. It is the key to whether the robot behaves intelligently, and its different aspects— intelligence, accuracy, concurrency performance, etc.—all have a key impact on the entire system.

The intelligent service engine's main functions include: text processing, syntactic analysis, semantic analysis, dialog management, sentence matching, and answer rendering. While adjustments can be made to the intelligent service engine's processing routines and module parameters for different business models and application scenarios, the engine's general processing procedure is as follows:



Filtering and error correction
- Non-lexical filtering
- Prefix and suffix filtering
- Stop word filtering
- English and spelling error correction

Lexical analysis
- Domain word segmentation and lexical annotation
- Named-entity recognition
- Attribute weighting

Context
- Context replacement
- Contextual rhetorical question
- Automatic reasoning

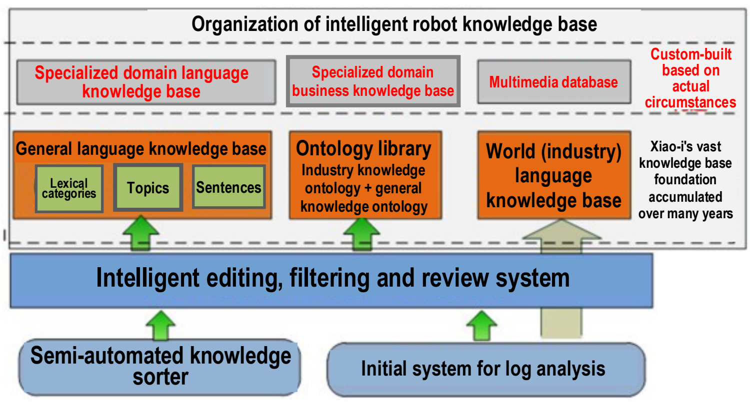
Knowledge point matching algorithm
- Semantic template matching
- Calculation of vector space similarity
- Ranking of sentence similarity calculations

Service navigation
- Conversion of natural language into command format Connection to data querying interface

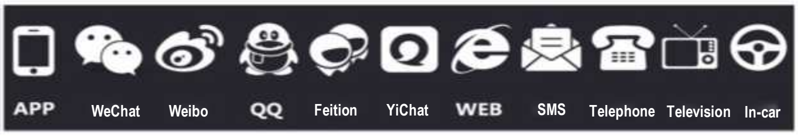
Unified management platform

Unified management and maintenance of the robot is carried out by means of the intelligent service engine and API provided by the robot's front-end platform. This includes knowledge management, service management, channel management, voice management, operations management (logs and reports), and system management.

From an engineering perspective, the knowledge structure supporting intelligent customer service applications can be divided into a business knowledge base and a language knowledge base. The language knowledge base is used to understand input questions organized with customized language, and the business knowledge base is used to locate answer content for questions after they are understood. The language knowledge base includes common words, common sentence patterns and phrases, domain-specific words, and semantic rule templates (sets), as well as grammatical stop words, sensitive vocabulary (敏感词汇), and other helpful content. The business knowledge base includes business knowledge documents, such as product descriptions, business introductions, rules of promotional activities, and FAQs. The business and language knowledge bases make correlations using the base class properties of the knowledge ontologies. If either of these two knowledge base parts is missing or poorly constructed, it will adversely affect the intelligent experience and problem resolution rate of the front-end robot. The knowledge organization structure is as shown in the figure below:



The intelligent customer service robot can carry out presentation and interaction through multiple types of channels, including WeChat, QQ, webpages, smartphone (iPhone, Android) apps, telephone, etc., and it can also provide semantic understanding capability to more human-computer interaction channels by means of standard interfaces (API). The dimensions of the semantic library can correspond to the access codes of different channels, and can simultaneously support specific requests for reply content from different channels.



（3） Value and results after project implementation

Official data from China Construction Bank in 2015 showed that the capacity of the "Xiaowei" (“小微”) chatbot service supported by Xiao-i was already equivalent to 9,000 manual agents, far exceeding the total service volume of its 95533 and 400 number manual agents. At China Merchants Bank, millions of daily interactions originally required the services of approximately 2,000-3,000 people. Following the introduction of Xiao-i's intelligent customer robot system, however, only around 10 staff are needed, and most of their work is devoted to increasing customer stickiness and to creative tasks.

Case 7: Identity recognition system for key groups

Field of application: public security

Application scenarios: transportation hubs, malls, hospitals, and other public places

Case provider: Chongqing Kaize Technology Co., Ltd.

（1）Customer needs and project outline

Following over 20 years of construction, China's public security system has begun to take shape, and is better able to maintain China's social stability, but due to constraints imposed by certain objective factors, construction of the public security prevention and control system has yet to fully meet the needs of social development. It is well known that population management is the foundation of China's social management. The uniqueness, accuracy, and authoritativeness of citizen identification have security relevance at all levels of the state. Taking advantage of these administrative vulnerabilities, some lawless elements fabricate false identity information to engage in illegal activities, or evade legal sanctions by means of fake information, seriously disturbing law and order and endangering public security. In order to protect social stability and national security, technical means based on advanced high technology are urgently needed to quickly and accurately verify and identify the information of those concerned. At the same time, when public security personnel screen for wanted criminals manually, it is like searching for a needle in a haystack. The success rate is extremely low, and its effectiveness is not apparent. The main practical problems are the following: First, because the group of offenders grows constantly, finding criminal suspects from a library of people's photos measured in the millions is not only costly and time-consuming, it may also result in omissions and other circumstances, greatly reducing efficiency in solving cases. Second, for the vast majority of investigative cases, the security organs still rely on ex post facto tracking and manhunts, and it is difficult to make up for the losses caused by cases that have already occurred. Finally, if precautions could be taken as a crime occurs, the losses could be controlled right away and kept to a minimum.

Adopting a highly efficient facial surveillance and matching system would, first, help public security investigators quickly identify and distinguish the true identities of specific individuals, turning previously unimaginable matching requirements involving libraries of millions of photos into a reality, thereby effectively providing meaningful help and solutions in practice for public security video investigation, public security management, criminal investigation cases, and other work. Second, it could help public security investigators handling cases track and search for wanted suspects, truly changing crime fighting into prevention, and could greatly reduce the waste of police resources and the probability of accidents occurring.

（2） Specific solution brief

In accordance with the "unified planning, unified standards, unified platforms, and unified management" approach to construction, build a software and hardware operation platform in an information center; integrate and use existing data resources, adopt industry-leading and mature portrait matching and recognition technology, and establish a feature database; in the information center, construct a public security portrait recognition application platform for the entire police force, and, using hierarchical authorization and interface provision, make it available for use department-wide by all kinds of police.

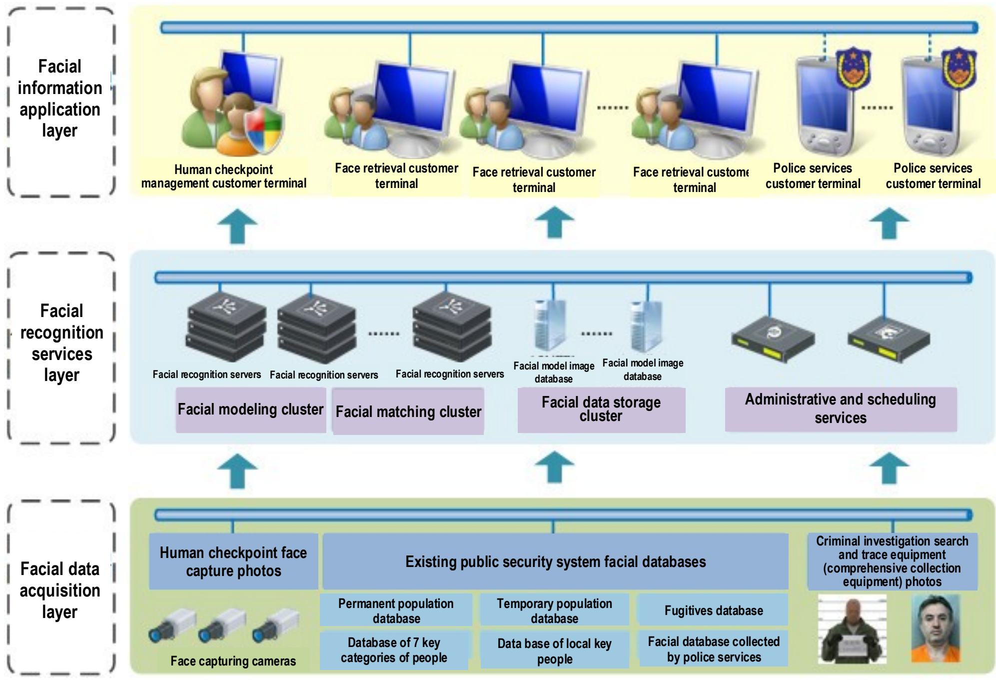
① Design a set of high-definition face acquisition systems, achieve high-quality automatic face capturing, automatic recognition, automatic matching, automatic alarm reporting, track playback, and other functions, accomplish "retention of images, features and tracks as people pass by," and achieve change and innovation in the "from image to person" and "from person to case" business model.

② Reasonably set up high-definition people monitoring points along the access routes of major locations in the city, forming surveillance of people with coverage of all regions and achieving tight surveillance coverage, and fully record people as they enter, exit or travel within the city.

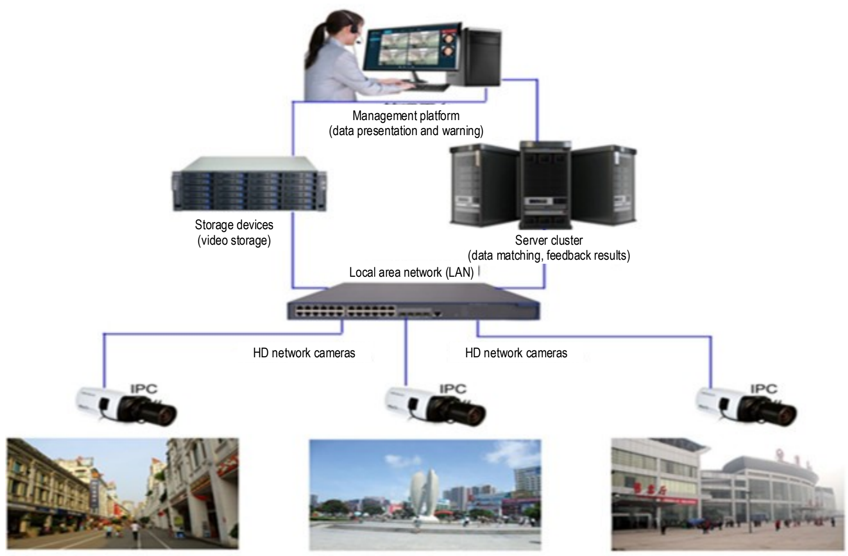
③ Relying on a dedicated public security image transmission network, and using a mature service-oriented architecture (SOA) system framework, construct a facial information integrated application platform, and achieve real-time transmission, unified storage, deep analysis, and deep application of city-wide facial monitoring point data.

④ Establish linkages between the facial information integrated application platform and public security databases, and provide face control and dynamic matching and warning, human tracking-related querying, human identity querying and other practical functions, offering effective support for public security-related prevention and control, criminal investigation, counterterrorism, and other work.

The system consists primarily of a facial data acquisition layer, a facial recognition service layer, and a facial information applications layer. The system has six main types of equipment: front-end video cameras, face detection servers, facial recognition servers, storage devices, a face database, and the facial recognition system platform.



Hardware structure:



（3） Value and results after project implementation

At present, the face capturing and matching system is mainly applied in the following areas:

Public security blacklist matching and real-time alarm reporting:

Set up monitoring points for entrances, exits, thoroughfares, and other key monitoring locations of some densely populated areas; on the back end, have strike, protect, and control (打防控) public security personnel carry out blacklist surveillance controls for key persons of concern; and achieve face matching and recognition by means of matching real-time video streams against the surveillance blacklist.

Identity confirmation for unidentified persons:

So that security personnel can avoid physical contact and conflicts during routine patrolling and identity verification, identity confirmation applications are achieved using the front-end cameras or cell phones to take pictures and the back-end database to carry out human information matching and analysis.

Law enforcement or investigative personnel carry out no-contact identity confirmation of individuals within the floating population without legally valid IDs, fixed addresses, legitimate professions, or legitimate sources of income.

Identity checking of priority individuals at key locations:

Targeting certain key control areas, such as those in large-scale safeguarding operations, or government and public security entrances, set up front-end cameras and carry out face capturing, and arrange daily screening checks of priority individuals by public security personnel.

Case application result 1:

① Chongqing Beicheng Tian Street Business Center area.

② Due to the high density and mobility of people in the Business Center area, all kinds of personal or public property were potentially exposed to theft risks. As a result, the public security authorities did on-site face capturing, matching, and identification of all people at events.

③ Local fugitives, drug addicts, and people with theft records were added to the surveillance database, and the dynamic face matching and early warning functions were enabled.

④ Real-time face matching, alarm reporting, and manual confirmation led to the successful on-site capture and interception of many drug addicts and people with theft records on the blacklist, effectively improving the area's security level.

Case application result 2:

① A theft occurred at 7:20 a.m. on December 5, 2014, at the XX convenience store (location A).

② A burglary occurred at 4:19 p.m. on December 15 at the XX community (location B).

③ By analyzing the two cases, the preliminary finding was that they belonged to a serial case, with the same gang committing the crimes.

④ By retrieving the face capture pictures from locations A and B, an area impact analysis was conducted, and the system automatically displayed the people who appeared at both crime scenes in order of similarity.

⑤ Supplemented by manual screening, it was discovered that two individuals, surnamed Zhang and Li, both appeared near the crime scenes, and thus the gang was conclusively identified.

Case application result 3:

The XX police station received a report of a missing mental patient. Based on identifying information provided by family members and clear digital photos, and using Kaize's key group identity recognition system, a spatial-temporal trajectory was reproduced.

Case 8: Cloud service platform for intelligent network video

Field of application: Internet media industry

Application scenarios: video recognition, video recommendation, social communication, video marketing

Case provider: Beijing iQIYI Technology Co., Ltd.

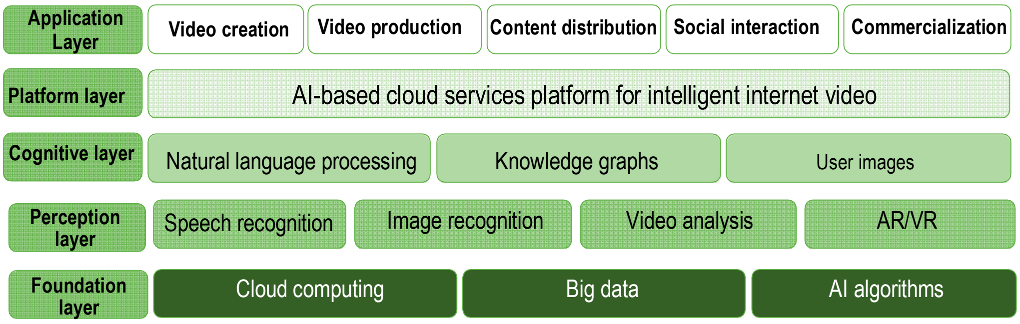
(1) Customer needs and project outline

The Internet video industry has seen rapid development in recent years, becoming the Internet service with the largest user base. According to the 40th China Statistical Report on Internet Development, released by the China Internet Network Information Center (CNNIC), the number of video users in China has reached 565 million, representing 75% of total netizens. With the number of users growing year by year, video content has grown exponentially. As China's biggest internet video sharing platform, iQIYI handles thousands of hours of newly added videos every day, generating hundreds of billions of user logs. The vast amounts of information content are generating more value, but they also pose new challenges for the internet video industry. Firstly, faced with such vast amounts of content, video platforms urgently need to optimize production and review (content moderation) processes, and increase content production efficiency, so as to provide users more convenient and smoother content services. Secondly, with users facing information overload and high "choice cost," platforms need to pick out and recommend quality content that is of most interest to users. Also, since unfocused advertising placement brings with it high marketing costs for enterprises, there is an urgent need for precise advertising placement and refined business operations.

For this project, iQIYI drew on its extensive experience in the Internet video industry. Its intelligent network video cloud service system, with relatively complete online functions, is able to perform intelligent video identification and processing automatically. By means of intelligent algorithms, moreover, it carries out big data analysis of user behavior, generates user profiles, and offers precise, personalized search recommendations. Finally, the system supports precision marketing and ad placement by business partners, and with its "Video in" and "Video out" technologies, it has innovatively opened up its e-commerce and video systems, achieving "buy what you see in the video" precision placement.

(2) Specific solution brief

The framework of iQIYI's cloud services platform for intelligent network video includes a foundation layer, perception layer, cognition layer, platform layer, and applications layer. The foundation layer provides the computing power, data, and basic algorithms needed for AI services, greatly decreasing the requirements of local hardware equipment and software systems, along with O&M costs and risks. The perception layer simulates human hearing and vision to achieve speech recognition, image recognition, video analysis, VR/AR registration and rendering, and other functions. The cognition layer simulates the brain's semantic understanding function to achieve natural language processing, memory-based inference from knowledge graphs, user profile analysis, and other functions, together constituting the iQIYI brain. By means of an open service interface, the platform layer empowers applications in the layer above it, such as video creation, video production, content distribution, social interaction, and commercialization. Most important of all is the applications system, which is for intelligent video production systems, intelligent content distribution systems, and intelligent commercialization systems. A structural diagram of iQIYI's cloud services platform for intelligent internet video is as shown below.



Intelligent video production system

The intelligent video production system relies on intelligent audio and video recognition technology to achieve content-based video topic segmentation, video standardization, and video content moderation. iQIYI's independently developed convolutional neural network (CNN) deep learning technology carries out high-precision celebrity recognition, emotion recognition, object recognition, scenario recognition, bi-directional long short-term memory (BLSTM)-based video subtitle recognition, and speech recognition, and obtains semantic annotations and cover images for video programming.

The vast and constantly growing amount of video content has increased the need for fast and accurate content moderation. Key technologies were developed for the intelligent content moderation system, including fast copyright detection based on audio and video fingerprints, and pornography detection based on blacklist/whitelist and CNN. The system automatically detects Chinese characters, human bodies, "wardrobe malfunctions" (露点), gunshots, fireworks, crowds of people, etc. By means of this function, and using deep learning to strengthen training and recognition of illegal advertising, pornographic or violent images, etc., greatly improves the efficiency of manual content moderation, so that a healthy and good video environment is maintained.

Intelligent distribution system

In the age of intelligent media, users have become both consumers and creators of content. While the enormous amount of content satisfies user demand, it also makes it harder to find required content. It was under these circumstances that the intelligent distribution system came into being. With big data analysis and AI technology as its foundation, the intelligent distribution system makes personalized recommendations by studying video content and users' interests and preferences. Through social networking outreach and hot topic discovery, users are provided quality, personalized content, thereby solving the information overload problem, and better serving the needs of users.

The different modules in iQIYI's intelligent recommender system are as follows:

① User profiles: This is the cornerstone of personalization, and it includes analysis of multiple dimensions, such as users' group attributes, historical behavior, content interests, and preference orientations;

② Feature engineering: This is the foundation of video content and quality analysis, and it includes a full range of depictions and metrics for videos, such as category attributes, content analysis, crowd preferences, and statistical characteristics;

③ Recall algorithm: This can select a diversity of preferred content from the video library, and includes a recall model with multiple channels, such as collaborative filtering, topic model, content recall, and SNS channels;

④ Ranking model: This scores and ranks the content of the recall channels and selects an optimal small number of results. In addition, the recommender system also takes into consideration how varied, fresh, deep, and surprising the recommendation results are. This degree of multidimensionality is better able to satisfy users' demand for diversity.

Also, iQIYI has also pioneered video social networking. The Bubble Community (泡泡社区) developed by iQIYI gathers together "circles" of users with similar interests to share, interact, and disseminate content. There are many types of circles (movie star circles, video circles, interest circles, game circles, manga circles, book circles, etc.), and different types of circles are enjoyed in different ways. For example, in movie star circles, you can join in quests for points, track stars' travels, etc.; and in video circles, you can watch videos directly. Relevant content (feeds) sponsored or edited and administered by the user are aggregated under each circle, along with peripheral information on related circles. By means of data on users' viewing, sharing, and reviews, it is possible to intelligently analyze public opinion and uncover trending topics. One can then further disseminate relevant content of interest to users in different user groups.

Intelligent commercialization system

The intelligent commercialization system uses AI technology, including those for "video in" advertising, "video out" advertising, and intelligent box office forecasting, to fully mine value from video content. Through big data analysis, with monitoring and statistical analysis of users' browsing, clicks, purchases, and other behaviors, user group targeting and merchandise popularity prediction can be carried out, thereby guiding business users better to produce the popular merchandise demanded by users in the market, to promptly adjust advertising placement strategies, and to promote e-commerce transactions.

"Video in" is a pioneering video implanting marketing approach. Content is implanted based on the movie/video scenario, visual effects of implanted items, such as placement position, angle, and lighting, are assured, and consistency with the original scenario is maintained. "Video out" is iQIYI's video content-based system for recommending relevant advertising. This system employs video parsing techniques to detect scenes and key frames in videos, then uses advanced CNN deep learning technology to detect and identify object scenes in the videos, and adds time-stamped object or scene labels to the videos. Finally, by means of keyword mapping derivation and statistical filtering based on knowledge graphs, stable and reliable advertising object labels are generated. In this way, when Internet users watch a movie or TV show, the advertising push engine can automatically display, in the corner of the video screen, ads related to the video content at the time, and do so dynamically, attracting the attention and purchases of users. For example, iQIYI's content relevance-based "Video out" advertising can identify scenes in a TV show and push the same model of woman's handbag, or use OCR subtitle recognition technology to push mobile game merchandise related to lines in the TV show.

The intelligent box office forecasting system uses deep learning technology to forecast movie box office figures and television show ratings based on episode information, actors, search indicators, social media attention, and other data, helping investors make precise judgments in copyright procurement and content creation.

（3） Value and results after project implementation

The intelligent video production system has greatly increased the efficiency of video production. The number of videos grew 20-fold from 2014 to 2017, but the number of employees only doubled. The production efficiency of iQIYI highlight clips was increased by 2.5 times using AI technology. Full automation of cover image generation has been achieved, and each day cover images are produced automatically for hundreds of thousands of user-generated content (UGC) videos. The emotion recognition technology applied convolutional 3D (C3D) and CNN models for the first time to accurately capture chronological changes in emotions, helping to discover the highlights in videos.

The intelligent distribution system creates accurate user profiles, uses AI technology to enable personalized search recommendations, and performs efficient content distribution. iQIYI's full-web search is the industry's leading full-web video search engine, covering up to 500 million videos across the internet. Peak search volume has now surpassed 300 million, and total daily directed traffic has surpassed 400 million. Overall directed traffic from intelligent recommendation has surpassed 600 million, accounting for 30% of total traffic, and its results reached number one in the industry in terms of "guessing what you like" for long videos and linked playing of short videos. iQIYI's Bubble Community is China's largest video social platform, with peak daily active users (DAU) currently nearing 70 million.

The intelligent commercialization system has opened up different dimensions—content production, human-computer interaction, e-commerce services—and increased the advertising and commercial value of iQIYI's Internet video platform. In iQIYI's machine learning-based multiple-time-window forecasting, the variance accuracy for movie box office 6 months out is 77%, and that for TV show traffic 6-12 months out is 88% . This provides strong support to investment purchasing, advertising, and marketing. "Video in" and "video out" advertising is disseminated in great amounts on shows like "Tiger Mom," "The Mystic Nine" and "The Rap of China," without adversely affecting viewing by users. This precisely placed video content-related advertising achieves shared growth of the cultural industry and e-commerce, and promotes the deep fusion of culture and S&T.

In summary, this case has gradually explored new models based on AI + media industry, and has had positive demonstration effects on the development of the entire internet video industry. The intelligent recognition-based internet video and cloud services platform has provided a powerful service platform for content producers, users, and business partners, leading the internet video industry's entry into a new era of healthy and sustainable development.

Case 9: China Mobile ID document matching-based real-name authentication

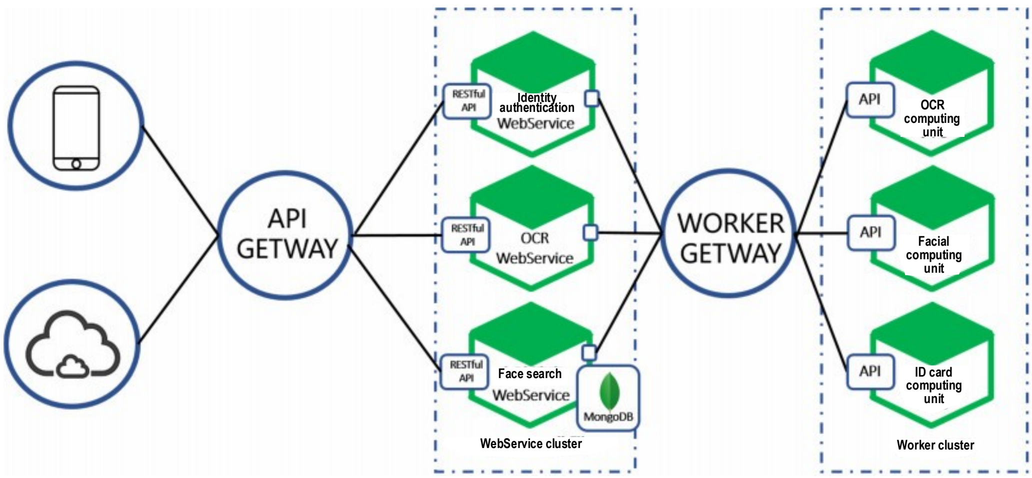
Field of application: real-name user identification, automatic ID document matching-based authentication

Application scenarios: large-scale facial recognition, ID document matching, OCR recognition

Case provider: Beijing Sensetime Technology Development Co., Ltd.

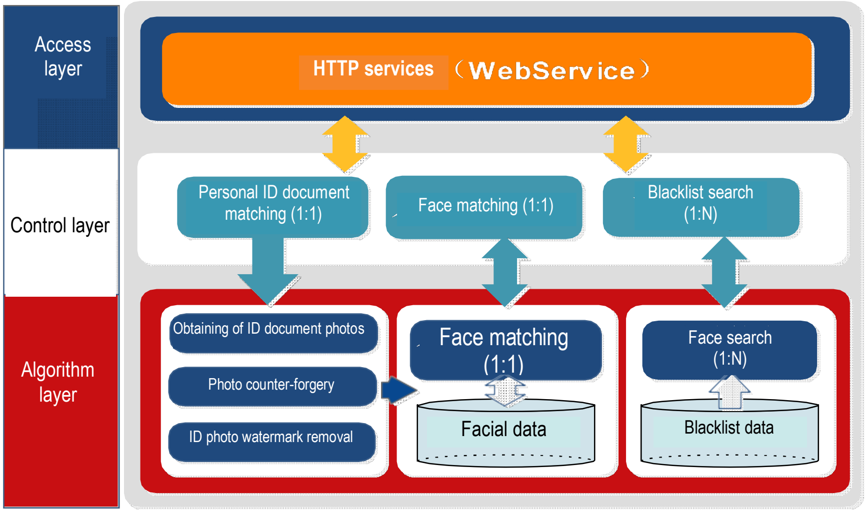
（1） Customer needs and project outline

Before any of China Mobile's 800 million users register an account or conduct significant business for the first time, some means must be used to verify the user's identity, so as to ensure that the actual identity of the person with whom the product operator is associated is true and correct, and to serve as the basis for safeguarding subsequent business development. When users carry out real-name authentication, they must provide a photograph of themselves, personal identification information (ID number/name, etc.), and other relevant information to the business back office for checking. The back office must also obtain other authoritative information based on the identifying information (for example, Ministry of Public Security photos), and do cross-checking of the different kinds of photographic information. Due to the large number of users (800 million), each step in identity verification needs to be carried out automatically, including facial recognition and OCR recognition of ID documents, to substitute for manual verification of faces and manual entry of ID documents. A diagram of the hardware and software architecture is shown below.



（2） Specific solution brief

Front-end ID document recognition and selfie capturing, with facial matching and identity verification done on a private cloud service, supports mobile, online complementary registration operations for the real-name system. It covers 800 million users nationwide, and the vast majority of online and offline channels. A diagram of the face verification back-end service is as follows.



In the project implementation process, image pre-processing, face detection, face matching, and ID document OCR components were provided, and after assessment the performance indicators all significantly exceeded the target originally set in the contract. Taking the hand-held photo ID judgment component as an example, contracts usually require an identification accuracy rate of at least 90%, but SenseTime's algorithm, after two rounds of optimization by technicians based on actual operations data, reached an accuracy rate of 97.3%. The correct recognition rate for ID numbers (entire numbers, not individual characters) reached 99.6%.

（3） Value and results after project implementation

The ID document matching system that SenseTime provides to China Mobile's online service company recognizes users' ID document information using AI technology, and judges whether users' uploaded photos are of the same people as those in users' ID document photos. During the project bidding process, SenseTime won out over a host of providers, in terms of core component performance, overall technical solution, support capacity, and other aspects, to become the operator's chosen partner. SenseTime's facial recognition and authentication were among the technologies that were far ahead of similar products in the market. Complementing its system, SenseTime also provided independently developed deep learning-based image processing technology that performs automatic photo orientation correction and quality enhancement, and intelligently handles environmental, lighting, imaging quality, and other disruptive factors. It also provided proprietary ID photo sharpening and processing technology to assure high recognition accuracy. Since coming online, the system has covered mobile users in 28 provinces nationwide, with more than 90 percent of the user ID consistency verification work in China Mobile's real name registration operations handed over to computers for automatic processing, and increasing by over a hundred-fold the previous efficiency of manual review, which could only process approximately 1 person per minute.

Case 10: COSMOPlat industrial Internet platform—innovation integrating AI and manufacturing

Field of application: industrial manufacturing field

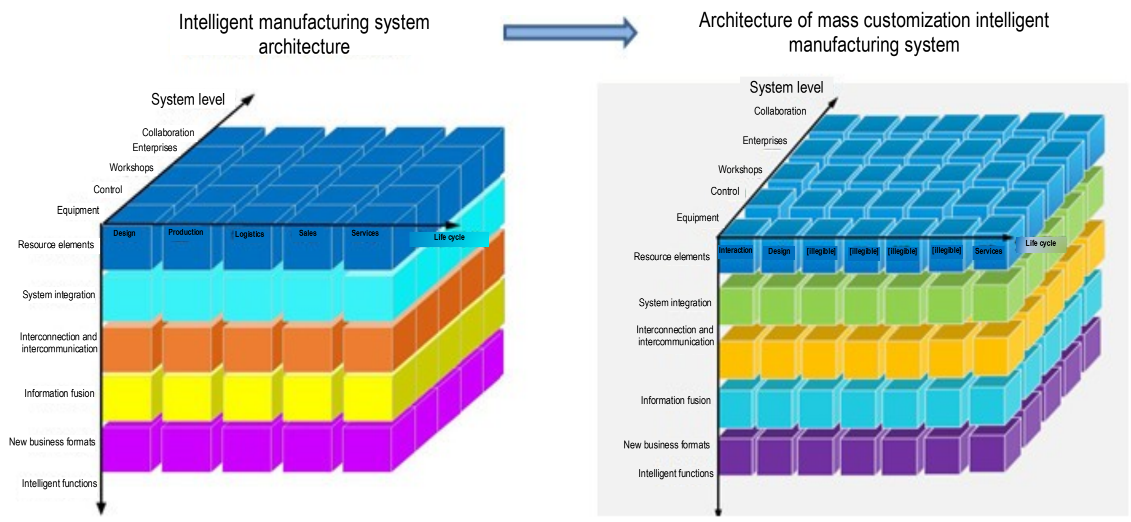
Application scenarios: smart manufacturing, smart products

Case provider: Haier Industry Intelligence Research Institute Co., Ltd.

(1) Customer needs and project outline

Under the strategic guidelines of Made in China 2025, Haier has used independent innovation to build COSMOPlat, an industrial Internet platform with independent intellectual property rights. COSMOPlat is a user-oriented, win-win multi-sided platform that adopts the Internet of Things (IoT) model. Haier's COSMOPLat platform can provide discrete manufacturing enterprises smart manufacturing and resource management solutions. IoT technology is used to achieve interconnected collaboration between humans, computers, and things, including the access and monitoring/analysis of devices, people, processes, and factory data, thereby meeting the informatization deployment, transformation, and intelligent upgrading needs of different enterprises, and achieving precision and efficiency in mass customization. Haier's COSMOPlat platform optimizes asset efficiency, based on asset models and operational big data, by means of real-time collection of device asset data for real-time monitoring and management of assets online. For example, it can collect real-time device data and, in conjunction with device mechanical analysis and modeling, achieve predictive maintenance, increase efficiency, and lower costs.

The figure below is the architecture of Haier's smart manufacturing system for mass customization.



National Intelligent Manufacturing Standard System Construction Guidelines (2015 version)

Specification of mass customization in the home appliances industry

(2) Specific solution brief

In Haier's COSMOPlat platform smart manufacturing solution, a variety of intelligent technologies are used to construct 7 application modules—user interaction, R&D, purchasing, manufacturing, logistics, and services[4]—and to achieve high-precision product innovation services and high-efficiency smart production services. All of the services on the COSMOPlat platform rely on "interconnected factories" developed by Haier to achieve hybrid, flexible production of home appliance products centered around users' personalized needs. The

[4] Translator's note: Although this sentence claims that the COSMOPlat platform features seven application modules, it only names six.

COSMOPlat platform at the core of Haier's Interconnected Factories adopts an intelligentized, digitalized, and flexible design philosophy. COSMOPlat's seamless connections are used to realize the entire process for refrigerators, washing machines, and other networked appliances, from personalized customization and remote ordering to smart manufacturing, while also achieving seamless connection of the entire process of smart products and smart manufacturing.

Haier's intelligentized Interconnected Factories

Haier's intelligentized "Interconnected Factories" include many intelligent units, including user customization, modular intelligent picking and matching, flexible assembly, modular assembly, intelligent detection, and customized delivery, which are integrated into the COSMOPlat platform, the "Twins" virtual-real fusion system (虚实融合双胞胎系统), RFID, smart cameras, dual-arm robots, AGV, network security, and other intelligent technologies. Using the Zhongchuanghui (众创汇) and HOPE online interactive design platforms, users can independently define the products they require. The platform integrates requirements, and after the requirements reach a certain scale, a user order is formed. At the same time, first-class resources are introduced for carrying out virtual design online, and orders can be sent directly to the factory and the module supplier. The whole process is driven in parallel, and required modular components are matched automatically. Immediate module delivery and on-demand batching is achieved by means of intelligent logistics systems such as factory automated guided vehicles (AGVs) and "power and free" overhead conveyor systems; and manufacturing information and data (manufacturing process data and networked appliance big data) is traceable and visualizable throughout the process. An intelligent order insertion function is also provided to VIP users and those with urgent needs. In addition, the "Twins" virtual-real fusion system can simulate all production processes offline, and it can also animate and display in real time the operating status and order data of the equipment in operation.

Haier product intelligentization

Haier's "U+" smart home platform is the world's first IoT solution in the smart home industry field. With Haier's own smart home appliances as the carriers, U+ provides multi-access point, holistic smart home solutions by means of protocols linking underlying and application layers, as well as interface opening. Haier's U+ smart home platform is a smart operating system, able to understand users' needs and proactively provide services. Centered on the home user, it connects people, home appliances, and services to empower home appliances and provide end-users with holistic intelligent services. For example, Haier's smart washing machines can automatically identify clothing fabrics, and add and purchase detergents. Users just need to put dirty laundry in the washing machine, and the machine can intelligently make judgments and complete the entire wash cycle automatically. Not only can Haier's smart refrigerators integrate seamlessly with smartphones, the external touch screen can also be used to see the food stored inside the fridge, browse images, watch videos, and search for recipes. It can also interconnect and interact with other household appliances. For example, when a user brings home steaks, it can provide the user recipes and send one to the gas range, which then cooks them at the correct temperature, with the hood automatically controlling the air flow in sync with the range. The whole cooking process is without human intervention, letting the user focus more on the cooking process itself. The dishwasher also automatically chooses the appropriate cycle and water temperature for cleaning the dishes after the meal. Haier's smart home appliance products also include bathroom heaters, exhaust fans, lights, and many other devices for intelligently controlled bathrooms. The bathroom lights automatically turn on after a user opens the door and enters, and turn off when the user leaves and shuts the door. When it is detected that the temperature in the bathroom is lower than the temperature required for comfortable bathing, it will turn on the bathroom heater in advance. And when it detects that there is too much steam in the bathroom, it automatically turns on the exhaust fan. Haier's U+ smart home platform has already been extended successfully to seven major areas (appliances, furniture, home decor, health care, security, robots, and communications), driving a transformation among companies from "hardware manufacturing" to "hardware+software+services" IoT ecosystems, and offering a new paradigm for innovative change in the IoT era.

(3) Value and results after project implementation

Haier's integration of user scenario big data and manufacturing data has promoted product iteration and experience enhancement. Intelligentized production is achieved through the interconnection and intercommunication of user data and production data. For example, the COSMOPlat cloud platform collected users' requirements via Weibo, WeChat, search engines, and other channels, and discovered various demand-related issues users had with all brands of air conditioners. It then revealed through data analysis that the main problem was air conditioning sounds. Air conditioning sounds mainly include noises and abnormal sounds. Noises can be distinguished by decibel levels, while abnormal sounds are endlessly varied. Using big data and AI technology, the COSMOPlat platform learned autonomously to distinguish abnormal sounds and control them automatically, and improved the accuracy of abnormal sound differentiation. After focusing on the noise issues, they could be traced back to the production process. Production process big data were used to analyze the causes of the abnormal sounds (including poor installation of air conditioning fans, poor motor installation, and burrs in the skeleton module), and those were further summarized to develop key measures to improve abnormal sounds, prevent them in advance, and improve user experience.

Haier's COSMOPlat platform is aimed at: driving corporate transformation and upgrading, and innovation through the fusion of AI and manufacturing; building new corporate organizational structures and operating models; forming new business models for manufacturing and services based on intelligentized fusion; and achieving mass customization. Due to the COSMOPLat platform's effects, product production efficiency was improved and the proportion of products that never need warehousing increased. COSMOplat is also "the most professional connector between enterprises and intelligent manufacturing resources," and while serving interconnected factories internally, it also provides solutions and value-added services for the transformation and upgrading of manufacturing enterprises, allowing enterprises themselves to continuously boost their mass customization capacity, and providing the most optimal user experience.