PERSPECTIVE
https://doi.org/10.1038/s42256-020-0183-4
nature machine intelligence

Towards a new generation of artificial intelligence in China

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Artificial intelligence has become a main driving force for a new round of industrial transformation around the world. Many countries including China are seizing the opportunity of the AI revolution to promote domestic economic and technological development. This Perspective briefly introduces the New Generation Artificial Intelligence Development Plan of China (2015–2030) from the point of view of the authors, a group of AI experts from academia and industry who have been involved in various stages of the plan. China's AI development plan outlines a strategy for science and technology as well as education, tackling a number of challenges such as retaining talent, advancing fundamental research and exploring ethical issues. The New Generation Artificial Intelligence Development Plan is intended to be a blueprint for a complete AI ecosystem for the country.

The past few decades have witnessed many advances in computing and artificial intelligence (AI)-related approaches, due to progress in machine learning, computer processing power, the accessibility of mobile internet, the availability of large amounts of data and data storage technology. This has triggered a series of breakthroughs that enabled AI to become an engine for economic development in many countries, including China. We expect that AI will redefine all aspects of economic activities and will lead to new demands, new products, new technologies and new forms of businesses of all sizes. China should seize the opportunity and trigger a major evolution of the economic structure.

Furthermore, we believe that Chinese AI researchers can make great scientific contributions to mankind. In the past 300 years, Western societies have been responsible for major scientific achievements. Today, in the era of AI, China can contribute to important scientific progress, building an open international research platform, and working with researchers and engineers from around the world to tackle the grand challenges that we are facing.

An AI plan for a new generation

In January 2016, the Chinese Academy of Engineering launched a major strategic consulting research project called AI 2.0 in China. During the launch ceremony, held in March 2016, the attending researchers decided to write a letter to the Chinese government to propose the initiation of megaprojects in AI. In the following months, led by the Ministry of Science and Technology of China, more than 220 AI experts from universities, institutes, companies and governments attended discussions and contributed to drafting the New Generation of Artificial Intelligence (NGAI) Development Plan.

In August 2016, according to the State Council, 15 megaprojects with the implementation period ending in 2030 were announced to reflect and incorporate new developments and trends in both national and international science and technology priorities and needs.

As the 16th programme, the NGAI Development Plan (2015–2030) was launched in July 2017 by the Chinese State Council[1], the first systematic and strategic plan in AI for China in this century. It sets out a national top-level plan for the overall thinking, strategic goals, main tasks and supporting measures for China's AI development through 2030 via three successional steps. First, by the end of 2020, China will close the technological gap with world-leading countries, and China's AI industry will compete at the highest international level. Second, by 2025, China will have achieved significant breakthroughs in fundamental research of AI and formulated the framework of NGAI, with some technologies and applications achieving a world-leading level, and AI becoming the main driving force for China's industrial upgrade and economic transformation. Third, by 2030, China is expected to become one of the world's premier AI innovation centres, and will have developed comprehensive and appropriate regulatory, legal and ethical principles for AI development.

By following the Development Plan, China's new-generation AI is positioned to transform big data into structured knowledge and support human decision making (big data intelligence)[2–5]. In addition, it will be able to employ data with different modalities (for example, visual, auditory and natural language) to perform learning and inference (cross-media intelligence)[6] and harness the intelligence of crowds to address complicated challenges in a paradigm of computational collective wisdom (crowd intelligence)[7]. Furthermore, there will be a step from the pursuit of an intelligent machine to the hybrid-augmented intelligence (human–machine hybrid intelligence)[8]. The new-generation AI will also emphasize intelligent systems capable of carrying out operations without human intervention (intelligent autonomous systems)[9].

Unlike AI strategies outlined by other countries, China's AI plan not only consists of science and technology issues, but also provides guidelines regarding education and ethics. The AI plan is intended to cultivate an AI ecosystem in China.

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Table 1 | The main national platforms of AI in China

National AI platforms	Mission	Enterprises/local governments	Government agencies
National Open Innovation Platforms	Each platform is expected to carry out activities on four key tasks listed as follows: research and development, ecosystem participation, sharing data and open-source software, and supporting the entrepreneurship of small and medium-sized enterprises	Baidu (autonomous driving), Alibaba (urban cognition), Tencent (medical imaging), iFlyTek (voice intelligence), Sensetime (intelligent vision), Yitu Technology (visual computing), MiningLamp Technology (marketing intelligence), Huawei (basic software and hardware), Ping An (inclusive finance), Hikvision (video perception), Jingdong (intelligent supply chain), Megvii (image perception), Qihoo 360 (safe brain), TAL Education Group (smart education), Xiaomi (smart home)	Ministry of Science and Technology
National NGAI Development Experimental Zones	Establish the cooperation with local governments (especially across the Jing-Jin-Ji Region, the Yangtze River Delta and the Greater Bay Area) to promote demonstration of AI technologies and to pilot experimental policies for AI development	Beijing, Shanghai, Hefei, Hangzhou, Shenzhen, Tianjin, Chong Qing, Cheng Du, Xi'an, Ji Nan, Deqing county (the only county from more than 2,300 counties in China)	Ministry of Science and Technology
Pilot zones for innovative application of AI	Promote the deep integration of AI and the real economy in order to accelerate the development of AI innovation and applications	Shanghai's Pudong, Shenzhen, Jinan-Qingdao (Shandong province)	Ministry of Industry and Information Technology

Collaboration between universities, government and industry

To enable leading AI-related enterprises to fully commit to addressing AI technologies and application demands of NGAI, in the past years the Ministry of Science and Technology established 15 National Open Innovation Platforms based on application-driven, enterprise-led and market-oriented principles, including Baidu (autonomous driving), Alibaba (urban cognition), Tencent (medical imaging), iFlyTek (voice intelligence), Sensetime (intelligent vision), Yitu Technology (visual computing), MiningLamp Technology (marketing intelligence), Huawei (basic software and hardware), Ping An (inclusive finance), Hikvision (video perception), Jingdong (intelligent supply chain), Megvii (image perception), Qihoo 360 (safe brain), TAL Education Group (smart education) and Xiaomi (smart home).

To promote cooperation with local governments for demonstrating AI technologies and to pilot experimental policies for AI development, replicable in other areas of the country at a later stage, China will construct around 20 new National NGAI Development Experimental Zones by 2023. Currently, Beijing, Shanghai, Hefei, Hangzhou, Shenzhen, Tianjin, Chong Qing, Cheng Du, Xi'an, Ji Nan and the county of Deqing have been selected as new zones.

In 2018 and 2020, the Ministry of Science and Technology issued two calls for proposals for megaprojects of 'science and technology innovation 2030—New Generation Artificial Intelligence'. The calls focus on fundamental AI theories (neural network, causal inference, game theory, collective wisdom, hybrid intelligence and brain-inspired intelligence), technologies (knowledge computing, adaptive perception and artificial systems and applications) and AI chips.

In China, the National Natural Science Foundation of China (NSFC) supports basic research, fosters talented researchers, develops international cooperation and promotes socioeconomic development. In 2018, AI and cross-disciplinary information sciences were newly added into the Directorate of Information Sciences of NSFC, which means that universities and institutes are eligible to apply funding from NSFC to AI.

China's government has become increasingly active in setting up a collaborative innovation system via the interactions among universities, government and industry for AI development. Based on the collaboration, universities, funding agencies, enterprises, and central and local governments in China have been connected together to develop the new generation of AI.

Areas of attention

AI has the potential to enhance every technology; in this sense, it is an enabling technology similar to the combustion engine or electricity. Table 1 summarizes the main national platforms to integrate AI with socioeconomic development in China.

Here, we introduce several areas of attention on AI deployed by these national AI platforms from the perspective of how AI drives socioeconomic advances for everyday consumers, autonomous driving, the medical industry and conversational AI for the internet of things (IoT).

AI for everyday consumers. In China, AI technologies are widely used in daily life, such as by local businesses and financial services. Consumers install a range of applications into their smartphones to benefit from AI and machine learning technologies. For example, many people are familiar with transactional 'super apps' such as Meituan or Dianping, which are amalgamations of lifestyle services that connect customers to local businesses. These applications have reshaped life for hundreds of millions of people in Chinese cities, expediting the booking and delivery of services such as food, hotel stays and movie tickets. For example, every day more than 600,000 active delivery people deliver food orders within, on average, 30 minutes . This efficiency is due to the powerful and smart dispatch system, which calculates 3 billion route plans every hour to optimize a rider's delivery volume and delivery time[10].

In the area of finance, with the rise of online consumer credit service and apps like WeChat pay and Alipay, the scale of the consumer credit market has grown rapidly in China: by the end of 2018, the consumer credit balance exceeded ¥8.45 trillion and total authorized credit cards exceeded 14 trillion[11]. Meanwhile, the consumer credit industry faces difficulties such as lack of credit data (more than 60% of the population in China lack credit records), weakness in risk management and inefficiency in operation service. Within these online credit services or applications, AI functions by processing internet-scale big data and adopting advanced algorithms to improve the quality of financial service decisions and efficiency of operations. Examples include using deep learning to utilize sequential behaviour data and the homogeneity effect in social network

relationships to identify group fraud attack, and using deep semantic language models to get to know the customers' demands and frequency of usage with the data generated from various perspectives, so as to improve the efficiency of customer service and the security of operations. In the Fintech Development Plan (2019–2021) published by the People's Bank of China, the integration of AI in finance is considered the key to improving the financial risk control level and service efficiency.

In addition, AI technologies have transformed the way people connect with valuable information in different modalities, including text, image, audio and video. By the end of 2018, China's mobile subscribers reached 1.17 billion, with the penetration rate at 82%[12]. The majority are using smartphones and popular mobile apps such as Douyin, IQiyi, Tencent Video, Toutiao, Kuaishou and Weibo for learning and recommendation. One of the most important technologies for information access is large-scale recommendation algorithms. Such systems deliver tens of millions of emerging news articles and videos every day, tailored to users' interests and tastes. For example, over 120 million people in China use the Toutiao app each day to consume news, videos and other content. User feedback is collected in real time and fed into advanced and distributed machine learning algorithms to adjust the models for the next item recommendation. The leading consumer apps employ AI technologies to improve the effectiveness and efficiency of information creation, moderation, dissemination, consumption and interaction.

AI in autonomous driving. Every year, around 1.3 million people lose their lives in traffic accidents, resulting in a cumulative financial loss of over US$600 billion[13]. As one of the world's most densely populated and congested countries, China has the potential to become the largest but also the most challenging autonomous driving market. Several autonomous driving start-up companies were founded in China in recent years, with the mission to develop autonomous driving solutions that can save lives and improve efficiency. To deploy autonomous driving solutions in various settings (including geography, weather, traffic, use cases and so on) that are constantly changing, agile, scalable and upgradable algorithms are required. The availability of sufficient data for perception, high-definition maps, driving behaviour and disengagement are prerequisites to develop such solutions.

The industry generally categorizes autonomous driving products as mass-produced advanced driver assistance solutions (ADAS) and full autonomy/autonomous vehicle solutions. Synergy between the two domains can be achieved with a consistent data-driven approach where the two domains share primary sensor sets and data principles. The data generated from various settings in ADAS vehicles will be essential to continuously evolve and improve the full autonomy solutions. Through continuous improvement of full autonomy technologies, the functions and modules will be migrated to ADAS offerings and provide advanced features. By addressing the two domains simultaneously using AI technologies, some companies will expedite the deployment of agile, scalable and upgradable autonomous driving solutions to meet future mobility needs.

AI medical industry. As the country with the largest population in the world, China has the potential to become the biggest AI medical market. In China, over 100 AI medical start-up companies have been founded in recent years, engaging in different domains including medical image analysis, drug discovery, surgical robotics and clinical decision supporting systems. Among them, the majority focus on medical imaging, especially on cancer imaging, including but not limited to radiology, pathology and radiotherapy. Their mission is to automate diagnosis, support treatment decision making and streamline the clinical workflow. Cancer is the leading cause of death in China and has become the primary area of focus for AI development[14,15].

Since 2012, deep learning has been shown to match and even surpass human performance in task-specific applications[16], especially in the area of radiographic imaging[17] and computational pathology[18]. However, the continued development of deep learning still has to address plenty of challenges existing in medical imaging. For example, deep learning requires large volumes of medical data and expert annotations to train a robust model against noise and/or partial missing labels. These high-quality annotations have to be acquired by experts with years of experience instead of crowdsourcing. This may lead to low efficacy in generating high-quality ground truth while those large-scale unlabelled datasets remain unexplored. In this case, weakly or semi-supervised learning may provide alternative solutions for this challenge[19].

Data silos and patient confidentiality must also be taken into account when taking advantage of large-scale, multi-centre medical data. Federated learning with a collaborative mechanism shows a potential promise to conquer this challenge without centralized training data[20,21]. At this time in China, tens of medical AI products have been successfully put into clinical trial, such as lung nodule detection from computed tomography scans, diabetic retinopathy categorization from fundus photos, and cervical cancer screening with Pap-smear images.

With the advent of digital standardization and the large-scale availability of medical data available in China, close collaboration between clinical experts and AI researchers will bring many useful AI-assisted systems into the clinical workflow, assisting physicians and ultimately improving patient management.

Conversational AI for IoT. Currently in China, billions of pieces of smart hardware make up the IoT[22]. Speech and language are natural choices for information exchange between humans and intelligent hardware. Therefore, conversational AI has raised great interest in industry and academia. Large technology companies such as Baidu and start-up AI companies such as AISpeech are all enthusiastically building full-chain conversational AI platforms with the goal of developing customizable virtual conversation assistants to empower all possible intelligent IoT devices. This is also a very challenging research issue. The research of conversational AI is mainly the study of a spoken dialogue system (SDS). A task-oriented SDS is of most interest to most researchers, and Q&A-based conversations or chit-chats are also popular research topics.

In the next few years, three trends in industry and academia can be expected in China. A first focus is perception technology operating in complex acoustic environments and non-cooperative interaction scenarios, for example in conference speech recognition with multiple speakers' simultaneous conversations. Second, cognition research will go further, focusing on context-sensitive language understanding and dialogue decisions. Here, the combination of data-driven and knowledge-based approaches may be an effective method in many tasks; the successful use of statistical dialogue policies will enable task-oriented conversation assistants to evolve by themselves while serving humans. For the third step, the concept of dialogue will extend from speech-based conversations to multimodal conversations, and conversation agents capable of handling speech and vision will be widely used in various forms of intelligent hardware.

Challenges and opportunities

China has a good foundation in the field of AI, in particular in technologies such as face and speech recognition, visual recognitio, and Chinese-language information processing. China has over 840 million internet users, the world's largest online population and more than half the total population of the country, offering a huge market for AI applications. However, there are some challenges to address to ensure a wide adoption of AI in China: the shortage of high-tech talent, the immature AI ecosystem and AI ethical issues.

Fostering home-grown AI talent. China attaches increasing importance to the cultivation of AI talent. China's Ministry of Education issued the Artificial Intelligence Innovation Action Plan for Colleges and Universities in April 2018 to the education departments at all levels and institutions of higher education. This action plan aims to advance China's universities to world frontiers in science and technology, energize their capabilities in AI technological innovation, talent cultivation and global cooperation, and provide strategic support for the development of new generation AI in China.

In March 2020, the Ministry of Education, the National Development and Reform Commission and the Ministry of Finance co-issued guidelines to urge universities to set up interdisciplinary talent-cultivation systems to substantially improve the level of graduate education in AI. The guidelines also encourage enterprises and social organizations to ramp up investment to support the development of AI-related disciplines and high-level talent training.

Universities are demanded to train two kinds of AI talent: one for fundamental research that can lead to original innovation and the other to translate the original innovation into pragmatic product designs. AI has become an undergraduate major at more than 200 universities in China, approved by the Ministry of Education. Many Chinese universities set up AI schools (such as Xidian, Nanjing University and Xi'an Jiaotong) and institutes (such as Zhejiang University, Peking University and Tsinghua University) in recent years for AI researcher training, especially AI PhD programmes.

The next breakthroughs of AI will be interdisciplinary endeavours that draw on neuroscience, physics, mathematics, electronic engineering, biology, linguistics and psychology to deliver theoretical, technological and industrial innovations that address complex societal issues and reshape the national industrial system[23]. Moreover, current AI systems are a long way away from interpretable artificial general intelligence (AGI) and interdisciplinary explorations are required to move closer to this goal.

China is fostering AI education in universities by strengthening the interdisciplinary links between AI and relevant partners, as well as collaboration with industry. AI ethics and responsibility to humankind are an important part of AI course design. To cultivate home-grown AI, China should upgrade the AI to a full academic discipline instead of offering a few core courses as a part of the computer science discipline.

It is also worth mentioning that there have been official AI textbooks for high-school students since the end of 2019. From 2020, these textbooks will be used nationwide in high schools to help students acquire concepts of AI to better prepare the students for AI education at universities.

Regulating AI ethics. Towards the long-term goal of making AI beneficial to human society, it is necessary to not only increase efforts in research and development and maximize the potential of AI, but also to pay more attention to ethical, legal and economic concerns brought out by the AI development, according to the NGAI Development Plan of China. In June 2019, the National Governance Committee for the NGAI issued Governance Principles for the New Generation Artificial Intelligence—Developing Responsible Artificial Intelligence. In April 2019, the High-Level Expert Group on AI of European Commission presented Ethics Guidelines for Trustworthy Artificial Intelligence. The Beijing Academy of Artificial Intelligence (BAAI) also published the Beijing AI Principles in May 2019[24]. The G20 supports the principles for responsible stewardship of trustworthy AI.

A focus for AI ethics in China is trustworthiness of AI developments and the prevention of harmful use. Ethics guidelines should help build trustworthy AI systems for daily life, which perform exactly as intended to guarantee AI systems' safety and reliability. A different focus for AI ethics, which is important in Europe, is on the data underlying the training of algorithms. Europe has strong data protection, limiting how much companies operating there can exploit people's personal data.

Researchers are now realizing that they need to embed ethics issues, such as security, responsibility, explainability and fairness into the formulation of their research and understand the implications of societal harms due to algorithmic injustice. For example, research can leverage federated learning and blockchains to mitigate the problem of data privacy, and de-bias algorithms to guarantee fairness to a certain degree[25]. The Private Aggregation of Teacher Ensembles is utilized to achieve private learning by carefully coordinating the activity of several different machine learning models[26].

The principles of AI ethics in China so far lack legal enforcement and policy implications. In order to formulate new laws and regulations, and ethical norms and policies related to AI development in China, the Chinese government resolves to evaluate the impact of AI technologies toward society. According to the Work Guidelines on the Establishment of National NGAI Innovation Development Experimental Zones published by China's Ministry of Science and Technology, long-term and cross-disciplinary social experiments will be studied in China to explore appropriate methods and means to support AI governance[27].

Nurturing an AI ecosystem. Accelerating the development of a new generation of AI is a key strategy for China, to boost developments in science and technology, to upgrade every industrial domain and to increase overall productivity[28,29]. An AI ecosystem could be a systematically interconnected network of various agents including start-ups, enterprises, investors, research agencies and markets in an environment of collaboration and knowledge transfer that combine to create innovative products and competitive services. In a healthy AI ecosystem, each participant across multiple industries and domains can find various ways to thrive.

Received: 9 November 2019; Accepted: 3 May 2020;
Published online: 16 June 2020

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Acknowledgements

We thank H. Shum and Z. Zhang for discussions and comments. We also thank the strategic consulting research project of the Chinese Academy of Engineering 'AI 2.0 in China', and the disruptive information technology research group of the Department of Information and Electronic Engineering at the Chinese Academy of Engineering. This paper is partly supported by AI Young Scientists Alliance, STCSM(Xuhui), SHEITC, NSFC (61625107).

Competing interests

The authors declare no competing interests.

Additional information

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