CHINA'S AI IMPERATIVE

The country's massive investments in artificial intelligence are disrupting the industry—and strengthening control of the populace

By **Christina Larson**, *in Beijing*

In a gleaming high-rise here in northern Beijing's Haidian district, two hardware jocks in their 20s are testing new computer chips that might someday make smartphones, robots, and autonomous vehicles truly intelligent. A wiry young man in an untucked plaid flannel shirt watches appraisingly. The onlooker, Chen Yunji, a 34-year-old computer scientist and founding technical adviser of Cambricon Technologies here, explains that traditional processors, designed decades before the recent tsunami of artificial intelligence (AI) research, "are slow and energy inefficient" at processing the reams of data required for AI. "Even if you have a very good algorithm or application," he says, its usefulness in everyday life is limited if you can't run it on your phone, car, or appliance. "Our goal is to change all lives."

In 2012, the seminal Google Brain project required 16,000 microprocessor cores to run algorithms capable of learning to identify a cat. The feat was hailed as a breakthrough in deep learning: crunching vast training data sets to find patterns without guidance from a human programmer. A year later, Yunji and his brother, Chen Tianshi, who is now Cambricon's CEO, teamed up to design a novel chip architecture that could enable portable consumer devices to rival that feat—making them capable of recognizing faces, navigating roads, translating languages, spotting useful information, or identifying "fake news."

Developers hope artificial intelligence–optimized chips like the Cambricon-1A will enable mobile devices to learn on their own.

Tech companies and computer science departments around the world are now pursuing AI-optimized chips, so central to the future of the technology industry that last October Sundar Pichai, CEO of Google in Mountain View, California, told The Verge that his guiding question today is: "How do we apply AI to rethink our products?" The Chen brothers are by all accounts among the leaders; their Cambricon-1A chip made its commercial debut last fall in a Huawei smartphone billed as the world's first "real AI phone." "The Chen brothers are pioneering in terms of specialized chip architecture," says Qiang Yang, a computer scientist at Hong Kong University of Science and Technology (HKUST) in China.

Such groundbreaking advances far from Silicon Valley were hard to imagine only a few years ago. "China has lagged behind the U.S. in cutting-edge hardware design," says Paul Triolo, an analyst at the Eurasia Group in Washington, D.C. "But it wants to win the AI chip race." The country is investing massively in the entire field of AI, from chips to algorithms. The Chen brothers, for example, developed their chip while working at the Institute of Computing Technology of the Chinese Academy of Sciences here, and the academy backed them with seed funding when they spun out Cambricon in 2016. (The company is now worth $1 billion.)

Last summer, China's State Council issued an ambitious policy blueprint calling for the nation to become "the world's primary AI innovation center" by 2030, by which time, it forecast, the country's AI in-

PHOTOS: (CLOCKWISE FROM TOP LEFT) STR/AFP/GETTY IMAGES; JIN KE—IMAGINECHINA; SHAN HE—IMAGINECHINA VIA AP IMAGES

Some firms in China now use artificial intelligence–powered facial recognition programs to confirm employee identities (far left) and authorize digital payments at fast-food restaurants (middle left). The Chinese government has begun using facial scans to identify pedestrians and jaywalkers (middle right), and even to dispense limited amounts of toilet paper in public restrooms (far right).

PHOTOS: (LEFT TO RIGHT) REX FEATURES VIA AP IMAGES; WANG ZHAO/AFP/GETTY IMAGES

dustry could be worth $150 billion. "China is investing heavily in all aspects of information technology," from quantum computing to chip design, says Raj Reddy, a Turing Award–winning AI pioneer at Stanford University in Palo Alto, California, and Carnegie Mellon University in Pittsburgh, Pennsylvania. "AI stands on top of all these things."

In recent months, the central government and Chinese industry have been launching AI initiatives one after another. In one of the latest moves, China will build a $2.1 billion AI technology park in Beijing's western suburbs, the state news service Xinhua reported last month. Whether that windfall will pay off for the AI industry may not be clear for years. But the brute numbers are tilting in China's favor: The U.S. government's total spending on unclassified AI programs in 2016 was about $1.2 billion, according to In-Q-Tel, a research arm of the U.S. intelligence community. Reddy worries that the United States is losing ground. "We used to be the big kahuna in research funding and advances."

China's advantages in AI go beyond government commitment. Because of its sheer size, vibrant online commerce and social networks, and scant privacy protections, the country is awash in data, the lifeblood of deep learning systems. The fact that AI is a young field also works in China's favor, argues Chen Yunji, by encouraging a burgeoning academic effort that has put China within striking distance of the United States, long the leader in AI research. "For traditional scientific fields, Chinese [scientists] have a long way to go to compete with the U.S. or Europe. But for computer science, it's a relatively new thing. Young people can compete. Chinese can compete." In an editorial last week in *The Boston Globe*, Eric Lander, president of the Broad Institute in Cambridge, Massachusetts, warned that the United States has at best a 6-month lead over China in AI. "China played no role in launching the AI revolution, but is making breathtaking progress catching up," he wrote.

The fierce global competition in AI has downsides. University computer science departments are hollowing out as companies poach top talent. "Trends come and go, but this is the biggest one I've ever seen—a professor can go into industry to make $500,000 to $1 million" a year in the United States or China, says Michael Brown, a computer scientist at York University in Toronto, Canada.

In a more insidious downside, nations are seeking to harness AI advances for surveillance and censorship, and for military purposes. China's military "is funding the development of new AI-driven capabilities" in battlefield decision-making and autonomous weaponry, says Elsa Kania, a fellow at the Center for a New American Security in Washington, D.C. In the field of AI in China, she warned in a recent report, "The boundaries between civilian and military research and development tend to become blurred."

JUST AS OIL fueled the industrial age, data are fueling advances of the AI age. Many practical AI advances are "more about having a large amount of continually refreshed data and good-enough AI researchers who can make use of that data, rather than some brilliant AI theoretician who doesn't have as much data," says computer scientist Kai-Fu Lee, founder of Sinovation Ventures, a venture capital firm here. And China, as *The Economist* recently put it, is "the Saudi Arabia of data."

Every time someone enters a search query into Baidu (China's Google), pays a restaurant tab with WeChat wallet, shops on Taobao (China's Amazon), or catches a ride with Didi (China's Uber), among a plethora of possibilities, those user data can be fed back into algorithms to improve their accuracy. A similar phenomenon is happening in the United States, but China now has 751 million people online, and more than 95% of them access the internet using mobile devices, according to the China Internet Network Information Center. In 2016, Chinese mobile payment transactions totaled $5.5 trillion, about 50 times more than in the United States that year, estimates iResearch, a consulting firm in Shanghai, China.

Baidu, which runs China's dominant search engine, both gathers and exploits much of these data. In parking garages under its futuristic glass-and-steel complex in northern Beijing, cars crowned with LIDAR sensors troll around on test runs for collecting mapping data that will feed Baidu's autonomous driving lab. In the main lobby, staffers' faces are scanned to open the security gates. Of China's tech titans—Baidu, Alibaba, and Tencent—Baidu was the first to pour resources into AI. It now employs more than 2000 AI researchers, including staff in California and Seattle, Washington.

A few years ago, Baidu added an AI-powered image search to its mobile app, allowing a user to snap a photo of a piece of merchandise for the search engine to identify, and then look up price and store information.

Early object recognition programs focused on outlines. But many objects—for example, plates of food in a restaurant—have basically the same outline. What's needed is more precise detection of interior patterns, or "textures," says Feng Zhou, a data scientist in Cupertino, California, who heads Baidu's new Fine-Grained Image Recognition Lab. Now, Baidu's AI image search can distinguish between, for instance, a stewed tofu dish called mapo tofu and fried tofu dishes. (A U.S. equivalent might be detecting the difference between oatmeal and rice.) Better algorithms have helped, Zhou says, but so has an abundance of training data uploaded by internet users.

The data deluge is also transforming academia. "When the AI textbooks were written, we didn't have access to that kind of data," Yang says. "About 5 years ago, we decided that classroom education was not sufficient. We needed to have partnerships with industry, because the big technology companies not only have lots and lots of data, but also a variety of data sources and many interesting contexts to apply AI." Today, a group of HKUST professors and Ph.D. students work on AI projects with Tencent, China's social media giant. They have access to data from WeChat, the company's ubiquitous social network, and are developing "intelligent" chat capabilities for everything from customer service to Buddhist spiritual advice.

Such collaborations are vulnerable, however, as China's academic outposts struggle to keep faculty members capable of designing new AI algorithms from decamping to industry. "University students know that AI is a very cool thing, which might also make you rich," Chen Yunji says.

The Chinese government is also drinking from the data firehose—and is honing AI as a tool for staying in power. The State Council's AI road map explicitly acknowledges AI's importance to "significantly elevate the capability and level of social governance, playing an irreplaceable role in effectively maintaining social stability."

Some worry that the government's embrace of AI could further stifle dissent in China. Enhanced technology for recognizing context and images allows for more effective real-time censorship of online communications, according to a report from The Citizen Lab, a research outfit at the University of Toronto. Also at the heart of this debate is facial recognition technology, which is powered by AI algorithms that analyze minute details of a person's face in order to pick it out from among thousands or millions of potential matches.

Facial recognition is now used routinely in China for shopping and to access some public services. For example, at a growing number of Kentucky Fried Chicken restaurants in China, customers can authorize digital payment by facial scan. Baidu's facial recognition systems confirm passenger identity at certain airport security gates. Recent AI advances have made it possible to identify individuals not only in up-close still photos, but also in video—a far more complex scientific task.

China's attitude toward such advances contrasts with the U.S. response. When the U.S. Customs and Border Protection last May revealed plans to use facial matching to verify the identities of travelers on select flights leaving the United States, a public debate erupted. In an analysis, Jay Stanley of the American Civil Liberties Union in Washington, D.C., warned of the potential for "mission creep": With new AI technologies, "you can subject thousands of people an hour to face recognition when they're walking down the sidewalk without their knowledge, let alone permission or participation."

In China the government is already deploying facial recognition technology in Xinjiang, a Muslim-majority region in western China where tensions between ethnic groups erupted in deadly riots in 2009. Reporters from *The Wall Street Journal* who visited the region late last year found surveillance cameras installed every hundred meters or so in several cities, and they noted facial recognition checkpoints at gas stations, shopping centers, mosque entrances, and elsewhere. "This is the kind of thing that makes people in the West have nightmares about AI and society," says Subbarao Kambhampati, president of the Association for the Advancement of Artificial Intelligence (AAAI) in Palo Alto and a computer scientist at Arizona State University in Tempe. In China, he says, "people are either not worried, or not able to have those kinds of conversations."

CHINA'S AI RESEARCHERS show no signs of slowing down. In October 2016, a White House report found that Chinese researchers now publish more deep learning–related papers in all journals than researchers from any other country. When adjusted for publication impact factor, the United States still produced the most influential AI-related papers, followed by the United Kingdom, with China only narrowly behind, according to a recent McKinsey Global Institute analysis.

Kambhampati adds that before 2012 or so, submissions from China to major AI conferences "used to be quite small." At AAAI's annual meeting earlier this week in New Orleans, Louisiana, he says, accepted papers from China nearly equaled those from the United States. "For the longest time, there was a general feeling that China was always second-rate in technology. That may have been true, but it's also changing quite quickly."

The government wants the boom to continue. At the end of 2017, the science ministry issued a 3-year plan to guide AI development, and named several large companies as "national champions" in key fields: for example, Baidu in autonomous driving, and Tencent in computer vision for medical diagnosis. Zha Hongbin, a professor of machine intelligence at Peking University here who consults for the government, says China plans to expand the number of universities offering dedicated machine learning and AI departments.

In the meantime, industry continues to bet heavily on AI. Last October, for instance, Alibaba announced plans to invest $15 billion in research over 3 years to build seven labs in four countries that will focus on quantum computing and AI.

A decade ago, China's best AI researchers might have left for plum jobs in Silicon Valley. Instead, increasing numbers of them are staying at home to lift the nation's AI industry, says Xia Yan, a 30-year-old data scientist who co-founded Momenta, an autonomous driving startup here. "Many of us are choosing to go from an academic background to running a company," Xia says. "We want to see our work in the real world. It's a new era." ■

Christina Larson is a freelance journalist in Beijing.

Closing the intelligence gap

The United States leads China in private investment in artificial intelligence (AI) and in the number and experience of its scientists. But Chinese firms may gain an advantage from having more data—including data not in the public domain—for honing algorithms.

	UNITED STATES	CHINA
Years experience of the nation's data scientists	More than half have more than 10 years.	Forty percent have less than 5 years.
AI patent applications, 2010–2014	15,317 (First in world)	8410 (Second)
Number of workers in AI positions	850,000 (First)	50,000 (Seventh)
Percent of private AI investment (2016)	66% (First)	17% (Second)
Global ranking of data openness	No. 8	No. 93

DATA: ASTAMUSE; LINKEDIN; MCKINSEY GLOBAL INSTITUTE