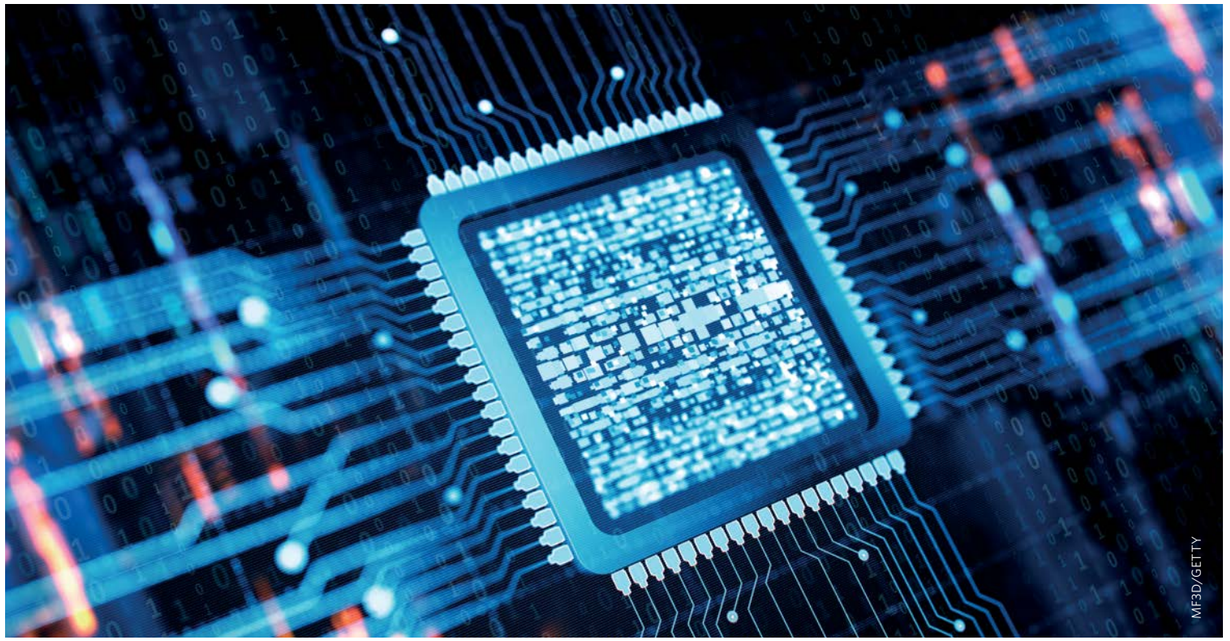
ADVERTISEMENT FEATURE

Engineering intelligent systems with AI

SHANGHAI RESEARCH INSTITUTE FOR INTELLIGENT AUTONOMOUS SYSTEMS

leverages Tongji University's strengths in autonomous systems and aims to stand at the forefront of artificial intelligence innovations.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The information technology revolution is rapidly changing our lives. Breakthroughs in computing and telecommunications, based on information theory, the communication and control theory, Turing's computational model, and powerful processors, are dramatically boosting productivity. Emerging artificial intelligence (AI) technologies are bringing a new information revolution.

As big research powerhouses look to AI to boost their technological innovation and economic development, China has also launched a plan to build up its AI industry. In Shanghai, China's commercial, and science and technology hub, the establishment of Shanghai Research Institute for Intelligent Autonomous Systems by Tongji University, announced by the mayor in December 2018, is the natural result of ever-growing investment.

Aiming to accelerate AI research, the new institute is built upon Tongji's traditional strengths in intelligent autonomous systems. "We expect to leverage the university's interdisciplinary research resources to tackle cutting-edge research problems and cultivate high-end talent in AI," said Jie Chen, president of Tongji University, and chief scientist of the newly established institute. "By integrating multilateral forces from Shanghai, China and worldwide, we will be a global hub of AI innovations."

A hub for AI innovations

The institute focuses on three key issues in AI research — autonomous and sensing systems, emergent intelligence, and collaborative and swarm intelligence. Specifically, the institute is dedicated to harnessing the novel properties of super materials to develop devices that extend our senses, and with real-time collection of massive data, supporting autonomous decision-making based on multi-source big data. In intelligent cognition, the team strives to develop collaborative autonomous agents with cognitive capabilities, like those of humans, by simulating the neural mechanisms of cognitive behaviours, and to enhance the capabilities of processing big data and developing brain-like intelligence. Another focus of the institute is the collaboration between biological, mechanical, and electronic systems, as well as the mechanisms of self-organisation and emergence for multi-agent collaboration and decision-making. Researchers hope to optimise integration and collaboration between humans and machines.

By gathering a multidisciplinary group of talented researchers, and building research infrastructure, the institute will undertake major national science and technology innovation projects. With research centres on novel algorithms and devices, and on autonomous agents for aerial, underwater and land uses, as well as R&D platforms on advanced technologies and applications of unmanned systems, the institute is bound to advance breakthroughs in AI with its leading research.

A leader in smart technologies

As China's pioneer in basic and applied research on intelligent autonomous systems, Tongji University researchers have made breakthroughs in the application of AI technologies, ranging from intelligent computing and distributed control, to smart transportation and cities, reported in leading international journals.

Tongji's team has investigated novel sensors for a wide range of applications by exploring new sensing mechanisms, theories, sensor structures, materials, and effective strategies for enhancing sensing performance. Their works on the control of molecular structures, semiconductor microstructures, and interface charges effects have led to the development of artificial skin, flexible photo sensing membrane and high-performance electronic nose, which can mimic various sensing functions of human bodies. By revealing a mechanism for multi-scale sensing, they have proposed new composite devices based on nanotube films and piezoelectric wafers. The team's idea for a small hyperspectral sensing system is a world first.

Working on integration between biological, mechanical, and electronic systems, another team has created a worm-like bionic robot. Linking motor neurons and biomorphic structure with the environment, the robot is optimised for improved movement. The team has also made breakthroughs in designing bionic joints by integrating bionic sensing and robotic control.

Based on the natural interaction and autonomous learning for developing robot intelligence, the team studying autonomy and interaction has built a model for robot development. Based on big sensing data, the model shows effective skill learning by robots without any human intervention.

In heterogeneous systems and decision-making, a Tongji team has invented methods for automatic, real-time traffic flow analysis to assess and control risks, ensuring safe driving. They have independently developed China's first intelligent traffic system, and first testing site for intelligent connected vehicles. Simulations of realistic urban and rural settings for intelligent connected vehicles, featuring highway and country roads, have enabled real-world testing for different types of driverless vehicles. The team has also participated in the construction of a photovoltaic roadway fitted with solar panels and the intelligent traffic planning for 60% of China's subway lines.

In smart city design, Tongji's urban planning research team has used machine learning to collect and mine sample data from 13,810 cities across the world. By training the machine to categorize these cities into different urban development phases, they have, in a world first, defined seven major categories of urban growth. Precise identification of a city's development stage will enable capturing of the driving forces or problems underlining its development, so land use layout and construction can be calibrated with the city's needs.

The group studying brain-like intelligence and bionic applications is dedicated to advancing AI technology through understanding of human neural networks. They have pioneered the use of single-cell transcriptomics to reveal the signal pathway to activate dormant neural cells, and built a new model for neural network structures. Using brain-wide association analysis, integrating imaging technologies and big data analysis, they have identified brain regions and connectivity significantly associated with autism.

Working on multi-agent collaboration, another Tongji team has established the theoretical framework that balances exploration and exploitation to improve machine learning. Led by Chen, who is well known for his research on control science and engineering, the research team has also disclosed how the uncertainty of information transmission, and the unmodeled dynamic environment influence the stability of collaborative control. They have proposed methods for multi-criteria collaboration of complex systems and multi-objective decision-making to improve system operations. Chen's research on multi-criteria optimization and control of complex systems in dynamic environments, and collaborative control of multiple intelligent agents has wide industrial applications.

Dedicated to creating world-class research environment, and attracting and fostering top talent to lead AI research, the institute aims to forge university-industry collaborations to improve autonomous systems. "We would like to contribute to AI technologies with our expertise," said Chen, "We hope more talented researchers will join our endeavour." ■

Three key issues in AI research:

- Autonomous and sensing systems
- Emergent intelligence
- Collaborative and swarm intelligence

Nine research areas:

- Metamaterials & sensors
- Multi-scale integration
- Nature-inspired computing
- Autonomous agents
- Biological, mechanical, and electronic system integration
- Autonomy and interaction
- Heterogeneous systems and decision-making
- Multi-agent collaboration
- Brain-like intelligence and bionics

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