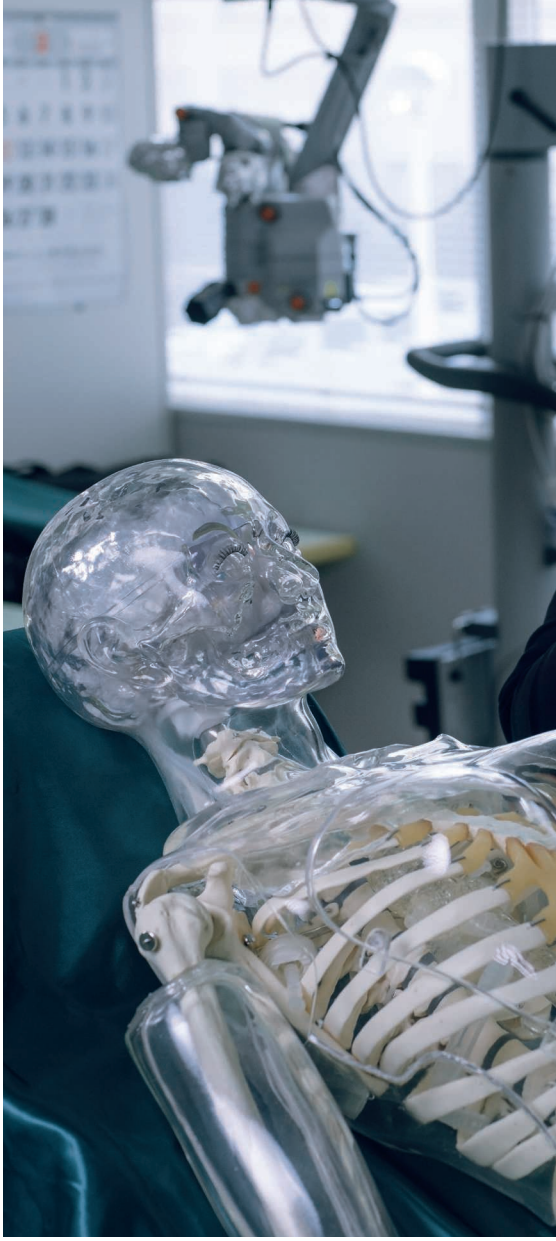
PILLARS OF A SMART SOCIETY

Across the scientific fields, Japanese researchers are bringing together the virtual and real worlds.



BY SMRITI MALLAPATY

Society is ready, says Japan, to enter its next stage of evolution, in which the real world is more intimately connected to the virtual world. In Society 5.0, as laid out in Japan's five-year plan, perennial problems of inequality, incohesion and estrangement will be left behind with the help of emerging technologies. People of all ages and ability will gain opportunities for enhancement, whether from superhuman physical strength, exclusive medical insights, untethered mobility, or informed decision-making.

For Japan, a super-smart society is not just an aspiration, but a necessity. Its proportion of people older than 65 is expected to reach nearly 40% by 2065, which will stretch the country's workforce beyond capacity. The work of the researchers featured here points to what Society 5.0 might look like.

KANAKO HARADA

Bionic builder

Kanako Harada is building a mannequin that mimics the inner workings of the human body. The 'bionic humanoid' offers a substitute for the use of cadavers and animal models in research and surgical practice.

The 41-year-old engineer at The University of Tokyo is one of 16 project managers appointed under a Japanese government initiative inspired by the United States Defense Advanced Research Project Agency (DARPA). ImPACT (Impulsing Paradigm Change through Disruptive Technologies) was launched in 2015 with a budget of 550 billion yen (US$5 billion) to back transformational ideas. Harada now leads a team of 150 researchers from Japanese and French institutions, companies and hospitals. Other ImPACT projects include a high-speed smartphone sensor that can detect hazardous molecules, bacteria, viruses, and air pollutants, and the ultimate efficient computer that only needs to be charged monthly.

The idea that robotic technology could mean better surgical outcomes has excited Harada since she first saw the da Vinci robotic surgical arm, designed by the Californian company, Intuitive Surgical. "It was like a dream come true," she says.

Surgeons have been using da Vinci for more than a decade to conduct minimally intrusive operations. Harada's team is developing similar robotic arms for sectioning and suturing the delicate tissue of the brain and eye. "No robots exist yet for this kind of surgery," says Harada.

Her two-armed system can precisely grasp a range of surgical instruments, including a 3.5-millimetre tip that slips through the nostrils like a snake to conduct microsurgeries. The goal of the three-year project, says Harada, is for her robots to achieve a level of accuracy and reach that humans cannot.

A prototype of a bionic eye developed by Harada's team has an inner membrane, several micrometres thick, which can be peeled using tiny metal graspers, the way surgeons would operate on an eye to improve vision. Ophthalmologists can also train using the model.

Harada hopes to see her surgical systems in operating theatres within the next decade.

NAOKI SUGANUMA

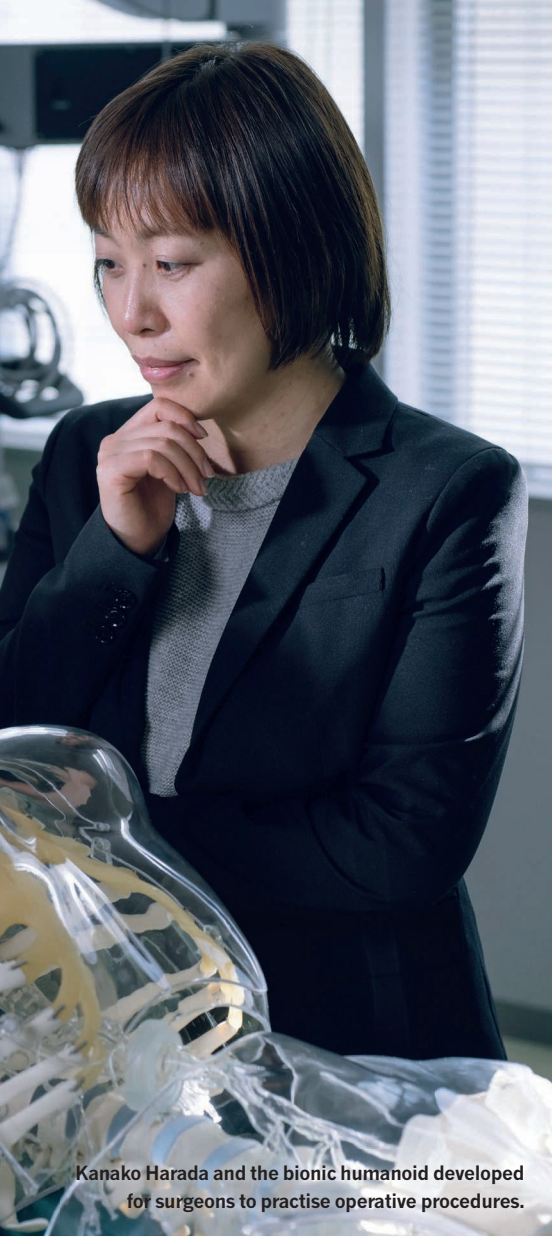
Test driver

Naoki Suganuma's laboratory has clocked more than 10,000 kilometres of autonomous driving — a distance roughly four times the length of Japan — in less than two years. Suganuma, a 42-year-old engineer at Kanazawa University, led the first Japanese tests of self-driving cars on public roads in February 2015. A Toyota Prius, fitted with Suganuma's satellite, radio, laser, and optical navigation system drove along busy urban streets and mountain roads, by day and by night. It was the first of many tests aimed at designing autonomous vehicles that could be used as a form of public transport.

"In 10 or 20 years, we could face a shortage of drivers," says Suganuma, referring to Japan's ageing population. The country became the world's first super-aged society in 2006, with more than one in five people above the age of 65. By 2065, that number is expected to rise to two in five.

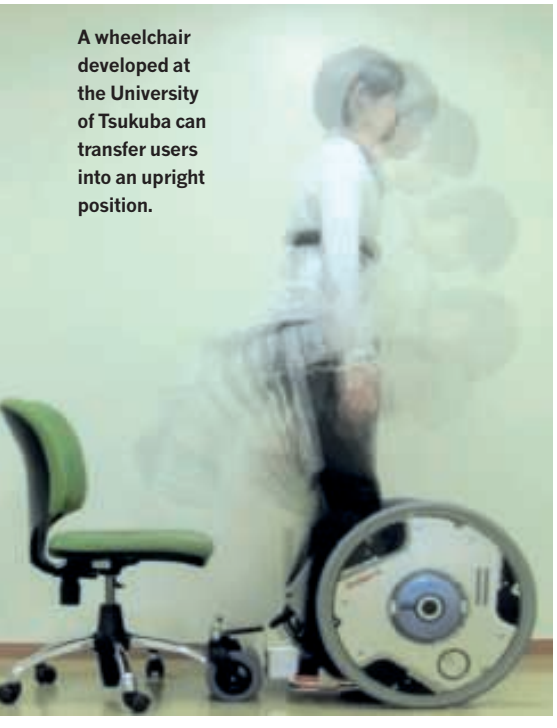
In the two decades since Suganuma started working on autonomous driving technologies, his laboratory has developed expertise in every aspect of the autonomous driving system, from the creation of digital maps, to perception, planning and control systems, and human–machine interfaces. It has also collaborated with many companies, including Toyota, Denso Corporation, and Sony.

For Suganuma, the most pressing problem is snow. In a white landscape autonomous



Kanako Harada and the bionic humanoid developed for surgeons to practise operative procedures.

IRWIN WONG



A wheelchair developed at the University of Tsukuba can transfer users into an upright position.

vehicles struggle to detect lines on roads, and distinguish roads from footpaths. His team is developing techniques to improve the positioning of vehicles along lanes in rainy and snowy conditions.

Thanks to the strong support of government for developing the technology, notably from the prime minister, Shinzo Abe, "Japan is the easiest country in the world to conduct public road tests of autonomous vehicles," says Suganuma. A strong automobile manufacturing base also gives it an edge in developing the complex systems needed to make effective self-driving cars, and compete with the United States and Germany.

Using data gathered from cars, says Suganuma, researchers in Japan could develop even more sophisticated artificial intelligence technologies. That is, he says, if companies agree to share their proprietary information for big-data mining. So far, car-makers have been reluctant to release their sensor data.

KENJI SUZUKI

Social enabler

Kenji Suzuki tries to see eye to eye with his research subjects, sometimes even literally. The physicist heads the Artificial Intelligence Laboratory at the University of Tsukuba. His multidisciplinary team, which includes computer scientists and electrical and biomedical engineers, as well as psychologists and philosophers, has designed a wheelchair that can transform into a roving platform. The mobility vehicle will allow people with lower-limb disabilities to meet people at eye height, seated or standing. "We don't design robots to replace people, we design robots to empower them," says Suzuki.

If all goes well, the vehicle will appear at the 2020 Paralympic Games in Tokyo. It is just one of the technologies that Suzuki's team is working on to enhance social interactions among people of diverse ages and physical ability. Other innovations include a technique for detecting facial expressions via the electrical signals generated by muscles, without relying on more overt visual cues that might not be as apparent in people with visual impairments or facial paralysis.

His team has also worked with hospitals to design a swallowing monitor. The artificially intelligent, horseshoe-shaped device wraps around the back of the neck to process sounds produced while swallowing. It can alert doctors, via a smartphone app, to any gulping errors, to head off the risk of pneumonia when food enters the lungs.

In 2015, Suzuki, 43, received funding from the Japan Science and Technology Agency for a start-up to bring the device to market. The company is expected to launch in April 2018.

With the Japanese government funnelling resources into Society 5.0, which prioritizes applied science and industry collaboration, Suzuki worries that young researchers under pressure to demonstrate value may not have the chance to cultivate ideas from basic research. "I was lucky," says Suzuki. "I spent 10 years developing these fundamental technologies, and now they are ready to transfer to society."

KENJI SUZUKI

NAGANO HIROFUMI

Blockchain developer

Cryptocurrency headlines can be terrifying for investors, from stories of people being locked out of millions of dollars' worth of bitcoins to hack attacks costing digital coin exchanges assets worth billions of yen. But researchers at Hitachi are developing technologies that could mollify investors' fears.

Blockchain, the technology that underpins cryptocurrencies, offers a way to execute financial transactions without an intermediary, such as a bank, at a significant saving of cost and time. In a blockchain system, transactions are accessed via private and public 'keys', made up of very long numbers. The problem, as the headlines attest, is that these keys are kept on personal computers or servers where they can be lost or leaked. Hitachi's system generates a digital signature using, for example, the unique vein pattern on the surface of a finger. Investors can access funds with the biometric key, which is harder for hackers to intercept. The technology, still in development, will "realize a secure and convenient blockchain system," says Nagano Hirofumi, a 44-year-old researcher at Hitachi in Tokyo.

Hitachi, the eighth-ranked corporate institute in the Nature Index, when assessed on its high-quality research relative to its total output in the natural sciences, began researching blockchain technology in 2015. Hirofumi and colleagues saw that blockchain's disruptive potential extends beyond the financial sector, even connecting industries using so-called smart contracts. "We can realize reliable and smart social infrastructure using blockchain," he says. Self-executing digital intermediaries could be used to set conditions in transactions; they might, for example, release funds deposited by a buyer only after receiving items from a supplier.

The challenge will be to design appropriate regulation. Information on blockchain platforms, including private data, is globally accessible. But many countries prohibit the export of such data, even if they are encrypted, says Hirofumi.

The Japanese government is discussing the possibility of a regulatory 'sandbox', he says. It would be a safe space in which to trial a framework, similar to those launched in the United Kingdom and Singapore, to encourage innovation in a controlled legislative environment. ■