PolyU 85th

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

PolyImpact

PolyU Inventions and Innovations that Benefit the World

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MESSAGE FROM THE PRESIDENT

IMPACTFUL INVENTIONS AND INNOVATIONS THAT BENEFIT THE WORLD

As PolyU marks its milestone 85th Anniversary this year, this book celebrates how the University has been harnessing its world-class research and knowledge transfer capabilities to make positive contributions — not only here on Earth, but even in space. Indeed, members of the PolyU community have developed groundbreaking solutions that may have seemed like science fiction long ago: A camera that works in extreme conditions on Mars, contact and spectacle lenses that can slow down the rate of myopia progression by around 60%, railway tracks that check themselves for cracks — these are just some of the stories that you will find in this book that demonstrate how PolyU is transforming the world around us.

We humans are unique in our ability to cooperate to find solutions to the many challenges that we face. That's why the University recently set up the PolyU Academy for Interdisciplinary Research (PAIR). PAIR brings together 16 research institutes and centres under one central research umbrella so that experts from different disciplines can collaborate and transform promising ideas into game-changing innovations. PAIR focuses on research in frontier areas such as artificial intelligence, carbon neutrality, deep space exploration, smart cities, smart energy, and many more. Thanks to PAIR, as well as the determined efforts of all PolyU researchers, PolyU will remain at the forefront of creating innovative solutions to the world's most pressing challenges.

Many universities nowadays attach a great deal of importance to entrepreneurship. Often, even the best research cannot make an impact unless someone has the vision, know-how and appetite to commercialise the technologies that they have developed. Some of the success stories in this book are start-ups that were set up by PolyU graduates: TOZI Innovations was founded by a School of Fashion and Textiles graduate, whose combination of technical expertise and business acumen enabled him to launch a successful company specialising in fashion fitting guided by artificial intelligence and 3D modelling. Other start-ups featured in this book have been established by PolyU academics and researchers: Vision Science and Technology makes soft contact lenses and spectacle lenses that are specially designed to slow down the progress of myopia in children.

PolyU takes pride in strongly supporting innovation and entrepreneurship. The University aims to nurture the next generation of entrepreneurs who aspire to use technology to create real societal impact. So far, PolyU's holistic innovation and entrepreneurship development framework has helped over 1,000 entrepreneurs and 450 start-ups at different stages of the entrepreneurial journey — from education, to ideation, to pre-incubation/incubation and acceleration for sustained growth.

For example, Hai Robotics is a young company founded by two PolyU engineering graduates with initial funding support from PolyU. Having developed the world's first Autonomous Case-handling Robot (ACR) system for warehouse automation, this unicorn is currently valued at around US$2 billion.

Over the following pages you can read about such stories and many more besides. We have presented each story in an easy-to-read format so that even non-experts can understand how PolyU is helping to solve real-world problems. Read the book from cover to cover if you want to know the full picture of how the University is fostering positive societal impact. Or read a particular chapter and marvel at an individual story of imagination and ingenuity. However you approach this book, I hope that you will feel as exhilarated as I do at how PolyU continues to be true to its motto: "To learn and to apply, for the benefit of mankind".

Professor Jin-Guang Teng
President
The Hong Kong Polytechnic University

PROLOGUE: HIGHLIGHTS OF THE IMPACT STORIES IN THIS BOOK

PolyU 85th

STORY NO.

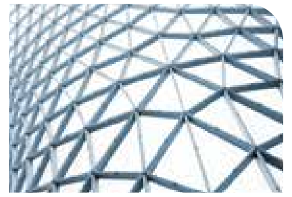
01
The Russian Space Agency ordered the Space Holinser Forceps for astronauts' use at their space station.

1995 – 2000

01
The Mars Rock Corer was used in the Mars Express Mission of the European Space Agency.

2001 – 2004

05
The second-order direct analysis with imperfections was adopted in the building codes of Hong Kong, the US and Europe.



09
The Nu-Torque technology and its industrial production method were developed to produce high-quality low-torque yarns.

11
Our research outcomes on Chinese language education were adopted or referred to in the public examination and school-based assessment in Hong Kong secondary schools.

08
The first arginine-depleting cancer drug (BCT-100) was developed.

06
The life-cycle optimisation and diagnosis technologies for energy saving in buildings were fully implemented in International Commerce Centre (ICC).

03
Structural health monitoring technologies were applied in long-span bridges such as Sutong Bridge, Stonecutters Bridge and Hong Kong-Zhuhai-Macao Bridge.

2005 – 2009

04
The optical fibre sensing technology for railway monitoring was adopted in SMRT, Singapore.

06
The life-cycle optimisation and diagnosis technologies for energy saving in buildings were implemented in an airport facility.

15
The world's first 3D ultrasound scoliosis assessment system, Scolioscan, was commercialised through PolyU academic-led start-up Telefield.

03
Structural health monitoring systems were installed in the Canton Tower in Guangzhou and the headquarters of Shenzhen Stock Exchange.

05
The second-order direct analysis with imperfections was adopted in the design of the Flower Dome and the Cloud Forest of the Gardens by the Bay in Singapore.

01/02
The Soil Preparation System was developed for the Sino-Russian Phobos-Grunt mission. The planetary remote sensing and mapping system as well as the Camera Pointing System were adopted in China's Chang'e-3 mission.

12
The nano-based indelible ink was applied in printing on the packaging of dairy products in Mainland China.

04
The world's first city-wide fibre optic sensing network was developed for monitoring train conditions in Hong Kong.

2010 – 2014

11
Our research outcomes on Chinese language education were again adopted or referred to in the public examination and school-based assessment in secondary schools after the introduction of the New Academic Structure (NAS).

16
PolyU start-up Hai Robotics was founded to provide state-of-the-art robotic warehouse solutions.

18
PolyU start-up BVP was set up to offer technology-enabled art experience to the visually impaired.

17
An AI-based 3D modelling technology was commercialised through PolyU start-up TOZI.

14
The DIMS and DISC lenses based on the myopic defocus technology were commercialised through collaboration with HOYA Corporation and through PolyU academic-led start-up VST respectively.

2015 – 2019

01/02
The planetary remote sensing and mapping system as well as the Camera Pointing System were adopted in China's Chang'e-4 mission.

15
The portable Scolioscan Air was launched.

08
Arginine-depleting cancer drug Pegtomarginase (or PT01) was licensed to Athenex.

03
Structural health monitoring systems were installed in the Shanghai Tower and the footbridge at PolyU campus.

05
The roof of the Spectacle at MGM Cotai, Macao, which was designed with the second-order direct analysis with imperfections, created a Guinness world record.

10
The neuromorphic vision sensor that emulates the retina's efficient compression of image data was introduced.

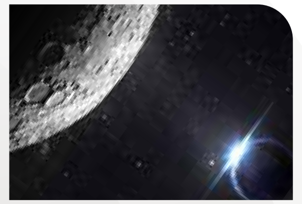
09
The Nu-Torque technology was commercialised and licensed to over 10 companies, and successfully applied to silk yarn spinning.

13
PolyU academic-led start-up Grand Rise was set up to commercialise the CareCoatex™ antimicrobial disinfectant coating.

17
PolyU start-up TOZI and Japanese conglomerate Itochu Corporation entered into a capital and business alliance.

2015 – 2019

01/02
The planetary remote sensing and mapping system as well as the Surface Sampling and Packing System were adopted in China's lunar mission Chang'e-5 and first Mars mission Tianwen-1.



13
PolyU academic-led start-up Grand Rise launched their disinfectant products. It won the Environmental Impact Award in JUMPSTARTER 2022 Global Pitch Competition, and was included in the "Forbes Asia 100 to Watch 2022" list.

08
Phase 1 clinical trial for arginine-depleting cancer drug Pegtomarginase (or PT01) began.

07
The sensors for tree monitoring were installed on 8,000 urban trees in Hong Kong. The smart tree monitoring system was transferred to the Tree Management Office of the Development Bureau.

16
PolyU start-up Hai Robotics launched the world's first Autonomous Case-handling Robot (ACR) system and gained the status of a unicorn.

11
The on-going C-for-Chinese@JC project created by The Hong Kong Jockey Club Charities Trust and co-created with other universities and NGOs has supported around 1,900 non-Chinese-speaking kindergarten students and their families.

From 2020

and many more to come...

01 NEW FRONTIERS NEW HORIZONS

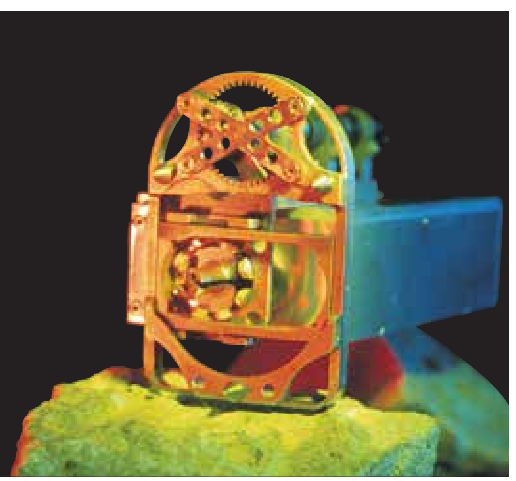
NEW FRONTIERS NEW HORIZONS

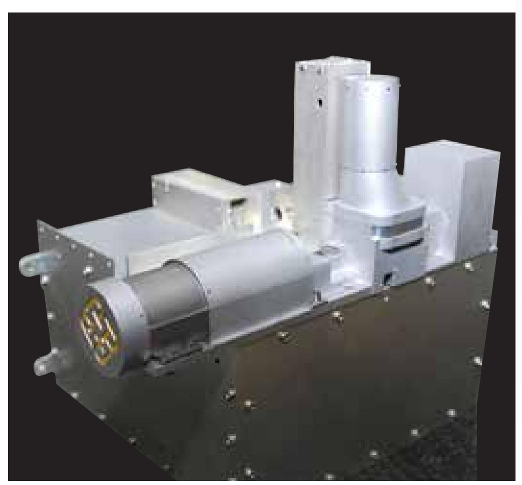
Aerospace technologies make exploration, discovery, and betterment of mankind possible

Humans are born to explore and push new frontiers. While such basic instincts can be fulfilled by trying out a new restaurant or travelling to a new destination, some of us are aiming for the stars, literally. Only by venturing outward into space can we gain valuable insights on how our planet works in totality. Our space expeditions have also led to the development of cutting-edge technologies that feed back into the economy and make our lives on Earth better. Many mod cons that we can't live without such as microchips in smartphones, GPS, satellite weather forecasts, solar cells and ultraviolet filters in sunglasses were all initially designed for use in space missions.

Written in the stars

Prof. YUNG Kai-leung, Chair Professor of Precision Engineering and Associate Head of the Department of Industrial and Systems Engineering, specialises in developing sophisticated instruments for deep space missions. His fascination with engineering dates back to the days when he was still a schoolboy — he made a photo developing machine for printing photos with found objects. In the 1960s, he developed a strong interest in precision engineering as he worked for a world-renowned precision engineering consultancy company in the UK. But it was not until his tenure at PolyU that he set foot in the realm of aerospace engineering.

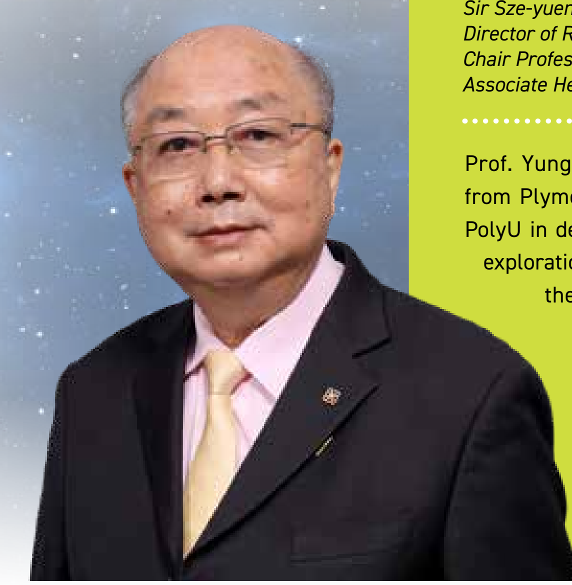




As early as 1989, Prof. Yung, together with a dentist friend, started to develop the Space Holinser Forceps, a precision gripping tool consisting of 70 inter-connectable components for space operations/missions. In 1995, the Russian Space Agency ordered the tool for astronauts to perform precision soldering on the former MIR Space Station. In 1997, he and his team started working on the Mars Rock Corer for the European Space Agency. The corer was onboard the Beagle 2 Lander during the Mars Express Mission in 2003. In 2007, Prof. Yung's team were commissioned to design a Soil Preparation System for the first Sino-Russian space mission to the Martian moon Phobos.

Contributions to China's space missions

As Hong Kong's first scientist to create instruments for China's space programme, Prof. Yung led the development of the Camera Pointing System used in the Chang'e-3 and 4 lunar



Prof. YUNG Kai-leung

Sir Sze-yuen Chung Professor in Precision Engineering
Director of Research Centre for Deep Space Explorations
Chair Professor of Precision Engineering
Associate Head, Department of Industrial and Systems Engineering

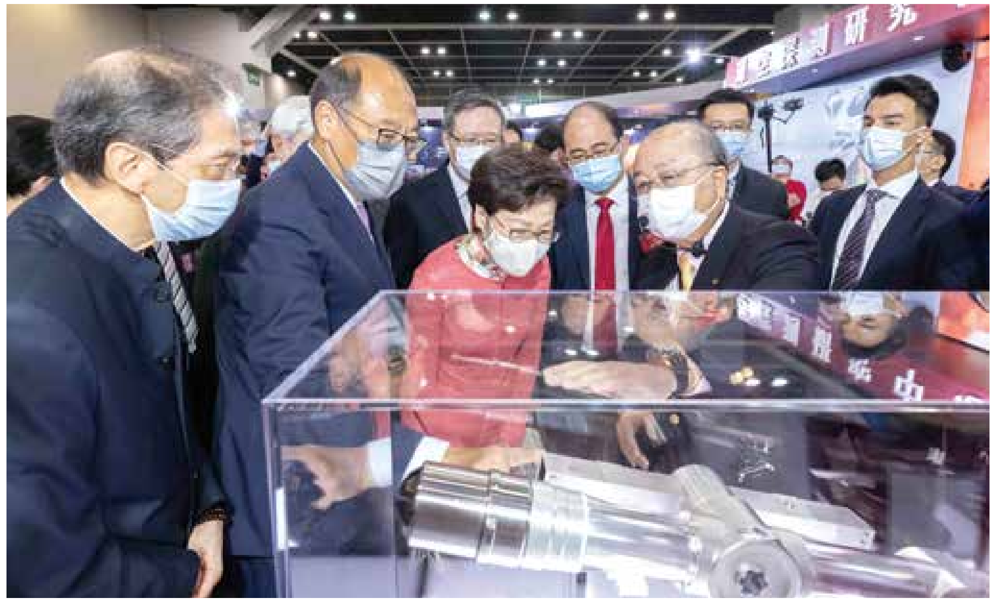
Prof. Yung received his PhD in microprocessor applications from Plymouth University in 1985. He has rich experience at PolyU in developing sophisticated instruments for deep space exploration missions, which include the Mars Rock Corer for the European Space Agency's Mars Express Mission; the Soil Preparation System for the Sino-Russian Phobos-Grunt Mission; the Camera Pointing System and the Surface Sampling and Packing System for China's Lunar Missions (Chang'e-3, 4, 5 and 6); and the Mars Surveillance Camera for the Tianwen-1 Mars Mission.

exploration missions in 2013 and 2019 respectively. Developed in collaboration with the China Academy of Space Technology (CAST), the system can provide precision motion 120 degrees vertically and 350 degrees sideways to capture images of the moon as well as the movements of the rover. It can withstand vast temperature differences and function reliably under one-sixth of the gravity on Earth.

In the third phase of China's Lunar Exploration programme, Prof. Yung led a research team and collaborated with CAST to develop the Surface Sampling and Packing

System for China's first mission to collect lunar samples and bring them back to Earth. The system, which was designed to collect around 2 kg of lunar regolith, was onboard the Chang'e-5 spacecraft in 2020. It will also be used on Chang'e-6, slated for launch in 2024.

Last but not least, Prof. Yung also contributed to China's first Mars mission Tianwen-1, which was launched in 2020. His team developed and manufactured the Mars Landing Surveillance Camera that monitored the landing status and the unfolding of the rover immediately after landing. Such information was critical to guide the Mars Rover successfully onto the Mars surface. The camera weighs only 390 g, but is strong and durable enough to withstand extreme temperature differences of 150°C during the nine-month journey between Earth and Mars, as well as the huge impact shock at landing — about 6,200 times the gravity on Earth.



Years of sweat and tears

Among all engineering endeavours, aerospace payloads involve the most stringent requirements in precision, efficiency and stability because of the extreme conditions they are subject to. They often take years to develop due to the countless technical challenges that need to be overcome. According to Prof. Yung, leanness is the core feature of instruments designed for space expeditions.

"Our task is to minimise redundancy in the design — to make the machines as small and light as possible without sacrificing performance and reliability. It takes hundreds of thousands of litres of fuel to propel a spacecraft beyond Earth's gravity. Every extra gram of weight that it carries adds to the launch cost and the risk of mission failure. So, we aim to achieve the highest strength-to-weight ratio using the optimal combination of materials and designs. We use theoretical calculations and simulation to minimise the machine structure to its bare essentials, and utilise the strength of its motion and its functional parts to double up as structural support."

From outer space to inner space

Not only do Prof. Yung's inventions navigate their way through the labyrinths of our body, but also those beneath our city. Given that underground water leakage wastes precious water resources, the Water Supplies Department of the HKSAR Government sought Prof. Yung's help to develop different types of in-line pipe robots to perform different tasks, including inspection, cleaning, and repairment.

Prof. Yung's pipe robots are equipped with retractable wheels that press against pipe walls so that it can defy the weights to climb upwards and go through tight 90-degree bends. It scans the thickness of pipe walls with ultrasonic probes, takes high-resolution photos and fixes defects with expandable epoxy stents, just like those used in balloon angioplasty. His pipe robots are the ultimate solution for proactive pipe care, so that underground water leakage of water pipes can be prevented.

Just as GPS and microchips were initially designed for space expeditions, Prof. Yung's aerospace inventions have also had a major impact on the betterment of human lives on Earth.

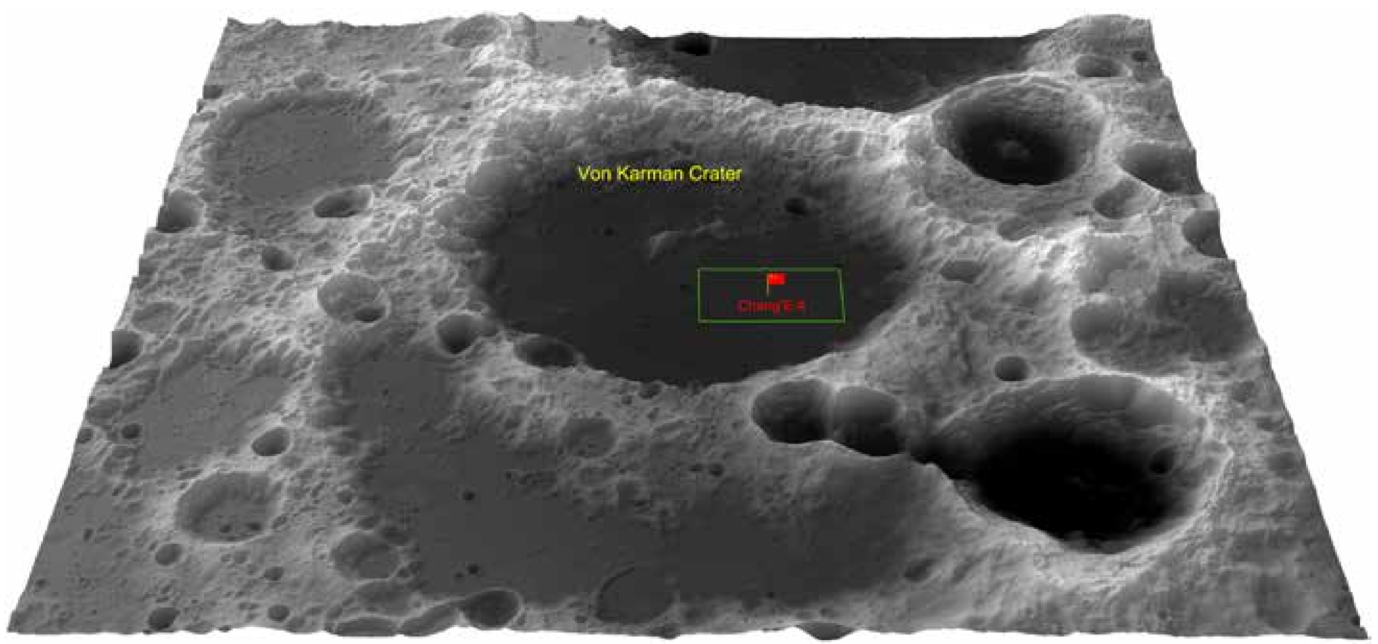
02 SEEING THE UNSEEN

SEEING THE UNSEEN

Remote sensing, multi-source data, computer vision and AI reveal surface details of the moon and Mars like never before

Jeff Bezos has been there. Richard Branson has been there. William Shatner, better known as Captain Kirk in the 60s sci-fi series Star Trek, has also been there. Humans are driven by our innate curiosity to explore the unknown. Seeing the Earth from space has proven to be a life-changing experience for astronauts. Scientists and scholars have been striving to see more of alien worlds not just to fulfil our curiosity, but also for the revolutionary scientific discoveries that our future generations can benefit from.

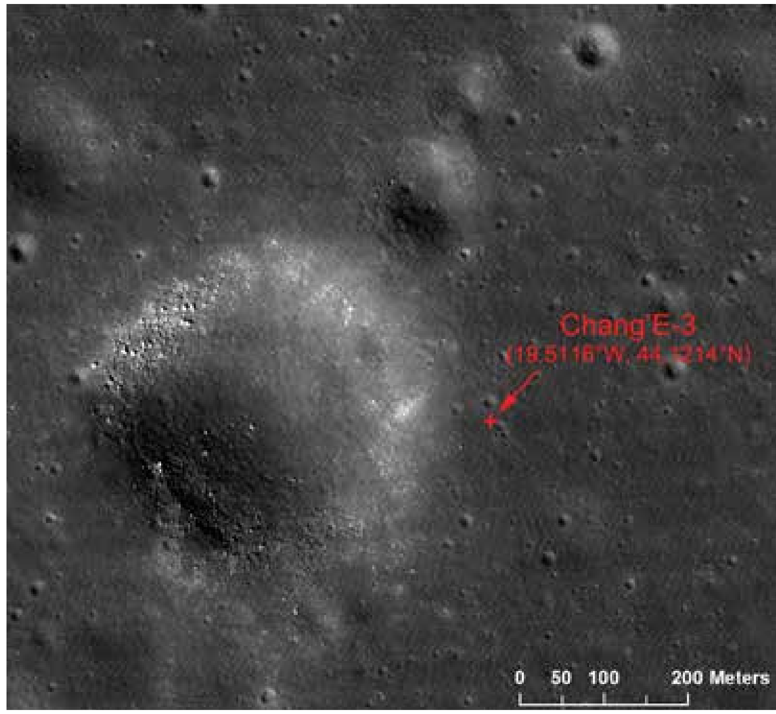
Spacecraft landing on planets and celestial bodies are especially important as they offer insights on how the universe works, the possibility of space colonisation, and space mining for minerals that the Earth is running out of. Just like any expedition on Earth, you need a good map for a landing mission. And for that matter, an accurate, detailed 3D map of the terrain is essential.



Trailblazing in the brave new worlds

Any planetary surface sloping more than 15 degrees could be dangerous to land a spacecraft on. Craters are very common features on celestial bodies and can be thousands of metres deep. Even rocks can be a hazard for landers and rovers. A spacecraft that lands in the wrong spot could be seriously damaged and unable to carry on its mission to explore the planet.

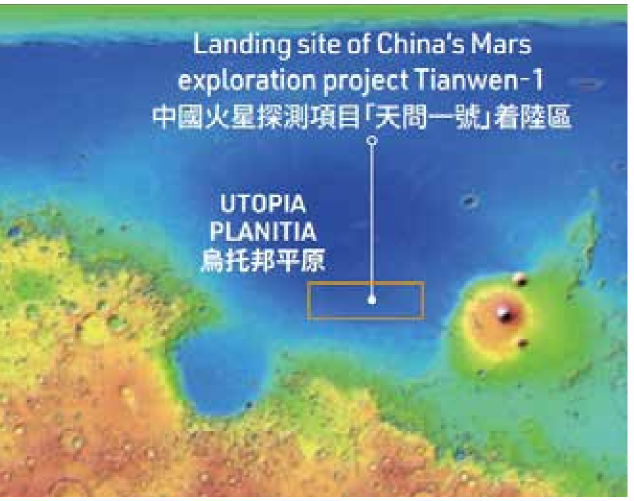
"That's why it's extremely important to choose a landing site carefully. A bad choice could damage the mission," explains Prof. WU Bo of the Department of Land Surveying and Geo-Informatics, who spearheaded a novel system that combines satellite images with laser scanning data from multiple sources across different platforms to render the 3D topography of planetary surfaces down to several centimetres.



Prof. WU Bo

Fiona Cheung Professor in Spatial Science
Associate Head, Department of Land Surveying and Geo-Informatics
Associate Director, Research Centre for Deep Space Explorations

Prof. Wu's main research area is planetary mapping and remote sensing. He worked as a postdoctoral researcher at the Ohio State University in the US from 2006 to 2009, and participated in NASA-funded projects for exploration missions to Mars and the Moon. Since joining PolyU in 2009, he has developed innovative 3D topographic modelling and intelligent geomorphological mapping techniques, and contributed to mapping and selecting the landing site for China's Chang'e-3, Chang'e-4, Chang'e-5 lunar missions, and the Tianwen-1 mission to Mars.



The China Academy of Space Technology has used Prof. Wu's planetary remote sensing and mapping system to evaluate landing sites, optimise orbit design, and improve surface operation on the Chang'e-3, Chang'e-4 and Chang'e-5 lunar exploration missions, as well as China's first Mars mission Tianwen-1.

Best of all worlds

Existing 3D mapping technologies include stereo photogrammetry and laser altimetry. Stereo photogrammetry uses two or more images taken from different positions (such as satellites) to measure the 3D topography of a surface. However, due to orbital and mission design, high-resolution photos of the same spot from two or more different angles are not commonly available. On the other hand, laser altimetry measures topographic heights and depths by sending laser pulses to a surface and analysing the reflected laser energy. Yet laser altimetry usually samples a large area with sparse measurements, so the result is usually low in resolution.

For high-precision and high-resolution topographic mapping, Prof. Wu developed a new 3D mapping model that incorporates information from various sources using different remote sensors and cameras across different platforms, including both images and laser scanning.

"It's a challenging job because different sensors have different configurations and spatial-temporal attributes. Their results are often inconsistent if not downright contradictory," explains Prof. Wu. But he managed to adjust the results from each source and combine them to synergetic effect to achieve the best accuracy. In order to pick a landing site for the Chang'e-4 mission, he modelled the lunar topography using images and laser scanning data collected by different satellites that orbit the moon to achieve the best result.

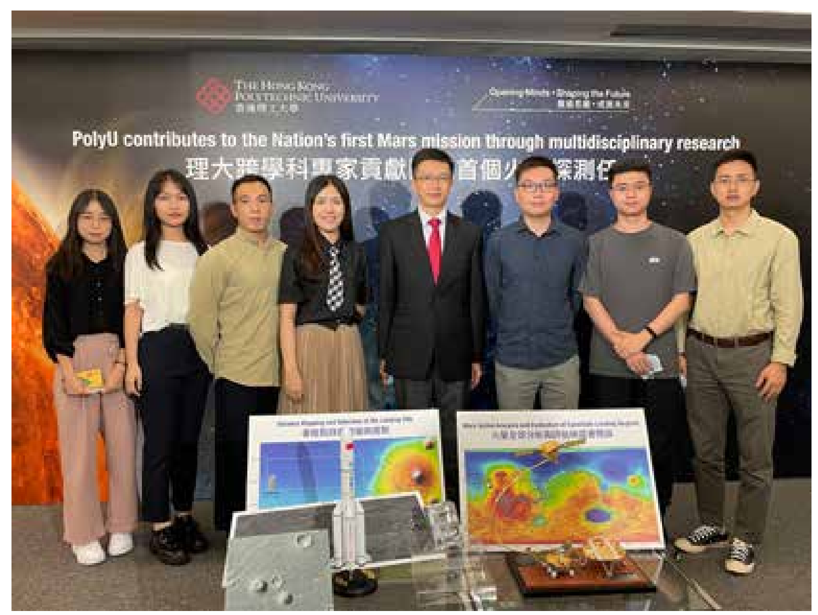
God is in the details

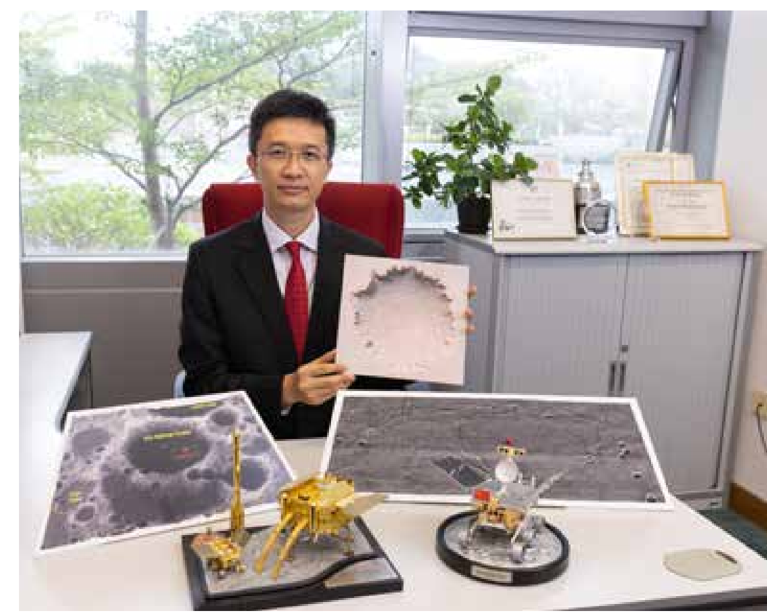
Multiple high-resolution images and laser scanning data give rise to inconsistencies that need much time and energy to reconcile. But having too few images and too little information can also be a problem. For locations on a planet where only one image is available, Prof. Wu uses photoclinometry to recover topographical details.

One of the key components in computer vision, photoclinometry estimates the gradient and shape of a terrain by analysing the shading information in a 2D image in relation to light direction and the reflective behaviour of the surface among other factors. Prof. Wu wrote a powerful algorithm that successfully reconstructs and preserves small features not shown in low-resolution models, such as small boulders and craters, to generate 3D models with a resolution as high as 1 cm/pixel.

Last but not least, artificial intelligence, namely active machine learning and deep learning, is employed to automatically detect and analyse geomorphological hazards such as rocks, craters, cones and dunes on a planetary surface. This can achieve 85% accuracy and greatly reduces the labour burden. It helps a lander avoid potential hazards for safe landing, and helps a rover travel safely on the surface.

Prof. Wu's high-precision, high-resolution remote sensing and mapping system enables us to see planetary surfaces in much greater detail than ever before, fuelling future spacefaring adventures as we address the question of our place in the universe, and usher in groundbreaking discoveries in science and engineering.





03 GUARDIANS OF THE GIANTS

Hong Kong-Zhuhai-Macao Bridge

GUARDIANS OF THE GIANTS

Structural health monitoring ensures the safety of large-scale infrastructure and architecture 24/7

Prevention is better than cure. Regular medical check-ups enable the early diagnosis of health issues so that the sick can be treated early before symptoms worsen and complications arise. This concept also lends itself well to megastructures such as bridges and skyscrapers: load-bearing structures age like humans do. The very fabric of these giants degrades naturally over time, compromising building strength. Experts thus strive to continuously monitor the structural condition and safety of megastructures for ultimate peace of mind.

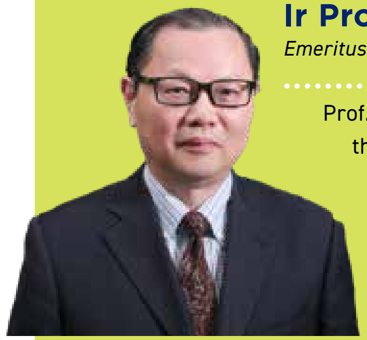
Led by Ir Prof. KO Jan-ming, Ir Prof. XU Youlin, Ir Prof. NI Yiqing and Ir Prof. XIA Yong of the Department of Civil and Environmental Engineering, the Structural Health Monitoring (SHM) team collaborated with scholars and researchers from the Departments of Electrical Engineering, Computing, Applied Physics, and Land Surveying and Geo-Informatics to develop smart systems that monitor the health of infrastructural and architectural wonders around the clock.

Tsing Ma Bridge

Ir Prof. KO Jan-ming

Emeritus Professor (Structural Engineering), Department of Civil and Environmental Engineering
Former Vice President (Research Development)
Senior Advisor, PolyU Research Institute for Sustainable Urban Development

Prof. Ko initiated and established the Structural Health Monitoring team in 1993. He co-chaired the Scientific Steering Committee of the State Key Laboratory on Structural Dynamics in Bridge Engineering in Chongqing, and was a Member of the Scientific Steering Committee of the State Key Laboratory on Disaster Reduction in Civil Engineering in Shanghai. He served as Editor-in-Chief of major peer-reviewed journals in structural engineering. He was the President of Asian-Pacific Network of Centers for Earthquake Engineering, Vice President of the International Society for Structural Health Monitoring of Intelligent Infrastructures (ISHMII), and Management Board Member of the Asian-Pacific Network of Centers for Research in Smart Structures Technology. Prof. Ko was inducted into the Hall of Fame of The Hong Kong Institution of Engineers (HKIE) in 2010. In 2011, he received the HKIE Gold Medal, and the Aftab Mufti Medal by ISHMII in recognition of his lifetime achievement in civil and structural health monitoring.



Ir Prof. XU Youlin

Emeritus Professor (Structural Engineering), Department of Civil and Environmental Engineering

Prof. Xu is a Fellow of Hong Kong Academy of Engineering Sciences (HKAES). He has written three scientific books, published over 310 SCI journal papers, and delivered more than 100 keynote or invited lectures at international conferences. He has been engaged in many high-impact knowledge-transfer projects, including health monitoring projects on the Tsing Ma Bridge and Stonecutters Bridge in Hong Kong, the CCTV Tower in Beijing, and the Shanghai Tower in Shanghai. He has received many prestigious awards, including the 12th Guanghua Engineering Science and Technology Award from the Chinese Academy of Engineering in 2018.

Ir Prof. NI Yiqing

Yim, Mak, Kwok & Chung Professor in Smart Structures
Chair Professor, Smart Structures and Rail Transit
Director, National Rail Transit Electrification and Automation Engineering Technology Research Centre (Hong Kong Branch)

Prof. Ni has published more than 250 SCI journal papers and over 330 conference papers. He is a recipient of the 2017 Structural Health Monitoring (SHM) Person-of-the-Year Award granted by the international journal Structural Health Monitoring. He is a Co-Editor-in-Chief of the *Journal of Infrastructure Intelligence and Resilience*, and of *Intelligent Transportation Infrastructure*. Prof. Ni also serves as an associate editor or editorial board member for ten other journals, including *Engineering Structures*, *Structural Control and Health Monitoring*, *Smart Structures and Systems*, and the *Journal of Civil Structural Health Monitoring*.

Ir Prof. XIA Yong

Professor, Department of Civil and Environmental Engineering

Prof. Xia is a Fellow of HKIE. He obtained his bachelor's and master's degrees from Huazhong University of Science and Technology, and his PhD from Nanyang Technological University. His major research area is monitoring the health of large-scale structures, including the Tsing Ma Bridge, Stonecutters Bridge, Canton Tower, Shanghai Tower and the Hong Kong-Zhuhai-Macao Bridge. He has co-authored five national standards and over 150 refereed journal papers. Prof. Xia has won the State Technological Innovation Award, HKIE's Structural Excellence Award, the Nishino Prize, and the Geneva International Invention Award.

Their portfolio includes, among many others, the Sutong Bridge and Jiangyin Bridge in Mainland China, the Tsing Ma Bridge and Stonecutters Bridge in Hong Kong, the Hong Kong-Zhuhai-Macao Bridge, the Canton Tower, and the Shanghai Tower — the tallest building in Mainland China as of 2022.

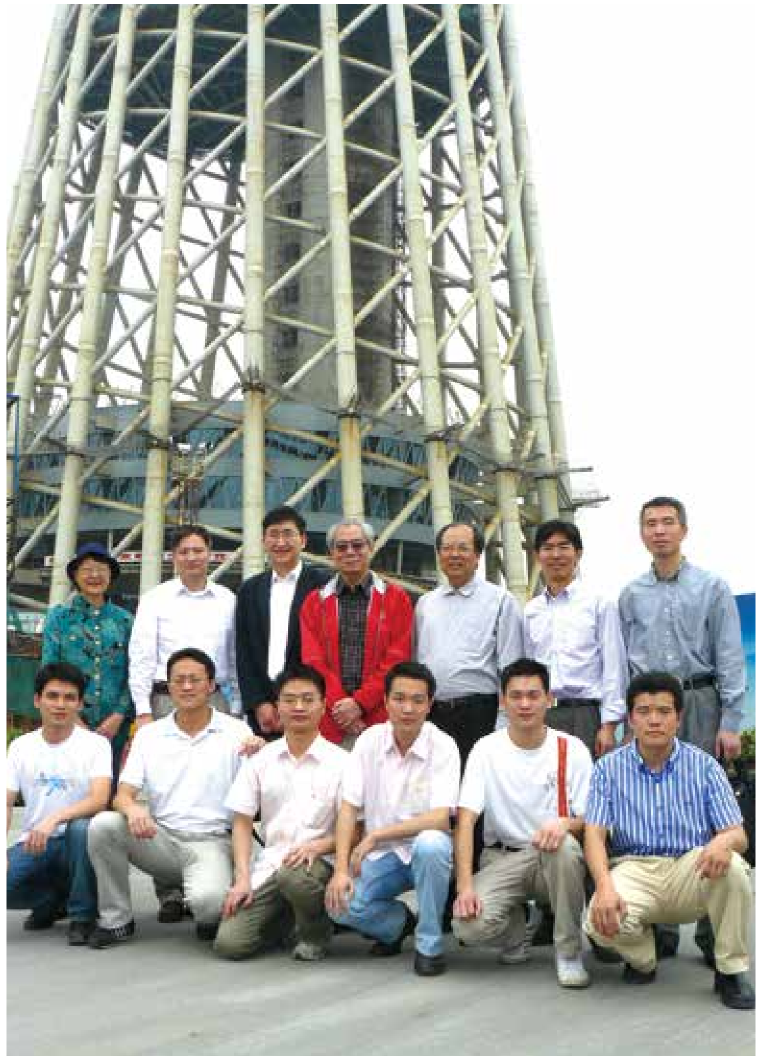
When seeing is not believing

Traditionally, engineers have used their eyes to check the health of structures, typically looking for defects such as cracks and spalling. However, in a megastructure, not all surfaces are accessible for visual inspection and invisible damage may develop deep under the surface. Visual inspection is also unable to measure the severity of a defect.

As a result, engineers have invented non-destructive methods to evaluate structural soundness using radiographs, optic fibres, x-rays, acoustic and ultrasonic waves, and by measuring vibrations. The SHM system uses many of these methods together with other advanced technologies.


Jiangyin Bridge


Sutong Bridge



Six modules of SHM

The team's SHM system uses a modular approach consisting of six modules. Engineers may integrate some or all of these modules into the system depending on the specific needs of a project. The first module is a sensory system, basically an array of advanced sensors. For the Canton Tower, a sightseeing landmark and a sky-scraping spire for TV and mobile phone signal transmission, 527 sensors were embedded in the fabric of the tower during construction. These include vibrating wire gauges for measuring strain and temperature, anemometers for measuring wind speed and direction, and digital video cameras and GPS for measuring displacement.

When the tower was completed, some 300 more sensors were installed, including fibre optic sensors, seismometers, accelerometers, inclinometers and wind pressure gauges, to monitor loading status, structural responses and environment effects. These sensors are especially useful during extreme events such as earthquakes and super typhoons.

The data collected by these sensors is sent to a computer via the second module — the data acquisition and transmission system. The third module then processes the data and provides system control, followed by the fourth module, which retrieves and stores the data and analyses the results. Finally, the structural health evaluation system provides diagnostic and prognostic analysis, while the inspection and maintenance system ensures the upkeep of all sensors and components.


Canton Tower

Spawning more research opportunities

Such data and results are not only vital for monitoring structural health post-construction, they also improve quality standards during construction while serving as invaluable raw material for further engineering and environmental research.

In the case of the Shanghai Tower, the in-construction SHM system helped the main contractor keep the accuracy of each floor's elevation within 5 mm, even though the original design specified a tolerance of 30 mm per floor. On the Hong Kong-Zhuhai-Macao Bridge, a National Observation and Research Station was established to collect data for further studies on environmental factors, material corrosion, and the structural safety of megastructures.


Shanghai Tower


Stonecutters Bridge

Always on the rails

Besides long-span bridges and super high-rise buildings, the SHM team also monitors the safety and structural health of railway networks. Railway operations are much more challenging to monitor than a bridge or a tower as tracks can extend for thousands of kilometres. The team made use of PolyU's proprietary Optical Fibre Sensing Technology to devise a system which lets engineers perform rail safety inspections remotely without time-consuming onsite visits and unnecessary service disruptions. The system can detect the status of various train components from afar in real time, enabling repairs to be scheduled before minor defects such as hairline cracks on bogies, wheels and rail tracks become worse.

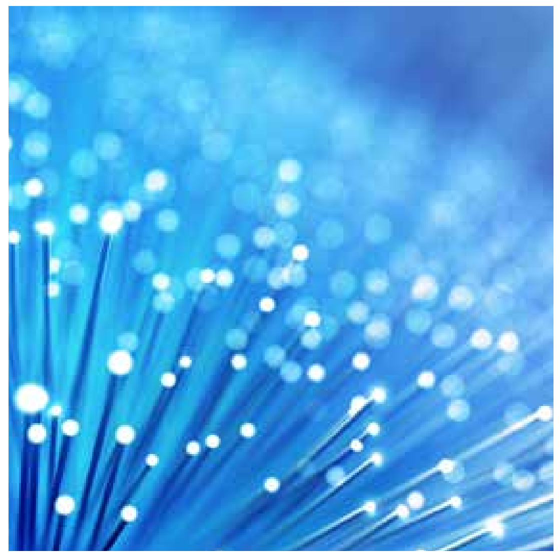
The self-sensing system was first used in the 2016 Rio Olympics, coupling ultrasonic guide waves via fibre optics with cutting-edge technologies such as power-harvesting smart sensors, the Internet of Things (IoT), cloud computing, and 5G wireless data networks. It is now a vital component of Hong Kong's Mass Transit Railway (MTR) system and many high-speed train routes in Mainland China, including the Beijing-Shanghai section. In future, the system will be deployed in all maglev trains in China and used in high-speed railways under extreme climate conditions, such as the section between Sichuan and Tibet.

With exceptional research and immense foresight, PolyU researchers protect the users of key infrastructure and architecture while fostering Hong Kong's status as a world-class centre for megastructure health monitoring and railway safety.

04 NO CRYSTAL BALL REQUIRED

NO CRYSTAL BALL REQUIRED

Optical fibre-based railway monitoring system predicts faults and prevents accidents



"If you were a superhero, what would your superpower be and why?" No, you're not reading a tabloid gossip column. This is a totally legitimate question to ask in formal job interviews these days — after all, even interviewers are entitled to a bit of fun, right? Precognition, the ability to see events in the future, might be one of the most popular answers because everyone is curious to know about the future, and maybe one can even prevent a disaster from happening by predicting it.

Prof. TAM Hwa-yaw from the Department of Electrical Engineering and his research team may not have superpowers, but they have prevented a potential derailment, and predicted various faults in train networks in the Netherlands, Australia, Singapore and India. How did they do that?

"The key is optical fibres that can act both as sensors and data transmission thoroughfares at the same time, enabling real-time monitoring of train, track, wheels and powerline conditions. With machine learning and big data analytics, we can accurately predict the defects and failures of critical train components in advance and schedule timely maintenance and repairs," says Prof. Tam.

Fibre Bragg grating (FBG) sensors

Hongkongers are no strangers to optical fibres, as most of us have high-speed optical fibre internet in our offices or at home. Based on the principle of total internal reflection, optical signals travel along an optical fibre at about 70% of the speed of light. But how does a glass fibre act as a sensor? "Layers of glass with higher and lower refractive indices are alternately created inside the core of an optical fibre. This periodic structure, typically 5 mm long, is called a fibre Bragg grating (FBG). It acts as a wavelength selective mirror that reflects only light of a certain wavelength, but lets the remaining light pass through," explains Prof. Tam.

When subject to pressure or vibration, FBG changes its period and refractive index. When it does this, it reflects light of a different wavelength. Thus, by analysing how the wavelength of the reflected light changes, FBG can be used as a sensor to detect defects and developing faults in the surrounding areas.

Prof. TAM Hwa-yaw

Chair Professor of Photonics, Department of Electrical Engineering
Associate Director of Photonics Research Institute

Prof. Tam is an IEEE Fellow, an OSA Fellow, and winner of the prestigious 2014 Berthold Leibinger Innovationspreis Prize for his Laser Sensing Technology contribution in railway monitoring. Prof. Tam conducts research in industrial IoT fibre sensor technologies for several industries. He has developed railway monitoring systems for about 10 countries, including the world's first city-wide sensing networks in Hong Kong and Singapore. Currently, he is collaborating with Collége de France, and Norwegian University of Science and Technology (NTNU), Norway, on the development of an IoT battery monitoring platform, and working with Melbourne University and the Royal Victorian Eye and Ear Hospital on smart cochlear implants. His research interests also include IoT optical fibre sensing networks for bone healing monitoring and robotics skin applications.

Passive sensors off the grid

"When there are minor irregularities, say, on a rail track or the wheels of a train car, the FBG sensors can pick up the vibration signatures. Over time, a huge volume of such data can be used for the development of the fault models to predict faults months before they happen." Better still, FBG sensors don't need electricity to operate, and thus don't interfere with nearby electric circuits and aren't affected by lightning. Hundreds of FBG sensors can be put on one single optical fibre as long as 100 km in length, making it the perfect solution for detecting potential faults in extensive rail networks over long distances.

So far, the team has developed different kinds of FBG sensors for different parameters, such as temperature, strain, inclination, level and magnetic field strength. "Currently, scheduled inspections and maintenance of tracks and trains are conducted during non-traffic hours. This has proved to be ineffective and expensive as train systems are running longer hours than ever. The trend is to conduct maintenance according to conditions, not according to schedules. Our optical fibre-based monitoring and prediction system is a great way for train operators to monitor the real-time condition of critical components without any disruption to services," says Prof. Tam.

Counter-checking sub-systems

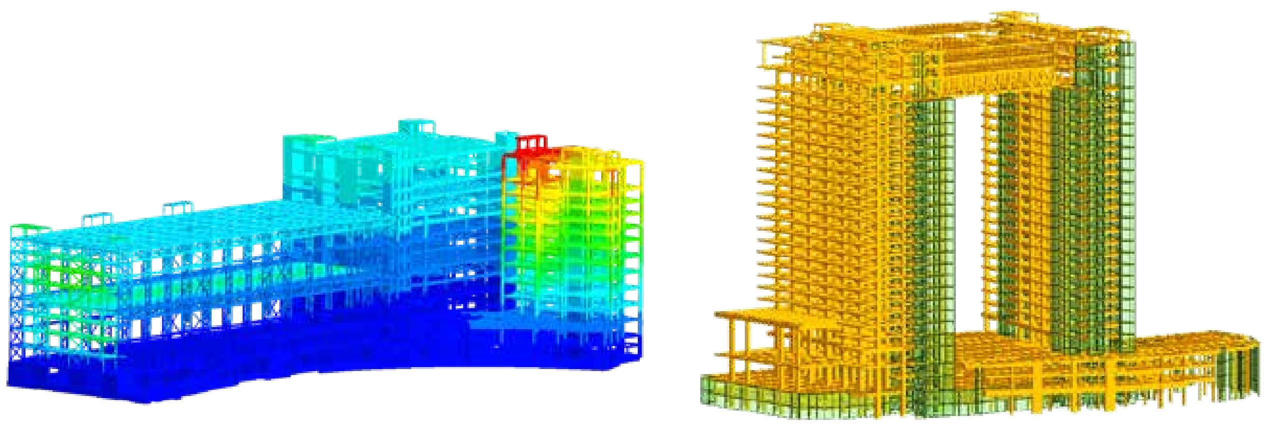
Besides using optical-fibre sensors attached to the track to monitor a train system, the team also uses in-service trains as inspection vehicles. The same sensors are also installed in running trains so that the two sub-systems can counter-check each other during traffic hours to make sure that they are functioning properly, and that the data collected are reliable. "It's like the trains are monitoring the tracks and powerlines, while the tracks are also monitoring the trains," Prof. Tam adds.

After more than fifteen years of research and development, the team's optical fibre-based railway monitoring system is currently used in Hong Kong's Mass Transit Railway (MTR) and Singapore's Mass Rapid Transit (SMRT) networks, safeguarding a combined total of 8.8 million passengers daily.

05 PROTECTING LIVES AND PROPERTY

PROTECTING LIVES AND PROPERTY

Advanced structural analysis greatly improves structural safety and reduces wastage of building materials



Gladiator fights in the ancient Roman Empire were probably one of the most brutal spectacles in human history. But the deadliest gladiator event was not the result of fatal combat between fighters; it was caused by an amphitheatre that collapsed and killed 20,000 spectators and by-standers. The structural failure of buildings and infrastructure can lead to severe physical injuries, loss of life and major financial losses.

Structural safety: a matter of life and death

When a structure is subject to stress, such as heavy loading, strong winds, or an earthquake, its structural parts move and change shape. When the load is greater than what the structure can bear, it fails and collapses. To ensure safety, engineers must calculate how big the load-bearing parts (such as beams, columns, walls and slabs) need to be to provide enough strength. In the last century, this was calculated by assuming a linear relationship between load and displacement, and then checking the possibility of failure with the coarse effective length method — a method known as first-order linear structural analysis.

However, first-order linear structural analysis was not realistic because a structure can no longer bear weight linearly as it deforms. That's why Ir Prof. CHAN Siu-lai of the Department of Civil and Environmental Engineering championed a new method of structural analysis known as second-order direct analysis with imperfections, or SODA, to predict the non-linear behaviour of structures. The result enhances reliability and safety while saving the cost of unnecessary building materials.

Effective length: a century-old concept

The effective length of a structural part is defined as the distance between its points of inflection. In a column supported by beams at both ends, the effective length is approximately the distance between the two restraining beams. The shorter the effective length of a structural part, the bigger its load-bearing capacity. In other words, if all variables are kept the same (i.e. the beam and columns are of the same material, cross section, thickness, etc.), a shorter column supported by two beams closely placed together can bear more weight than a longer column supported by two beams placed further away from each other.

The weakest point of a column is the point furthest away from the supports, meaning the centre of the column in this case. When the load on the column exceeds its weight-bearing capacity, the column is likely to buckle at the centre, sagging outward. It makes perfect sense so far, provided that all structures are rectangular blocks built with beams and columns. This approach was used in the past century until the day when SODA was introduced.

Ir Prof. CHAN Siu-lai
Retired Chair Professor in Computational Structural Engineering, Department of Civil and Environmental Engineering

Ir Prof. Chan was Chair Professor in Computational Structural Engineering at PolyU until he retired in 2022. His research interests include the stability analysis and design of steel; composite and concrete structures; nonlinear finite element analysis; glass and slender skeletal structures; steel, rock and flood barriers; bamboo and aluminum scaffolding; and pre-tensioning structures. He has received numerous awards from PolyU, from the education ministry of Mainland China, and from The Hong Kong Institution of Engineers' structural and geotechnical divisions for his research, technology transfer, and industrial design projects.

The era of unorthodox architectural forms

As construction technologies advance and new structural materials emerge, developers and architects also become more ambitious in making a statement with organic shapes and unconventional forms. It can be extremely difficult to calculate the effective length of a specific part in a freeform structure. Rafters in long-span shallow dome roofs, for instance, have parts that cannot be classified as either beams or columns.

Prof. Chan explains, "The problems with the effective length approach is the need to make many assumptions at the outset. An engineer has to assume where the weakest point is in a structural part and how it will buckle in times of failure. Of course, it's not a difficult job when working with textbook examples with frames made of a few members. But in the real world, an organic-shaped structure can consist of tens of thousands of structural parts with awkward angles and curvatures. Making accurate assumptions about each of them becomes very difficult or even infeasible."

Worse still, in the conventional first-order linear analysis, the design stage does not allow for imperfections. Stability checks are performed based on an engineer's experience after the initial design. For uncommon structures with a complicated buckling mode, even an experienced engineer may not be able to tell exactly which parts of the structure bear the biggest load and how they might buckle in times of failure. To play safe, an engineer tends to strengthen all parts of a structure unnecessarily, leading to additional construction cost and wastage of building materials.

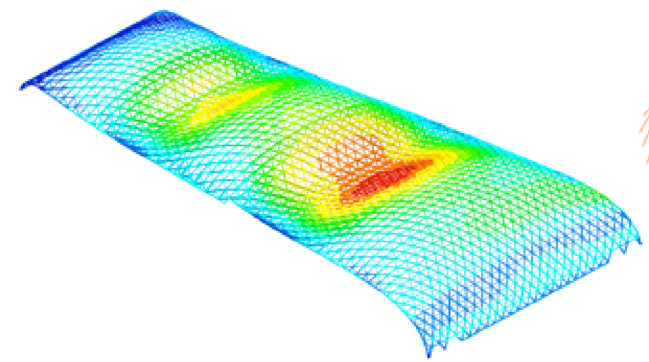
Second-order direct analysis (SODA)

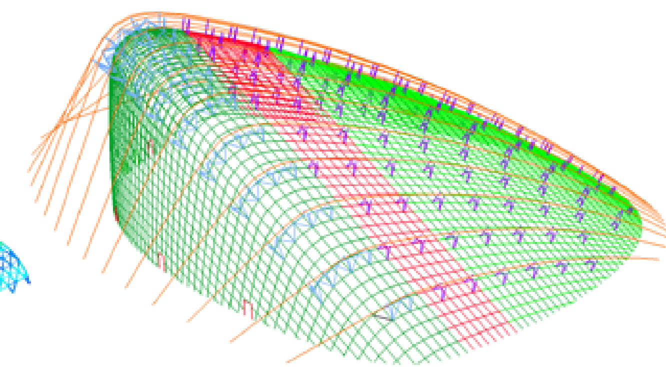
As early as in 1984, when Prof. Chan was still a PhD candidate, he felt the need to develop an analysis system for structural design that would predict the nonlinear behaviours of structures. Scientists had long been discussing the nonlinear behaviours of materials, but Prof. Chan was a pioneer in successfully applying nonlinear theories to the practical construction of buildings and structures. After years of research, and publishing hundreds of academic papers, SODA has been adopted in the building codes of many countries and territories since 2005, including the Code of Practice for the Structural Use of Steel in Hong Kong, the Specification for Structural Steel Buildings in the US, and the European standard Eurocode 3: Design of steel structures. SODA also appeared in the Code for Design of Steel Structure in China, GB 50017, in 2017.

The Spectacle at MGM Cotai, Macao

Protecting end-users and construction workers

To put it simply, SODA is a holistic simulation of a structure under various conditions, such as earthquakes, hurricanes, and gravitational loads, considering all possible imperfections at the outset. With this method, an engineer no longer needs to calculate the effective length of any specific structural part, or prescribe design rules for buckling strength checks. The structure is considered as a whole so that there's no need to design an individual part at all. Engineers no longer need to conduct stability checks as an afterthought, or unnecessarily strengthen all structural parts just to be on the safe side.





"SODA accurately reflects the true behaviour of a structure, including the temporary and permanent structures after completion and the temporary support system during construction. This protects the safety not only of end-users, but also construction workers at construction stage," says Prof. Chan.

Based on SODA, the team developed analysis software known as NIDA, an abbreviation for Nonlinear Integrated Design and Analysis, which is widely used by engineers in Mainland China, Hong Kong and Taiwan, as well as Australia, Greece, Singapore, Ireland and the UK. For instance, in the roof of the Spectacle at MGM Cotai in Macao, the use of SODA saved hundreds of tons of structural steel, yet the structure — the holder of the Guinness record for the world's largest free-span gridshell glazed roof (self-supporting) — was safer and more stable as a result. In collaboration with the National University of Singapore, Prof. Chan's team has also applied SODA in designing the iconic roofs of the Flower Dome and the Cloud Forest at Marina Bay, Singapore.

The Flower Dome and the Cloud Forest, Singapore

06 MAKING BUILDINGS SMARTER AND GREENER

MAKING BUILDINGS SMARTER AND GREENER

Smart central air conditioning technologies lead to steep cuts in energy consumption in buildings throughout their life-cycles

"Smart" is one buzzword that always catches public attention. Our phones are smart. Our cities are smart. And of course, our buildings are only smart when they are energy efficient. In Hong Kong, over 90% of electricity is consumed by buildings, and central air conditioning accounts for more than 50% of total energy consumption in commercial and industrial buildings. However, poor efficiency of air conditioning systems due to improper or obsolete design, operation, control and maintenance means that much of the energy is wasted.

To boost the overall energy efficiency of commercial and industrial buildings, Prof. WANG Shengwei of the Department of Building Environment and Energy Engineering led a research team to formulate all-round optimisation strategies that enhance the energy performance of buildings in general, and of air conditioning systems in particular.

International Commerce Centre

Holiday Inn Express Hong Kong SoHo
Source: Hong Kong Green Building Council Limited

Optimised design — probabilistic approach

Central air conditioning systems are complex and gigantic in scale. In a perfect scenario, an air conditioning system functions best if its energy efficiency is optimised throughout its life cycle, meaning from its design and conception stage, to its operation stage. Prof. Wang's team uses a probabilistic approach in the design stage to simulate and predict the cooling load, operating conditions and reliability of the air conditioning equipment.

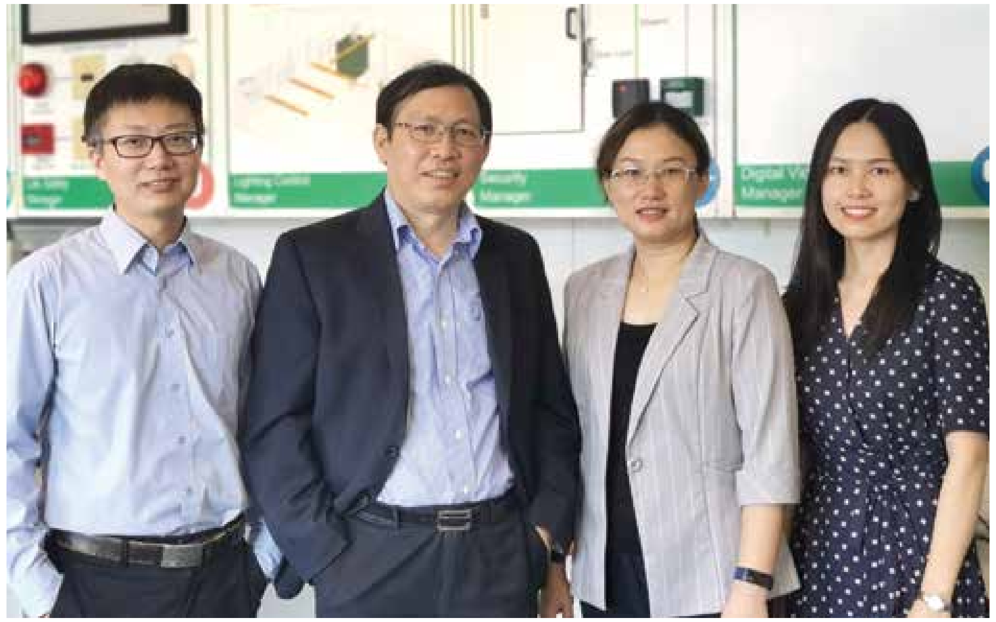
"The common practice is to design chiller plants based on peak cooling loads, but they only need to run at full load a few days each year. That means for the rest of the year, the chiller plants are oversized and much energy is wasted as a result. Our approach considers each factor affecting the energy efficiency and performance of an air conditioning system as a probability distribution. How these factors interact with each other under different circumstances can be predicted and addressed in the design stage. That helps us design chiller plants with an optimal configuration and size," explains Prof. Wang.

Optimised commissioning — adaptive balancing

Traditionally, the design of a central air conditioning system is tuned to certain specific conditions or balance points, but the actual system characteristics may differ significantly when it is in operation. Prof. Wang thus includes different operation options in his design solutions to allow flexibility.

Ir Prof. WANG Shengwei
Director of Research Institute for Smart Energy
Chair Professor of Building Energy and Automation
Otto Poon Charitable Foundation Professor in Smart Building

Prof. Wang is a fellow of IBPSA, CIBSE and HKIE. His research expertise covers building energy and automation systems, particularly the optimal design and control of building systems, diagnosis and commissioning, and energy-flexible and grid-responsive buildings. He was one of the top 150 highly-cited scholars worldwide in Energy Science and Engineering in 2016 (Clarivate Analytics) and was ranked 20th worldwide in Building and Construction in 2021 (Stanford analysis). He is very successful in securing research grants and in collaborating with industry to save energy in buildings.



"For example, instead of building one bigger pump of 100% required capacity, we build three smaller pumps that add up to the same capacity. That gives the leeway of running one to three pumps according to the actual need. When the cooling demand is low, the system may choose to turn off one or two small pumps to save energy." This is called adaptive balancing between performance and energy cost. In an application case, the probabilistic chiller design with coordinating pump design resulted in a 41% reduction in energy consumption[1].

Optimised diagnostics — automated troubleshooting

In the operation stage, one important measure is fault diagnosis as components may fail over time leading to performance degradation. Components also need to be cleaned or tuned up from time to time for high efficiency. Thus, Prof. Wang's team devised a system to check where the fault is when an air conditioning system is not performing optimally, and to fix the problem as soon as possible. In newer information-super-rich buildings with built-in IoT sensors and building automation systems that collect a bulk volume of data every day, the team deploys big data analytics to locate the problem quickly and accurately. But even in older information-poor buildings where very little data is available, the team may still be able to deeply analyse energy use at whole building level to locate the pain points that lead to wastage.

[1] Hangxin Li & Shengwei Wang (2020) A systematic and probabilistic approach for optimal design and on-site adaptive balancing of building central cooling systems concerning uncertainties, Science and Technology for the Built Environment, 26:7, 888-900, DOI: 10.1080/23744731.2020.1776068

Optimised control and demand responses — for smart grids and more

Renewable energy is desirable, but green sources such as solar energy and wind energy are intermittent in nature. Experts have been finding ways to build smart grids where consumers and producers can communicate to flexibly alter their energy consumption and supply patterns for less wastage and higher efficiency. Besides various optimal control strategies that enable air-conditioning systems to operate at high energy efficiency, Prof. Wang has also been developing grid-responsive building technologies to optimise interoperation with future smart grids.

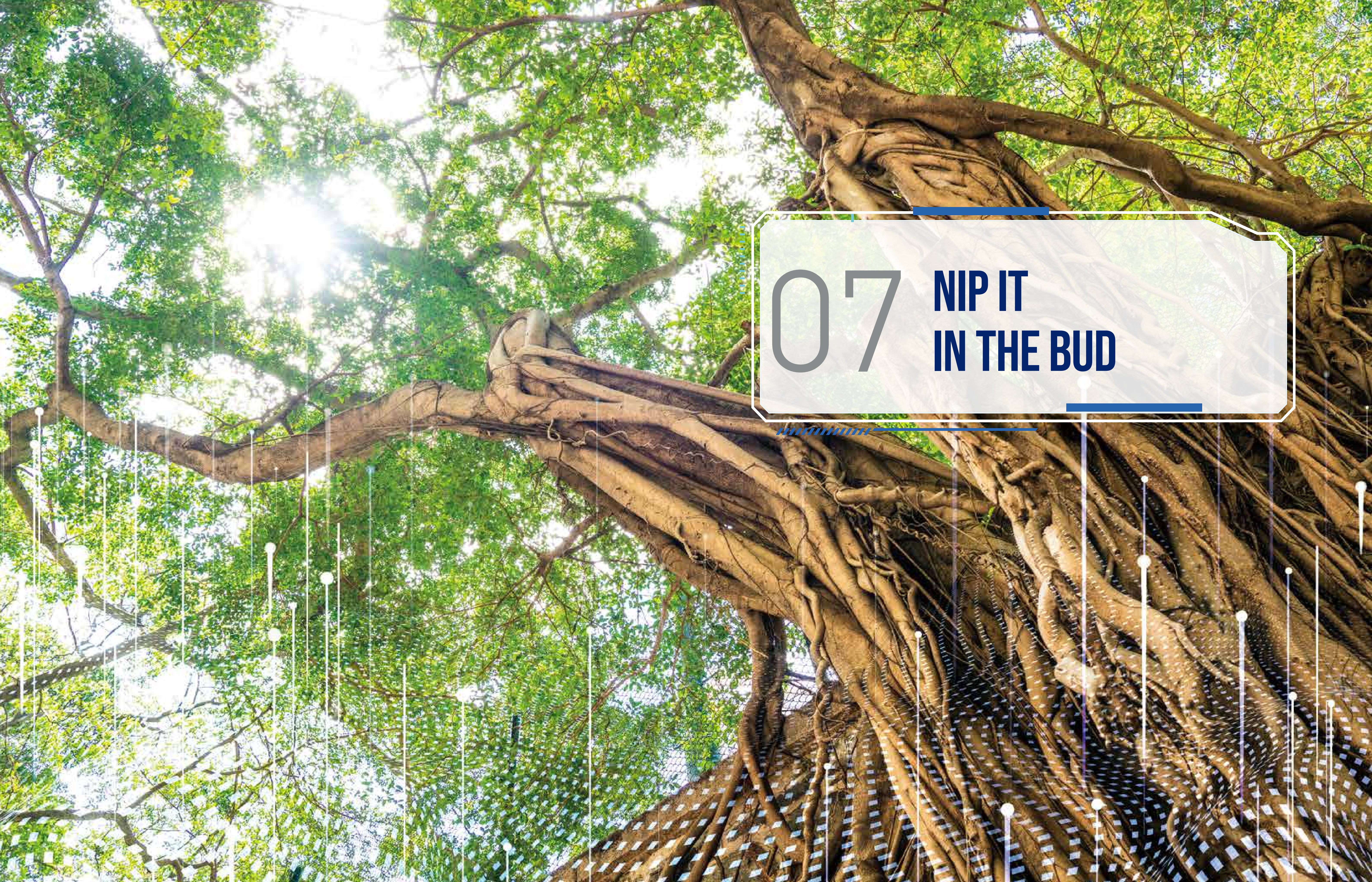
"A grid-responsive building lets the power users and suppliers work in synergy to maintain a balance between demand and supply. The key is to encourage users to consume less power when the grid is short of generation and consume more when generation is sufficient," says Prof. Wang. For instance, when suppliers foresee a drop in, say, solar energy in the coming 48 hours, they notify users, who can store energy before this happens. Or, when a heatwave is expected to arrive in a few days, users may store more energy ahead of time to run their air-conditioners. And yes, in future, there may be some kind of energy storage device in every home.

Saving millions of kWh of electricity each year

For over ten years, Prof. Wang and his team have been conducting consultancy projects for both public and private clients to optimise the air-conditioning systems for various kinds of premises such as commercial complexes, shopping malls, hotels and the production buildings of bio-medicine companies. Among these buildings are household names including International Commerce Centre (ICC) and Holiday Inn Express. The energy efficiency of these buildings has been greatly enhanced, saving millions of kWh of electricity each year, equivalent to millions of dollars in electricity bills.

The latest version of these technologies, namely smart, energy-efficient and energy-flexible building technologies, are currently being implemented and demonstrated at a new super-large commercial complex in West Kowloon, which is being developed by a major property developer in Hong Kong.

07 NIP IT IN THE BUD



NIP IT IN THE BUD

Smart Monitoring System for Urban Tree Management ensures public safety and improves urban resilience

Trees are valuable assets beloved by city dwellers. They are the lungs of the cities, producing oxygen and absorbing carbon dioxide. They provide shade and cool off our cities. They stabilise slopes and prevent soil erosion. They are also mentally soothing

to look at. However, pests and diseases as well as weather events such as typhoons and heavy rainfall can threaten urban trees. The risk of falling trees needs to be closely monitored, especially in a densely populated metropolis like Hong Kong.

Extreme weather and tree health

In September 2018, super typhoon Mangkhut wreaked havoc territory-wide and toppled tens of thousands of trees. More than 1,000 roads were blocked by the debris, paralysing public transport. As climate change happens, extreme weather events like super typhoons and floods are expected to become both more intense and more frequent. The need to monitor urban tree health and stability is thus more pressing than ever for public safety and urban resilience.

It was against this background that Sr Prof. Charles WONG Man-sing from the Department of Land Surveying and Geo-Informatics collaborated with The University of Hong Kong, The Hong Kong University of Science and Technology, and Friends of the Earth (Hong Kong) to develop a smart system to monitor the tilting angles of the city's trees.

The result is not only an advanced warning system of potentially dangerous leaning trees, but also a tool for in-depth studies of how various factors affect tree stability. The data collected over time will be of paramount importance to devising holistic strategies to manage urban trees.

Sr Prof. Charles WONG Man-sing

Associate Dean, Faculty of Construction and Environment
Professor, Department of Land Surveying and Geo-Informatics

Prof. Wong received his BSc, M.Phil. and PhD from PolyU, in 2003, 2005 and 2009 respectively. His areas of research include remote sensing, geographic information science, the internet of things, and geomatics technology. He has received funding support from the UGC Teaching and Learning Funding Scheme, the Collaborative Research Fund, the General Research Fund, the Environment and Conversation Fund, the Construction Industry Council Research Fund, the Public Policy Research Funding Scheme, the Hong Kong Jockey Club Charity Trust, and the HKSAR Government.

For the love of it

In 2003, when Prof. Wong was working towards his Master of Philosophy degree, he studied the use of remote sensing imagery in vegetation mapping. For research purposes, he had to hike extensively in Shing Mun and Tai Mo Shan Country Parks to map out the vegetative habitats. "It was physically demanding, but the experience provoked my interest in nature and trees," he says.

Then in 2017, Prof. Wong had the chance to take part in the first annual forum of the University-Government-Industry Consortium for Sustainable Urban Development hosted by PolyU's Research Institute for Sustainable Urban Development (RISUD). There he met the Head of the Greening, Landscape and Tree Management Section of the Development Bureau of the HKSAR Government. They exchanged some ideas about tree management that later became part of the three-year pilot scheme funded by The Hong Kong Jockey Club Charities Trust.

AI, smart sensors, GIS and big data

Leveraging artificial intelligence, smart sensor technology and a geographic information system (GIS), Prof. Wong's Smart Monitoring System for Urban Tree Management uses tailor-made wireless sensors attached to the lower part of tree trunks. The sensors detect the tilting angle of each tree with a built-in accelerometer. Data are regularly sent to a remote cloud server for processing and analysis. When a monitored tree tilts beyond the tilt threshold, the system notifies the user on three levels — Alert, Alarm and Action. Arborists and tree workers may then examine the tree without delay.

Towards holistic tree management

The system is not limited to monitoring trees and intervening early to prevent potential falls. The GIS-based platform can also collect environmental data associated with a tree, including aspect, topography, proximity to pedestrians and traffic, rainfall, wind speed, and wind direction.

This information can be analysed further using big data analytics to explore how these attributes contribute to tree tilts or falls. "When we have accumulated enough information, we will be in a better position to advise which trees need more diligent care and monitoring. Policymakers can also devise a holistic urban tree management strategy that takes all factors into account, informing the future design of the urban landscape," says Prof. Wong.

Education and community engagement

Alongside the smart monitoring system, the team also developed an educational mobile application. Users can access the tilting status of certain trees and some examples demonstrating how the system works. To improve awareness of tree management at community level, the team recruited university and secondary school students in a train-the-trainer programme. Around 100 university students were appointed as ambassadors. They attended a series of lectures to equip themselves with tree care and tree management concepts, and then passed the knowledge to about 3,600 secondary school students.

Three-year pilot programme

Funded by The Hong Kong Jockey Club Charities Trust, PolyU launched the Jockey Club Smart City Tree Management Project in 2018. The project was a three-year pilot scheme that builds on the Smart Monitoring System for Urban Tree Management developed by Prof. Wong's team. When the pilot programme was completed in 2021, sensors were installed on about 8,000 urban trees. Meanwhile, the Smart Monitoring System for Urban Tree Management was officially transferred to the Tree Management Office (TMO) under the Development Bureau of the HKSAR Government.

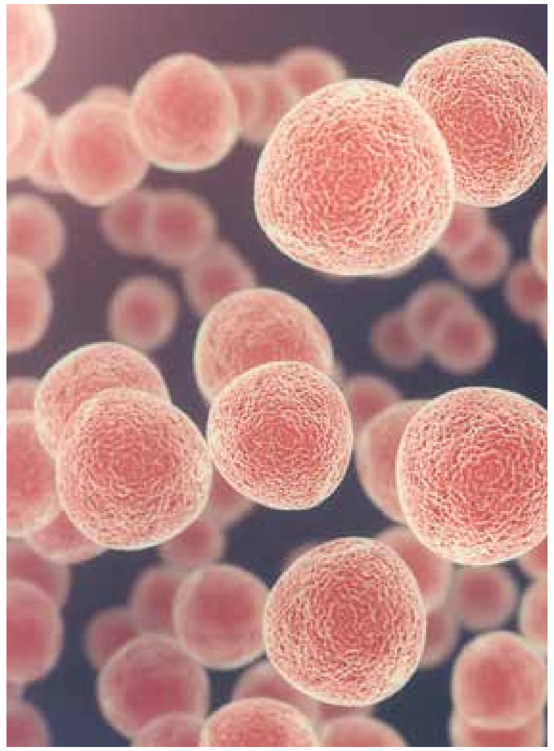
PolyU strives to address societal needs with far-reaching, pioneering research and aptly-conducted knowledge transfer. With the Smart Monitoring System for Urban Tree Management, Hong Kong policymakers can greatly enhance the city's urban resilience as it develops towards a smart, sustainable city with a holistic urban tree management plan.

08 STARVING CANCERS TO DEATH

STARVING CANCERS TO DEATH

Promising anti-cancer drug Pegtomarginase, or PT01, targets only malignant cells

The global outbreak of the COVID-19 pandemic disrupted our daily lives, overloaded our healthcare systems, and weakened the global economy. According to statistics from Johns Hopkins Coronavirus Resource Centre, COVID-19 had claimed over six million lives worldwide as of March 2022[1]. However, it is estimated that cancer killed more than three times as many people during the same period. Cancer accounted for nearly ten million deaths in 2020, making it the leading cause of death worldwide[2]. While the coronavirus may have drawn most public attention, many more are living with a diagnosis that isn't always curable.



[1] Home page. Johns Hopkins Coronavirus Resource Centre. Retrieved from https://coronavirus.jhu.edu/ on 14 March 2022
[2] Cancer Fact Sheet. World Health Organization. Retrieved from https://www.who.int/news-room/fact-sheets/detail/cancer on 14 March 2022

Considering the fatal nature of many cancer types, scientists have been investigating novel approaches to deter cancer cells. Prof. Thomas LEUNG Yun-chung and Dr Thomas LO Wai-hung of the Department of Applied Biology and Chemical Technology's Lo Ka Chung Research Centre for Natural Anti-Cancer Drug Development and State Key Laboratory of Chemical Biology and Drug Discovery at PolyU, are among those who have found a potential cure for a wide range of cancer types. Their brainchild, Pegtomarginase, or PT01, is an anti-cancer drug based on the concept of arginine deprivation, targeting only malignant cells without harming healthy normal cells.

Arginine deprivation — targeted cancer therapy

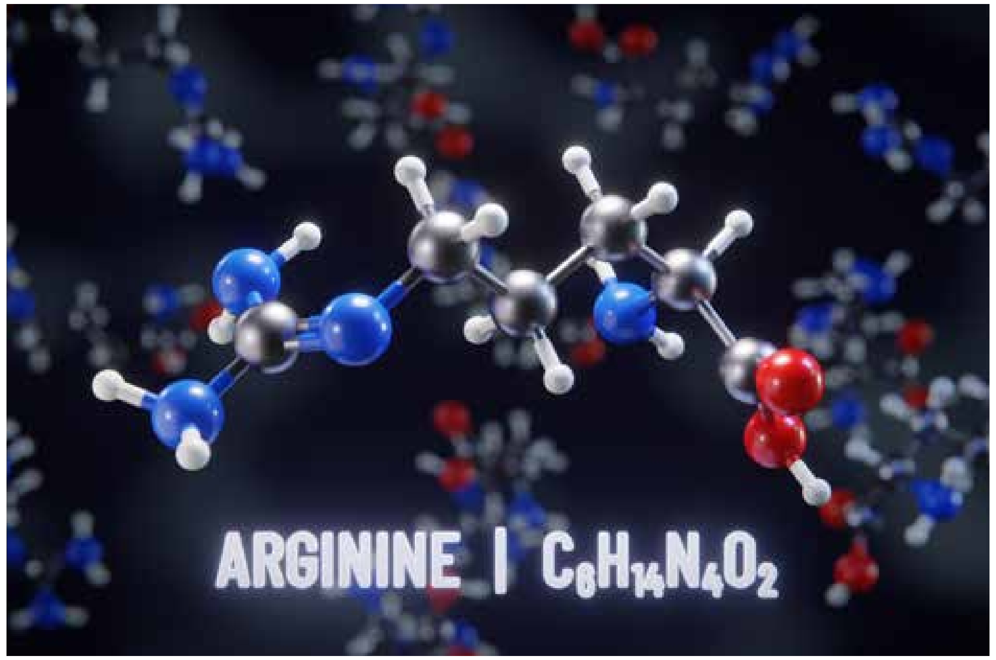
Prof. Leung has an extensive background in biotechnology and molecular biology, particularly protein engineering that uses rational design to convert protein molecules into pharmaceutical drugs. Around 2000, when the technology was still relatively new, liver cancer patients had a near-zero survival rate over five years. That prompted Prof. Leung's interest in developing an anti-cancer drug leveraging rational design and protein engineering.

After studying the physiology of liver cancer cells, Prof. Leung and Dr Lo started their first research in 2003 on a drug that starves cancer cells by cutting off the supply of a vital nutrient, an amino acid known as arginine.

Prof. Thomas LEUNG

Director of University Research Facility in Life Sciences
Professor, Department of Applied Biology and Chemical Technology
Lo Ka Chung Charitable Foundation Professor in Pharmaceutical Sciences
Director, Lo Ka Chung Research Centre for Natural Anti-Cancer Drug Development

Prof. Leung received his PhD from the University of Oxford, UK. Focusing on translational research, he developed the anti-cancer enzyme drug PT01 in collaboration with Dr Thomas LO. The research was based on Prof. Leung's pioneering work indicating that human arginase can starve cancer cells to death whilst leaving normal cells unharmed. Three cancer drugs invented by Prof. Leung — PT01, NEI-01 and BCT-100 — are currently undergoing clinical trials.



In 2007, they published a pioneering paper on the world's first use of human arginase to inhibit the growth of liver cancer cells.

Their research led to several generations of arginine-depleting cancer drugs, including BCT-100 in 2008, BCA-PEG in 2013, and NEI-01 in 2014. In 2019, a different formulation of the drug was licensed by the American pharmaceutical company Athenex, and was named Pegtomarginase, or PT01. In the same year, the US Food and Drug Administration (FDA) approved the Investigational New Drug (IND) application of PT01 to commence clinical investigations. A phase 1 clinical trial subsequently started in late 2021.

Starving cancer cells of arginine

Many cancers cannot synthesise arginine, an amino acid essential for their survival. Instead, they have to absorb arginine from the human body. This has given rise to a new approach to cancer treatment by starving cancer cells to death using an enzyme that cuts off their external supply of arginine. As normal cells do not require as much arginine and can produce it on their own, they are not affected by the treatment. In the past, arginine-depleting drugs used enzymes of non-human origin, which triggered the immune response of neutralising antibodies and compromised their effects. Human arginase is produced by the liver and is commonly found in the human body. It doesn't trigger an immune response, but it is unstable and its action is too short-lived to significantly reduce the level of arginine in the body.

Effective on many cancer types

Prof. Leung and Dr Lo thus engineered human arginase to stabilise the enzyme to last long enough in the body to reduce arginine levels. "We use E. coli bacteria in advanced recombinant DNA technology to create human arginase. Then, by employing rational design and protein engineering, we modified the enzyme by attaching one long PEG chain to stabilise it, while effectively strengthening and extending its arginine-depriving action at well-tolerated doses. In fact, a patient needs just one injection of PT01 per week for a significant healing effect," explains Prof. Leung.

Subsequent research showed that PT01 has synergistic effects when used together with other approved cancer treatments, including immunotherapy and targeted therapy, providing remarkable healing efficacy for a wide range of cancers including liver, breast, cervical, pancreatic, colorectal, lung, gastric, prostate cancer and melanoma. Prof. Leung believes that PT01 is theoretically effective on many other cancer types, but it will take time to test it on other cancers, including late-stage cancers that are incurable at present.

PolyU endeavours to improve people's quality of life with innovative research and knowledge-based solutions. PT01 is an example inspired by creative problem-solving, promising a new ray of hope for cancer patients everywhere.

09 TEXTILES WITH AN INNOVATIVE TWIST

TEXTILES WITH AN INNOVATIVE TWIST

Nu-Torque yarn-spinning technology makes better quality, more eco-friendly garments

Fashionistas around the world eagerly anticipate leading tastemakers to shed light on how to style their wardrobes twice a year. The global fashion industry is valued at US$3,000 billion, accounting for 2% of the world's GDP[1]. We need new clothes every season, but few wonder why yarns are still spun using the same principle as almost 200 years ago.

[1] "Global Fashion Industry Statistics". Retrieved from https://fashionunited.com/global-fashion-industry-statistics/

Reinventing a 200-year-old technology

In 1828, the first ring spinning machine was invented, twisting fibres together into a yarn to be knitted or woven into fabric. The more twists there are, the stronger the yarn is. But the high twist also gives rise to a problem — the residual torque in the yarns causes garment seams to twist and curl up.

As a result, all fabrics and garments have to undergo an extra step known as "setting" to make the seams straight. Yet this extra step consumes energy, damages the fibres, and generates pollutants including waste gas, waste water, and chemical discharges, not to mention the fact that the seams will start to twist again after a few washes.

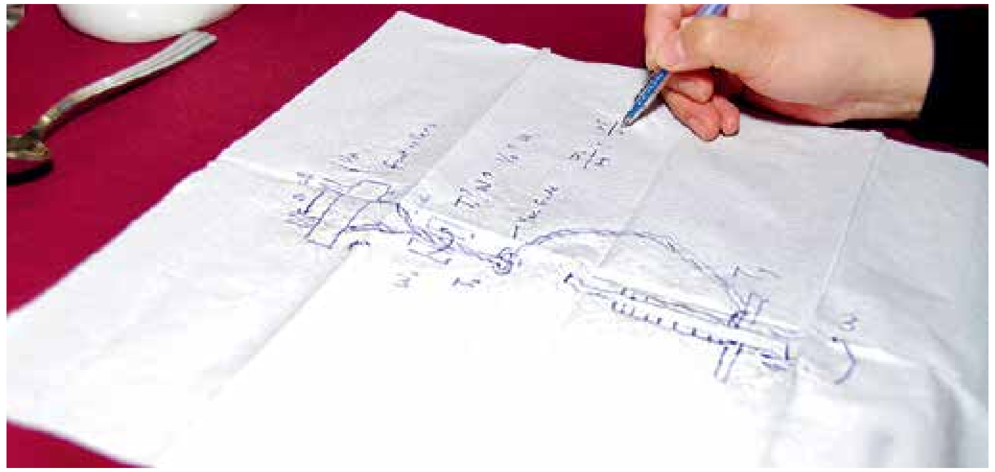
For almost two centuries, a yarn with high strength, but low twist and low torque has been considered impossible. That was until Prof. TAO Xiaoming, Chair Professor of Textile Technology at the School of Fashion and Textiles, and her team developed a revolutionary yarn spinning technology known as Nu-Torque. "The system can be retrofitted easily on conventional spinning machines, and uses a physical process to modify the yarns, with absolutely no chemicals involved. It is truly a green technology that improves productivity, saves energy, and reduces emissions," says Prof. Tao.

Minimal costs, maximum improvements

Prof. Tao hypothesised a new yarn theory that adjusts fibre configuration and stress distribution in a single yarn, so it has high strength, but low torque and low twist. The spark of the idea, however,

Prof. TAO Xiaoming
Chair Professor of Textile Technology
Founding Director of Research Institute for Intelligent Wearable Systems

Prof. Tao is known for her leading research work on intelligent fibrous materials, green textile manufacturing technology, fibre-based devices, and wearable technology. Prof. Tao is the recipient of numerous prestigious awards, including the Honorary Fellowship of the Textile Institute International, the Founder's Award of the Fiber Society, and the Guanghua Engineering Scientific and Technology Award of the Chinese Academy of Engineering.



flared up not in a research laboratory, but in a restaurant. Back in 2001, Prof. Tao was having dinner one evening. At that time, she had already spent years trying to solve the problem of residue torque. "I suddenly remembered something about yarn structure I had read when I was a doctoral student," she recalls. "A new idea occurred to me and I immediately wrote it down on the back of a paper napkin at the dinner table. It was about increasing the number of residual turns in the yarn and changing the tightness of the twists."

Prof. Tao and her team repeatedly experimented with their hypothesis and invented a single-step method in 2005. To make their invention more practically applicable to existing automated production lines, they had to overcome numerous technical challenges to ensure low installation and operation costs. Industrial production of the first Nu-Torque yarn was made possible in 2006.

Since then, the team has been honing different versions of the technology for different fibres and different machines, with 12 patents granted so far. In 2019, the team successfully applied Nu-Torque technology to spin silk yarn for the first time. Not only are Nu-Torque yarns less prone to twists and curls after washing, fabrics made with them tend to be softer, glossier, and less hairy.

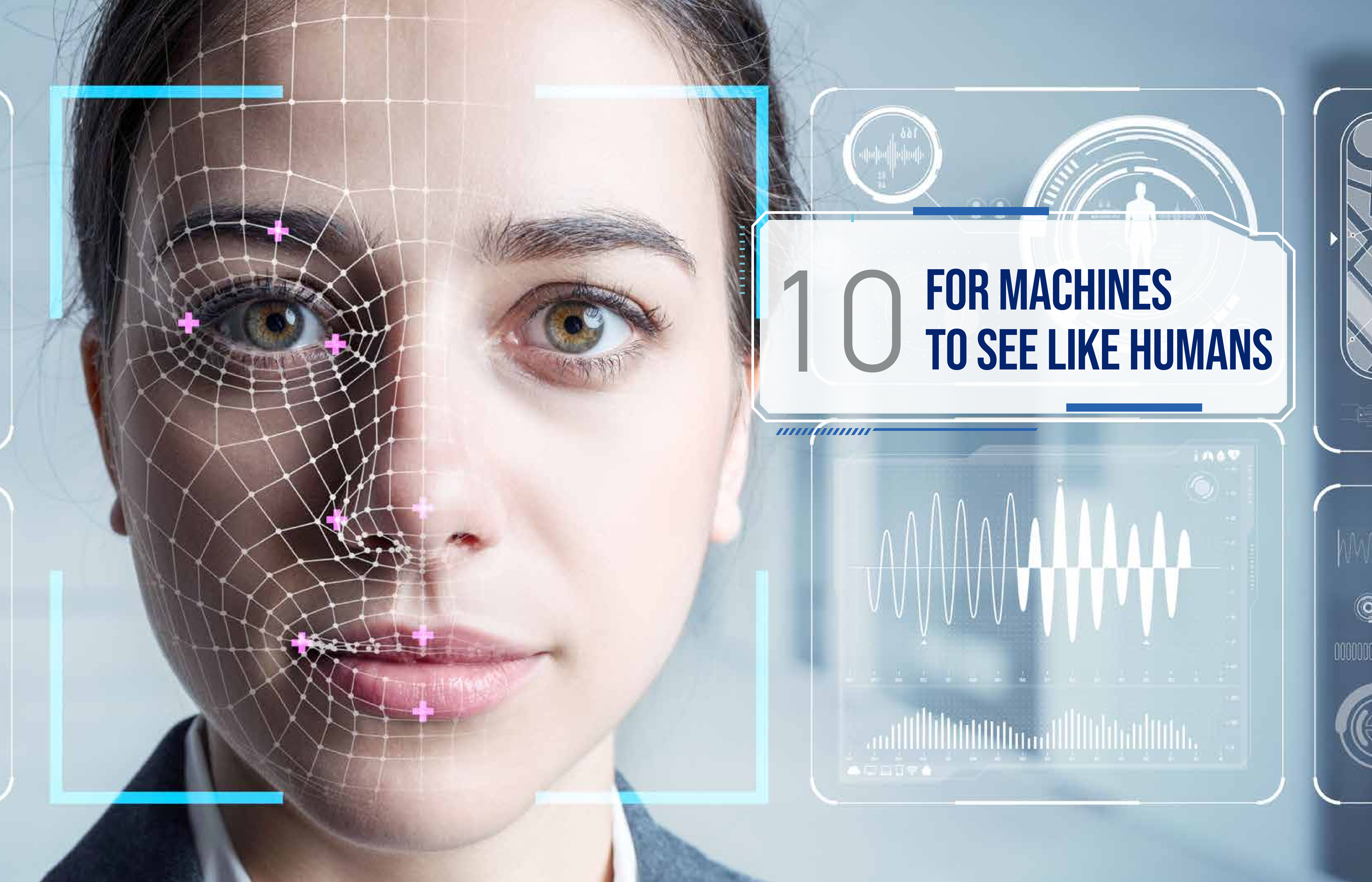
In addition to spinning low-torque yarns, the team also established a yarn evaluation system for quality assurance. The system can continuously measure and analyse the structural property of a yarn while it is being spun. For the first time ever, residual torque in a yarn can be monitored and controlled in real time on a spinning machine.

Attracting luxury and mass brands alike

Nu-Torque technology has made a splash throughout the textile industry and is now used by over 10 leading textile manufacturers around the world. Fabrics and garments made with Nu-Torque yarns are widely sold in the US, Europe, Japan, and China. "I didn't expect Nu-Torque to be this big," says Prof. Tao. "I hope the success of Nu-Torque makes entrepreneurs understand that technology is not something intangible and impractical. Technology actually contributes to their competitiveness."

Manufacturers using Nu-Torque technology unanimously reported an improvement in productivity, ranging from 20% to 40%, as each yarn now requires fewer twists to achieve the same strength. This enhanced productivity also implies less energy consumption. What's more, Nu-Torque reduces the environmental impact of the textile industry. By eliminating the yarn plying and setting steps, less waste gas and waste water, and fewer chemicals are emitted into the ecosystem.

10 FOR MACHINES TO SEE LIKE HUMANS



FOR MACHINES TO SEE LIKE HUMANS

A retina-like sensor captures, pre-processes and stores images for more efficient data transfer and processing

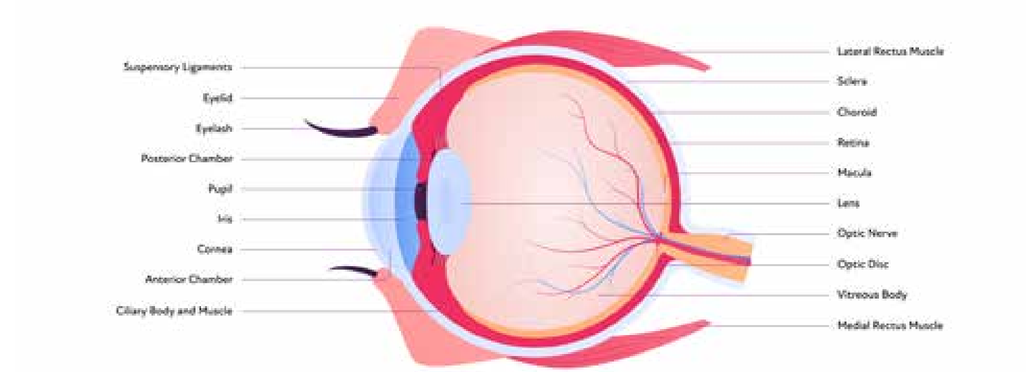
Have you ever wondered how social media can recognise your face a split second after you post a photo? This is an example of artificial intelligence deployed in machine vision — yes, machines can now "see" you after they process photos and videos to extract useful information. In the past decade, scientists and engineers have been building artificial visual systems based on conventional electron devices. But human vision is still a lot more efficient.

The human retina is analogous to an image sensor in a camera, but it's so much more than just a light-sensitive surface that collects data — it also processes the images it receives, filtering off unimportant or irrelevant information, before sending the image as neural signals to the brain. Research has shown that the retina compresses visual data roughly 100,000 times before sending it to the brain via the optic nerve[1]. In other words, the retina not only registers the image, but also processes and encodes data into an efficient form for neural transmission.

[1] "The Decadal Plan for Semiconductors". Retrieved from https://www.src.org/about/decadal-plan/.

Nature-inspired R&D

Intrigued by the neural filtering function of the human retina, Prof. CHAI Yang, Assistant Dean (Research) of the Faculty of Science and Professor of the Department of Applied Physics, had the idea to emulate the retina's efficient compression of image data as early as 2017. The following year, Prof. Chai and his research team published their first paper on optoelectronic memory, a device that senses images and performs logic operations. In 2019, they introduced their neuromorphic vision sensor that captures, pre-processes and stores images in analogue format. Since then, he has been approached by many companies for collaboration and product development.



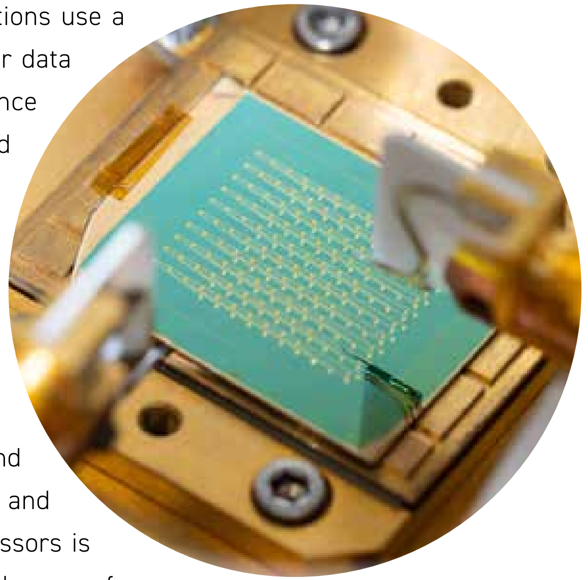
Age of information overload

Nowadays, all smart home appliances have sensors. Most new vehicles have dozens of sensors to monitor engine condition, and the internal and external environments. Owing to the increasing popularity of Internet of Things (IoT) applications and the falling cost of producing sensors, the number of sensors around us has been growing steadily since 2010. It is estimated that there will be 45 trillion sensors in the world by 2032, producing 10^{20} bits of data each second. Let's put that in context — say, with 4Tb

Prof. CHAI Yang
Associate Dean (Research), Faculty of Science
Professor, Department of Applied Physics

Prof. Chai is Vice President of the Physical Society of Hong Kong, a member of The Hong Kong Young Academy of Sciences, and an IEEE Distinguished Lecturer. From 2017 to 2019, he was also Chair of the IEEE ED/SSC Hong Kong Chapter. Among the awards he has received are an RGC Early Career Award, an IOP Semiconductor Science and Technology Early Career Award, the Faculty Award for Outstanding Achievement, the ICON 2DMAT Young Scientist Award, and the PolyU President's Award. He has published over 100 papers in journals including *Nature*, *Nature Nanotechnology*, and *Nature Electronics.*

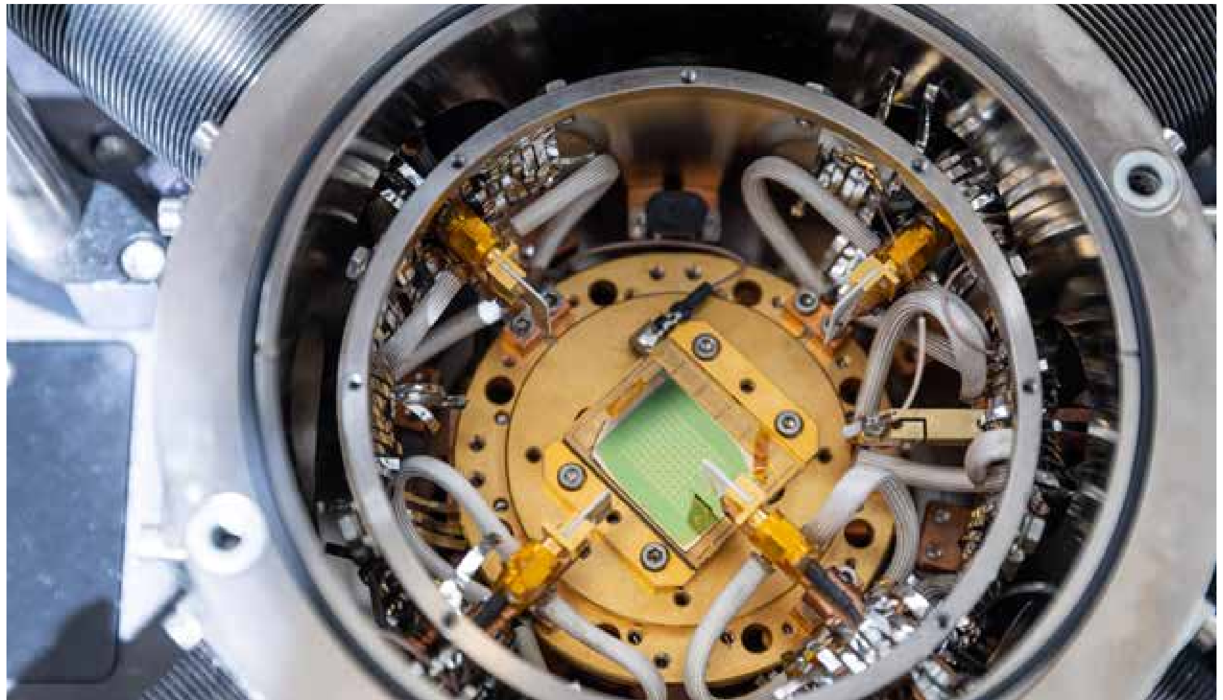
portable hard drives — for every second, you'd need 25 million of those hard disks to store that volume of data.



Although these sensors seem to respond instantly, most applications use a combination of edge and cloud computing, meaning not all sensor data are processed and analysed within the car or the home appliance itself. For example, if your car is smart enough to identify a road sign, its image sensor has to convert analogue images into digital data first. Such conversion is itself time- and energy-consuming. Then the bulk digital data, much of which is redundant and even irrelevant to the scene, such as sensor noise, is amplified and uploaded to a storage centre before being sent to processors for computation.

The transfer of redundant data between sensors, storage units and cloud processors puts wireless bandwidth under immense strain and causes delays. The sheer volume of data to be analysed by processors is also hefty, especially when much of the data is redundant. That's why some form of in-sensor or near-sensor computation to simplify and compress the data would be useful to reduce data traffic and make processing more efficient.

"It's especially important for applications that need near real-time feedback from cloud processors, such as driverless vehicles, robotics and intelligent manufacturing. Pre-processing images on a sensor like the human retina helps shorten uploading and downloading time, and also makes the workload a lot smaller for remote processors to analyse those images," explains Prof. Chai.



Synaptic filtering

The revolutionary sensor developed by Prof. Chai and his team is designed to pre-process images in analogue format, enhance contrast and reduce noise at sensory terminals, and store the image temporarily before exporting the compressed data to external processors in digital format.

The sensor imitates the human retina on various levels. Artificial learning conducted on the sensor replicates the retina's synaptic filtering. "The sensor can learn to filter the data by adjusting the sensitivity of each light-sensing unit, just as the human retina processes image data. The processing is done off-chip and takes time. But once it learns to see, the sensor can capture the image, reduce noise and remove redundant data," explains Prof. Chai.

Visual adaptation to various background lighting conditions

Also inspired by the human retina, the sensor temporarily memorises images in a way similar to the afterimage phenomenon we've all experienced. If you look at a bright sign for a minute at night, you'll still see the sign for a few seconds when you close your eyes. Prof. Chai and his team got their inspiration from the cone and rod cells in the human retina. The result is that the sensor can adjust the sensitivity of the light-sensing units to cope with a scene that is too bright or too dark.

"When we walk into a cinema from the bright outdoors, our eyes see only black at first," he says. "But after a few seconds, we can see in the dark. That's because the human retina can adapt to different background lighting conditions. Our neuromorphic vision sensor imitates this process. When the output is so bright that every pixel is washed out, the sensor gradually reduces its sensitivity to adapt to the light intensity. Similarly, when the output is too dark and without detail, the sensor adapts by increasing its sensitivity." In other words, the afterimage retained on the sensor for a few seconds works like an in-sensor memory.

Pre-processed image data from a neuromorphic vision sensor is fed into an artificial neural network for image recognition. Compared with other sensors without pre-processing, results showed that a neuromorphic vision sensor greatly increases recognition efficiency, while shortening the time needed for such recognition and reducing the energy consumed. This is very useful for many purposes, including the development of face recognition and authentication, automatous vehicles, medical visualisation, and industrial manufacturing.

11 SPURRING SOCIAL INCLUSION AND HIGHER-ORDER THINKING

SPURRING SOCIAL INCLUSION AND HIGHER-ORDER THINKING

Research on Chinese language education in Hong Kong better integrates non-Chinese-speaking children and cultivates higher-order thinking

Hong Kong is an international metropolis and both Chinese and English are its official languages. However, Chinese proficiency is required for school and university entrance, and is expected by most employers, especially for entry-level jobs. In a 2016 survey, of 1,500 job advertisements, only one explicitly mentioned that the position did not require the ability to understand, read or write Chinese[1].

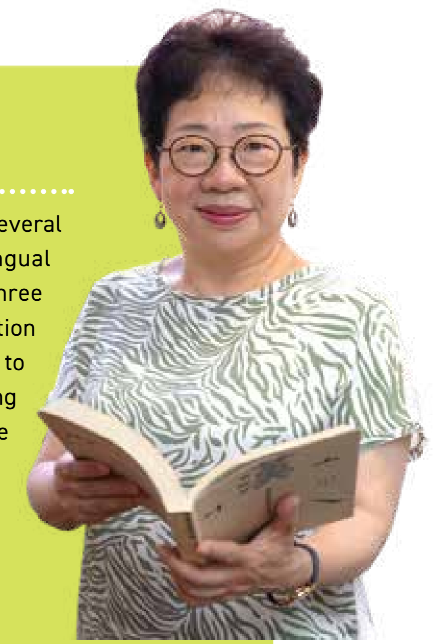
For young secondary school graduates, Chinese language abilities seem essential for employment. However, even native Chinese speaking students find it difficult to master the language. The challenge of learning Chinese is even greater for children from minority communities. And this is why scholars from PolyU's Department of Chinese and Bilingual Studies have been conducting research to enhance the Chinese skills of both Chinese speaking and non-Chinese-speaking (NCS) students.

[1] Cheuk, Mandy. "Cantonese is the key to success for Hong Kong's ethnic minorities." 21 Aug 2020. Hong Kong Free Press. Retrieved from https://hongkongfp.com/2020/08/21/cantonese-is-the-key-to-success-for-hong-kongs-ethnic-minorities/

Racial segregation

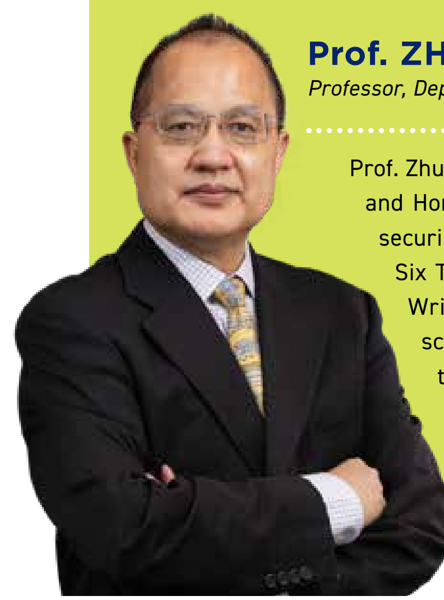
According to the 2016 Population By-census, non-Chinese people accounted for 3.6% of the Hong Kong population (excluding foreign domestic workers), while the population aged between 15 and 24 more than doubled between 2006 and 2016[2]. From 2006 to 2013, NCS schoolchildren were enrolled in either expensive private international schools or "designated schools" — schools that received extra financial support for they admitted a significant number of NCS students.

The so-called "designated school" system was criticised as being racially segregated and discriminatory, and was eventually abolished. Afterwards, the Government started to allow NCS students to take part in the central allocation of places in primary and secondary schools to foster equal opportunities in education. At present, about 70% of both primary and secondary schools in Hong Kong have NCS



Prof. CHAN Shui-duen
Research Professor, Department of Chinese and Bilingual Studies

Prof. Chan has served PolyU for over 30 years, in which time she has taken on several different roles including former Head of the Department of Chinese and Bilingual Studies and former Associate Dean of the Faculty of Humanities. For almost three decades she has been involved in the work of several committees of the Education Bureau (EDB). Since 1999, she has been commissioned by the EDB to deliver close to 40 professional service / R&D projects with a cumulative consultancy fee exceeding HK$27 million. In July 2015, Prof. Chan was awarded the Medal of Honour by the HKSAR Government for her valuable contributions to the Hong Kong education sector, especially on language education and research.



Prof. ZHU Xinhua
Professor, Department of Chinese and Bilingual Studies

Prof. Zhu collaborates with government and educational organisations in Singapore and Hong Kong on a long-term basis. He has conducted more than 30 projects, securing HK$30 million in external grants. His research outcomes, such as the Six Types of Reading Comprehension Processes and Four Traits of Integrated Writing Competence have made a significant impact on policymaking and school practice in Chinese language education, and have appeared in first-tier international journals such as *Assessing Writing, Assessment and Evaluation in Higher Education*, and the *Journal of Second Language Writing*. His contribution to knowledge transfer includes more than 30 keynote presentations organised by government departments.

[2] Chu, Ricky. "Hong Kong's education gap hurts ethnic minorities as much as society at large." 8 Oct 2019. Hong Kong Free Press. Retrieved from https://hongkongfp.com/2019/10/08/hong-kongs-education-gap-hurts-ethnic-minorities-much-society-large/

students enrolled. Yet the integration of NCS students in mainstream education gave rise to another problem — NCS students often find it hard to catch up with native Chinese speaking students in Chinese classes and to use Chinese as the medium for other subjects.

Culture shock

To bridge the Chinese-language ability gap between native Chinese speaking students and NCS students, Prof. CHAN Shui-duen believes work has to be done on all levels, especially in early childhood education. "Before the Government introduced the Education Voucher Scheme and then a number of subsidies to the kindergarten sector, many less well-off parents in minority communities chose to have their children skip pre-primary education since it was optional. Others prefer to send their children to English-medium kindergartens. The result is that their children are

overwhelmed on their first day of primary school — instead of learning from scratch, they are expected to have acquired a certain level of Chinese proficiency before Primary 1 since most native Chinese students are already fluent in spoken Chinese when they start their primary education," she explains.

Prof. Chan, who has been contributing to the local Chinese language curriculum for over 30 years, is devoted to devising a progressive framework of Chinese learning for NCS students in Hong Kong. The framework includes developing a vocabulary and grammar list, compiling teaching materials for primary students, and designing 12 Chinese learning courses in workplace contexts. From 2014 to 2018, Prof. Chan delivered 56 teacher training workshops on the teaching of Chinese to NCS students, attracting 1,500 teachers, of whom 95% gave positive feedback.

Play to learn

Prof. Chan also plays a pivotal role in C-for-Chinese@JC, a $95 million project created and funded by The Hong Kong Jockey Club Charities Trust, co-created by three local universities and two non-governmental organisations. C-for-Chinese@JC aims to prepare NCS kindergarten students for primary education, and for their early integration into the community. To date, the project has supported over 1,890 students and their families.

"Children tend to learn a new language faster when they are exposed to it early on. In C-for-Chinese@JC, we set up a game room at PolyU where children can learn Chinese while playing games on touch-screens and other electronic devices," says Prof. Chan. "The project also included the publication of 18 Chinese story books for NCS children to learn the basics of Chinese in a fun and engaging way," she adds.

The project has notched up several key achievements: 96% of the NCS students who took part in the project showed an improved Chinese language score, and over 98% of parents who were trained felt more confident in supporting their children's learning and transition to primary education. Building on past learning, the Trust has extended its support for C-for-Chinese@JC by developing a set of "Culturally Responsive Education Benchmarks" for kindergartens. The project is expected to benefit 42,000 kindergarten students, including 5,100 NCS students and their families by 2026.

Higher-order thinking in language use

Meanwhile, the Chinese language curriculum in Hong Kong has long been criticised for focusing on lower-level thinking, such as memorising a text and explaining its literal meaning. "In today's fast-paced world, with the constant bombardment of messages from various sources, simply memorising, understanding, and summarising the content of classic texts is no longer adequate to cope with the job requirements of a real-life workplace. That's why we champion the training of higher-level thinking among students, including elaboration, evaluation and creation," says Prof. ZHU Xinhua, who developed the Six Types of Chinese Reading Comprehension Processes and Four Traits of Integrated Writing Competence, both instrumental in shaping the Chinese language curriculum in Hong Kong. In a survey with in-service Chinese teachers, most reported positive impressions towards both frameworks. Some teachers believed that higher-level thinking is "an essential life skill"[3].

Major paradigm shifts in Chinese education

Besides improving higher-order thinking skills among students when writing and reading Chinese, Prof. Zhu has also contributed to the improvement of public examination standards from norm-referenced to criterion-referenced assessment. "A norm-referenced test assesses the test taker's performance against other test takers. In the past, grades were given after test takers were ranked on a bell curve, and perhaps the top performing 10% of test takers scored an A. On the other hand, a criterion-referenced test assesses the test taker's ability against a predetermined standard without taking into account how other test takers perform," says Prof. Zhu.

In the Chinese language papers of the Hong Kong Diploma of Secondary Education Examination (HKDSE), students are now graded in a criterion-referenced manner. Prof. Zhu's research has also resulted in significant paradigm shifts within the educational sector, as teachers are shifting from teaching for exams to teaching for developing skills, and from emphasising rote learning to an ability-oriented approach.

All in all, both Prof. Chan and Prof. Zhu have made a tremendous impact on the Chinese language education system in Hong Kong, improving the Chinese language proficiency and practical skills of both native Chinese-speaking students and NCS students.

[3] Li, Zhu, and Cheong. "Secondary teachers' conceptions of integrated writing skills: Are teachers' conceptions aligned with the curriculum objectives." 6 May 2020. Retrieved from https://link.springer.com/article/10.1007/s12564-020-09629-x

12 REGAINING PUBLIC TRUST IN FOOD LABELLING

REGAINING PUBLIC TRUST IN FOOD LABELLING

Tamper-proof ink deters alterations of food expiration dates

Ever since the HKSAR government implemented a mandatory nutrition labelling scheme for pre-packaged food in 2010, the first thing we might look at when shopping for groceries is the expiration date. This is especially important for perishable foods with a short shelf life such as milk or bread. We want to make sure there is enough time to enjoy the food before it expires, because eating spoiled food could lead to serious illness such as food poisoning. That being said, can we really trust the expiration date printed on the package?

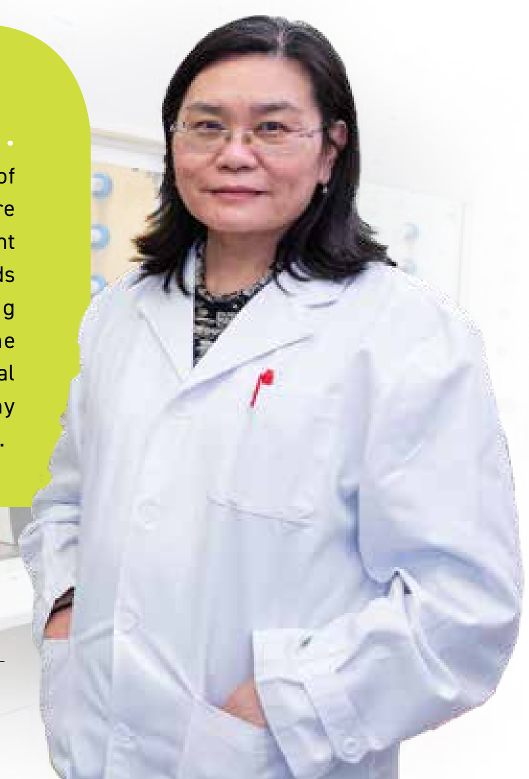
A question of trust

A quick internet search would make your heart sink — news of tampering with food expiration dates seems to spring up all over the world. In some cases, unscrupulous vendors were found to have altered expiration dates so that they could continue

selling food that had expired months earlier[1]. The fact that the printed text on food packages can be easily removed with a solvent, such as nail varnish remover, could be a loophole that invites tampering. Besides taking expiration dates with a grain of salt, consumers may rely on experts and scientists, who keep looking for new ways to stop vendors altering food labels.

Prof. LI Pei
Professor, Department of Applied Biology and Chemical Technology

Prof. Li received her PhD in chemistry from the University of Ottawa, Canada in 1990 and has been working at PolyU for more than 30 years. Her research involves the design and development of synthetic strategies to prepare novel types of polymer colloids and composite particles for diverse applications, including controlled drug release, gene therapy, bio-imaging, enzyme immobilisation, biomolecular and chemical separations, functional coatings, and wastewater treatment. She has received many awards for her achievements in research and technology transfer.



[1] Griffith-Greene Megan. "Grocery store secrets: Best-before dates tampered with, workers claim." 06 Nov 2015. CBC News. Retrieved from https://www.cbc.ca/news/health/loblaws-best-before-tampering-1.3306395

In light of this, Prof. LI Pei of the Department of Applied Biology and Chemical Technology, a pioneer in the design and synthesis of core-shell nanoparticles, developed a non-erasable ink that combats illegal altering of expiration dates and ensures food safety.

Double layers, double colours

The ground-breaking nano-based tamper-proof ink includes two or more colorants. After the ink is printed on food packaging, some of the dyes in a droplet of ink interact with the plastic surface of the packaging to form a permanent mark, while some float on top. As a result, the top-layer dye can be easily removed using an organic solvent, but the bottom-layer dye forms permanent bonds with the plastic surface of the food packaging.

“Printing this ink on multi-layered packaging provides a double-layered, double-coloured print. If a vendor tries to tamper with the expiry date, they can wipe off the black dye in the first layer, but not the bottom red or blue layer. The print will then show in a different colour, so that customers can tell this vendor is not honest, and has tampered with the expiry date,” explains Prof. Li.

An ink formulation for every application

Hallyuen Holdings Ltd (Hallyuen), which has been funding Prof. Li’s research since 2011, founded a new company in 2013 to commercialise her research outcomes. A series of ink formulations have since been invented, including indelible inks,

migration-resistant inks, oil-resistant inks, alcohol-resistant inks, rub-resistant inks, and water-resistant inks. They are applicable to industries as diverse as food and beverage, daily necessities, pharmaceuticals, power and communication, fibre optics, electronics, and automotive parts.

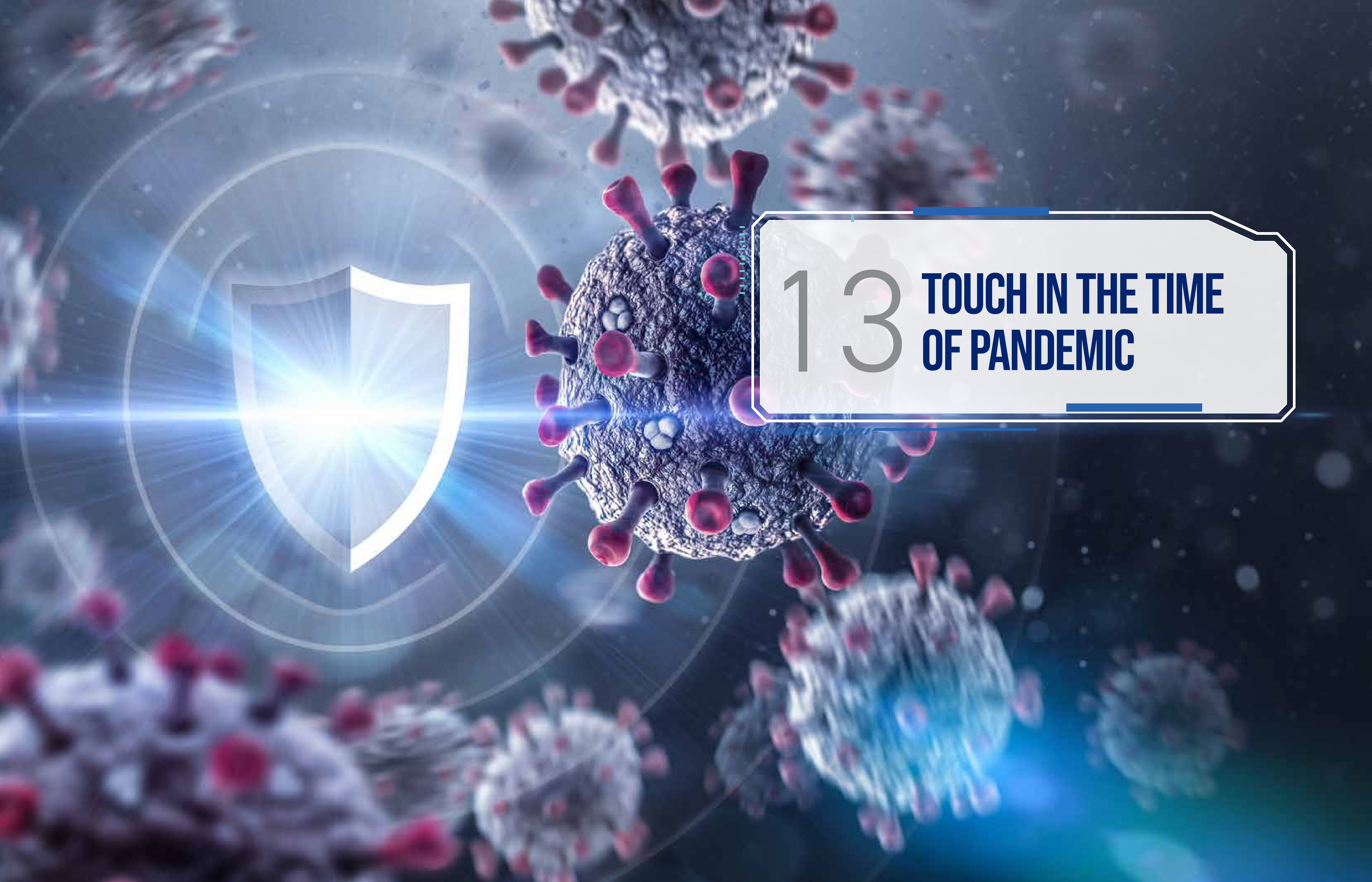
Protecting billions of consumers

According to Hallyuen, counterfeit products and the resale of products with altered expiry dates lead to financial losses worth tens of billions of RMB for enterprises in China every year. Despite the slightly higher cost incurred, many consider Prof. Li’s special ink formulations a worthy investment.

Annually, over 30 billion items of food and other packaging are printed with her tamper-proof ink, amounting to more than 14% of sales volume in China’s fast-moving goods industry. Among the products using the ink are those of three of the top dairy producers in the world, Nestle, Yili and Mengniu. Prof. Li’s other ink formulations have also gained widespread use. Rub-resistant inks, for instance, are now used by 23% of China’s cable and wire industry, helping customers identify authentic products.

All in all, Prof. Li’s inventions have brought significant benefits to industry, the economy, and public health.

13 TOUCH IN THE TIME OF PANDEMIC



PolyVentures

TOUCH IN THE TIME OF PANDEMIC

Non-toxic, eco-friendly antimicrobial coating reduces risk of disease from surface transmission

Maybe it's pressing a lift button with a key. Or opening a door with an elbow. Or grabbing a handrail with a piece of facial tissue. We have all acquired a skill or two to avoid touching any surface in public places with bare skin ever since COVID-19 broke out. Vigilance against surface transmission makes sense as the virus can stay active on plastic and stainless steel for up to 72 hours[1].

In February 2020, the World Health Organization (WHO) issued guidance confirming that the virus can be spread via contaminated surfaces[2]. In May 2020, the WHO recommended that frequently touched surfaces in community settings such as offices, public transport, schools and shops be disinfected regularly[3]. Since then, caretakers have been cleaning and disinfecting every high-touch surface around the clock, leading to a manpower crunch. Moreover, certain disinfectants may irritate human skin and pose health risks upon prolonged exposure. Toxic chemicals may also leak into our ecosystem, contaminating water and other resources. A lasting solution that keeps high-touch surfaces virus- and bacteria-free without using any harmful substance would be highly desirable.

[1] "COVID-19 and Food Safety: guidance for food businesses". 7 April 2020. World Health Organization. Retrieved from https://www.who.int/publications/i/item/covid-19-and-food-safety-guidance-for-food-businesses

[2] "Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)". 16-24 February 2020. World Health Organization. Retrieved from https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf

[3] "Cleaning and disinfection of environmental surfaces in the context of COVID-19". 16 May 2020. World Health Organization. Retrieved from https://www.who.int/publications/i/item/cleaning-and-disinfection-of-environmental-surfaces-inthe-context-of-covid-19

Safe, durable and powerful

This explains why Prof. LI Pei, an expert in new functional materials and polymer chemistry from the Department of Applied Biology and Chemical Technology, led a research team to develop CareCoatex™ antimicrobial coating. CareCoatex™ is a non-toxic and eco-friendly spray that kills 99% of common bacteria and viruses, with a long-lasting action of up to six months. It uses core-shell particles with amphiphilic properties — meaning the particles have an oil-based core and a water-based outer shell. After the spray is applied on a surface, water evaporates and the oil-based cores firmly fuse with each other, forming a durable coating.

These special core-shell particles developed by Prof. Li also allow the use of natural biopolymers as starting materials. "Natural antimicrobial biomaterials are the safest option for both humans and the environment. I modified food-grade chitosan from crustacean shells and encapsulated thymol from the culinary herb thyme to further boost their natural antimicrobial properties," she says.

Prof. LI Pei
Co-founder and Chief Scientist
Grand Rise Technology Limited
(Biography on p.89)

Dr Tenny LAM
Co-founder and Chief Executive Officer
Grand Rise Technology Limited
PolyU DBA Graduate (2022)

Antimicrobial spray with natural active ingredients

Chitosan forms the outer shells of the particles in CareCoatex™ spray. The particles create a positively charged hydrophilic layer over the hydrophobic film-forming cores. Negatively charged pathogens are killed when they are in contact with the chitosan-thymol based coating. Experiments show that the spray kills 99% of common bacteria and viruses. Not only does it offer contact killing, but also time-release action for as long as six months. Besides high-touch surfaces like doorknobs, elevator buttons and medical devices, it can be sprayed on fabrics and clothing, or even used in antiseptic wipes.

To commercialise CareCoatex™, Prof. Li co-founded a start-up with Dr Tenny LAM, a PolyU DBA graduate and a savvy chemical manufacturer looking at revitalising his family business with cutting-edge research outcomes. As soon as COVID-19 broke out, they strived to speed up the commercialisation process so that more lives could be saved. Their products were officially launched in Hong Kong and Mainland China in 2021.

A start-up catapulted to success

In 2020, their start-up Grand Rise Technology Limited successfully secured investment from an angel investor, with matching funding from the PolyU Tech Launchpad Fund (TLF) Scheme. They also partnered with one of Hong Kong's leading listed chemical giants, leveraging the company's established sales and customer service network all over China to market CareCoatex™. Later that year, Grand Rise was accepted in the Incu-Tech incubator programme by Hong Kong Science and Technology Parks. Moving into PolyU's Inno-Hub in 2021, the company has been providing an antimicrobial coating service in China and Hong Kong, including PolyU campus, M+ Museum, Hong Kong Palace Museum, etc.

In 2022, Grand Rise donated CareCoatex™ coating to a mobile cabin COVID-19 hospital in San Tin, while collaborating with the largest non-woven fabric manufacturer in southern China for Asia's first face mask treated with an antimicrobial coating containing natural active ingredients. In the same year, the company was also shortlisted among the top ten start-ups in the Jumpstarter 2022 Global Pitch Competition, winning the Environmental Impact Award. What's more, it has made its way to the prestigious "Forbes Asia 100 to Watch 2022" list.

In line with PolyU's motto "To learn and to apply, for the benefit of mankind", Prof. Li's ground-breaking research has not only had a disruptive impact on industry and academia, but has also resulted in real-life applications that save lives and protect public health.

14 CONTAINING MYOPIA BOOM

PolyVentures

CONTAINING MYOPIA BOOM

Non-invasive interventions dramatically slow myopia progression in children

Myopia, or near-sightedness, is the most common eye disorder. It affects around 30% of people worldwide and its incidence is increasing at an alarming speed. Experts call it a global epidemic and expect close to half of the global population to be myopic by 2050[1]. About 10% of those with high myopia — the medical term for severe myopia — are exposed to increased risk of cataracts, macular degeneration, retinal detachment, glaucoma, and even blindness[2]. Thus, myopia progression isn't just about getting a pair of glasses with a new prescription. It could lead to serious consequences, and needs to be controlled — especially among developing children, who often exhibit the fastest progression.

[1] Holden BA et al. "Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050" May 2016. Ophthalmology. Volume 123, Issue 5, Pages 1036–1042.

[2] Mehta, Meesurg and Wen, Angie. "Myopia: A Global Epidemic: An overview of the problems and efforts to address it." September 2019. Retina Today. Retrieved from https://retinatoday.com/articles/2019-sept/myopia-a-global-epidemic

But how can we combat this epidemic? While myopia cannot be reversed, it's possible to slow its progression or stop it from becoming even worse. Surgery and medicated eye drops help control myopia to some extent, but optical interventions such as myopia control eyeglasses or contact lenses are less invasive, more affordable, and well tolerated by most children.

Prof. Carly S. Y. LAM

Professor, School of Optometry

Professor Lam has a long-standing research interest in myopia. She and her research team have won awards for research excellence including the OPO Bernard Gilmartin Award, the Grand Prix for the invention of the DIMS spectacle lens, and the Grand Prize for the DISC lens at the International Exhibition of Inventions in Geneva. She is a member of the UK College of Optometrists and a Fellow of the American Academy of Optometrists. She is currently President of the Asia Pacific Council of Optometry (APCO).

Prof. TO Chi-ho

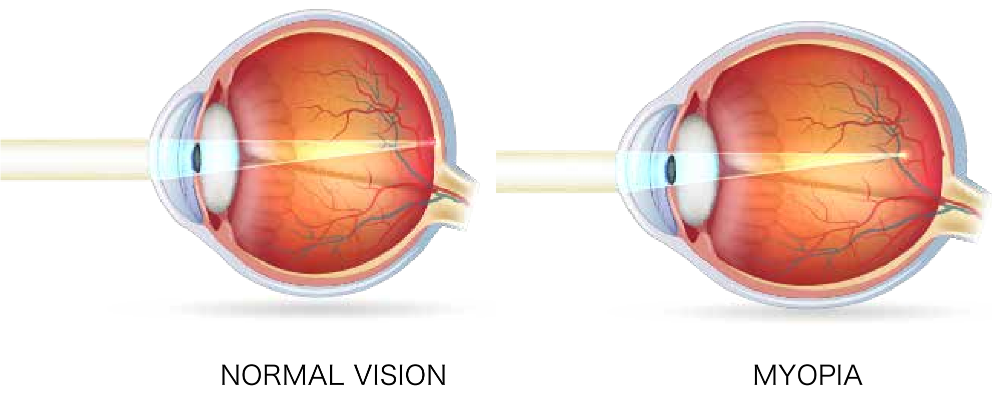
Visiting Chair Professor of Experimental Optometry, School of Optometry

Prof. To graduated in optometry from the then Hong Kong Polytechnic in 1987. He then obtained his PhD from the College of Cardiff at the University of Wales (currently Cardiff University), UK. In 1993, he returned to the Hong Kong Polytechnic to work as a lecturer, and became Chair Professor in 2019. Prof. To is one of the inventors of the Defocus Incorporated Soft Contact (DISC) lens and the Defocus Incorporated Multiple Segment (DIMS) lens. He is an Honorary Member of the Hong Kong Association of Private Practice Optometrists, and a Member of the Scientific and Medical Advisory Board of Retina Hong Kong.

Dr Dennis TSE

Associate Professor, School of Optometry

Dr Tse obtained both his BSc in optometry and his PhD from PolyU. Upon receiving his PhD, he spent two years at the University of Newcastle in Australia as a visiting postdoctoral fellow. In 2011, he joined the Department of Ophthalmology of Baylor College of Medicine in the US, where he received further postdoctoral training on retinal physiology from Prof. Samuel WU. He returned to his alma mater in late 2014 and is currently an Associate Professor in the School of Optometry.



Defocus for myopia control

In light of this, Prof. Carly S. Y. LAM, Prof. TO Chi-ho and Dr Dennis TSE, all from the School of Optometry, have since 2000 led a research team investigating the effectiveness of controlling myopia using vision correction simultaneously with myopic defocus. In the early years of their research, the result of controlling myopia progression was hit-or-miss. The team are the only researchers in the world to have recorded their hypothesis testing from birds to mammals, and then to humans for clinical trials. Their hypothesis is now widely accepted by optometrists and medical scientists.

The mechanism behind the technology is based on our eye's ability to change its shape to focus images sharply on the retina. Myopia occurs when an eyeball is too long. But an eyeball can be steered toward shortening itself to receive images if images are focused slightly in front of the retina, something known as myopic defocus. Over time, this slows the rate at which the eyeball grows longer, thus slowing myopic progression. In the meantime, wearers still need to go about their daily life and need to see clearly. Thus, the perfect lenses for myopia control should introduce myopic defocus and clear vision at the same time.

DISC: a soft contact lens to slow myopia

This technology has given rise to two products: DISC lenses and DIMS lenses. The Defocus Incorporated Soft Contact (DISC) lenses have concentric rings of alternating correction zones and defocusing zones. "The correction zones let the wearer see clearly while the defocusing zones produce out-of-focus images that retard myopia progression. In clinical trials, DISC lenses were proven to slow myopia progression among children aged between 8 and 13, who had worn the lenses for at least 8 hours daily, by 60% on average," says Prof. To.

Passionate about the technology, Prof. To strongly believed that it could improve the lives of many children and was thus determined to turn his research into products that could make a difference in the real world. Eventually, in 2018, DISC lenses were commercialised by Vision Science and Technology Co. Ltd (VST), an academic-led start-up co-founded by Prof. To and PolyU optometry alumnus Mr Jackson LEUNG. The company obtained HK$1.1 million of funding support from the HKSTP-PolyU Tech Incubation Fund and the PolyU Tech Launchpad Fund. In 2019, the second generation of daily disposable lenses, known as DISC-1 DAY, was also launched in Mainland China and Hong Kong to great success. Plans are now afoot to venture into Asia Pacific markets.

DIMS: a spectacle lens to slow myopia

While contact lenses suit some people very well, they are unsuitable for others due to eye shape, health conditions or other impairments, or after surgery. To cater to spectacle wearers, the Defocus Incorporated Multiple Segments (DIMS) spectacle lens was jointly developed by PolyU and HOYA Corporation, based on the same mechanism of myopic defocus. However, it's not as easy as blowing up DISC lenses to fit spectacle frames.

"The challenge lies in the fact that the eye moves behind the spectacle lens, so we need to create myopic defocus no matter where the eye looks," says Prof. Lam. The team came up with the solution of dividing the lens into zones. The central zone is a regular concave lens for correcting vision at the centre of the retina. This is surrounded by a ring zone covered in a honeycomb of small lenses that focus light slightly in front of the retina to create peripheral myopic defocus. Clinically proven to slow myopic progression among children in Hong Kong by 59%, DIMS lenses were launched by HOYA Corporation in a number of markets under the trademark MiYOSMART in 2018, earning commendation from users and their parents worldwide.

Helping children combat the myopic epidemic worldwide

Some may consider near-sightedness not a big issue as long as one wears glasses. But this is not true. Myopia is a global epidemic, a major public health concern, and the leading cause of visual impairment in children[3]. DISC and DIMS lenses offer effective myopia control, slowing or even halting the development of sight-threatening high myopia.

DISC lenses are currently available in Hong Kong and Mainland China. They have been generally well received by users, who found them effective in controlling myopia. As of June 2022, around 300,000 boxes of DISC-1 DAY lenses had been sold. Meanwhile, as of February 2022, DIMS lenses had helped more than 1,000,000 children around the world control their myopic progression since they were launched in 2018. DIMS lenses are commercially available in Hong Kong and 20 other countries and territories in Asia, Europe, North America, Australasia and Africa. They are currently the first line of treatment for myopia control around the world.

As more myopic children gain access to them, DISC and DIMS lenses are rays of hope to combat the global myopia epidemic. They are true exemplars of the excellence of PolyU's research and its successful commercialisation, making a positive impact on society by improving children's quality of life.

[3] Mehta, Meesurg and Wen, Angie. "Myopia: A Global Epidemic: An overview of the problems and efforts to address it." September 2019. Retina Today. Retrieved from https://retinatoday.com/articles/2019-sept/myopia-a-global-epidemic

15 WHEN LIFE THROWS YOU A CURVE

PolyVentures

WHEN LIFE THROWS YOU A CURVE

Radiation-free 3D scanning helps tens of thousands of scoliosis patients monitor their condition

"Stop slouching!" "Stand up straight!" Caring mothers never get tired of correcting their kids' posture. But is it just bad posture? Or is it scoliosis?

Scoliosis, the medical condition of having a sideways-curved spine in the shape of a C or an S, affects about 3.5% to 5% of adolescents in Hong Kong and China[1,2]. About 20% of sufferers experience progressive curvature that requires them to wear braces or undergo surgery[3]. Onset is observed in most patients between the ages 10 and 17, and females are eight times more likely than males to progress to a curvature that needs treatment.

[1] Fong DYT, et al. A population-based cohort study of 394401 children followed for 10 years exhibits sustained effectiveness of scoliosis screening. Spine J. 2015 15: 825-833.

[2] Fan H, et al. Prevalence of idiopathic scoliosis in Chinese schoolchildren. Spine. 2016; 41(3): 259-264.

[3] Bunnell WP. The natural history of idiopathic scoliosis before skeletal maturity. Spine 1986;11:773-6.

When radiation knocks you sideways

As teenagers grow rapidly, regular and continual monitoring of scoliosis is essential. Such check-ups are usually done with X-ray imaging. However, research shows that scoliosis patients receiving an average of 16 radiographs during the treatment period are five times more likely to develop cancer 25 years after treatment[4]. This means that scoliosis patients cannot receive X-ray scans too frequently, and their condition thus cannot be monitored as closely as it should be. What's more, X-rays can only reveal spinal curvature in 2D, while scoliotic deformities are typically 3D in nature.

In light of this, Ir Prof. ZHENG Yongping, the Founding Head of the Department of Biomedical Engineering, developed Scolioscan, the world's first 3D ultrasound scoliosis assessment system, so that all teens can be screened for scoliosis without radiation hazard. His system can even be used to predict future progression, truly a groundbreaking invention in scoliosis management.

Ir Prof. ZHENG Yongping

Henry G. Leong Professor in Biomedical Engineering
Chair Professor of Biomedical Engineering

Prof. Zheng received his PhD in biomedical engineering from PolyU in 1997. After a Postdoctoral Fellowship at the University of Windsor, Canada, he joined PolyU as an Assistant Professor. He was promoted to Professor in 2008, and to Chair Professor in 2019. From 2012 to 2020, Prof. Zheng served as the Founding Head of the Department of Biomedical Engineering. He is currently Director of the Jockey Club Smart Ageing Hub, and of the Research Institute for Smart Ageing. Prof. Zheng's research interests include biomedical ultrasound and smart aging technologies.

Founder
Telefield Medical Imaging Limited

[4] Simony A, et al. Incidence of cancer in adolescent idiopathic scoliosis patients treated 25 years previously. Eur Spine J 25 (10): 3366-3370, 2016.

Prof. Zheng's team went on to develop a portable version of the system, known as Scolioscan Air, designed to be brought to local communities, including schools, for mass screening. All components, including a palm-sized ultrasound probe, a tracking camera and a tablet computer, can fit easily in a suitcase. A typical scan only takes 30 seconds, with accuracy comparable to the original Scolioscan.

When fear of radiation leads to delay in treatments

Normally, X-ray examinations are recommended no more frequently than once every six to twelve months. But six months is a long time for rapidly developing teens with progressive scoliosis. As Prof. Zheng explains, "We need other means to monitor their condition safely, and ultrasound is the answer. A patient may receive ultrasound scans as frequently as needed without any radiation hazard."

The fear of radiation has prevented some patients from seeking medical interventions. Prof. Zheng recalls a case that deeply touched him. "A mother in Beijing wrote me an email after reading about Scolioscan. She said a doctor suspected her daughter, then aged two, had scoliosis and was prescribed an X-ray scan. She understood the radiation hazard of X-ray imaging and was worried that her daughter would be subject to high doses of radiation if she was diagnosed with scoliosis at such an early age. This matter has lain close to my heart ever since. When we introduced Scolioscan to Beijing, we invited her daughter for a scan and her case has since been followed up without exposing her to radiation hazard," he says.

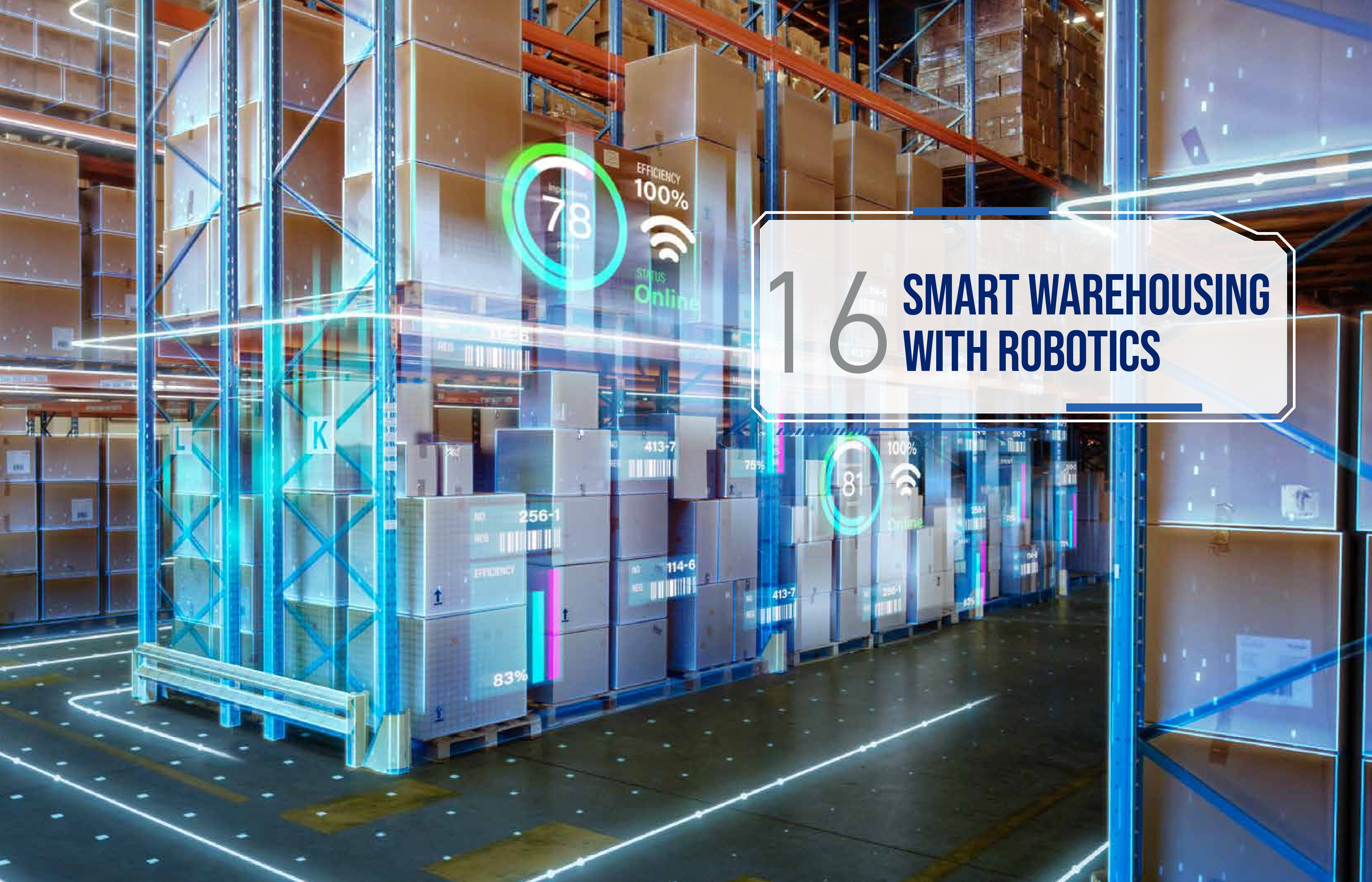
When thousands of patients benefit worldwide

A clinical study in a hospital in Hong Kong has proved that Scolioscan helps patients avoid at least 50% of X-ray radiation[5]. With Scolioscan's visualisation of spinal curvature, patients in a hospital in Shenzhen, China, were also found to be more motivated to try conservative treatments such as exercises. Scolioscan also allows healthcare professionals to evaluate the effects of such treatments in real time during exercise or brace fitting, greatly enhancing scoliosis management.

The system has been commercialised by Telefield Medical Imaging Limited, a start-up co-founded by Prof. Zheng, and is now being used in the Netherlands, Italy, Germany, Bosnia, Poland, Romania, Australia and China. So far, over 20,000 scoliosis patients have been spared harmful exposure to radiation. Scolioscan has also contributed to a comprehensive five-year school scoliosis screening programme with ultrasound assisted brace design and monitoring. At least 6,000 schoolchildren are expected to benefit from this programme.

Voluntary organisations from around the world are also interested in acquiring Scolioscan for children in Tanzania, Ghana, Sri Lanka and the UK. Prof. Zheng's work has truly made a global impact as scoliosis assessment has become more accessible to teens around the world. In addition to medical device registration in the EU and Australia via CE and TGA, Scolioscan has recently been registered in Mainland China via NMPA. Currently, Scolioscan has been installed in Beijing, Shanghai, Guangzhou, Shenzhen, Zhengzhou and Jinan, among other cities. Many more will be installed in different cities starting from 2022 to serve more and more scoliosis patients in Hong Kong, the nation, and around the world.

[5] Pang et al. Using ultrasound to screen for scoliosis to reduce unnecessary radiographic radiation: a prospective diagnostic accuracy study on 442 school children. Ultrasound in Med & Biol. 47: 2598-2607,2021.



16 SMART WAREHOUSING WITH ROBOTICS

PolyVentures

SMART WAREHOUSING WITH ROBOTICS

PolyU-nurtured unicorn creates a blue ocean market with the world's first Autonomous Case-handling Robot system

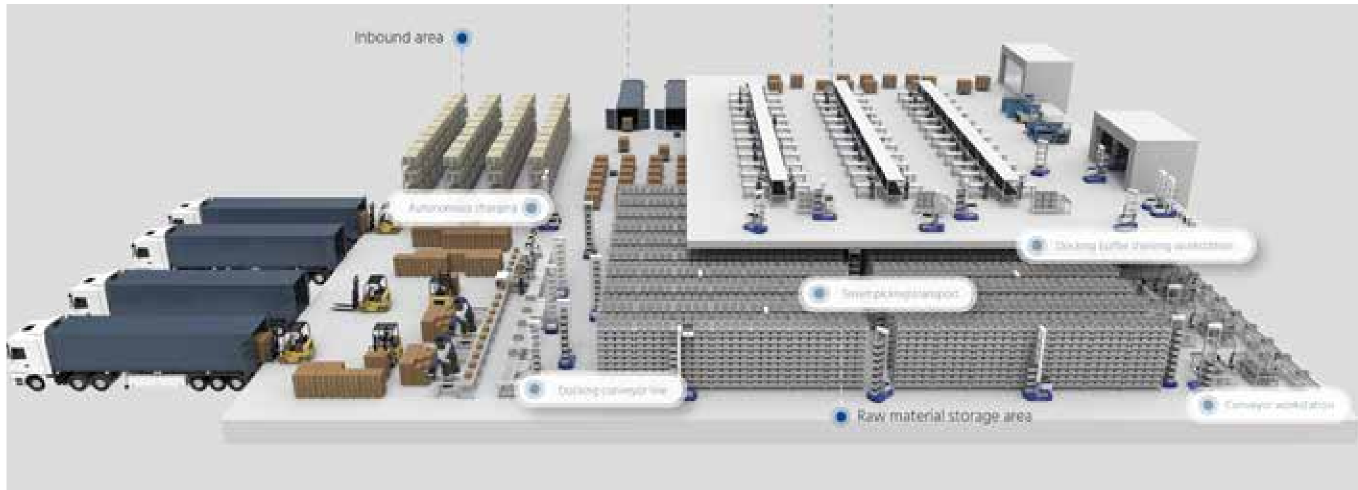
Hai Robotics Co., Ltd. (Hai Robotics), one of PolyU's strategic partners, was nurtured under the University's entrepreneurship ecosystem and has become a unicorn after completing its seventh round of financing with institutional investors. The start-up has grown rapidly by capitalising on the manufacturing advantages of the GBA and the opportunities of the Mainland China market. With a valuation of around US$2 billion, the company is widely recognised as a pioneer and leader in Autonomous Case-handling Robot (ACR) systems.

Hai Robotics was founded in 2016 by two graduates of PolyU's Department of Electronic and Information Engineering — Mr Richie CHEN (2012) and Mr FANG Bing (2014). The two first partnered up during their undergraduate studies when their supervisor Prof. LU Chao challenged them with postgraduate level research projects. They continued to receive PolyU's entrepreneurship education after graduation. With funding support of RMB200,000 from the University's cross-border entrepreneurship seed fund, they founded their first start-up in 2014.

Their first product was an optical communication control module, for which they received orders from the world's top laboratories, including NASA, Huawei and Bell. Subsequently, they envisioned high future demand for robots due to an ageing society, and decided to devote themselves to robotics R&D, leveraging experience they gained from the robotics competition at PolyU.

Devoted to robotics R&D

In 2016, having identified a significant market for warehouse robots, the partners visited more than 30 warehouses to understand the industry's pain points. But they were held back from developing their business idea by a lack of capital. Again, it was their alma mater which gave them the necessary support, granting them an entrepreneurship fund of HK$700,000, enabling them to forge ahead in their entrepreneurial journey.



World's first autonomous case-handling robot

They spent more than four years on research and development before Hai Robotics launched the world's first ACR, HAIPICK. The robot can increase customers' storage density by 80% to 130% and offers a threefold to fourfold improvement in efficiency. The system is also able to respond swiftly to changes in storage requirements. In addition, the two PolyU alumni developed an ancillary intelligent management platform, a multifunctional workstation and an intelligent charging station.

Since its inception, Hai Robotics has sold more than 1,500 robots to customers from a wide range of industries, including footwear, medical, electronics, power and retail, in more than 20 countries, including China, Japan, South Korea, Australia, Europe and the US. It has set up wholly-owned subsidiaries in the US, Japan, Singapore and the Netherlands, and accumulated more than 400 intellectual property rights to maintain its leading position.

Planting the seeds of entrepreneurship

"PolyU's entrepreneurship education and support cultivated our ability to innovate and cope with challenges, and provided financial assistance when we were short of capital," Bing says. In May 2021, to recognise young business leaders who have created value, *Fortune China* released a list of 40 elites aged below 40, on which Richie appeared. Looking back on his entrepreneurship journey, Richie says, "PolyU planted the seeds of entrepreneurship and irrigated our growth to allow us to survive the initial difficult years. The company is still in its growth phase. We are grateful that PolyU continues to provide help for our talents and market expansion."

PolyU's entrepreneurship ecosystem cultivates its first unicorn

PolyU is proud that Hai Robotics is the first unicorn start-up nurtured under its ecosystem. In recent years, PolyU has continued to encourage innovation, promoted undergraduate scientific research, set up a problem-oriented interdisciplinary scientific research platform, and facilitated school-enterprise partnerships to support scientific research and entrepreneurship. It has also supported pre-incubation for entrepreneurs, increased resources to help commercialise laboratory technology, and set up venture capital funds for midstream and downstream investment to promote the commercialisation of scientific research results. More unicorns are expected to emerge from PolyU's innovation ecosystem in the near future.

17 REMOTE FITTING IN A SNAP

PolyVentures

REMOTE FITTING IN A SNAP

AI-based 3D modelling technologies enable accurate body measurement for the fashion industry and beyond

Shenzhen TOZI Technology Co., Ltd (TOZI), a start-up founded by PolyU PhD graduate Dr ZHU Shuaiyin, bears the mark of the University's world-class research in fashion and textile technology. Using artificial intelligence and 3D technologies, its innovation allows body measurement and fashion fitting to be done remotely in seconds, with privacy intact and in the user's total comfort.

Attracting young talent

"I was a student representative offering hospitality to a delegation from PolyU's ITC in an exchange programme," remembers Dr Zhu of his first encounter with ITC, i.e. the Institute of Textiles and Clothing, now the School of Fashion and Textiles (SFT). He was at the time a computer science major at Xian Jiaotong University, a tertiary institution in Mainland China that had frequent academic exchanges with PolyU.

"From the delegation, I learnt about PolyU's research capabilities, as well as its mission and vision. I was immediately impressed by the many innovation applications created by the university, and the fact that it is a leader on multiple research fronts," adds Dr Zhu. He recalls that PolyU was involved very early in developing anti-static work clothes for the staff of the China National Space Administration (CNSA), and other new materials with civil applications.

Not long after graduating, Dr Zhu learnt that PolyU was recruiting research professionals. He wished to pursue his studies in AI research related areas in a top institution and decided to consult Dr Tracy MOK, currently Associate Professor of SFT. Dr Mok counts fashion pattern engineering, digital human modelling, and 3D scanning and sizing among her wide-ranging research areas.

AI potential in textiles and fashion

"Dr Mok and I exchanged a lot of ideas," Dr Zhu recalls. "She encouraged me to research AI and 3D technologies and apply them in the fashion and textile field." After completing his master's degree in 2013 at PolyU, Dr Zhu spent a year as a research assistant, before enrolling in a PhD programme, also at PolyU, in 2014. "Naturally, my research proposal focused on how to apply AI and 3D technologies in the fashion and textile industry."

Dr ZHU Shuaiyin
Founder, Shenzhen TOZI Technology Co., Ltd
PhD Graduate (2017), School of Fashion and Textiles

But scanning image-based 3D human body modelling was in fact nothing new. As Dr Zhu is quick to point out, relevant studies and technology date back as far as the 1980s. "The original scanning technology itself is very capable of recording a person's body shape," he explains, "and the person must wear tight fitting clothes for the process". However, the use of the technology was very limited in the fashion and clothing industry, where the priority is precise body measurements.

The photography-based technology developed by Dr Zhu and his team takes the nature of the industry into consideration. "We are aware that very precise measurements are needed to faithfully render the wearer's body shape in bespoke fashion. But in ready-to-wear fashion, accurate measurements instead of precise measurements are enough to help the wearer pick the right size."

As anyone who has been an online shopper can attest, a particular size provided by two different brands does not always correspond to the same fitting. As online shopping grows rapidly worldwide, technology-enabled accurate body measurement means that on the one hand an online shopper can make a more informed purchase, while on the other hand the supplier can enjoy increased cost efficiency thanks to fewer incorrect fittings.

Simple tools, easy-to-use

Technology built on artificial intelligence, data analytics and 3D modelling comes with an added advantage over complicated scanner-based technology, as users can simply take pictures of themselves with their smartphones. Dr Zhu estimates the

measurement accuracy to be within 1.5% of the actual measurement if the shopper wears reasonably tight-fitting clothing, or 2.5% if clothed in loose fitting garments.

Five years after constantly refining the algorithm, in 2016 Dr Zhu deemed the technology mature enough, and set up TOZI to commercialise the technology. Always a staunch supporter of entrepreneurial spirit, PolyU offered the company a seed fund, while also providing an office space in PolyU's InnoHub in Shenzhen for the young team to deal with the complexities that a start-up typically encounters.

In the year after its inception, TOZI secured major funding support of over RMB10 million from Shanghai-based Fosun International, one of the biggest private enterprises in Mainland China. In addition to relevant technology applications, Zhu believes the financial backers consider the young company's innovative spirit as much as its sustainable operations and technological progress.

International appeal

Very soon, TOZI's technology received attention from overseas brands, with Japan's made-to-measure Aoyama Taylor and the department store group Mitsukoshi Isetan among its first overseas clients. More recently, the company entered into an advanced stage of agreement with one of the most eminent international luxury clothing brands based in Paris, France. In 2019, Japanese leading trading conglomerate Itochu Corporation announced a capital and business alliance with TOZI with the aim of creating synergy in its textile business.

TOZI currently has a compact team of around 15 people, most of them engineers. While focusing on the trends of the textiles and clothing industry, the team has also identified potential applications of their technology in other areas including healthcare and body-building. This development is yet more proof that the applications of a new technology can be truly borderless.

18 ART EXPERIENCE THAT TRANSCENDS VISION

PolyVentures

ART EXPERIENCE THAT TRANSCENDS VISION

Technology enables the visually impaired to learn, work and experience the rich visual world

People with normal vision can appreciate works of art at any museum whenever they want. But this is not the case for the visually impaired. How can they, for example, appreciate the finer details of a masterpiece like the *Mona Lisa* by the great Renaissance master Leonardo da Vinci?

Now, however, the visually impaired can appreciate great art, albeit not with their sense of sight. Since mid-2020, following a collaboration between Beyond Vision Projects (BVP) and the Hong Kong Museum of Art, those with limited vision have been able to walk into the museum to experience and enjoy selected exhibits with the help of accessible tactile audio materials.

The Tactile-Audio Interaction System (TAIS) is an application converted from years of research work led by Dr Rico CHAN at the PolyU School of Design (SD). TAIS employs a unique two-and-a-half dimensional (2.5-D) tactile system with embedded buttons and a mini-computer supporting pre-recorded audio descriptions. These enable the visually impaired to appreciate the visual world using their highly developed senses of touch and hearing. TAIS inventor Dr Chan made innovative use of existing digital parts and technologies by repurposing them to achieve the desired outcome of helping the visually impaired community.

Originally from Malaysia, Dr Chan completed both his master's and PhD studies at SD. The focus of his PhD studies was to enhance the museum experience for the visually impaired in Hong Kong. He wished to deal with the common misconception that visually impaired persons are not interested in going to museums just because they cannot see the exhibits. "There's no reason not to take care of visually impaired persons in public spaces," says Dr Chan.

User-centric design

As a trained graphic designer, Dr Chan once believed that design was all about aesthetics. His experience at SD changed that perception. "I never thought about how design can impact people's lives," he recalls. "The course on User-centric Design taught us to put users into the centre and design things that will improve their lives and meet their needs." Later on, during his PhD studies, he reviewed a wealth of documentation on serving the visually impaired in museums and found a way for those with

Dr Rico CHAN
Chief Executive Officer and Founder
Beyond Vision Projects Limited
PhD Graduate (2017), School of Design

compromised sight to understand visual information. Even though some research dates back more than half a century, he was perplexed by how little progress had been made in real-world applications.

Dr Chan made a solemn pledge to turn the research project into practice after speaking to visually impaired individuals and receiving their assistance for his research. In 2016, he founded BVP, with seed funds from PolyU. In 2017, following the establishment of BVP, he was involved in a project to design and convert three masterpieces into 2.5-D touchable tactile paintings for the Asian Art Museum in San Francisco. All three tactile displays featured Braille and a QR code for the pre-recorded audio descriptions.

Helping people with limited vision to understand visual information

The three components of the 2.5-D touchable tactile paintings represented, for the first time, an entirely new experience for the visually impaired to appreciate works of art in a way they had never been able to enjoy before. At first, because it was a solo effort, it took weeks to convert a single painting into the required format with Braille, a relevant QR code, and an audio description. Since then, Dr Chan's team has converted nearly 50 paintings.

The converted paintings are diverse in style. In addition to the *Mona Lisa*, there is *Dance (1)* by French Fauve artist Henri Matisse, *Composition with Red, Blue and Yellow* by Dutch abstract painter Piet Mondrian, as well as *Ignorance = Fear* by American pop artist Keith Allen Haring. Most of the 2.5-D touchable tactile works are on display at the studio of Beyond Vision International (BVI), a charitable entity of BVP formed in June 2020.

Early in its development, BVP slightly shifted its focus. As well as offering the visually impaired this amazing new museum experience, in 2018 it started to run a pilot project called Tactile Visual Vocabulary

System (TVVS) at the Ebenezer School and Home for the Visually Impaired. "The project focuses on designing and converting images from primary school general studies textbooks to create close to 500 TVVS-enabled learning materials so that visually impaired students can make the most of learning opportunities," Dr Chan explains.

Following the pilot project, BVP received its first funding support from the Lee Hysan Foundation. Partly thanks to this subsidy, by early 2022 BVP's initiative had benefitted more than 50 visually impaired students at Hong Kong's only school for the blind, helping students of various ages and levels of visual impairment.

After these projects, the team caught the attention of organisations sharing the same vision. In August 2020, BVI received its second major funding from the city's respected Robert H. N. Ho Family Foundation. Thanks to that generous support, BVI began contemplating how to create job opportunities for visually impaired persons. In collaboration with WWF Hong Kong, between November 2021 and February 2022 the Beyond Nature Project successfully trained a group of visually impaired young people to become part-time qualified eco-tour guides for the WWF. Some of them now stand ready to contribute to nature and the wider community.

Reach beyond Hong Kong

Following years of development, both the TAIS and the TVVS now have a much broader reach. For example, in partnership with Seoul-based NGO Another Way of Seeing, BVI launched their first Korean TVVS in Seoul in early 2022. This was followed by a collaboration with the NGO Etch Empathy in Singapore, for the Gardens by the Bay project.

Dr Chan has long felt that the only way he can return the favour to the visually impaired for their help is to turn his research into something that can be put into real practice. His sentiment was the first spark for setting up BVP, and later BVI, and it remains embedded in the team's various activities. Meanwhile, at the heart of this start-up lies the PolyU spirit to help the advancement of humankind through practical applications of research and ideas.

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