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HKU BULLETIN

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Whether you see it as good or bad, artificial intelligence (AI) looks here to stay, with profound impacts for almost every corner of human activity. Even before the arrival of ChatGPT, HKU scholars were probing its potential – from developing and adapting their own AIs, to exploring the potential for drug discovery and access, to considering the legal and policy implications for innovation. They have also been considering AI's effects on creativity and its potential to harm. Needless to say, their explorations have only just begun.

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Illustration by Midjourney
This image was created using the prompts illustration, vector, embracing future with AI, and AI revolution.

THE RISE OF AI

ChatGPT and other generative artificial intelligence technologies burst on the scene this year seemingly all of a sudden. AI scholar Dr Qi Liu and Professor Yiu Siu-ming, developer of the new spinoff, Stellaris AI, explain where these technologies came from and where they are going.

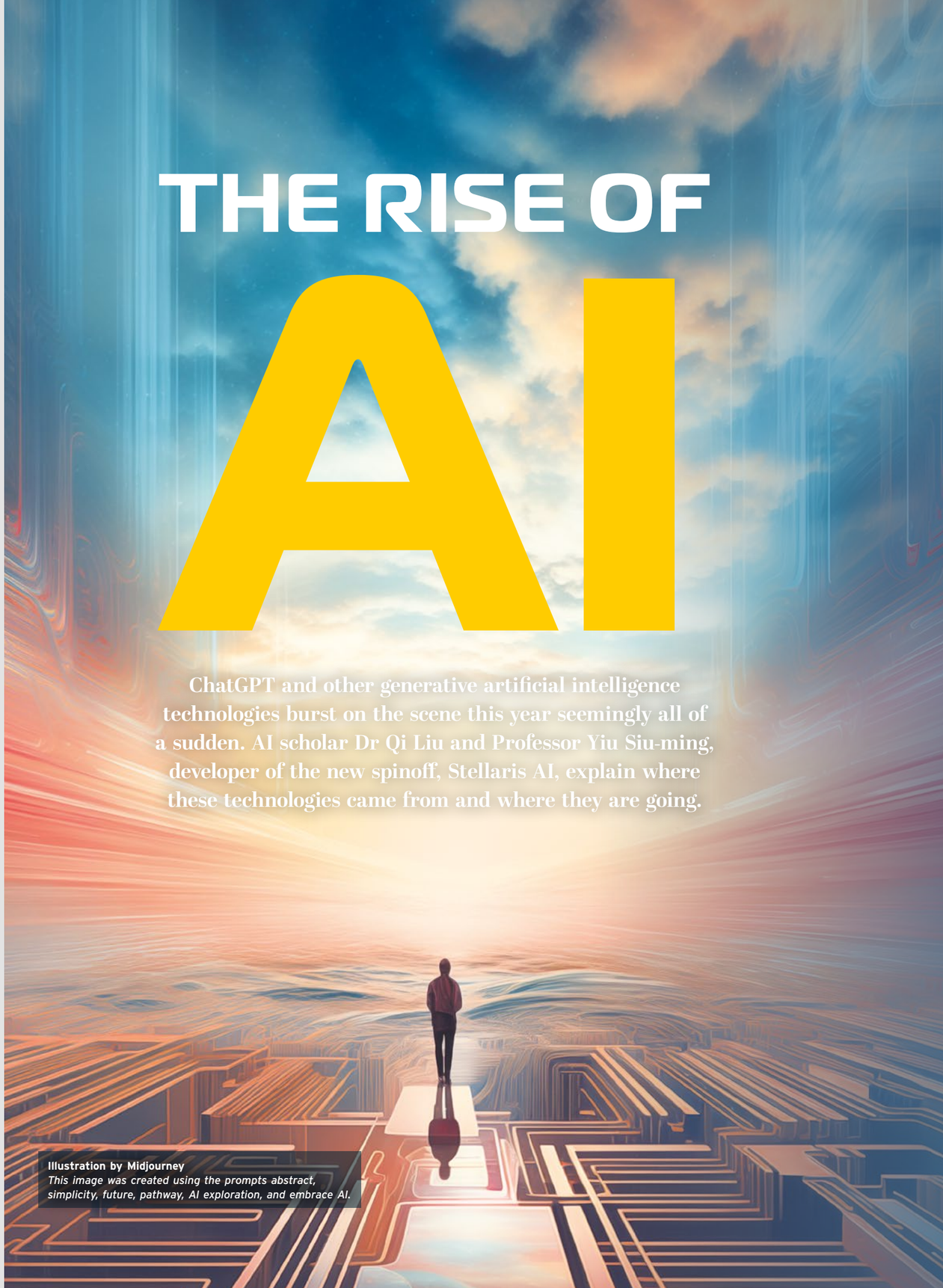

Illustration by Midjourney
This image was created using the prompts abstract, simplicity, future, pathway, AI exploration, and embrace AI.

The arrival of ChatGPT may have excited media and social media experts and the general public about the prospects of artificial intelligence. But to engineers, there was nothing new under the sun.

The concept of AI has been around for decades. Back in 1950, the British scientist Alan Turing even offered a definition of AI: when a person is unable to tell if they are communicating with a human or a computer.

And since then, says Dr Qi Liu, Assistant Professor of Computer Science who received an Honourable Mention in the global 2023 AI 2000 Most Influential Scholars list, the technology has evolved in waves, taking new steps every decade or two. First, it was based on a rules-based approach, then probabilistic or statistical methods, and then, when these were both found too limited to handle real-world scenarios, neural networks.

The concept of neural networks, which underpins machine learning and consists of nodes passing information back and forth to each other until a consensus is reached and lessons are learned from mistakes, actually dates back to the 1940s. But it was out of fashion until about a decade ago, when it was used to recognise images, such as whether a photo was a dog or a cat. Since then, it has been widely explored and had game-changing effects in learning from vast amounts of text data.

"ChatGPT 4 is like a simulated human brain. It can already do a little bit of reasoning and it understands human text well. Many people feel excited about this progress and want to build on top of it," Dr Liu said. "But there is a lot of headroom for improvement. It is more like a starting point."

Developing capabilities

His colleague, Professor Yiu Siu-ming, also in the Department of Computer Science, agrees. "Generative AI is not magic. We've been doing research on this for a long time. In fact, right now it's very similar to Google. The difference is that rather than just giving you links, it gives you a summary. But later on, there should be more useful applications."

Both academics are working to develop those capabilities and address some of the shortcomings, such as the poor performance of generative AIs in handling mathematics and other non-text-based questions, hallucinations, possible misalignment with human values (for instance, providing instructions on making bombs) and huge energy consumption.

Dr Liu, for instance, is trying to get AI to combine other modalities with text, such as recognising an image of Barack Obama and being able to answer questions about him. He is also working on the recognition of structured datasets such as charts and tables, which fall between text and images. The latter could be useful for businesses and already he has been approached by industry about its use in detecting money laundering.

Dr Liu and his team are also trying to reduce 'hallucinations', in which the AI makes up facts and citations, by connecting it to better quality information, and to make AIs more energy efficient by reducing the quantity of data or length of time required to train them.

> "AI is here to stay and people should embrace it."
>
> Professor Yiu Siu-ming

Embracing it

Professor Yiu, for his part, recently launched the spinoff Stellaris AI with his former PhD student, Dr Jacob Jikun Wu. They have developed an alternative ChatGPT-like system with hundreds of billions of parameters that is unique in using Cantonese. The model has shown promise where other models falter, such as mathematics and logic, and importantly, is not at risk from copyright or access issues related to overseas-owned AI.

"We are now the only ones in Hong Kong to train a model from scratch without relying on OpenAI [which owns ChatGPT]. The next step is how to make use of this," Professor Yiu said.

The team are looking into making AI work as a personal assistant, for instance by checking flight availability and booking a seat, or buying stocks based on an individual's financial background and acceptance of risk.

"AI is here to stay and people should embrace it. Problems like bias and false information are not new, they exist in society and in other technologies, too," he said.

Dr Liu also believes everyone will have to adapt. "People are worried AI will replace their jobs. I think the tendency is not reversible. They need to embrace AI in their daily work to improve efficiency. That is a good thing. People can always find other things to work on that are more creative or less intensive," he said, but he added: "We still need to be careful to avoid doing harmful things to human beings or society."

THE THREAT OF HARM

AI's capacity to be harnessed for harm is an unknown – all the more reason to get better governance controls in place before it is too late, argues philosopher Dr Nathaniel Sharadin.

Illustration by DALL·E of OpenAI
This image was created using the prompts machine learning, biological and chemical synthesis, cyber vibes, spores and molecules, and photorealistic.

ChatGPT has a hidden prompt that begins before users enter their query. It asks the AI to be kind, ethical and helpful to the user. But there is no guarantee the subsequent information or actions taken will be similarly positive. With more large language learning models (LLMs) similar to ChatGPT coming online, there is a prospect of AIs being manipulated to dangerous ends.

This is a worry of Assistant Professor of Philosophy, Dr Nathaniel Sharadin, who is also a Research Affiliate at the Centre for AI Safety in San Francisco. He originally was concerned about AI's misalignment with human values, such as being hurtful or racist. He's less concerned about that now – recent AI models have become better in this regard, he said – but that does not rule out the potential to do damage in future.

"I'm more worried that these systems are much more capable than we really understand. And the capabilities for misuse are pretty stark," he said. "Biological misuse is the most obvious example. LLMs are great at quickly finding promising drug targets, but they also need to know how to identify and formulate dangerous molecules to avoid harm. It doesn't mean this is happening now, but it obviously increases the threat of biological or chemical misuse."

To illustrate what that threat might mean, consider that the French government asked drug researchers using a model specific to drug discovery, to seek out harmful targets as an exercise in what might happen. In less than six hours, the model found 40,000 potential chemical weapons, including some of the deadliest chemicals around, such as sarin.

Lowering the bar

"It's important to say with some confidence whether an LLM can produce formulas for novel pathogens. For the record, I don't think ChatGPT has the capabilities to do this at the moment because I don't think it has enough of that training data. But it's very clear that some models can and that would be very dangerous," he said.

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> Dr Nathaniel Sharadin

One of the problems is the difficulty in understanding the capabilities of AI models, a question that Dr Sharadin has been exploring. There are two methods – benchmark against existing information or interact and poke around with the AI to test its limits. Both have major limitations for dangerous substances. For example, there is no benchmark for synthesising smallpox, so how can one know whether an AI can do this? And the interaction approach cannot provide systematic evidence of capabilities because every single capability would need to be tested.

"Just because you can't test it with a benchmark or interaction is not evidence that AI can't do it," he said. "Another worry is that you could have LLM assistants in the lab acting like a coach, to explain why something has failed. It lowers the bar of technical know-how for chemical and biological pathogens."

Despite the bleakness of the situation, and the rapid pace that AI is developing, Dr Sharadin believes it is still possible to address the lurking threats. While the current polarised world is unlikely to produce treaties as successful as those on biological and chemical weapons, within nations the solutions might be easier.

A hard problem

"It's a hard problem, but the first step should be that companies do not train increasingly large, capable models and release them publicly because this is dual-use technology with a high capacity for misuse," he said. "Model developers should also remove things like the repository of dangerous molecules from their training data, which they're not doing. There is no reason why ChatGPT needs to see this in its training."

China has acted to rein in its companies, but in the US, which is the leader in AI development, there are no controls at all. "With the pace moving so rapidly, I'm worried that even though present-day models are not by themselves extraordinarily dangerous, there is increasing scale for that," he said.

The release of the open-source LLM, Llama 2, by Meta makes matters worse. Unlike ChatGPT, whose architecture and operations are controlled by OpenAI, any user can download Llama 2 and fine-tune it to their liking, such as training it to respond in nefarious ways. All that is needed is English language skills and a computer. Setting aside concerns about new chemicals and weapons, the effects of that capability will likely soon be felt by much of the world.

"It's certainly going to make a nuisance of itself. More than a billion people vote next year. If you think misinformation on the internet is a pain, wait till you see what can be done with a system that can produce realistic, human-tailored, micro-targeted misinformation in a heartbeat," he said.

AI FOR SOCIAL GOOD

Artificial intelligence models developed at HKU are helping identify early-stage biomarkers for Alzheimer's Disease, as well as air pollution at the individual street level.

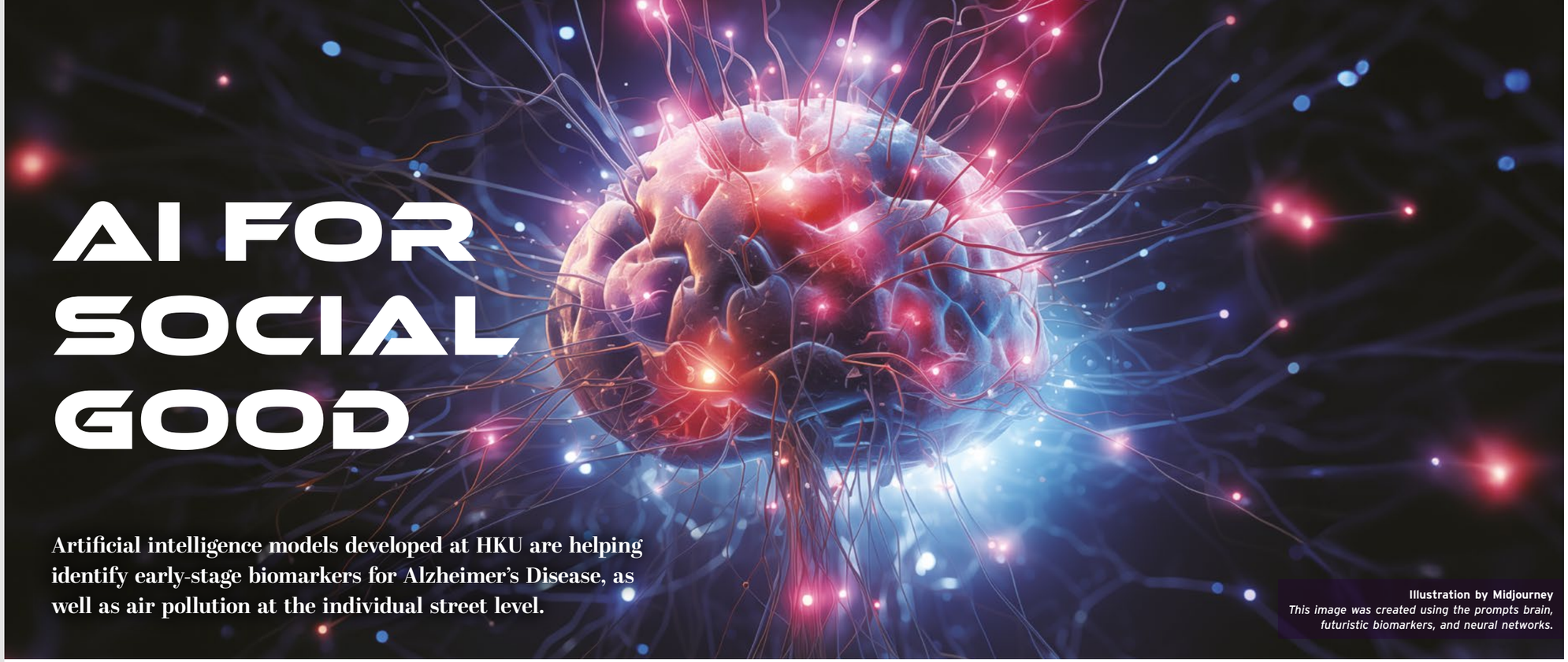

Illustration by Midjourney
This image was created using the prompts brain, futuristic biomarkers, and neural networks.

> "Our aim has been to use AI- and data-driven research models and interdisciplinary approaches to improve people's health and quality of life."
>
> Professor Victor Li On-kwok

When Professor Victor Li On-kwok and Dr Jacqueline Lam Chi-kei of the Faculty of Engineering started working together more than a decade ago, their aim was simple: how can big data be harnessed for positive change in our societies? Professor Li brought information engineering expertise, Dr Lam urban planning. Their initial focus was on air pollution given its detrimental impacts on health and the environment and they began to work with various departments in the University of Cambridge.

Emerging from that work have been ongoing collaborations that now also cover AI in Medicine, as well as the HKU-Cambridge AI to Advance Well-being and Society and HKU-Cambridge AI for Neuro-disease research platforms.

Over the past three consecutive years, for instance, they have been awarded an exceptional three Healthy Longevity Catalyst Awards by the US National Academy of Medicine (NAM) for applying AI and big data to the challenge of early detection and treatment of patients with Alzheimer's Disease (AD).

"Our aim has been to use AI- and data-driven research models and interdisciplinary approaches to improve people's health and quality of life," Professor Li said. "These models have become more powerful in recent years thanks to advancements in computational capacity and the availability of more big data."

Combing for biomarkers

Their focus on AD has been inspired by the fact that around 50 million people worldwide currently suffer from AD and related forms of dementia, including 10 million people in China, resulting in irreversible brain damage. Despite the urgent need for treatment solutions, there is a lack of effective restorative treatments or preventative therapeutics for AD. One treatment, Aduhelm, was approved by the US Food and Drug Administration in 2021, but it has side effects and its effectiveness remains inconclusive.

The research led by Professor Li and Dr Lam, with collaborators Professor Illana Gozes from Tel Aviv University, Dr Yang Han, and Dr Jocelyn Downey from HKU Engineering, aims to accelerate the search for more effective AD drugs by applying new causal AI techniques and domain-specific pathological knowledge. Their approach combines AI with neuroscience and immunology expertise and has led to a breakthrough in methodology by creating a biomedical graph that incorporates genetic mutations and pathological knowledge. This is expected to improve the speed and accuracy of drug discovery for AD.

They are also preparing to develop a model to comb huge health datasets from the US and the UK for biomarkers, such as genetic, protein biomarkers, and linguistic markers, that could determine if the disease can be detected before the onset of symptoms. Linguistic markers, in particular, could detect if a person's language is becoming impaired, which might be a very early signal of Alzheimer's. The team hope to identify such new linguistic biomarkers for different languages.

"Our linguistic team, including Dr Lawrence Cheung from the Chinese University of Hong Kong and Professor James Rowe from Cambridge, shall work with us to develop a standardised set of assessment tools so we can collect natural language data from patients while also making good use of the available linguistic data," Dr Lam said. This work will be supported by their 2023 NAM award, with additional funding expected from other sources.

Recently, the HKU team also established the HKU-Cambridge AI for Neuro-disease research platform with Professor David Rubinstein and Professor James Rowe of Cambridge, to apply their AI model to predict AD and possibly other neural diseases such as Parkinson's and Huntington's Disease.

Air pollution alerts

Other major achievements include a HK$50 million Theme-based Research project awarded in 2017 by the Research Grants Council that enabled them to estimate air pollution at the individual street level, thus allowing a fine-grained assessment of health impacts.

This work was inspired by the limitations of the current air quality alert system. Hong Kong has only 18 air quality monitoring stations, but the air quality can vary a lot between them. The team sought to fill in the blanks by inputting other information related to air quality – such as traffic congestion, wind direction and speed, the presence of tall buildings, and temperature and humidity – to create 110,000 virtual stations that can estimate the air pollution on any given street.

"Increasingly, our mission has been reinforced in different parts of the world where there have been increasing alerts on the effects of air pollution on health and mortality. For a while, attention was mostly on greenhouse gases, but now people realise the health impacts of air pollution have not gone away," Professor Li said.

"AI is just a tool and it can be very meaningful and powerful if we aim to make good use of it to improve the situation for weak and vulnerable people in society, while minimising its undesirable effects," Dr Lam said.

BETTER ACCESS TO BETTER DRUGS

Illustration by Midjourney
This image was created using the prompts AI for medicine, and using AI to identify newly available drug.

Dr Shirley Li Xue of the Li Ka Shing Faculty of Medicine combines real-world data, simulation modelling and decision analytics to show policymakers, healthcare professionals, the pharmaceutical industry and the public how new, seemingly expensive medicines can achieve cost-effectiveness for improving health.

Warfarin is a standard drug in Hong Kong to prevent blood clots in patients with atrial fibrillation. But it is not easy to use. Patients need to monitor their kidney function and regularly return to the clinic for checks. Yet, there are alternative drugs that do not require this monitoring. The major catch is that they are more expensive.

In health economics, this is not just a dollar and cents dilemma. The 'incremental cost-effectiveness' considers the money side and the possibilities of better health with an improved quality of life and an extended lifespan. Applying this approach to warfarin, Dr Shirley Li Xue, a joint appointee of the Departments of Medicine and of Pharmacology and Pharmacy, and her colleagues showed it is cost-effective for Hong Kong's Hospital Authority (HA) to go for the higher-priced drugs. This factor contributed to the HA's decision to add these to the public formulary.

"We used the cost of innovative medicine minus the cost of standard care divided by the difference in quality-adjusted life years and compared this with the government's willingness to pay for an additional year of perfect life. When it is below that threshold, although the drug is more expensive than conventional treatment, it can still be affordable and cost-effective," she said.

That study, published early this year, dovetails with Dr Li's ambitious new project to bring a more transparent and rational approach to determining which medicines should be made accessible to patients who use the public hospital service. Currently, that service does not tend to systematically factor in local evidence of cost-effectiveness but waits for evidence from other jurisdictions.

Providing evidence

Dr Li's three-year Research Impact Fund project aims to demonstrate the effectiveness of health technology assessment (HTA) for enlisting new drugs. HTA has been adopted by many countries, from the UK and US to Mainland China and India, but not yet Hong Kong.

"Currently, we don't know how drug enlisting decisions are made," she said. "Value for money or HTA are not written into the guidelines. Drug enlisting decisions should be evidence-based, transparent and fit-for-local-needs."

Her project, called Horizon Scanning of the Medium to Long-Term Burden of Chronic Disease and Care Needs to 2030 in Hong Kong, aims to provide that evidence. It focusses on three therapeutic areas – mental health (specifically, depression), auto-immune disease (inflammatory bowel disease) and oncology (prostate cancer) – and involves experts in health economics, big data, pharmacology and pharmacy, computer science, social science and medicine from HKU, Queen Mary Hospital, the Chinese University of Hong Kong, London School of Economics and Political Science, Newcastle University, Fudan University and the Hong Kong Association of the Pharmaceutical Industry.

The team are first collecting big data from population-wide de-identified HA electronic medical records to understand the disease burden and patients' unmet needs. Second, they are using classical and novel simulation models including artificial intelligence to forecast the burden of these diseases over the next 10 years, such as incidence, mortality, and healthcare cost. And third, they are scanning and verifying the global horizon for innovative drugs using ScanMedicine, an AI-based global medical innovation database, cross-checking the potential candidates with clinical expertise, global drug manufacturers and ongoing clinical trials.

Bridging the gap

The information will be combined into a decision toolkit to aggregate the identified innovative drugs' safety, efficacy and cost-effectiveness in Hong Kong.

"Industry always strives for breakthrough therapies, but policymakers are sometimes puzzled about which one they should buy because resources are limited," Dr Li said. "We want to bridge their dialogue and use healthcare big data, artificial intelligence projections and decision analytics to let policymakers know other options."

Dr Li said it was necessary to develop a localised HTA ecosystem because each place has its own healthcare system, needs and budget. HTA also improves transparency in decision-making. "We hope that with this project, we can make an important step towards establishing HTA in Hong Kong. We should at least reach a similar level to our neighbours in the Asia Pacific," she said. "Fundamentally, our goal is to benefit patients."

Transparency is also built into her HTA project. She and her team will make the analytical results and research report available through a website and collect feedback from users. Once they have refined their decision toolkit, they aim to hold workshops for decision-makers, healthcare providers, clinicians, industry partners and students, and develop a lecture series HTA101 explaining horizon scanning and how to use evidence to inform decisions on new drug listing.

"I hope our work will help Hong Kong catch up in using real-world evidence and AI to identify newly available drugs for quicker and better decision-making," she said.

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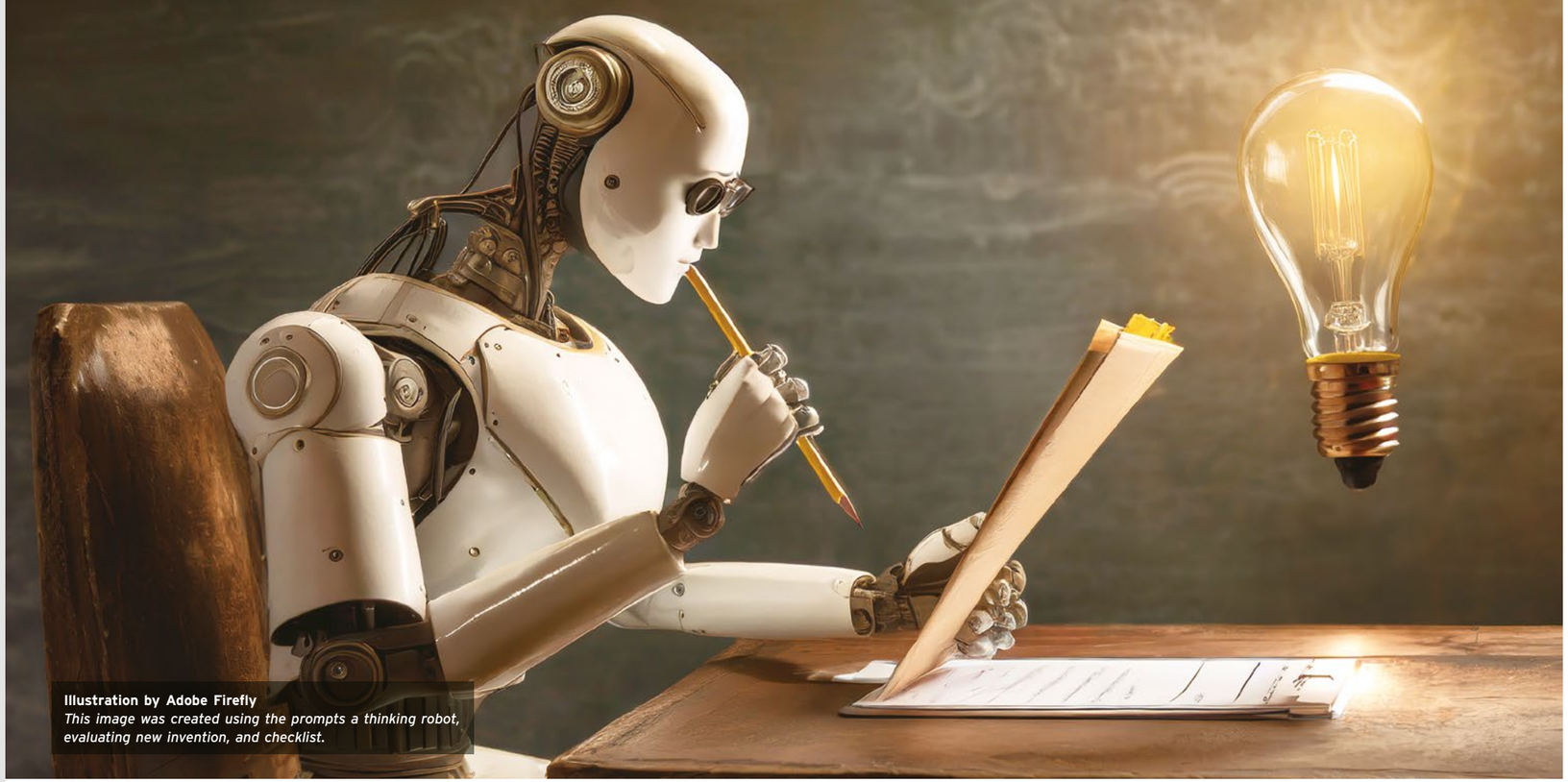


Illustration by Adobe Firefly
This image was created using the prompts a thinking robot, evaluating new invention, and checklist.

TESTING INNOVATION

AI could determine how innovative an invention is. It may one day also have the potential to create new inventions itself. Dr Ryan Whalen has been looking at the ramifications for the law and innovation policy.

How does one determine if an invention is truly innovative, worthy of a patent? Or, say, a song is truly original, worthy of copyright protection? The answer is not very straightforward, says Dr Ryan Whalen of the Faculty of Law, who is using large language learning models to try to improve that decision.

"These are really difficult doctrinal questions to answer that we historically have used pretty hazy legal tests to answer," he said. "The jurists have built up language and multi-prong tests to determine this, but frankly, a lot of scholars and practitioners think this comes down to gut feelings.

"If you're a patent examiner, you're reading a specification of an invention and comparing it to the sum total of human knowledge that preceded it, and asking yourself, is this obviously a new step or not? It's a difficult question to answer with any degree of certainty and objectivity."

This is where data and AI can come in. Dr Whalen has developed a model that can study the natural language of a patent application and compare it to other patents and scientific publications to get a more explicit signal of its originality. He layers that on top of the social network of the inventor to see whether the patent filer's invention is non-obvious compared to those of his contacts (non-obviousness makes it a candidate for a patent).

The intention is to provide jurists with more information. "At this point, it's much more appropriate to use AI tools to aid human decision-making rather than be a kind of automated decision-making machine. They provide another signal that might help patent judges make a really tough decision," he said.

Networks and innovation

In China, interestingly, the question of originality is often left to private operators. Alibaba has a platform to compare new products being uploaded with existing ones, to see if there is any infringement of intellectual property (IP). This is faster and more efficient than going through the courts, but it does raise questions about allowing private corporations to be in charge of granting and arbitrating IP rights, he said.

Dr Whalen has also applied his model to innovation policy by looking at collaborative research and the backgrounds of the collaborators, including their disciplines and previous outputs. He and his team find that while the most popular collaborations are between people of similar disciplines working on a similar problem, followed by people of very different disciplines working on a problem that neither of them has worked on before, they do not produce particularly high-impact results.

"The best type of collaboration we identify is where there is a substantial difference between the collaborators, so they work in different fields but they choose to work on a topic that's somewhat in the middle between them. These types of collaborations are highly under-represented in the empirical data, but they are quite successful.

"One of the conclusions we draw from that is when you're developing innovation policies and looking at funding at the university or grants level, you might want to take this topographic reality into consideration to guide things like academic hiring and funding disbursements," he said.

> "At this point, it's much more appropriate to use AI tools to aid human decision-making rather than be a kind of automated decision-making machine."
>
> Dr Ryan Whalen

Teething issues

AI is not only an assessment tool, though. It may also one day create innovations itself – in which case, to whom would a patent or copyright be granted? The issue has excited his students, but Dr Whalen believes it is a niche problem that will not exist for the foreseeable future. First, because humans are inevitably involved in terms of directing AI to solve certain problems. And second, if AI did take over product development, it would undermine the profit incentive that underpins patents and motivates developers to bring their products to market.

Even if – when – AI is able to invent things, "it can be remedied quite easily from a legislative standpoint. You just tweak the inventorship definition to include artificial intelligence but grant the patent to the operator of the AI – the person who used it," he said.

Dr Whalen said it was important to bear in mind that AI is still going through teething issues. "Right now, it's basically a highly sophisticated autocomplete machine," he said.

Still, it already has the potential to impact the legal profession by doing tasks that lawyers typically see as low value in terms of income, such as writing wills, or even high value in terms of doing complicated research that generative AI could far more easily conduct and summarise. "For sure there will be resistance to this, but there will also be rewards for agile firms that are able to adopt these new technologies quickly," he said.

A CHALLENGE FOR CREATIVES

With the help of AI, you can press a button and, voila, create a new song in seconds. That technology is a promise to some, but a nightmare for others. Musicologist Dr Rujing Stacy Huang has been exploring this dilemma.

Illustration by Adobe Firefly
This image was created using the prompts AI programme generating music, musical notes, and moving melody.

Dr Rujing Stacy Huang, Presidential Postdoctoral Fellow in Music, is one of the few humanities scholars in the world working at the intersections of music and AI. In 2021, she was recruited to join 'MUSAiC', a five-year, EU-funded research project based in Sweden, to investigate the critical issues arising from AI's disruption of music – the only humanities scholar in a team of computer scientists and engineers. Since then, she has engaged in countless conversations with different stakeholders on the perceived impact of AI over the creative fields.

A computer scientist recently told her they did not see why their children should learn to play any musical instrument if AI could complete the task for them. They excitedly related how machine learning would soon be generating all the music humans need and in unbeatable quality.

"What is striking in this statement is that it prioritises the function of music as a commodity and a sheer data output, while erasing the entire embodied, aesthetic experience of music," she said.

But that doesn't mean there is no place for AI in music. "At the extremes we hear two opposing views around creative AI. One is that it makes everyone an artist, and this is the best era to be a creative; the other is that AI signifies the end of art, and the death of the true 'artist'." Rather than choosing sides, Dr Huang is more interested in exploring the fundamental questions and assumptions embedded in such narratives. Specifically, she has been considering questions relating to ethics, authenticity, artistic skill and de-skilling, and more generally the shifting nature of creative work.

'Machine folk'

On authenticity, for instance, her collaborator Associate Professor Bob Sturm created an algorithm that can generate tunes in the style of Irish traditional music. On the surface, such 'machine folk' may seem to diminish authenticity by bypassing the human creator (the 'folk') and their community, story, culture, history and identity – elements most essential in defining folk music. But not quite, said Dr Huang.

"In this case, Sturm would share some of the generated tunes with the traditional musicians' community, including his Irish accordion teachers. The tunes would then be practised, played, taught, exchanged, and eventually they would enter a musician's tune collection. I call this a process of authentication, when a 'machine folk' comes to live. After all, authenticity is never fixed but is always in the becoming," she said.

She has also brought a classical Chinese philosophy perspective to her work. "In my work, I have argued that in reaching beyond Western systems of thought, we may open up new perspectives for thinking critically and responsibly about (music) AI."

> "We're interested in discovering how AI can meaningfully push the boundaries of creative expression."
>
> Dr Rujing Stacy Huang

Recently, Universal Music Group urged Spotify to remove a song where AI was used to 'deep-fake' the vocals of Drake and The Weeknd.

"This incident points to the age-old question about what in music is copyrightable. Should the human singing voice be subject to copyright protection? And, besides the question of legality, is unconsented AI voice cloning ethical?" she asked.

Human-AI partnership

Also intertwined is the issue of musical labour. "Is virtuosic skill as conventionally conceived still vital when defining the next generation of working 'artists'? Can art be generated instantly and with minimal effort? Consider songwriting via the press of one button." But Dr Huang also cautioned against oversimplifying the power of AI: "When deployed with nuance, AI tools can unleash previously unimaginable, creative possibilities."

In 2021 and 2022, Dr Huang co-organised the AI Song Contest (AISC), an annual, international competition exploring human-AI partnership in songwriting. Besides the song, entrants must submit a four-page 'process document' and teams typically consist of both musicians and scientists. The contest has received coverage from *The New York Times*, *Science*, *Scientific American*, *Billboard*, *BBC etc*. In Spring 2023, via a partnership with Sony, AISC launched its inaugural Artist Residency at the Sony Computer Science Laboratories in Paris. Dr Huang currently sits on the board of directors for the AISC Foundation, a non-profit entity based in the Netherlands.

Dr Huang (second from right) was a panellist at the AI and Music Industry Forum organised by IFPI Sweden (International Federation of the Phonographic Industry) and STIM (Swedish Performing Rights Society) in Sweden in May 2023.

"As a process-driven contest, we're interested in discovering how AI can meaningfully push the boundaries of creative expression," she said.

Dr Huang, who was recently invited to share her research with Google's Montreal Office and the Google Magenta team, stressed the urgency of bridging technological development with critical, humanistic inquiry. She sees HKU as a place where this has started to happen, through initiatives such as the new Bachelor of Arts in Humanities and Digital Technologies, and the AI & Humanity Lab. "You'd be surprised at how rare this is. It is not an easy bridge to build, but it's worth the hard work."

TEAMWORK AT THE NANOSCALE

Dr Tang Jinyao of the Department of Chemistry is showing that nanoparticles created by humans can behave as communities – much like bees and ants – to achieve more as a unit than individually.

Nanoparticles are programmed microscopic particles that can respond to external stimuli such as light to perform functions, such as moving towards a chemical target or light source. The hope is that they can be harnessed for energy saving, drug delivery and other purposes. But they have a limitation: they are typically programmed as individual actors. Put a vast amount of them in a solution and their behaviour becomes unpredictable.

Dr Tang Jinyao has addressed this problem by treating nanorobots as a group rather than individuals. This follows on from his 2016 achievement developing the world's first light-seeking synthetic nanorobot, which is about the size of a blood cell and is propelled by light through photochemical reactions.

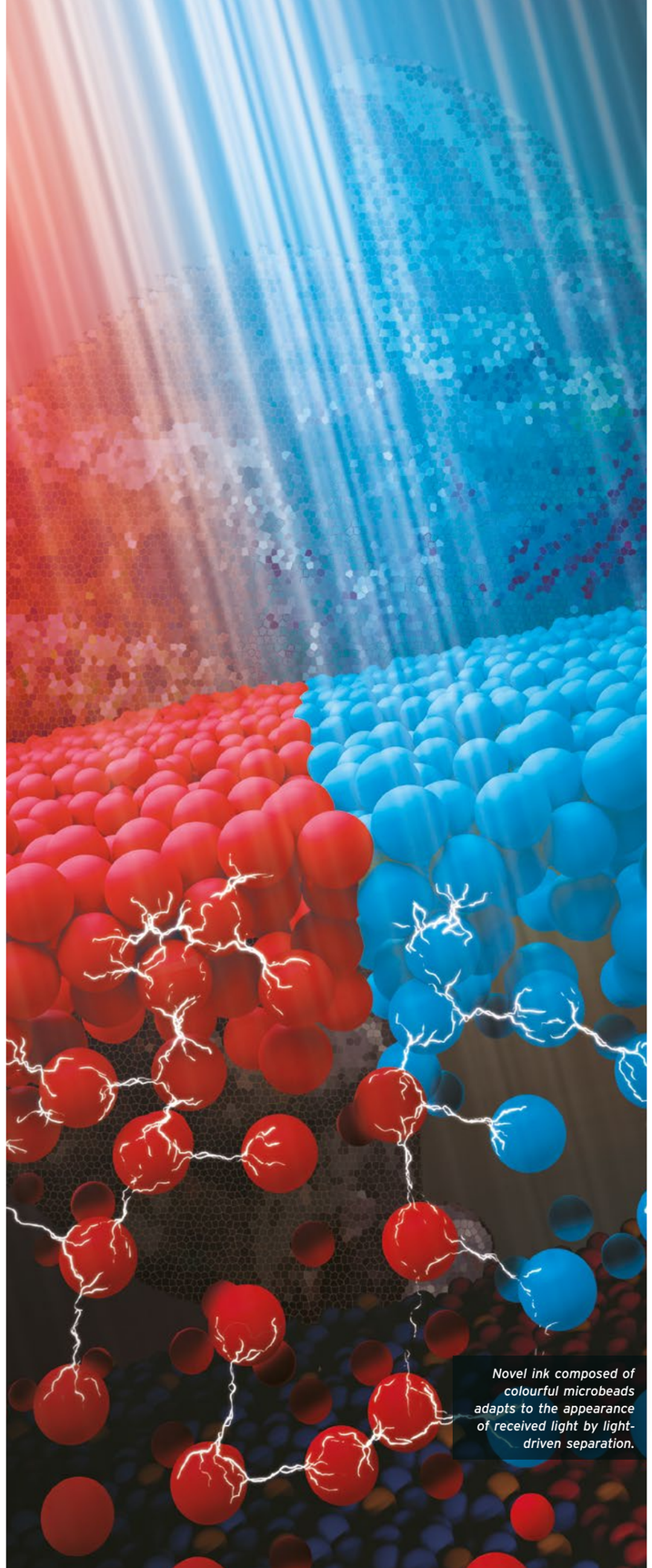
A lot of hope was pinned to that discovery and its potential to deliver drugs and treatments for healthcare. But Dr Tang and his team found the individual nanoparticles were too small to be programmed for complex actions.

"However, we started to realise they could actually be a community. Like individual ants or bees in nature, they do not do much on their own. But as a group, they start to perform very smart functions. Materials science takes the same approach. We treat matter as a group of molecules or atoms and try to figure out the properties. In this case, we started to look at how our particles or nanorobots interacted with each other to see if some kind of intelligence or functions could emerge," he said.

Like oil in water

Further studies showed that when a large number of light-seeking nanorobots were placed in a solution, the nanorobots behaved as a random mixture. But when different organic dye molecules were attached to the nanorobots, either red, blue or yellow, and a red light was shone on the solution, the red nanorobots absorbed the light and interacted with each other to dye the solution red – "like oil molecules in water attracting each other," he said.

To Dr Tang this offered a new insight – that collectively, nanoparticles are like a material rather than individual units. Moreover, he showed they are active particles, not dead inert matter which is what most materials are made of. "This is basically the first example of how we can use active things for material applications. It is just one example and I expect more will emerge," he said.



Novel ink composed of colourful microbeads adapts to the appearance of received light by light-driven separation.

> "This is basically the first example of how we can use active things for material applications. It is just one example and I expect more will emerge."
>
> Dr Tang Jinyao

Possible applications could be using the nanoparticles to create electronic ink that reflects colour (similar to a Kindle, which only displays black and white) or produce camouflage or colour-shifting materials, such as a shirt that turns white under sunlight and black in the dark, or a building that changes colour to absorb sunlight when it is cold and repel it in the heat.

He noted that while this was not intelligence per se, he also showed in other circumstances that a simple group 'intelligence' can emerge when programmed nanoparticles work together to make decisions in a complicated environment. That work is supported by a Croucher Senior Research Fellowship.

Following the leader

The basic interaction still involves nanoparticles attracting or repelling each other but they are programmed to follow each other's lead. Each particle can only sense its local environment, but when there are a lot of them, they propagate information through their interaction chains and come to a consensus on which direction to go in.

An example of how this might work beyond the experimental lab is with cancerous tumours, which give off weak signals. The nanoparticles ostensibly could be programmed to sense the signal, with those closest to the tumour sensing the tumour first. They would move towards the tumour, attracting other particles, which would build up to a consensus for all other particles to follow. However, Dr Tang cautioned that tumour targeting is still only an aspiration and more work is needed.

"Other researchers have not really realised the importance of the interaction between different particles, so we want to at least develop several theories or protocols on programming these groups," he said. "One way of doing that is to study them as a material because there are techniques in materials science that we could apply. And of course, we want to develop new techniques."

Dr Tang noted that communication between nanoparticles was what linked his two lines of study. He hopes in future to uncover other properties of active matters and intelligent matters and find useful applications, though these will not likely be in the biomedical field at this stage given the regulations and complexities involved. "There's no product yet but we want to make the first one. Hopefully, others will follow and there will be more investment in this research," he said.

Colour changes to a picture caused by pigment particles rearrangement after exposure to light.

ABOVE AND BEYOND

A team from the Department of Mechanical Engineering have developed PULSAR, a new uncrewed aerial vehicle (UAV), which is revolutionary for its single actuation, flight efficiency, and fully autonomous navigation with an extended sensor field of view (FoV) via self-rotation.

The vehicle's full name is Powered-flying Ultra-underactuated LiDAR (light detection and ranging) Sensing Aerial Robot (PULSAR), and the development team describe it as an agile and self-rotating UAV whose three-dimensional position is fully controlled by actuating only one motor to obtain the required thrust and moments.

Mr Nan Chen, PhD candidate of Mechanical Engineering and lead author of the paper which has been published in *Science Robotics* said: "The greatest advantage of UAVs lies in their ability to break free from the constraints of terrain, swiftly reaching places that are hard for humans to access, and providing efficient real-time environmental observation. UAVs are used in various applications, such as aerial photography, express transportation, search and rescue, and building mapping. There is a lot of potential in the industry for multiple further applications."

The team, from the Mechatronics and Robotic Systems (MaRS) Laboratory led by Dr Fu Zhang, have been working on UAVs since 2018, aiming to achieve a simple and reliable structure design and fully autonomous navigation. Autonomous UAVs typically have visual sensors to perceive obstacles and explore environments, but their perception capability is limited by a small sensor FoV. The MaRS team solved this problem by leveraging self-rotation to extend the sensor FoV without consuming extra power.

"Before PULSAR, we already had the Gemini II, a compact and efficient dual-rotor UAV with a servoless design," said Mr Chen. "While, theoretically only one actuator is enough to realise a powered flight, in fact, when using one motor, the counter-torque of the motor cannot be fully counteracted and must result in an uncontrollable self-rotation of the UAV body."

Self-rotation motion

The team first asked themselves how a self-rotation motion could be utilised. The question they wanted to answer was: since the FoV of LiDAR often tends to limit the efficiency of 3D reconstruction of environments, wouldn't combining self-rotation motion with LiDAR enable scanning for a larger FoV? "Therefore, we designed PULSAR whose revolution derives from the facts that fully autonomous flight is achieved with a minimal number of actuators, plus the self-rotation motion very inherently leads to a larger FoV of LiDAR," said Mr Chen.

"While the self-rotation motion can extend the LiDAR FoV, the firm support of an efficient and robust algorithm of LiDAR localisation is indispensable, because the high-speed rotation movement is a substantial challenge for such algorithms," he added.

"The LiDAR localisation algorithm employed by PULSAR is FAST-LIO2 – which is an efficient LiDAR-inertia odometry also developed by our MaRS laboratory. Notably, FAST-LIO2 demonstrates remarkable robustness to the aggressive motion. In the future, we plan to use UAVs like PULSAR as a platform to explore more advanced and more robust LiDAR localisation algorithms."

In addition to the extended FoV, the use of a single actuator has other advantages, as it reduces the energy conversion loss of the propulsion system during flights, meaning that PULSAR consumes 26.7 per cent less power than widely used quadrotor UAVs with a similar propeller area, while retaining a good level of agility.

> "Uncrewed aerial vehicles are used in various applications, such as aerial photography, express transportation, search and rescue, and building mapping. There is a lot of potential in the industry for multiple further applications."
>
> Mr Nan Chen

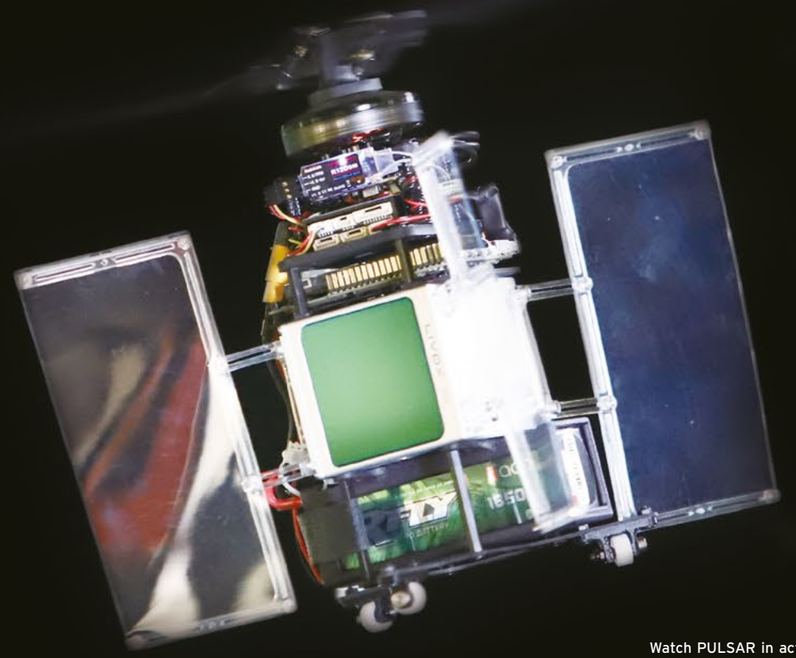
The onboard LiDAR sensor enables the PULSAR's ability to perform autonomous navigation in unknown environments, and to detect obstacles – whether static or dynamic – in panoramic views without any external instruments.

The team have been experimenting with the PULSARs in environment exploration and multidirectional dynamic obstacle avoidance with the extended FoV via self-rotation, which could lead to increased perception capability, task efficiency, and flight safety.

Intricate systems

Asked about his own particular fascination for UAVs, Mr Chen said: "The applications for UAVs are undoubtedly multiple and exciting, and at the same time they are also intricate systems that demand a compact structure to reduce overall weight, an efficient propulsion system to extend flight duration, stable and reliable control, mapping, and planning methods to ensure flight safety, and efficient algorithms to accommodate limited onboard computing resources. In these aspects, UAVs still have many issues that are worth exploring and solving.

"Our next step will be to combine the characteristics of both self-rotation and single-actuation with the advantages of fixed-wing UAVs, for supporting long-distance environmental observation tasks," he added, "because while PULSAR has higher efficiency than most quadrotor UAVs, it is still hard to compare with the fixed-wing UAVs in the aspects of flight efficiency and flight speed."



Watch PULSAR in action

SHEDDING LIGHT ON THE DARK

A study has provided the most direct evidence yet that dark matter does not constitute ultra-massive particles, as is commonly thought, but instead is made up of particles so light that they travel through space like waves.

Illustration generated by AI depicting complex caustic patterns due to gravitational lensing by ultralight dark matter. (Courtesy of Chamoth Weerasinghe)

The existence of dark matter (DM), the mysterious substance that makes up 80 per cent of the universe's mass, was first reliably inferred in the 1930s, although not fully recognised until the 1970s. What particle makes up DM, however, remains an enigma. For decades, physicists have hypothesised that weakly interacting massive particles (WIMPs) are the strongest candidate, but laboratory experiments have failed to find evidence to back the theory.

The new study adds to the increasing evidence against WIMPs that has been gathered from astronomical observations. "Our findings make way for a new paradigm where ultralight DM particles are strong contenders for dark matter, deserving the full weight of scrutiny as has been paid to WIMPs," said Mr Alfred Amruth, lead author of the study.

Dr Jeremy Lim, Associate Professor in the Department of Physics and Mr Amruth's supervisor on the research, said: "At present, the Standard Model does not allow for any particle having the properties of dark matter. There are many theoretical extensions to the Standard Model, predicting particles over a wide range of masses – from ultralight particles (such as the ones we infer from our study) to ultra-massive particles. The question is which of these theoretical extensions are correct: if we can identify the correct theoretical extension, then we would know the correct path towards new physics."

The findings have attracted a great deal of interest, an example being the study's selection as the cover story of *Nature Astronomy* earlier this year.

> "Much research has already been spurred by our work showing ultralight dark matter's ability to resolve the long-standing lensing anomalies in astronomy."
>
> Mr Alfred Amruth

"That was something we were very happy about," said Mr Amruth, who has just completed his PhD defense and is remaining at HKU on a Dissertation Year Fellowship. He first came to HKU from Sri Lanka in 2013 as an undergraduate, and for those 10 years, Dr Lim has been his research supervisor. The two of them collaborated on this work with Professor Thomas Broadhurst, Ikerbasque Research Professor at Spain's University of the Basque Country; Professor George Smoot, a Nobel Laureate in Physics from the Hong Kong University of Science and Technology; and Dr Razieh Emami, Research Associate at the Center for Astrophysics, Harvard & Smithsonian.

"Our demonstration that ultralight particles are a strong candidate for DM will now help mobilise further research (theoretical and observational) into ultralight DM to assess whether it truly is a correct description," said Mr Amruth. "The possible existence of such ultralight particles was first proposed by String Theory, and this particle is capable of resolving the astrophysical problems faced by massive DM. Much research has already been spurred by our work showing ultralight DM's ability to resolve the long-standing lensing anomalies in astronomy."

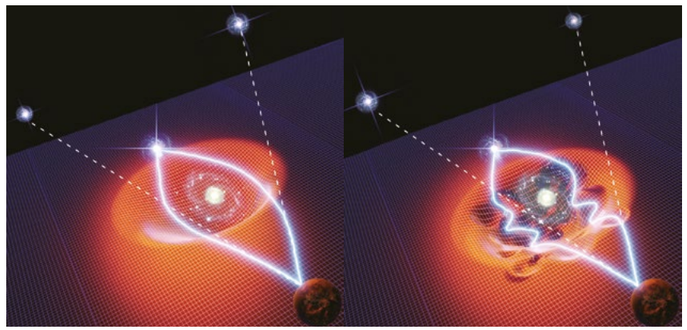
Gravitational lensing

The evidence the team use in particular, arises from the phenomenon of gravitational lensing (courtesy of Einstein's general theory of relativity), where anything with mass can bend the path of light. "Over the past two decades, when we looked at astronomical observations of quasars (the very bright nuclei of galaxies constituting visible evidence for vigorous accretion on to their central supermassive black holes) which are lensed by a foreground galaxy, it was typically difficult to reproduce the observed positions and brightnesses (also known as lensing anomalies) of the lensed galaxies if one used a massive particle DM model," explained Mr Amruth.

"However, when one uses ultralight DM, we can resolve these lensing anomalies and reproduce the observations of the lensed galaxies. Our motivation was the long-standing problem of lensing anomalies, as well as the fact that no one has attempted to calculate the lensing properties of ultralight DM before. We take these together, in the spirit of the scientific method, and make theoretical predictions which can be compared with the observations of lensed galaxies."

Their theory has already inspired more research papers which further investigate the possible mass range of ultralight DM particles from the perspective of particle physics experiments. "There has also been research in astronomy looking at observations of lensed galaxy clusters to place further constraints on the mass of the ultralight DM particle," said Mr Amruth. "In addition, we are currently working on a follow-up paper which finds that ultralight DM can resolve lensing anomalies in the first type-Ia lensed supernova [a type of supernova that occurs due to an accreting white dwarf approaching a mass of 1.4 times that of the Sun]."

Asked about his initial interest in astrophysics, Mr Amruth said: "I've always been very passionate about the universe and how it works – I focussed on research about DM since it composes the majority of mass in our universe and we still don't know what it is! This is of fundamental importance since DM, much like fire and electricity, has the potential to be the next discovery which propels humanity into a spacefaring civilisation! Ultimately, what this is all about, is to identify the path to new physics, which will be an incredible revolution for modern science."



These 3D renderings illustrate differences in gravitational lensing for the case of heavy particle dark matter (left) and ultralight dark matter (right). The dashed lines indicate where two lensed images (of the same background quasar) would form, enabling the researchers to observe them via telescope.

EVERYTHING UNDER THE SUN

Scientists have developed a catalyst that turns the damaging greenhouse gas methane into an essential chemical, formaldehyde, using the power of sunlight.

Carbon-heavy methane ranks high on the climate change blacklist, with a global warming potential that is more than 80 times that of carbon dioxide over a period of 20 years. It is also in abundant supply – the recent global increase in methane (CH_4) is primarily attributed to the shale gas revolution – and is useful for thermal power generation.

However, to mitigate its harmful effects while at the same time offering environmental benefits, scientists have been working on ways to achieve direct CH_4 conversion into value-added chemicals such as methanol, formaldehyde and formic acid – thereby creating considerable economic advantages too.

Professor Zhengxiao Guo from the Department of Chemistry and Professor Junwang Tang, now at Tsinghua University's Department of Chemical Engineering, have taken a major step towards achieving this with the development of a highly active catalytic material that can efficiently convert methane into an essential chemical in a waste-free manner.

Professor Guo said: "Converting methane into other chemicals is a tremendous opportunity to achieve net-zero energy. One of the challenges though, is that methane is an extremely stable molecule and very resistant to activation, particularly under mild or ambient conditions. Thus, achieving high activity and selectivity in catalytic methane conversion has long been considered by chemists to be a significant challenge."

Catalytic material

The team's innovative catalytic material is derived from tungsten trioxide (WO_3 catalyst) and features a dual active site comprising copper and tungsten atomic species that work in tandem to ensure an effective and selective conversion process. Tungsten trioxide nanocrystals were used as the substrate due to their visible-light responsive property.

"Converting methane into other chemicals is a tremendous opportunity to achieve net-zero energy. One of the challenges though, is that methane is an extremely stable molecule and very resistant to activation, particularly under mild or ambient conditions."

Professor Zhengxiao Guo

Hence, the conversion process is achieved highly selectively using visible light, meaning there are no unwanted by-products and ensuring it is an eco-friendly alternative to current production methods. "Current production of formaldehyde involves methanol oxidation or dehydrogenation, above 250-700 degrees Celsius, and consumes a considerable amount of energy," said Professor Guo.

The new process exhibited nearly 100 per cent selectivity and high conversion efficiency, significantly outperforming previously reported photocatalysts. The findings have been published in the prestigious journal *Nature Communications*.

"Key to realising such direct conversion and selectivity is the regulation of the reactive oxygen species (ROS), enhancing the conversion of methane and promoting desorption of the desired products, whilst suppressing its mineralisation to CO_2. This is like creating an electronic conduit for the value-added chemical to be produced, rather than letting the whole process run completely downhill," said Professor Guo.

"Mechanistic analysis revealed that copper helped move electrons around and create reactive molecular species, while the tungsten helped activate the methane gas. The copper acted as electron acceptors and promoted photo-induced electron transfer from the conduction band to dioxygen, generating reactive hydroperoxyl radicals."

At the same time, the adjacent tungsten atom that had a partial positive charge facilitated 'hole' transfer, as effective electron-hole separation is critically important for efficiency. The preferred adsorption and activation site of water produced reactive hydroxyl radicals and effectively activated methane to methyl radicals. The synergy of the adjacent dual active sites boosts the overall efficiency and selectivity of the conversion process.

Solar power

"It is highly desirable to turn methane into low-carbon and high-value-added chemical products, using abundant solar power," said Professor Guo. "However, product selectivity and production efficiency are key to success. Here, we have achieved very high selectivity, but the efficiency can still be improved to make the process more practically viable.

"This requires in-depth understanding of the photo-electronic behaviours that govern the conversion process and further engineering of the catalyst system. Interestingly, those two tasks may benefit from the advanced technologies that underpin the two recent Nobel Prizes in Physics and Chemistry, respectively: the use of attosecond spectroscopy to probe photo-electronic behaviours and the application of quantum dots to promote the overall electron transfer efficiency. Those are indeed some of the focussed directions of our multidisciplinary consortium, currently funded by the UGC Theme-based Research Scheme."

This is not the first time that Professor Guo has successfully 'harnessed the sun' to effect transformation. Last year, working with another research team, he developed a process to catalyse net-zero green hydrogen from the sun using a fundamental catalyst protonation process to promote solar-driven hydrogen generation from water, without any CO_2 emissions.

Professor Guo (second from right) and his research team working on photocatalysis in the laboratory.

SKIN AND BONES

Bioanthropologist Dr Michael BC Rivera uses ancient skeletons to reveal the lives of peoples from the past. He also brings that expertise into present-day conversations about race and diversity.

A plastic cast skeleton on display as part of a public outreach project Dr Rivera co-leads in Fanling, where members of the public can learn about bioarchaeology and archaeological excavation.

When Dr Michael BC Rivera was 13 years old, he was captivated by the American television show *Bones*, about a forensic anthropologist who uses her skills to solve mysteries. Dr Rivera wanted to do the same thing, but in Hong Kong, where he grew up, there were no university programmes offering this training. He went to the UK instead, ultimately earning a PhD in bioarchaeology – a branch of biological anthropology that studies human skeletons from the past to learn about the lives of individuals and societies.

Now he is back, bringing his skills to HKU where he is Lecturer of Interdisciplinary Studies in the Faculty of Social Sciences and Co-Manager of the Human Bone Collection in the Faculty of Dentistry, trying to advance his field here through research, teaching and public engagement.

"I study human skeletons that are hundreds or thousands of years old. Just like in the TV show, if you laid out an archaeological skeleton in front of me, I could tell you, for instance, how old that person was when they died, whether they were healthy, what they ate, what kind of physical activities they did. Based on details of their burial, I might also be able to tell you something about their gender and cultural identities," he said.

In his dissertation, he investigated the historically understudied topic of people living on coasts, focussing on skeletons from modern-day Estonia and Latvia that were 1,000 to 10,000 years old. Among his findings were tiny bone growths in their inner ear – what clinicians call 'swimmer's ear' – indicating they spent a lot of time in the water. Their thick arm and leg bones also indicated an active lifestyle on land.

Common traits

He hopes to do similar work in Hong Kong as ancient skeletons come available. He runs bone labs for his Common Core course on bioanthropology, 'All You've Ever Wanted to Know About Humans'.

"A common question I get asked is whether nature or nurture forms us. My answer is it's both – the environment can change our bodies, but at the same time, our species' genes are probably coded to be flexible and adaptive," he said.

This idea dovetails with his research and teaching interest in race and diversity. Dr Rivera teaches a history course called 'Making Race'. Many ideas about race or ethnicity originated when European colonisers and scientists – including Charles Darwin – made negative comparisons with the different indigenous people they encountered around the world based on skin colour, body shape, clothing and other superficial details. These ideas made their way into public consciousness, but they are not aligned with science, Dr Rivera said.

> "I had to go abroad to enter this field. Now, I'm able to give these young people that experience I craved so much many years ago, here in Hong Kong."
>
> Dr Michael BC Rivera

"There's a biological evolutionary reason for different skin colours – it's due to different exposures to sunlight and UV radiation. If a person with fair skin moves to a place with high sunlight, their skin will get darker. If a person with dark skin moves to a place with low sunlight, they need to take Vitamin D supplements. It's a trait we all have. That should unite us as a species, not divide us," he said.

"I want more young people in Hong Kong and public audiences to know more about this history and be conscious of how we talk about race or think about human biology in today's society."

Engaging the public

Public engagement is a key part of his work. In his Common Core course, students must produce a public-oriented project, such as a YouTube video, social media post, school talk or exhibition. He teaches students communication skills to help improve the effectiveness of their projects.

He is also reaching out to other scholars in Hong Kong, the Greater Bay Area and Southeast Asia, and trying to provide excavation and teaching opportunities for senior students who want to pursue archaeology.

In one case, he was sought out to lead an excavation near Tai Tam Reservoir to recover the remains of a warplane that crashed in 1945. The site was overgrown but, after being discovered by local history enthusiasts, targeted for investigation in 2021. American experts were meant to come and lead the project, but the COVID-19 pandemic intervened. So Dr Rivera, who had recently arrived at HKU, was recruited instead and worked virtually with military archaeologists in the US. He also recruited about 200 volunteers, many of them students, to help in the study – a factor that caused him to tear up when the media interviewed him about the project.

Dr Rivera shows a schematic for the Grumman TBM Avenger aircraft in front of a tent full of artifacts. The Avenger plane crashed nearby more than 70 years earlier during the US Navy's efforts to protect Hong Kong from the Japanese forces in WWII.
(Courtesy of Ben Marans)

"I was asked why this was significant for me. It was because this had come around full circle. I had to go abroad to enter this field. Now, I'm able to give these young people that experience I craved so much many years ago, here in Hong Kong," he said.

WEATHERING EXTREMES

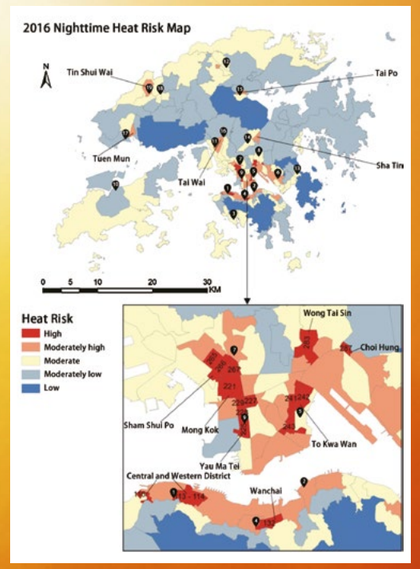
Cities need new ways of assessing the impact of extreme weather events and responding to their growing frequency, says Dr Chao Ren, who has done groundbreaking applications in this field.

Very hot weather is on the increase worldwide, challenging existing mechanisms for dealing with these events, as numerous recent disasters have revealed. Hong Kong is no exception. The city experienced its hottest summer on record this year and high temperatures posed a health risk to vulnerable groups such as the elderly. Yet, as research by Dr Chao Ren, Associate Professor of the Faculty of Architecture has shown, government facilities offering cool shelter are not matching up with the worst-affected areas of the city.

Dr Ren specialises in applied climatology and climate responsive design and has been working with the Intergovernmental Panel on Climate Change, World Meteorological Association (WMO), World Health Organization (WHO) and Hong Kong and national authorities to assess the impacts and responses to climate change at the urban level.

"Consecutive hot nights are a silent killer in Hong Kong, more than hot days, and we will have more and more of them. So how can we make our society ready for this and make the government aware that climate change adaptation and city resilience are a big issue they have to tackle, beyond reducing carbon emissions?" she said.

For Dr Ren, the answer starts with better information. As an architect, she has increasingly moved her focus from the built environment to the bigger picture of how it interacts with climate change and human health and how to build better resilience into urban planning.



A nighttime heat risk map in 2016 detailing the locations of the 19 heat shelters around Hong Kong. It shows that some hot spots with a high risk at nighttime such as Mong Kok and Choi Hung do not have any shelters.

> "Consecutive hot nights are a silent killer in Hong Kong, more than hot days, and we will have more and more of them."
>
> Dr Chao Ren

SARS origins

Her work in this field began, surprisingly, in the wake of the SARS epidemic in 2003. The virus was found to have travelled between the floors of buildings and between buildings, and one of the causes was poor ventilation. Dr Ren, a young academic at the time, became involved in a government-commissioned study to devise an urban climate map of the city and identify resources such as seaside breezes and cooling hillside air. This ultimately led to a government requirement that new development plans consider these pathways, as well as the adoption of a new term, 'non-building area', to forbid development in areas critical for urban ventilation.

The segue from ventilation to the urban heat effect was a natural one because both are impacted by the built environment. It has been the main focus of her activity over the past decade. Singapore and cities in such places as Europe and Taiwan have sought her expertise on urban ventilation and urban heat island effect. Dr Ren also wrote a book targeted at cities in Mainland China, *Breathing Cities*, that sold out within a year of publication in 2016 and led to her being invited by China's meteorology administration to help devise guidelines on city wind corridors and technical notes for industry.

But she is also interested in contributing to the longer-term perspective. "It's not enough that we only consider the current situation. More importantly, we need to factor the future changing climate into our city planning and design," she said.

Dr Ren is doing this through an ongoing collaboration funded by the Research Impact Fund (RIF) to work with cross-disciplinary experts, multiple government departments and NGOs on extreme weather at the district level.

Hot and cold

So far, they have identified the elderly and women to be most vulnerable to extreme heat and shown the mismatch of heat shelters to areas of need. The research also inspired the Hong Kong Observatory to enhance precautions in 2021 for the elderly and people with chronic medical conditions during hot weather, initiate a new weather warning in 2022 for extremely hot temperatures and define a new extreme hot indicator in 2023.

Dr Ren has also worked with the Hong Kong Green Building Council to raise awareness of the microclimate around buildings, which can aggravate the urban heat effect, and to devise new standards for sustainability and climate risk and resilience for buildings.

The RIF project has been extended to include extremely cold weather, since extremes at both ends of the temperature scale are more likely with climate change. She is also collaborating with the Hong Kong Red Cross and social workers on policies to alleviate urban heat impacts among vulnerable and low-income populations.

Internationally, the WMO has sought Dr Ren's input on guidelines for integrated weather services, such as improving the resilience of city infrastructure, and for urban climate application studies. She is also a member of the management committee of the Global Heat Health Information Network funded by the WMO and WHO.

"I feel lucky that my research can make a real and meaningful contribution to society and change policy, and has even been recognised at the international level. My future direction will focus more on social justice and city resilience under a changing climate," she said.

MORE THAN SKIN DEEP

HKUMed scientists have invented a novel microneedle patch that treats skin infections such as acne through the minimally invasive, transdermal delivery of ultrasound-responsive antibacterial nanoparticles.

Acne affects around 80 per cent of teenagers worldwide and causes significant distress, both physical and emotional. It is usually caused by excessive lipid secretion – often during puberty – clogging hair follicles on the skin which enables *Propionibacterium acnes (P. acnes)* bacteria to flourish. This leads to pimples which can be multiple and may develop into a chronic skin condition, sometimes leaving permanent scarring.

The microneedle patch has been developed as a non-antibiotic approach that is delivered painlessly and not only treats bacterial infections but promotes skin repair too.

"Ultrasound-responsive antibacterial nanomaterials are introduced to the microneedle patch that responds to bacterial infections quickly and efficiently," said Professor Kelvin Yeung Wai-kwok, leader of the research team from the Department of Orthopaedics and Traumatology in the School of Clinical Medicine. "We are treating acne without the use of drugs."

When subjected to ultrasound stimulation, the modified nanoparticles – comprising ZnTCPP and ZnO – can produce a substantial amount of reactive oxygen species (ROS) that effectively oxidises the key cellular macromolecules of bacteria. The effects are also fast: the results showed that the killing of *P. acnes* bacteria mediated by ROS can reach to 99.73 per cent after 15 minutes of ultrasound stimulation. At the same time, the treatment reduces inflammatory markers, making the spread of further skin infections less likely.

> "Our aim is for this treatment to be widely available to those who need it. We have designed it to be highly effective and cheap to produce, and we want it to be available where it will have a real benefit."
>
> Professor Kelvin Yeung Wai-kwok

Acne is sometimes treated with antibiotics, but this is controversial as they can potentially induce drug-resistant bacteria, and may be ineffectual when bacteria are drug-resistant or when they migrate to subcutaneous tissue. Also, the antibiotics have to get through the skin barrier, so efficiency can be quite low.

Trans-dermal delivery

Professor Yeung said: "Ours is non-antibiotic, trans-dermal delivery – the antibacterial nanoparticles permeate the skin using a microneedle patch engineered with ultrasound responsive metal-organic framework. We load the microneedles and, subject them to stimulation of the ultrasound then can generate a substantial amount of ROS. If we don't trigger the ultrasound then no ROS is generated.

"Some people question if ROS might kill normal skin cells as well as affected ones, but if no ultrasound is triggered no ROS occurs – it's stable and we can control the delivery. Therefore, biologically it is safer than other antibacterial nanoparticles, such as nano-silver.

"Furthermore, the treatment actually enhances skin healing, as it promotes different types of dermal cells to grow. The zinc ions released from the nanoparticles are left on the skin and stimulate skin tissue to heal, while the microneedles are biodegradable and will dissolve."

The team initially developed the technology for orthopaedic purposes, to deal with bone infections.

"But when we realised how innovative and efficient it is, we decided to look beyond our own area and develop the microneedle for use in a field that would make a bigger impact on society," said Professor Yeung.

"Some microneedle acne solutions do already exist, but they do not present any antibacterial feature. Antibiotics tend only to be available on prescription," he added. "This new treatment would be suitable for use over-the-counter, without prescription. In addition, the specific killing mechanism of ROS, means that this design should also be effective against other skin infections induced by fungi, parasites, or viruses, such as athlete's foot."

Difficult next step

So far, all the testing has been on animals – mice injected with bacteria to produce acne. The research team are now ready to take the next step but is hampered by a lack of funding.

"We're ready to go to human clinical trials, but it's difficult to get to the next level," said Professor Yeung. "To go to the next step of testing on humans, we need industry to take an interest and come in with funding. But we are scientists not business people, so making that leap is hard.

"Our aim is for this treatment to be widely available to those who need it. We have designed it to be highly effective and cheap to produce, and we want it to be available where it will have a real benefit. Skin infections affect many people and are prevalent around the world."

First author of the paper, Mr Yiming Xiang, who is a PhD candidate under Professor Yeung's supervision and has more than seven years' experience in the field of bacterial infections, said: "As researchers, I hope that we can merge our technological advancements with the challenges we face in our daily lives, enabling technology to extend beyond the confines of academia and be accessible to every ordinary person."

Professor Kelvin Yeung Wai-kwok (right) and his PhD student Mr Yiming Xiang (left).

LABELLED WITH DIAMONDS

The novel use of diamond microparticles to create sophisticated high-security labels is set to have a major impact in the battle against counterfeit goods.

Counterfeiters grow smarter and use ever more sophisticated technologies each year, producing a huge variety of fake goods – from medicines through electronics to fashion – and causing health risks and the loss of billions of dollars worldwide. To fight back, the anti-counterfeiters are also upping their game.

Taking the sophisticated technology to the next level, a team from the Department of Electrical and Electronic Engineering have collaborated with counterparts in different fields of expertise to create innovative high-security labels which are impossible to replicate.

Research team leader Dr Zhiqin Chu said he hopes the significance of incorporating such advanced materials as diamond microparticles – which are ideal for their 'chaotic', and therefore unclonable, properties – will focus interest on this research field and inspire more innovations in anti-counterfeiting technologies.

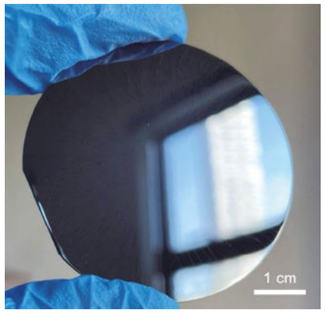
"We made the labels by planting tiny artificial diamonds, known as diamond microparticles, on a silicon plate using a method called chemical vapour deposition (CVD)," said Dr Chu.

Unique, unclonable pattern

"Because the diamond microparticles are all different shapes and sizes, when scattered on the silicon substrate, they settle in a unique pattern each time, thereby creating the equivalent of a fingerprint for each label which is impossible to copy. In the anti-counterfeiting industry, this phenomenon is known as PUFs, or Physically Unclonable Functions."

Additionally, the research team exploited the distinctive characteristics of diamond microparticles containing silicon-vacancy (SiV) centres, a kind of photoluminescent defect centre in the diamond lattice that has attracted much attention in various fields due to its unique optical and spectral properties. It can emit bright near-infrared photoluminescence when excited by green light, reducing the difficulty of distinguishing confidential from disturbance information.

> "Because the diamond microparticles are all different shapes and sizes, when scattered on the silicon substrate, they settle in a unique pattern each time, thereby creating the equivalent of a fingerprint for each label which is impossible to copy."
>
> Dr Zhiqin Chu



A two-inch diamond Physically Unclonable Functions label under natural light.

According to Dr Chu, the inspiration that led the team to develop the security labels was actually the concept of PUFs itself. "PUFs are physical systems that produce unpredictable and irreproducible outputs," he explained. "We realised that diamond microparticles have some particular advantages for PUFs, such as the inherently randomised features of each particle plus their high stability, biocompatibility, and optical properties. By incorporating them into security labels, we aimed to create an unparalleled level of security and authenticity verification."

The team's previous work includes the use of diamond-based colour space-correlated Raman spectroscopy for multilevel optical anti-counterfeiting and linear polarisation modulation of nanodiamonds for high-dimensional anti-counterfeiting. It was while working on the fabrication of high-quality diamond microparticles, that they found the diamond particles contain SiV centres with superior properties, enabling a wide range of practical applications.

Collaborative efforts

The development of the novel security labels is the result of a collaborative research effort between HKU, Sun Yat-sen University and Peking University. The HKU team focussed on studying the properties of diamond microparticles, designing and implementing the idea of using them for anti-counterfeiting, understanding their behaviour when incorporated into the security labels, and optimising their performance.

The Sun Yat-sen University team contributed to the theoretical analysis and simulation of the optical scattering of the diamond microparticles; and the team at Peking University provided the expertise and facilities for the CVD process of growing the diamond microparticles.

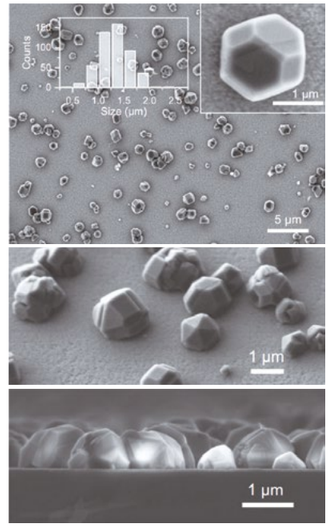
While they have been used in various industries already for their exceptional properties, the application of diamond microparticles (heterogeneously grown by CVD on Si substrate) specifically for anti-counterfeiting purposes is unique to this team.

"There has been significant interest from various industries regarding the potential of these security labels," said Dr Chu, "including from industry partners who are interested in using them in product labels such as luxury goods, pharmaceuticals, high-end electronics, and valuable documents."

Further advantages are that the labels are cheap to produce (about US$1 to make 10,000), physically robust and able to withstand heat and chemicals. "Diamonds possess characteristics such as high hardness, chemical inertness, thermal stability, and unique optical features that make them ideal for practical anti-counterfeiting applications. For example, the hardness of diamonds ensures their durability and resistance to wear, making them difficult to tamper with or replicate," said Dr Chu.

Currently, the team are finessing the research and development process, conducting extensive testing and validation of the diamond-based security labels. "We aim to assess their performance in real-world scenarios, evaluate their durability, and optimise their manufacturing process for large-scale production," said Dr Chu.

"Simultaneously, we are actively engaging with industry partners and potential clients to gather feedback and refine the labels based on specific application requirements."



The top view (top), side view (centre) and cross section (bottom) of electron microscopy images of a diamond Physically Unclonable Functions label. The indiviadual diamond microparticles and their spread on the silicon substrate are clearly visible.

OUTSIDE-OF-CLASS ACTION

The Faculty of Law's Clinical Legal Education programme offers a Free Legal Advice Scheme to members of the public facing legal problems, and gives law students the opportunity to get first-hand knowledge of dealing with real-life cases.

Launched in 2010, the Clinical Legal Education (CLE) programme is still the only live client programme offering preliminary legal advice to ordinary citizens in Hong Kong. Over those 13 years, the programme has handled more than 2,600 cases under the Free Legal Advice Scheme, as well as over 400 Miscellaneous Prisoners Cases – assisting remand prisoners whose earlier applications for legal aid have been refused to re-apply so that they can have legal representation for their appeals. A total of over 900 students have participated, and the Faculty has 23 CLE students in the current semester.

Interested members of the public may apply to the CLE office, which identifies cases with real legal issues, and assigns them to students who have registered for the six-credit CLE course. During an initial interview session, CLE students work in pairs taking instructions from the lay clients about the material facts and issues of the case relevant to the legal advice to be sought.

They then write a case summary and conduct legal research for submission to the CLE teacher and volunteer lawyer in charge of each case. Later, the students will attend the advice sessions where the volunteer lawyers who are practising solicitors and barristers, give preliminary legal advice to the clients. The students record the advice given and submit a summary to the volunteer lawyer for approval and the CLE office for their records.

Experiential learning

"The value of CLE is two-fold," said Ms Julienne Jen, Principal Lecturer in the Law Faculty and interim head of the Department of Professional Legal Education. "For members of the public, it gives them free access to legal advice and assistance with applying for legal aid. For students it is a rare chance for experiential learning through interviewing real clients and conducting legal research under the supervision of teachers and voluntary lawyers. They also gain exposure to the courts by attending civil and criminal appeal hearings.

"From the teaching point of view, one of the CLE's greatest values is that it instils the pro bono culture in the students' heads. When students go on to train in a law firm, they simply will not have time to do this. But we hope in the years that follow they will remember and include pro bono work in their practice."

While legal aid is extensively available in Hong Kong, a lot of people don't have the expertise to use it effectively. Ms Jen cites cases of medical negligence as an example, where clients don't know if they have a case or not because they simply don't have access to the required medical expertise.

"I ask CLE students to take time to review the client's medical documents, doctor's reports *etc*, and really study them closely so that we have the facts and I can explain clearly and in detail if the client has a case or not," she said. "From the public's point of view, a key part of what the CLE achieves is imparting knowledge, so the clients – even if it turns out they do not have a case – at least don't walk away feeling aggrieved or ignored."

> "From the teaching point of view, one of the Clinical Legal Education's greatest values is that it instils the pro bono culture in the students' heads."
>
> Ms Julienne Jen

One of the CLE research assistants is student Tony Ho Yi-chun. "The CLE is a rare opportunity to gain practical experience that we can't get anywhere else," he said. "We're allowed to manage real cases under the supervision of experienced legal practitioners. For the first time, we can take what we learn in class and put it into practice."

"I've worked on, for example, employee compensation cases, where I've interviewed the clients and handled documents, such as medical records and reports, court submissions, and tax documents, that we wouldn't usually experience at university. You learn real practical skills early on, from effective office communication, managing client's expectations to formulating a litigation strategy."

Another student research assistant Maxine Law Chin-yuet added: "We also get to observe how practitioners offer advice and manage clients. The CLE course enables us to develop different lawyering skills through handling real cases of different kinds. While the CLE office only provides preliminary oral legal advice in general, in exceptional cases the office may assist clients in their application for legal aid, such as setting out the merits of the client's case by way of letter."

The Faculty of Law also has experiential learning opportunities in other areas through a series of programmes offering the public more specialised advice, including Disability Rights, Equality Rights, Global Migration, and the Refugee & Human Trafficking Programme, which assists with legal casework for victims of trauma including asylum seekers, refugees, and victims of trafficking and sexual exploitation. For students, the programme provides a unique opportunity to learn about international human rights and refugee law.

Student Hiko Ng volunteered as an English and mathematics teacher at a primary school in Tanzania for six weeks and had an unforgettable experience improvising her teaching methods and resources to meet the needs of children.

EDUCATING FOR THE FUTURE

Hong Kong's only undergraduate degree to combine early childhood and special education has had to navigate a lot of hoops since its launch in 2019 – the social movement, COVID-19, GenAI and the continuing decline in the city's population. But Programme Director, Dr Diana Lee Pui-ling, has prepared students with ample career pathways that will meet future needs, locally and beyond.

Children with special educational needs (SEN) need extra support throughout their school days. But typically, training for this support has not been offered where it could arguably do the most good – among early childhood educators.

Interventions usually work best if they start when children are very young. But until the Bachelor of Education in Early Childhood Education and Special Education was launched at HKU in 2019, such dual specialism was not offered in the city, despite a blatant need.

"There are growing numbers of children locally and internationally with SEN – the numbers are increasing. And in Hong Kong, many children with mild special needs are attending mainstream kindergartens and primary and secondary schools. Teachers are expected to know how to handle these children, but in fact many of them don't and they find it difficult to manage a whole class of diverse needs when they are not trained for this," said Programme Director, Dr Diana Lee Pui-ling.

"Early identification and intervention for children with SEN can benefit children during the critical years of development.

> "There are so many different things they can do with this degree besides serving as classroom teachers in Hong Kong."
>
> Dr Diana Lee Pui-ling

Waiting until they are in primary or secondary school might be a bit late. So that is why we launched this programme."

Keeping options open

The five-year programme requires students to undertake a variety of practicums. In their second year, they spend two weeks in a childcare centre for two-year-olds. In their fourth year, they spend six weeks in a special childcare centre with children who have moderate to severe physical and developmental needs. And in their fifth year, they have an eight-week placement in a kindergarten with an integrated programme where they work with typically developing children alongside those with mild to moderate needs.

"We place them in very different settings so that when they graduate into the workforce, they will know what to do in each place," Dr Lee said.

This gives students options for their future and Dr Lee has been opening the curriculum even further to cater to students who may not want a traditional teaching career. A director from the Hong Kong Academy for Performing Arts has been brought in to teach art, music and puppetry, a class that has attracted students who are thinking of working in areas like music or drama. A product designer has taught students how to create professional teaching aids for children – two student designs were selected by the designer's company for commercial production and Dr Lee said some students are now thinking of setting up their own start-ups in this field.

Dr Lee has also arranged opportunities for students to go overseas if they wish – so far experiences have been organised at the University of Cambridge and in Tanzania, Turkey and Romania – or take up summer internships, some of which are paid.

Preparing for the real world

Students also must produce independent research projects in their final year, which is 2023-2024 for the first intake. Some of the topics they are investigating include the implementation of sex education in schools to help children and schools learn how to prevent child abuse, how to conduct research with children with special needs, and how non-Chinese speaking students learn Chinese and their parents' views on this. "The students are not only trained as future educators and therapists for children, but as researchers," Dr Lee said.

The programme admits only 18 students and competition is high – this year had 16 applications for each spot. Some are motivated by having family or friends with SEN, others by diversity itself – two male students have enrolled, saying they want to change the stereotype that early childhood education and SEN are the domains of women and to provide male role models for children.

Dr Lee continues to bring in more opportunities for students to grow. In January, final-year students will join an Interprofessional Education and Collaborative Practice programme organised by the Li Ka Shing Faculty of Medicine, alongside Medicine, Pharmacy, Nursing, Social Work, and Speech-Language Pathology students, to discuss cases of developmental delays in children. This collaboration mimics real-world situations.

She is also taking them to the Greater Bay Area, which has affiliated schools for Hong Kong and Macau students, to get students thinking about teaching opportunities in the region. She is trying to expand overseas teaching opportunities, too.

"The birth rate in Hong Kong is continuing to decline so I want to prepare students for a less-predictable future. There are so many different things they can do with this degree besides serving as classroom teachers in Hong Kong," she said.

Students were exposed to designing teaching aids for children with cognitive, sensory and physical needs. This Happy Fishing teaching aid was one of the student designs selected for commercialisation.

A HEAD START ON RESEARCH

Undergraduate research programmes are equipping students with essential research skills for their future, whether that will be pursuing graduate studies or coping with information overload.

When Cai Xuheng was an undergraduate student in computer science at HKU, he was keen to jump into research – not just as a research assistant, but to lead his own project and develop his own ideas. He got his wish in 2022 when he was accepted to HKU's Undergraduate Research Fellowship Programme (URFP), which admits the brightest students (minimum GPA of 3.5) in their final year to work on their own projects or with established researchers at HKU or universities abroad.

Under the supervision of Dr Chao Huang in the Department of Computer Science, Cai published two first-authored papers and presented them at a top international conference. He graduated in June 2023 and is now enrolled in a Master's programme in computer science at Stanford University.

"The URFP allowed me to be the owner of my own research and work on every step of the whole research pipeline, including coming up with research ideas, reading the related literature, designing and performing the experiments, and writing the papers. These hands-on experiences are critical in building solid research skills," he said.

Cai is not alone in enjoying these benefits. Every year since 2011, the URFP has provided funding (currently, HK$15,000 for students based in Hong Kong and HK$40,000 for those going overseas) and a free hand to students who are keen to pursue research beyond their course requirements.

A stepping stone

The students are selected by their faculties and this year, more than 50 students enrolled, doing research in such places as Harvard University, Berkeley, the University of British Columbia, as well as HKU (students can choose from more than 40 institutions on four continents). The project must last not less than eight weeks and be completed over semester or summer breaks.

"The University wants to promote a research culture and provide opportunities for students to boost their skills," said Audrey Chung of the Horizons Office, which runs the programme. "The URFP can be a stepping stone to doing a research postgraduate degree."

Li Dantong is a second-year PhD student in computer science at Yale University who did his URFP at HKU with Professor Giulio Chiribella. He would like to see more opportunities for undergraduate research.

"My experience was immensely valuable in shaping my academic path. Nowadays, undergraduates often need to invest significant time in research before applying to graduate schools. The URFP provided the motivation and platform for me to engage in research actively," he said.

Overseas experiences also prove eye-opening, as George Wong Yin-pok, now doing a PhD in chemistry at the University of California, Los Angeles, found. "It allowed me to gain insight into how research is done differently in the United States compared to Hong Kong. I was able to create connections with overseas institutions that were important for my graduate school application and in my future research career."

Future ready

While URFP is aimed at the top 90-percentile of students, the University is keen for all students to gain research skills. HKU joined the Laidlaw Programme in 2017–2018 which provides research and leadership training for first- and second-year students with a minimum GPA of 3.0. The programme runs over two summers, and students get to apply their skills in community projects either in Hong Kong or overseas. For instance, students recently built a nursing station in Fiji and raised awareness of physical and mental health, established a support group for healthcare workers working with dementia patients in Hong Kong, and conducted digital literacy workshops for underprivileged children in Shanghai.

> "We really want to enthuse students about the research possibilities at HKU. We want them to think of it much sooner, starting from their first year."
>
> Professor Pauline Chiu

The opportunity to gain research capabilities is expanding even wider this year with the launch of the Future Readiness Initiative for incoming students. This programme includes two short online and self-paced courses on communication skills and research skills, and it is intended to prepare students for university life and beyond. While not mandatory, students are strongly encouraged to complete the courses and will receive out-of-classroom credits for doing so.

On the research component, students are introduced to research methods and how to sort through masses of data, analyse them and draw conclusions – skills that have immediate real-world application given the huge amounts of data, true and false, that are circulating, and that also will serve students well during their university studies.

"We really want to enthuse students about the research possibilities at HKU," said Associate Vice-President of Teaching and Learning at HKU, Professor Pauline Chiu. "Normally, that doesn't happen until the final year when they have to do a capstone or dissertation project. We want them to think of it much sooner, starting from their first year."

A poster session of the Undergraduate Research Fellowship Programme 2022-2023 was held where selected Research Internship Award recipients presented their research findings to the University community.

ART ACROSS THE DISCIPLINES

A screenshot from the educational video on rubbing demonstration, featuring a tiger stele in seal script from the Late Qing Dynasty (1840–1911).

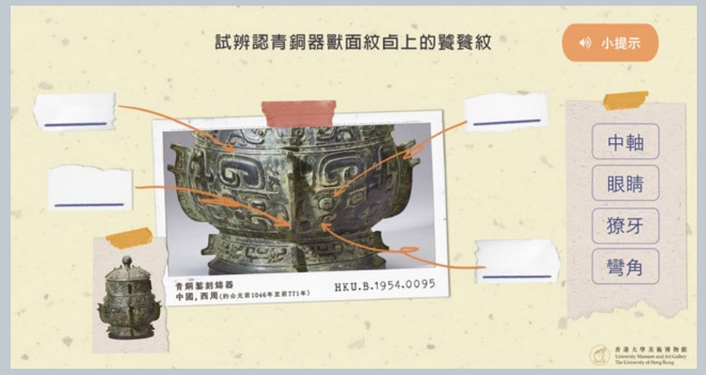
The University Museum and Art Gallery is bringing its collection to primary and secondary schools in a virtual format, using animations, quizzes, videos and other tools to show how art interacts with science, history, language and other disciplines. The general public is also welcome to participate.

Art's value is usually couched in terms of its aesthetics, but it can also be a window to understanding history, science and technology, the evolution of language and all sorts of disciplines. The problem for Hong Kong students and residents is that there have been few resources in Chinese to explore this multidisciplinary aspect of art. The University Museum and Gallery (UMAG) is hoping to change that with its new ULearning Labs, an online platform that offers opportunities to learn and have fun with art.

The project was inspired initially by the COVID-19 pandemic when it was not possible for people to visit UMAG. But it has evolved to bring the museum's collections to light and reach new audiences, especially in schools.

"We have a wealth of knowledge and collections built up over 70 years, but we found that a lot of this information was not really getting across to primary and secondary school students. So we have revisited it and packaged it to be relevant to the school curriculum," said the curator of education, Ms Elena Cheung, who developed ULearning Labs.

She interviewed teachers in 25 schools on their content needs in everything from visual arts to Chinese language to general studies and used that to inform the development of online activities and resources, such as quizzes, animations and galleries, on specific topics. There were then two rounds of feedback from teachers and one round from students to fine-tune the website.



A diversified range of online activities and resources are available on ULearning Labs. The example shown here is a quiz on the taotie *mask motif commonly seen on Chinese bronzes.*

Roar of the tiger

An example of how UMAG content and learning have been paired is in rubbings, which are taken to preserve rock carvings before the elements destroy them. Some rubbings can be 2,000 years old, but they are usually not very visually exciting, being only black and white. The website offers an engaging way into the topic, starting with the roar of a tiger and accompanying animation.

"We usually describe rubbings as 'black tigers' because it is difficult to detect whether they are real or fake," Ms Cheung said. Information is provided on why people do rubbings and the challenges in verifying them. There are also educational videos demonstrating how to do a proper rubbing and how to write the character for 'tiger' in the classical way (seal script) as it has changed over the centuries.

> "We have a wealth of knowledge and collections built up over 70 years, but we found that a lot of this information was not really getting across to primary and secondary school students. So we have revisited it and packaged it to be relevant to the school curriculum."
>
> Ms Elena Cheung

The virtual tours offer a 360-degree view of the gallery space. Users can click on the exhibits to see a high-resolution image of them.

Quizzes and animations are embedded into each course to keep students engaged, for instance by identifying and naming different kinds of bronze vessels and their uses and showing how bronzes and ceramics are made – the latter taps into chemistry, too.

"We are trying to be diverse and find cross-disciplinary elements from each object, so we choose topics where there is a story to tell, whether that is about the shape, motifs or medium of the object," she said.

Virtual tours

There are also artist videos, such as one featuring Spanish artist Alberto Reguera, whose work was exhibited at UMAG in early 2023. He talked about his work and did a live performance where he extended one of his paintings from a small canvas onto a specially constructed canvas wall, accompanied by a recording of music played on the Chinese instrument *zheng*.

The website also features virtual tours of the gallery with a 360-degree view of the space. Visitors can click on specific items, such as a painting or vase, and get a high-resolution image and information and quizzes about the object – this is especially helpful for students and schools who are located far from the HKU campus. The hope is that they may also be inspired to visit the museum in person.

The project was supported through HKU's Knowledge Exchange Fund and Ms Cheung has continued to collect feedback from schools on the different modules. One surprising request was to provide an English-language version for local schools (initially, it was thought a Chinese version would be sufficient). There was also a request to provide phonetic pronunciations of Chinese characters to help users learn how to say more archaic terms.

"We hope to increase accessibility to our collections and bring the museum into the school and home," Ms Cheung said.

The general public can also access the ULearning Labs content through the stream called 'interest' (the 'courses' stream is for schools), as well as the virtual gallery, dictionary and resources pages.

Learn more about the ULearning Labs

Students visited elderly in their homes and taught them simple strengthening exercises and how to use smartphones.

GENERATIONS CONNECT

A new outreach programme has HKU students visiting more than 10,000 underprivileged elderly in their homes to help improve their health and technological literacy.

Few people in Hong Kong have the breadth of understanding about COVID-19 and how to deal with it as Professor Sophia Chan Siu-chee. She was Secretary for Food and Health from 2017 to 2022 and was charged with planning Hong Kong's response to the pandemic. When she returned to HKU last year (she was formerly head of the School of Nursing), she was quickly approached by donors who wanted to tap her expertise and find a way to help a group that had been badly affected by the pandemic: those elderly living in impoverished circumstances who were not very mobile and often were isolated.

Professor Chan was immediately interested but she wanted teaching and research to come into play, too. The result has been Generations Connect, a two-year project she is leading in which 1,000 students in the Medical Faculty will visit 10,000 underprivileged elderly in their homes. The students conduct health assessments and guide the elderly in improving their e-health literacy, such as demonstrating how to navigate the Hospital Authority's HA-Go and eHealth app where they can book medical appointments and access their health records and health information.

"This is a win-win situation. On the one hand, it is an opportunity for our nursing and medical students to communicate and work with the elderly face-to-face. For the elderly, especially those living alone, they get an assessment and health information, and they love to have people visit them and talk to them," Professor Chan said. Research also benefits from the data students collect in health questionnaires administered to the elderly.

Team efforts

The project was launched in January 2023 with HK$10 million in funding from the Sino Group and Ng Teng Fong Charitable Foundation and involves 18 charitable organisations and NGOs who are helping to identify elderly in need in 18 districts. Students are trained by both the Faculty and NGOs on how to communicate with the elderly. They also provide the elderly with information on four themes – e-health literacy, non-communicable diseases prevention, post-COVID prevention measures and psychological well-being – and encourage them to join the government's new District Health Centres (DHCs) and receive health promotion services.

Initially, the project was meant to involve mainly nursing students – about 50 nurses joined a pilot study in November 2022 – but now students of any programme in the Faculty of Medicine can participate, including those taking a Common Core course even if their major is in another faculty.

Students go in pairs to conduct interviews and administer the questionnaire and theme-based interventions – for example, they might demonstrate how to do simple strengthening exercises and help the elderly use their smartphones. (All participants must have smartphones but many are not adept at using them; "that's where the challenge is," said Professor Chan.) The students contact their host two weeks later for a telephone follow-up.

Faculty researchers subsequently follow up after three months and six months to see how successful the interventions have been, for instance, whether unvaccinated elderly need to get their COVID-19 jabs or if participants are using e-health apps.

By the end of the summer, more than 100 students had visited over 3,000 elderly. Scheduling times that work for everyone can be a challenge, but the NGOs are helping with this. The latter have also recruited 'young elderly' from their centres to assist students with the visits as needed.

Promoting care in the community

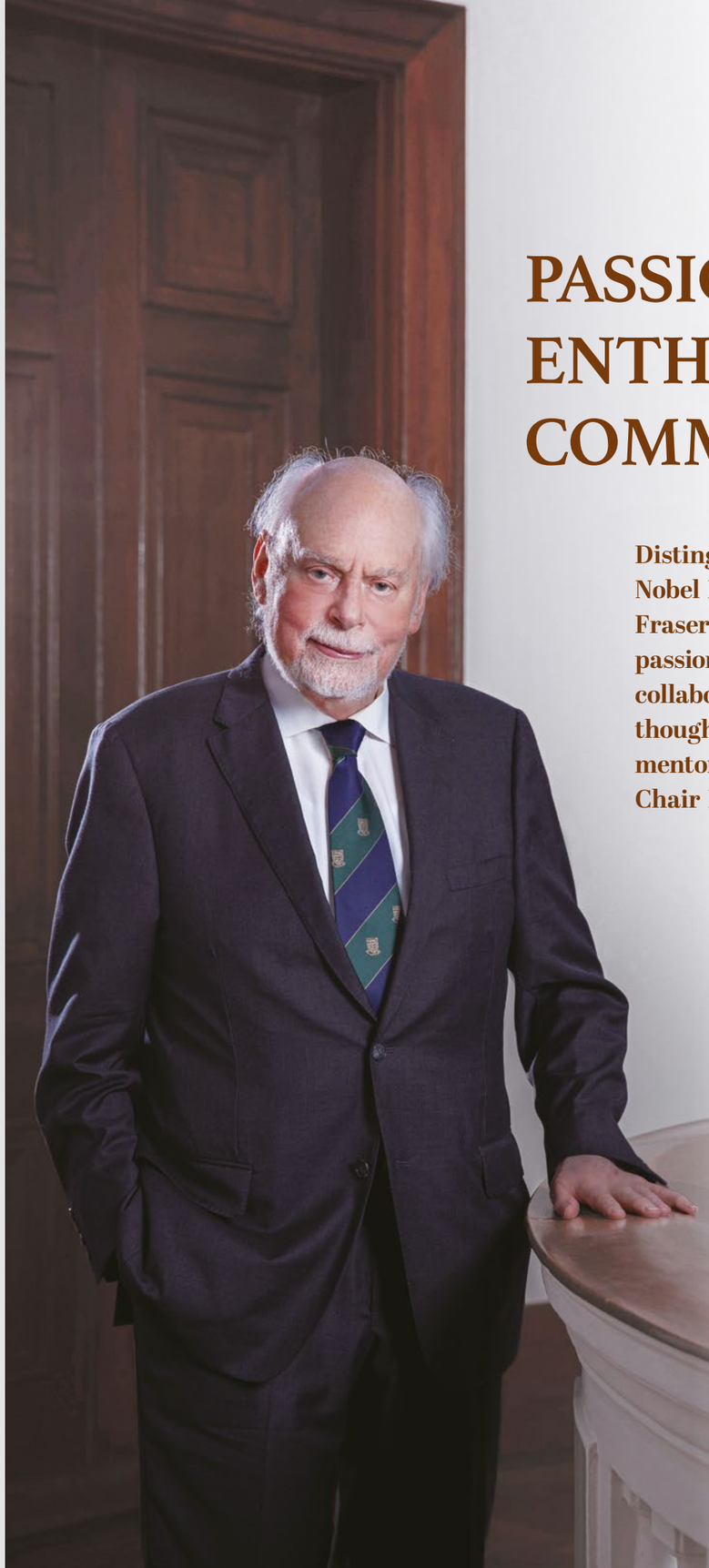
Professor Chan's team are also doing a qualitative study on the effects of the project on NGOs, students and the elderly. Although it is too early for results, a follow-up to the pilot study found low e-health literacy among elderly participants fell from 66 per cent to 56 per cent, and nearly 90 per cent of students said the experience improved their ability to communicate with the elderly and equipped them with more knowledge about elderly health and primary healthcare.

"Our population is ageing so we need to nurture our next generation of healthcare professionals to know how to promote health among the elderly," Professor Chan said. She hopes the project will also inspire students' interest in primary healthcare, an area where Hong Kong has lagged in the past. While in government, Professor Chan set up a steering committee on primary healthcare development and established the territory-wide DHCs to provide primary care.

"Healthcare is not just surgery or hospital care. We also have more people in the community who have health needs and require help. The healthcare system was not constructed to address this, so we need to build up students' understanding and skills. Visiting elderly in their homes is a very good learning and practical experience for our young students studying the healthcare professions," she said.

> "Our population is ageing so we need to nurture our next generation of healthcare professionals to know how to promote health among the elderly."
>
> Professor Sophia Chan Siu-chee

Professor Chan (second from left) at the volunteer recruitment booth of Generations Connect.



PASSION, ENTHUSIASM, COMMITMENT

Distinguished chemist and Nobel Laureate Professor Sir Fraser Stoddart aims to instil a passion for research excellence, collaboration and original thought in the students he mentors in his new role as Chair Professor at HKU.

A proud native of Scotland, Professor Sir Fraser Stoddart comes to HKU after a remarkable career that has included time at top universities around the world, most recently at the renowned Northwestern University in the US. Retirement was looming, but Professor Stoddart "wasn't ready to hang up my boots yet" and Asia beckoned.

Before joining HKU this September, Professor Stoddart already had connections with the University and with President and Vice-Chancellor Professor Xiang Zhang. "We were both faculty members at UCLA – he in Mechanical and Aerospace Engineering and I in Chemistry," said Professor Stoddart. "We collaborated and published a paper together, and I visited him at HKU in 2019. Earlier this year, he spoke to me on the phone about Hong Kong and about the emergence and expansion of HKU under his leadership towards becoming a hub for the development of new areas in science and tech."

The arrival of such a distinguished chemist at HKU is very significant for the University's current development plans. "Having Fraser Stoddart, a Nobel Laureate, join us is a landmark," noted Professor Peng Gong, Vice-President and Pro-Vice-Chancellor (Academic Development). "It's a turning point for our University to move to the next stage of excellence."

Excellence, particularly in research, was another factor that brought Professor Stoddart to Hong Kong. "The talent – here, and in the whole of China – in chemistry and materials science, and the leadership in research and the development of fundamental ideas, and maybe even in applications, has already passed to China from the US, and it will only get stronger as the years go on," he said.

Unique attitude

"On top of that dynamic, there is the unique attitude of young researchers at the graduate and postdoc levels. I get immense pleasure out of supervising and mentoring young Chinese students in science and chemistry. They are passionate, enthusiastic, committed."

He is bringing 12 postdoc level researchers from his Northwestern Lab with him and they will establish a lab at HKU. "Ten are Mainland Chinese, one Korean, one Indian. All immensely talented, hugely productive, very hardworking. Among the 12, there're probably around six research areas going on at any one time, including on molecular machines and in the area of carbohydrate chemistry."

Professor Stoddart feels his own move to Hong Kong is only the beginning. "Over the next few years this city will become a magnet for people who want to come and do extraordinary things in science and engineering. Excellent basic research is being carried out here at HKU in the areas of chemistry and materials science, and it will create a hub of excellence at every level in terms of conceiving new research lines, implementing them and then putting them out into the public domain through scientific papers.

> "Excellent basic research is being carried out here at HKU in the areas of chemistry and materials science, and it will create a hub of excellence at every level..."
>
> Professor Sir Fraser Stoddart

"Hong Kong is a gem of a place too for the opportunities to step into the Chinese universities very easily – a godsend for those of us who want to continue collaborating, because there is a lot of superb expertise in departments of science across China."

While here, Professor Stoddart will be doing research, as well as teaching on a one-to-one basis the young researchers, mainly at the postdoc level. "I look upon my job as a professor to be more about mentoring young people to do the very best in their research activities than trying to formulate new research goals myself."

One of the lessons he aims to instil in them is the importance of collaboration. "Most of my research has been done collaboratively and published collaboratively – it brings a much higher level of achievement than you could ever achieve on your own. I encourage my postdocs to collaborate, because the more minds you bring into tackling a research problem, the better outcome you achieve."

Nobel advice

Perhaps, not surprisingly, ambitious students often ask his advice on getting a Nobel Prize! His answer is always: "Do your own thing." He feels that the field of molecular machinery currently needs more clever people to populate it. But his advice when students leave his laboratory is: "Don't do Stoddart research, do something new. You've got to spend time until you find something – it won't be that nobody has ever worked on it – there'll be fragments in the past, as there was for me with the mechanical bond.

"I searched and eventually became convinced there was a major contribution to be made to chemistry by making mechanical interlocked molecules. My major contribution was the introduction to chemistry of another bond – the mechanical bond. That's what I tell my postdocs – try to repeat what I did but in a different context."

Professor Stoddart is convinced that HKU has potential to be a regional hub of excellence. "The time is right. There's interest at the top level and that will attract the very best students particularly from Mainland China. I get enquiries daily from people in stellar universities in China wanting to join my lab. I think the next decade is going to be an amazing one for HKU."

HKU'S NEW TECHNO HONCHO

Mr Paul Wang Peng, Director of the new Techno-Entrepreneurship Core, is driving a culture change to embed innovation and entrepreneurship more deeply across the University.

How do you help ambitions become a reality? That's the task for Mr Paul Wang Peng, head of the Techno-Entrepreneurship Core (TEC), which was conceived in late 2022 and officially launched in June.

Hong Kong and the Greater Bay Area are being positioned to become a world-leading hub of technological innovation and entrepreneurship. University professors, students and alumni will be a major source of that activity. However, many lack the entrepreneurial skills and support to make that happen.

Enter Mr Wang, who has done everything from founding a start-up to working with established businesses and, for the past decade, training and supporting young entrepreneurs. Now, he is focussed on building up capacity at HKU for transferring discoveries and innovations to the market.

"There are great foundations here, but they have been scattered around the forest," he said. "Our focus at TEC is to coordinate and be a bridge that connects people and helps them build synergies."

Mr Wang and his team are both digging those foundations deeper and building them up higher by making entrepreneurialism a more prominent facet of HKU culture and life.

Through the TEC, they are centralising current initiatives and establishing a one-stop portal to access training, mentors, networks, incubation support, feedback, and guidance on funding possibilities.

In most cases, teams are looking to establish their own start-ups rather than license discoveries to existing companies, which tends to be less impactful. This is not without challenges and Mr Wang said they aim to help HKU researchers and entrepreneurs navigate the hurdles.

Connecting and incubating

"There are two very challenging bottlenecks: one is that researchers usually lack market insights when they make their discoveries. They do interesting work, make a natural discovery, then think maybe it could be of commercial value. They don't know if the market wants it or needs it, so many lab techs never make it to the market, or are not protected properly.

"Second, when they try to do a start-up, they do not have the right team that understands the commercialisation process and is prepared for the upcoming rough ride."

TEC therefore is beefing up its support in these areas. A 'start-up connector' has been launched that unites existing programmes, such as those offered through the Centre of Development and Resources for Students, MBA and alumni offices, and student networks, to help researchers and aspiring entrepreneurs find a match.

> "HKU has some of the top researchers and students in the world. They have genuine faith in science and the passion to make great impact. We need to give them the right tools and environments to make these things happen."
>
> Mr Paul Wang Peng

The TEC co-organised the Techno-Entrepreneurship Camp in August 2023 for HKU members interested in research commercialisation.

This is in addition to internship and entrepreneurial training programmes aimed at students.

HKU also has a co-incubation programme with Hong Kong Science and Technology Park, DeepTech 100, that provides up to HK$1.4 million to support promising start-ups. There is also entrepreneurship training, including one-on-one mentoring and a structured programme to take participants out of their comfort zones, uncover blind spots in their ideas, and build a sustainable business model.

To send a strong message of support for innovation, the policy on profit sharing between the University and inventors has been revised to increase the inventor's share to 80 per cent from 33.3 per cent. A more start-up-friendly licensing practice has also been adopted.

The potential is there

Funding is of course another critical factor. HKU launched the Entrepreneurship Engine Fund in June 2023 with a target funding pool of HK$400 million. It aims to provide 'patient capital' for early-stage ventures that have promise but are still not ready to seek private investment, and to boost growth-stage HKU research-based start-ups along with partner venture funds.

HKU's networks are also being strengthened by reaching out to alumni start-ups. For instance, the nationwide InnoValley start-up competition launched in April 2023 is a magnet for HKU-affiliated innovators and inventions from across the country and has received more than 200 applications from six cities leading up to a grand finale in December.

"We have good start-ups, but a lot are flying under the radar. We're trying to bring them back," Mr Wang said.

Mr Wang is a big believer in the potential that already exists within the University. He points to successes such as Archireef from the Coral Biogeochemistry Lab in the School of Biological Sciences, which attracted investment from a venture capital fund backed by Abu Dhabi's government, and Clearbot, founded in 2019 by international students at HKU which won the JUMPSTARTER 2022 Global Pitch Competition. Both have been reported on in *Forbes* magazine.

"HKU has some of the top researchers and students in the world. They have genuine faith in science and the passion to make great impact. We need to give them the right tools and environments to make these things happen," he said. "We want to get the whole university excited about this and unleash the potential that is already here."

PEDAL TO THE METAL

The head of the new HKU Teaching and Innovation Learning Centre (TALIC), Professor Cecilia KY Chan, brings unstoppable energy and expertise in both education and engineering to her job – a valuable combination as AI and other technologies rapidly become more ingrained in learning.

Professor Cecilia KY Chan thrives on being busy. Before the age of 30, while she was assistant professor at an Irish university, she added a Masters in Education to her PhD in Electronic Engineering and at the same time introduced initiatives that vastly increased student retention rates from about half to nearly 95 per cent.

In 2008, when she arrived at HKU's Centre for the Enhancement of Teaching and Learning (CETL) and the whole educational landscape in Hong Kong was embarking on a major transition to four years of university from three, she got to work not only supporting teachers and helping design outcome-based assessment, but also developing new initiatives in such areas as e-learning, experiential learning and authentic assessment.

And now, after dealing with the challenges that COVID-19 brought for learning and assessment, she is jumping into the field of generative artificial intelligence (GenAI) in education. On July 1, she was named the Director of TALIC, a one-stop shop for teaching support at HKU that brings together CETL, the Technology-Enriched Learning Initiative and the Teaching and Learning Evaluation and Measurement Unit.

The University wants all teachers to embrace GenAI and Professor Chan's role is to give them the support they need to make this happen.

Rapid results

She worked night and day to oversee the launch of WhatsApp support, a dedicated website called AI in Education (soon to be launched), an AI clinic for teachers and a five-week self-paced online module on AI literacy for staff and students – all available by the start of semester in August. There is also an assessment guide in the making and she even got involved in the details of producing information leaflets and team T-shirts.

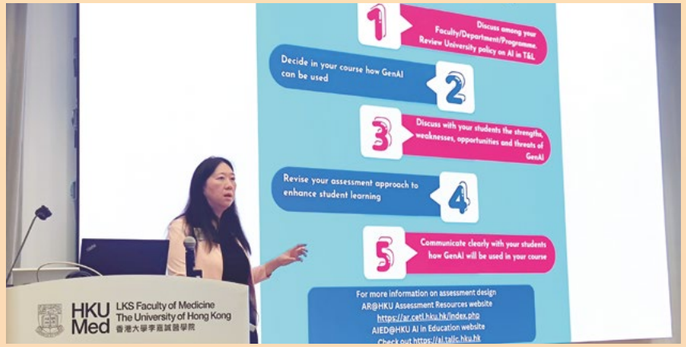
This is on top of regular outreach to the different faculties and staff, building collaborations and networks with other institutions in Hong Kong and globally, as well as doing her own research.

"I like busyness," she said. "When you provide teaching support, you have to be energetic or it just won't work – people will just go back to their research and not focus on developing their teaching."

To pack it all in, she admits to not sleeping very much, but her enthusiasm sustains her. For instance, in the early days of the pandemic, she was one of the first in the world to organise global seminars on Zoom where professors from top universities met to discuss teaching and learning online. Thousands of people joined the talks from across the continents.

Information leaflets designed by Professor Chan and her team covering a range of subtopics under Redesigning Assessment with Generative AI.

She has also managed to continue her own research and bring it into her work at CETL and TALIC. Professor Chan has published on the need for students to obtain 21st-century skills in work that has attracted interest from more than 20 universities, such as Oxford, Tsinghua and Sydney.



Professor Chan presenting on how to harness the potential of GenAI while mitigating its challenges in higher education.

These skills include such things as communication, teamwork, critical thinking, resilience and leadership that are not taught directly but are highly valued in the workplace and in meeting society's needs.

Transferrable skills

Existing courses often incorporate these skills indirectly so last year she developed a system to accredit these courses – hoping also to inspire other teachers to follow suit.

"21st-century skills are important. I'm living evidence of that. I came from engineering, I applied myself and then I became an education professor. I have skills that I can transfer," she said.

Professor Chan believes such skills will also be important in navigating GenAI because students still need to apply critical thinking, information literacy and so on. "I don't think GenAI can replace teachers – students still want a human teacher that can talk to them and empathise. But if we want to be better than AI, we need to understand it better."

For her, that means improving AI literacy, which the online course for staff and students addresses; raising awareness of safety and security issues and potential risks; and promoting responsible AI usage, which will vary from discipline to discipline. Teachers also need to consider how to design assessment using AI, such as reverse engineering essays and getting students to think critically about the output they receive from GenAI. TALIC's programmes address a lot of these topics.

Building a community of practice among teachers is also important to share successes and failures so Professor Chan plans to organise an international conference on AI in education next year. If funding is secured, she also hopes TALIC could develop HKU's own GenAI system to secure data behind its own privacy walls. "The whole education landscape is changing. We're doing a lot to address that and it's exciting," she added.

> "I don't think GenAI can replace teachers – students still want a human teacher that can talk to them and empathise. But if we want to be better than AI, we need to understand it better."
>
> Professor Cecilia KY Chan

The ***HKU Bulletin*** reports on activities, events and research initiated by members of the University. It aims to keep the local and international communities informed of new breakthroughs and achievements in all of our faculties and disciplines.

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