FUSION

ISSUE 21
2022

THE POTENTIAL OF
TECHNOLOGY AND DESIGN

SUTD'S NEW MULTI-FACETED SUSTAINABILITY PLAN

Guiding efforts in using technology and design thinking to build a happier world by design.

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A Drone That Can Fit In Your Pocket

A single-winged drone that can be easily folded, making it very versatile for various missions.

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SINGAPORE UNIVERSITY OF
TECHNOLOGY AND DESIGN

SUTD & ÉCOLE 42 SIGN MOU TO SET UP FIRST TUITION-FREE, NO INSTRUCTOR PROGRAMME IN SINGAPORE

"Digital technology is a powerful vector of equal opportunity and non-discrimination."

SUTD signed an MOU with Paris' École 42 on 23 November 2021 to set up a tuition-fee free, instructor-less computer science programme to help develop a pipeline of tech talent for the burgeoning digital economy in Singapore. Supported by SkillsFuture Singapore, this Continuing Education and Training programme, called 42 Singapore, will offer modules in computer programming, cybersecurity, network infrastructure, data science and more.

This is the first partnership between École 42 and a Singapore autonomous university. The MOU was signed by SUTD President Professor Chong Tow Chong and École 42's Chief Executive Officer, Ms Sophie Viger, and witnessed by Singapore Minister for Education Mr Chan Chun Sing, the Ambassador of France to Singapore His Excellency Marc Abensour and SUTD Chairman Mr Lee Tzu Yang.

Prof Chong said, "SUTD continues to challenge traditional modes of teaching by embracing École 42's unique programme design. 42 Singapore will be accessible for everyone who is 18 and above, regardless of academic background and professional coding experience. We believe the 42 Singapore programme will provide an alternate pathway to train a highly skilled talent pool of programming experts and address the manpower shortage in the digital arena."

Ms Sophie Viger, CEO of 42, said: "We are very pleased with the signing of the MOU between 42 and SUTD, the first step in what is expected to be a successful collaboration. Joining 42 is a great opportunity to access, tuition fee free, a proven training of excellence and to become, regardless of gender or origin, a professional with skills that are in demand worldwide. Digital technology is a powerful vector of equal opportunity and non-discrimination, it is a great satisfaction to contribute to fostering access to an inclusive and equitable education in the country."

The new 42 Singapore programme will be open to anyone 18 and above (and completed NS for Singaporean males) regardless of their prior academic qualifications. This provides an alternative skills-based pathway for participants who are looking to re-skill or upskill, to keep pace with the technology advancements in related industries. Students under this programme do not have to pay tuition fees. There are no formal lessons, textbooks and teachers. Students will learn at their own pace, advancing stage-by-stage through project-based learning, peer-to-peer learning and gamification.

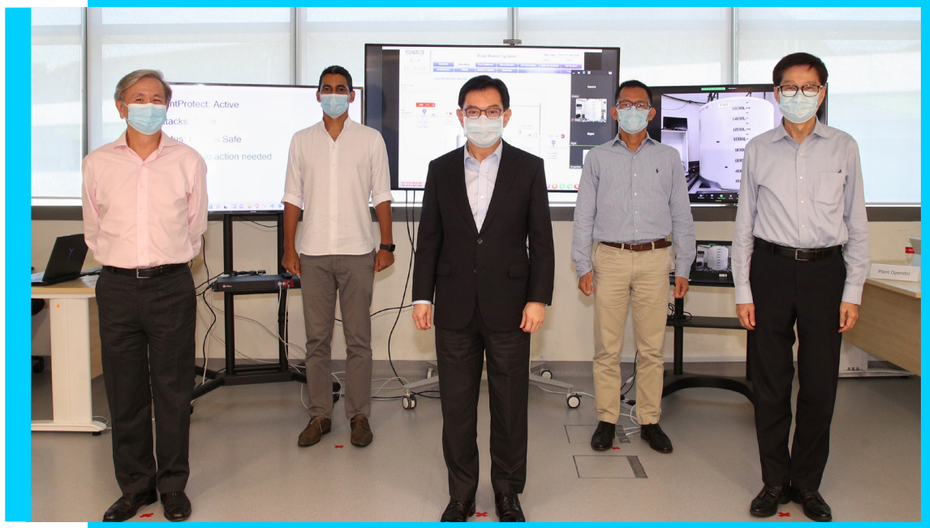
Slated to commence by end 2022, student recruitment will be done through one or more admissions exercises a year. SUTD plans to enrol up to 150 students a year, and about 450 in three years. Students in this programme will be part of École 42's international network of 36 campuses.

EDUCATION MINISTER CHAN CHUN SING VISITS SUTD

The Minister for Education, Mr Chan Chun Sing went for a tour in SUTD on 23 November 2021. Accompanied by several MOE representatives, including the Permanent Secretary (Education) Mr Lai Chung Han, Minister Chan met SUTD Board Chairman, Mr Lee Tzu Yang, and various members of SUTD's senior management. Following the meeting where SUTD president Professor Chong Tow Chong gave a progress update on the University, Minister Chan and his delegation joined a class of Freshmore students in their 2D interdisciplinary project demonstration. The students shared how they integrated the learnings of four different modules to airdrop a parachute for safe delivery of emergency supplies to the ground. The visit ended off with a closed door dialogue session between Minister and about 40 students at the multi-purpose hall.

From left: SUTD provost Prof Phoon Kok Kwang, chairman Mr Lee, president Prof Chong, MOE Minister Chan and PS (Edn) Mr Lai

DPM HENG VISITS ITRUST



iTrust and Attila Cybertech Pte Ltd hosted Deputy Prime Minister Heng Swee Keat at SUTD on 22 Nov 2021. Mr Heng, in his capacity as Chairman of the National Research Foundation (NRF), was given a showcase of how NRF-funded research and industry collaboration have been translated into actual products and services provided by the companies. Two such technologies were presented to Mr Heng and the visitors.

The first is PlantProtect developed by iTrust, which works in concert with other iTrust-developed anomaly detection technologies to perform four crucial functions in the event of a cyber attack: (1) Monitor (2) Detect (3) Prevent, and (4) Recover. During a "live" demo to Mr Heng, iTrust Centre Director Professor Aditya Mathur, Cyber Tech Lead Francisco Furtado and Research Associate Siddhant Shrivastava demonstrated how PlantProtect monitored a critical infrastructure (using iTrust's Secure Water Treatment (SWaT) testbed), raised an alert when a cyber attack was launched, automatically stopped the process from further degradation and brought SWaT back to its normal state.

Attila's chief executive officer Mr David Ong presented the ADPICS Commander, a machine learning-based technology developed by the company to provide plant operators with an overview of their network assets to

"1 Monitor
2 Detect
3 Prevent, and
4 Recover"

monitor in real-time their plant and security status. In doing so, the ADPICS Commander's predictive prevention alerts plant operators to perform maintenance before actual failure occurs, thereby saving costs and downtime. In his demo, Mr Ong also explained how ADPICS Commander, using a fully integrated Data Diode, protected the plant from network intrusion by cyber attackers.

At the visit, Mr Heng was accompanied by Ms Chan Lai Fung, Permanent Secretary, NRF, Mr David Koh, CEO, Cyber Security Agency (CSA), Mr Gaurav Keerthi, Deputy CEO, CSA, and Mr Beh Kian Teik, Deputy CEO, NRF.

To recognise their outstanding contributions to the university since its establishment, SUTD conferred its first honorary degrees to two founding members of its Board of Trustees (BOT):

Mr Sam Goi

Founder and chairman of Tee Yih Jia and SUTD's current Patron for Advancement

Mr Philip Ng

Chief executive officer of Far East Organization and founding Chairman of SUTD's BOT

SUTD CONFERS FIRST HONORARY DEGREES TO MR PHILIP NG AND MR SAM GOI

The conferment took place at SUTD's Class of 2020 Commencement Ceremony on 31 October 2021.

Mr Philip Ng had contributed significantly to the founding of SUTD, having chaired the Steering Committee set up for its establishment in 2009. He personally led the discussions with SUTD's first partner universities Massachusetts Institute of Technology and Zhejiang University to form a three-way education collaboration. This enabled the creation of a unique university that embraced the best of what the East and West has to offer to academia and research. As the Chairman of SUTD's BOT, Mr Ng was deeply involved in identifying and hiring the academic and administrative leadership of the university. He provided guidance and oversight for the SUTD campus development project. Mr Ng also mooted the idea for first-year students to stay on campus for the bonding experience with their peers.

Mr Ng said: "I am deeply honoured to be conferred an Honorary Doctor of Letters today. By the Grace of God, I was able to embark on a wonderful journey with SUTD to nurture technically grounded leaders to serve societal needs through technology and design. SUTD has a growing track record in applying technology innovations to solve complex issues. It is well placed to feature more actively in shaping Singapore's built environment particularly in environmental sustainability, where there is room for greater academic input and an informed discourse."

Mr Sam Goi, Chairman of Tee Yih Jia Food Manufacturing, was a former member of the SUTD BOT and the previous Chair of the SUTD Advancement and Development Committee. He had served in these roles since 2010 and provided exceptional leadership on all fundraising matters. In addition, he proactively helped open doors to connect the university with his vast network of potential donors.

Mr Goi was also instrumental in helping with the SUTD-Lee Kuan Yew fund-raising campaign in 2013. The impact of Mr Goi's contribution was immense, as he helped SUTD to build up its endowment fund and achieve fundraising success within a short timeframe. Majority of the funds raised go towards providing scholarships and financial aid to needy students. This is in line with his lifelong mission to nurture young talents in service of society and Singapore.

> **"SUTD would not be what it is today if not because of Philip and Sam's foresight and stewardship"**

Mr Goi said: "I would like to thank SUTD for this conferment. I feel extremely honoured to be given this recognition and I accept it with the greatest humility. This degree conferment – although awarded to me – is not my own. I am merely a representative accepting this honour on behalf of all those I've worked with, and those who share my passion for philanthropy and education. I also would like to share this recognition with all my friends who have worked together with me to serve the purpose of further education, and I am extremely grateful to SUTD for the affirmation and acknowledgement today."

Professor Chong Tow Chong, SUTD's President, said: "I'm very pleased to be able to confer these Honorary Degrees of Doctor of Letters to Mr Philip Ng and Mr Sam Goi. We are immensely grateful to them for their exceptional contributions to SUTD since its establishment. SUTD would not be what it is today if not for Philip and Sam's foresight and stewardship in providing valuable guidance and advice as we built the new university from scratch."

SUTD'S NEW MULTI-FACETED SUSTAINABILITY PLAN

SUTD has launched a multi-faceted sustainability plan (SSP) to guide its efforts in using technology and design thinking to build a happier world by design. SUTD believes that changing of mindsets and behaviours is key to building a broad-based culture of sustainability, and will be using participation by all members of the SUTD community as the yardstick in its approach to measure the success of its sustainability efforts.

The SSP will build on SUTD's international leadership in design and engineering innovation by framing three key commitments for creating new sustainable technologies:

1

To transform SUTD campus into a green experimental ground for test-bedding of new sustainable technologies (OASIS – Open Arena for Sustainability Innovation and Solutions)

2

To launch a new research initiative on Circular Economy to generate sustainable products and software solutions

3

To provide hands-on sustainability learning/ education for students

A new design centre, SUTD DesignZ, will be set up to lead the University's sustainability efforts. The centre's Director, Professor Tai Lee Siang, and SUTD's Chief Sustainability Officer, Professor Erwin Viray, will spearhead the efforts. Senior management, student leaders, alumni, faculty and staff will be involved to influence key decisions and drive the sustainability agenda.

SUTD president Professor Chong Tow Chong said: "Changing behaviour is a long journey and that is why we have to start young, because it is the next generation that will have to shoulder the responsibility of dealing with the likes of climate change, global warming and the environment."

A 3D-printed vertical farming system

COLLABORATION WITH PARTNERS

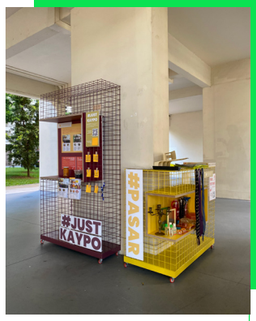
SUTD will be working with partners from the industry and community under the SSP. With SingHealth, SUTD will collaborate on a first-of-its-kind ground-up effort to achieve a smart low-carbon district. This long-term collaboration will see the development of smart, low-carbon campuses at Changi General Hospital and the upcoming integrated general and community hospital campus in Bedok North.

"As we shape the future of healthcare, sustainability is an important part of the conversation. This includes building efficient technologies and infrastructure that are sustainable in the long run, and having smart healthcare campuses that will optimise resources and improve the healthcare experience for our patients. We are delighted to join SUTD on this journey of sustainability, and look forward to actively incorporate programmes, designs and innovations as we enhance care for our patients and the community by co-creating a healthier and more sustainable environment," said Professor Lee Chien Earn, Deputy Group CEO (Regional Health System), and Chairman, Planning Committee, Eastern General and Community Hospitals.

SUTD will also be working closely with the North West Community Development Council (CDC) to explore various projects that can help residents advance towards a greener culture and bring about behavioural changes in the community. This includes a project with SUTD's Greenprint Club to design a green library from recyclable materials for residents at the HDB void decks in Bukit Panjang.

Alex Yam, mayor of North West CDC, said: "Sustainability is deeply rooted in North West District's DNA. Through North West CDC's network and resources, we are keen to collaborate with SUTD in providing an out-of-classroom experience for students to identify opportunities in the community and build connections with more residents through green initiatives of their own."

SUTD is also working with green developer City Development Limited (CDL), to jointly explore cutting edge green building products and innovations to achieve low-carbon and net zero outcomes. Besides working with CDL on helping the National Library Board revamp My Tree House, the world's first children's green library, SUTD will also help CDL explore new sustainable construction methodology to extend the CDL Green Gallery at the Singapore Botanic Gardens.



An example of a ground-up green initative by SUTD students

> "In the global race to zero, digitalisation and technology are vital in addressing the climate crisis."

Ms Esther An, CDL Chief Sustainability Officer, said, "In the global race to zero, digitalisation and technology are vital in addressing the climate crisis. Partnerships across various industries and sectors can amplify action and deepen impact, as well as bring us closer towards national and global goals. Since 2017, innovation has been identified by our internal and external stakeholders as the top ESG issue that underpins our sustainability strategy. CDL is pleased to collaborate with SUTD on new and innovative solutions that further elevates the performance of our existing projects, and as a result, advances our vision of developing sustainable cities and communities."

SUTD ushers in a new dawn for energy research in Singapore

By developing devices that consume less energy, SUTD researchers are laying the groundwork for a more sustainable future even in the face of the climate crisis.

As we contend with a warming world, technological advancements are set to play a key role in helping individuals, organisations and countries alike reduce carbon emissions in the energy sector. According to the International Renewable Energy Agency (IRENA) the clock is ticking: even if two-thirds of the world's energy is supplied by economically viable, scalable and renewable sources, population growth and the rising energy demand could still outpace current decarbonisation efforts.

Grim as IRENA's warning may be, it highlights the urgent need for further innovation, driven by R&D. With this year's Nobel Prize in Physics going to pioneers in climate modelling, efforts to address the climate crisis across all fronts will surely be top of mind in the years to come.

Accordingly, the 14th Singapore International Energy Week (SIEW) held from 25 to 29 October 2021 revolved around the theme 'Advancing the energy transition'. As the Republic shines a spotlight on what a future powered by sustainable energy may look like, three researchers from SUTD's Science, Mathematics and Technology (SMT) cluster are also heeding the call through their efforts to contribute to a more energy-efficient world.

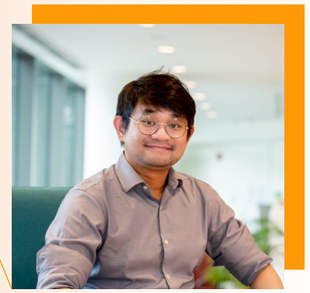
Thinking out of the silicon box

While mobile phones, laptops and smart devices have become indispensable especially in an increasingly digitalised world, the growing demand for higher-performance and smarter electronics is driving up our overall energy footprint, noted Assistant Professor Ang Yee Sin.

"Modern devices are composed of transistors—tiny electrical switches made of silicon that process digital information," explained Ang. "To create faster and smarter electronics, we need to reduce the physical size of these transistors so that more can be fitted into our phones and laptops, which can then handle larger amounts of digital data."

However, these transistors are quickly approaching the limits of miniaturisation. At the nanoscale level, these tiny transistors start exhibiting bizarre quantum behaviour, causing them to function in uncontrollable ways. "To tame such adverse effects, more electrical power is often needed, significantly increasing the energy consumption of electronics," said Ang.

Recently, Assistant Prof Ang and his team demonstrated how a newly discovered family of semiconductors made of two-dimensional (2D) materials, which are just a few atoms thick, require less voltage and power to operate thanks to a protective, non-conducting outer layer. Their findings pave the way for an exciting, energy-efficient future beyond current silicon-based technology.



ASSISTANT PROFESSOR ANG YEE SIN

A whole new world of computing

ASSISTANT PROFESSOR DESMOND LOKE

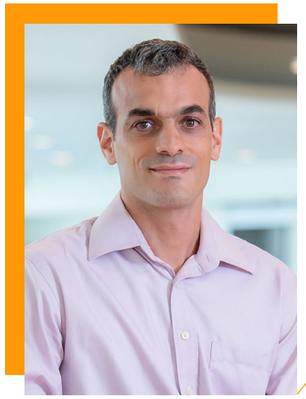
Elsewhere, scientists are also exploring alternatives to conventional technology like brain-inspired computing. Motivated by the computational power and efficiency of the human brain, research into brain-inspired computing involves the creation of new algorithmic approaches and hardware capable of highly sophisticated information processing.

"Brain-inspired computing systems are one of the leading contenders for next-generation digital computing," explained Assistant Professor Desmond Loke. "Recently, they've attracted significant interest because they can be as lightweight, energy-efficient and adaptable as the human brain."

However, emulating the brain's ability to rework neural connections—called neuroplasticity—in an ultralow-power manner is easier said than done. Loke's interest therefore lies in enhancing the energy-efficiency of artificial synapses, which mimic the gap used by neurons to pass along electrical signals for communication.

To this end, his team introduced for the first time an enhanced metal-electrode fabrication process into their artificial neuromorphic system. By using phase-change materials, or a kind of semiconductor with unique electrical properties, Assistant Prof Loke shared that they've designed devices that consume about 82 percent less power than traditional artificial synapses.

"Our experiments have demonstrated that the artificial neural network system with phase-change material synapses can simultaneously perform brain-like processing and memory functions in an ultra-low power manner," he concluded. "Our findings provide a promising strategy to someday build artificial neuromorphic systems for applications in bionic devices and multifunctional robotics."



ASSOCIATE PROFESSOR
DARIO POLETTI

A quantum leap in sustainable energy

Given the complexity of these energy-efficient alternatives, researchers like Associate Professor Dario Poletti, are also tackling the challenge at its most fundamental level, taking a closer look at the phenomena governing such systems.

Consider the case of nano-electronics. According to Associate Prof Poletti, one of their biggest challenges is the heat generated in these small systems and their impact on design and performance.

"By controlling the transport of heat at the nanoscale, one could channel the heat out or cool systems more effectively and efficiently," he explained. "Quantum mechanics allows us to design materials that better control heat transport, like heat diodes."

Accordingly, one of Poletti's main research interests revolves around developing nanoscale systems that can convert energy or leverage heat currents to generate useful work.

"In a recent collaboration with researchers from the National University of Singapore's Centre for Quantum Technologies, we implemented an engine that runs on a single atom, and showed that intrinsic limitations arise when one tries to convert heat into useful work at the nanoscale," he shared. By gaining a deeper understanding of these systems, such engines may eventually be engineered to cool and control the energy flows of nanomachines or quantum computers.

"The multi-disciplinary research ecosystem of SUTD is thus well-aligned to address the carbon neutral challenge."

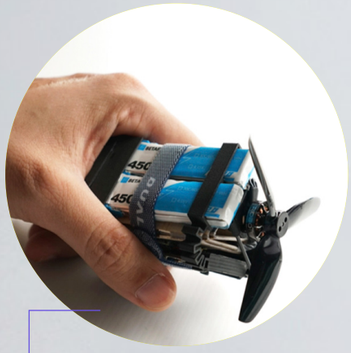
From characterising novel materials to understanding how to develop energy-efficient technologies, SUTD is well-poised to help accelerate Singapore's efforts to transition to more sustainable energy sources and work towards a carbon-neutral future.

"SUTD provides a 'one-pot' platform to tackle the carbon-neutral challenge, covering from fundamental material physics, computational device design, device fabrication and engineering to system-level research, such as the energy-efficient CPU architecture and '5G and beyond' communication technology. The multi-disciplinary research ecosystem of SUTD is thus well-aligned to address the carbon neutral challenge," concluded Assistant Prof Ang.

F-SAM in mid-flight, during a position-controlled flight experiment in MOCAP environment.

A DRONE THAT CAN FIT IN YOUR POCKET

SUTD researchers have designed and developed, F-SAM, a single-winged drone that can be easily folded, making it very versatile for various missions from climate monitoring to military use.



Folded F-SAM is small enough to fit inside a person's hand, allowing ease of transportation and storage.

Weighing just 69 grams, the monocopter has a single actuator and is small enough to fit in your pocket and can be launched by hand or from the ground within seconds.

F-SAM, which stands for Foldable Single Actuator Monocopter, was inspired by samara seeds. They are known for their uniquely shaped single-winged seeds that spin and float, before landing further away from the trees they are released from.

In the event of a power failure, F-SAM has also been designed with an in-built natural fail-safe, allowing it to descend to a soft landing.

The research team was led by Associate Professor Foong Shaohui from the Engineering Product Development Pillar.

"This work is particularly impactful as it illustrates how a fully controllable flight can be achieved with just 1 controllable actuator as most drones require at least 4 independent actuators. Besides its high efficiency, F-SAM goes a step further by also demonstrating its flexibility and compact size, allowing it to be effortlessly folded into a roll," explained Associate Prof Foong.

CORRECTLY CLASSIFYING COUGHS WITH MACHINE LEARNING

A specific deep neural network model called Bidirectional Long-Short-Term Memory can use cough sounds to distinguish sick from healthy children, paving the way for preliminary screening.

SUTD researchers have shown that deep learning models can accurately distinguish between healthy and sick children using only their cough sounds. These findings, published in the journal Sensors, could open the doors to more efficient screening for respiratory diseases in kids —and may lift a huge burden off of patients, parents and physicians alike.

In children, coughs can be a sign of several respiratory illnesses, including asthma, rhinosinusitis and infections of the respiratory tract. The ubiquity of cough as a symptom means that doctors often have to conduct additional tests and procedures in order to deliver a definite diagnosis.

"These tests require hospital visits, are not without risks to the child and place demands on healthcare resources," said SUTD Assistant Professor Chen Jer-Ming, who led the study. "Moreover, such visits have other negative social or economic impacts on the child and his or her family, such as time away from work and requiring specific childcare arrangements."

The need to ease this burden on patients as well as the overall healthcare system has led to a growing interest in harnessing minute differences in cough sounds to distinguish one respiratory condition from another. However, most studies have relied on cough audio carefully recorded in recording studio settings, making them unsuitable for real-world applications, where background noise and low-grade equipment could compromise the quality of the recorded coughs.

To address this problem, Assistant Prof Chen and collaborator Dr Hee Hwan Ing from KK Women's and Children's Hospital and Duke-NUS Medical School used cough recordings collected with smartphones in a live hospital setting, to reflect true 'ecological' conditions. Next, to help them accurately classify the cough recordings as diseased or healthy, the team turned to a specific type of deep neural network model called Bidirectional Long-Short-Term Memory (BiLSTM).

Compared with other artificial neural networks, BiLSTMs are made up of individual units that can remember values over an arbitrary amount of time. Such a memory mechanism, Chen explained, makes BiLSTMs particularly suited to handle sequential data like audio.

To train and test their model, the team used cough recordings from 89 children with asthma, 160 with lower respiratory tract infection and 78 with upper respiratory tract infection. For comparison, they also included cough sounds from 89 healthy children.

The team found that BiLSTM could accurately classify individual cough sounds as healthy or diseased 84.5 percent of the time. When considering all of a patient's audio samples, the predictive model had an accuracy rating of 91.2 percent. This means that out of 10 patients that provide their cough recordings, BiLSTM will be able to correctly identify nine as either healthy or sick.

> **"This study is only the first step towards developing a highly efficient deep neural network model that can differentiate unhealthy cough sounds."**

However, when trying to distinguish among the different pathological coughs, the model was less accurate. For instance, the model misattributed nearly three-fourths of asthma coughs to infections of the respiratory tract. In turn, more than 60 percent of children with asthma were wrongly diagnosed with lower respiratory tract infection.

"Analysing the audio features of unhealthy versus healthy, recovered coughs collected from the same child revealed the fact that unhealthy coughs, irrespective of the underlying conditions, are much more similar with other unhealthy coughs," Assistant Prof Chen pointed out. Such an observation is in line with anecdotal records that even doctors themselves find it difficult to distinguish diseases based on cough sounds alone.

Nevertheless, the researchers found that much of the model's misclassification occurred when attempting to distinguish different diseases; BiLSTM remained highly accurate at differentiating healthy from sick kids.

Despite its potential to transform respiratory disease screening in the paediatric department, there is still work to do before the present BiLSTM model will be ready for clinical deployment.

In particular, the development of a smartphone app that can collect audio input, forward it to a central server for processing and display results to the end-user, will be key in making the model usable in the clinical setting. Once deployed, the technique can then be continuously refined using further audio data from patients, to improve its accuracy at detecting pathological coughs.

"This study is only the first step towards developing a highly efficient deep neural network model that can differentiate between different unhealthy cough sounds," Assistant Prof Chen said. "Such an automated, 'in the field' approach will support clinical screening of respiratory illnesses associated with cough, contributing to health monitoring and screening, especially in remote and developing communities."

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Office of Marketing & Communications, SUTD
8 Somapah Road, #06-301
Building 3 Level 6, Singapore 487372
T: +65 6303 6600
W: www.sutd.edu.sg/newsletter

SUTDsingapore

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