



# FUSION

THE POTENTIAL OF  
TECHNOLOGY AND DESIGN



SINGAPORE UNIVERSITY OF  
TECHNOLOGY AND DESIGN

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ICEHOTEL  
JUKKASJÄRVI, SWEDEN  
TAKEN BY AN SUTD STUDENT ON EXCHANGE

## NEW INITIATIVES AT SUTD



### OVERSEAS IMMERSION FOR FRESHMORS

With current advancements in technology, the barriers between culture and business across countries are becoming almost non-existent. Hence, starting this year, students who join SUTD will have the opportunity to experience overseas immersion trips to ASEAN member countries and others within Asia.

Leveraging the real world as part of the strategy to expose students to experiential learning, these overseas trips will serve as a pre-cursor for students to better understand the region and build networks, providing them with a global perspective which would be useful as they enter the workforce. By linking the trips to their courses, students will be able to connect what they have learnt in the classrooms to the real world, developing their critical thinking and problem solving skills.

SUTD Freshmore students will receive a subsidy that could cover airfare and possibly the accommodation cost when they participate in these overseas immersion trips.

This new initiative serves to complement and augment the slew of existing overseas programmes, while offering all SUTD students the opportunity for an overseas experience.

SUTD President, Professor Chong Tow Chong said, "Overseas exposure plays a vital role in students' experiential learnings, widening their mindsets and enhancing their education beyond book knowledge. For a start, we anticipate that up to half of each batch of students will go on overseas experiences in their first year, with the others choosing to travel in their junior or senior years. The plan is to be able to send all Freshmore students overseas by 2021. We are also mindful of the costs, which is why we will be providing all participating Freshmore students with a substantial subsidy to defray the costs of these trips."

### ENHANCED SUTD SCHOLARSHIPS AND BURSARIES

SUTD's bursary and scholarship offerings have also been enhanced to ensure that SUTD's education is more financially accessible for students.

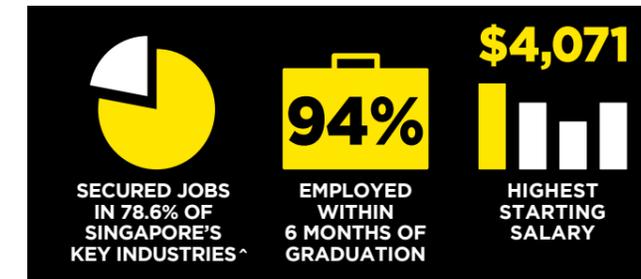
The SUTD Education Opportunity Grant (SEOG), which was established to help deserving needy Singaporean students pursue their studies at SUTD, will now be tiered based on qualifying students' financial circumstances.

This will allow more students, including those who come from families with monthly per capita income of up to \$2,250 to receive more support. Specifically, with the Enhanced SEOG, and after taking into consideration the tuition grant subsidy by the Government, all eligible students from families with monthly per capita income of less than \$690 will be guaranteed a free undergraduate education and fully subsidised Freshmore (first three terms) hostel fees.

Additionally, SUTD will be offering more scholarships which not only cover the subsidised tuition fees for undergraduate studies, but also guarantees and funds an overseas experience of at least eight weeks' duration during summer under the Global Leadership Programme. These are the SUTD Global Distinguished Scholarship and the SUTD Global Merit Scholarship, and there will be about 50 more of these scholarships awarded this year to outstanding students compared to 2018.

Prof Chong added: "Our newly enhanced Education Opportunity Grant aims to help students based on their financial circumstances, and those with greater financial need can receive more assistance or even a free education. We also continue to emphasise the importance of global exposure for students by offering more scholarships that guarantee overseas experiences. Together with the enhanced scholarship and financial assistance offerings, more than half of SUTD students admitted will receive some form of financial support."

## 4<sup>TH</sup> CONSECUTIVE YEAR OF HIGH EMPLOYMENT RATE AND STARTING SALARIES FOR SUTD GRADUATES



Based on the results of the annual Joint Graduate Employment Survey conducted by SUTD and five other autonomous universities – NTU, NUS, SIT, SMU and SUSS. \*Mean gross monthly salary and overall employment rate. ^Based on the Economic Development Board's list of Singapore's industries and key activities.

Results of the latest Graduate Employment Survey (GES), jointly conducted by all six public universities (NTU, NUS, SMU, SIT, SUSS and SUTD), revealed that more than nine in 10 SUTD fresh graduates were employed within six months of completing their final exams. 285 out of 334 SUTD fresh graduates participated in the 2018 GES. Overall employment rate increased by 2.6 percentage points, from 91.4% in 2017 to 94.0% in 2018, with 86.0% of graduates in the labour force having secured full-time permanent employment.

In terms of starting salaries, the median gross monthly salary for fresh graduates employed in full-time permanent jobs increased slightly to \$3,850 in 2018, compared to \$3,700 in 2017. Their mean gross monthly salaries increased to \$4,071 in 2018, compared to \$3,859 in 2017. SUTD's graduates from

the Information Systems Technology and Design pillar led the cohort with a starting mean gross monthly salary of \$4,544 and a median salary of \$4,400. Top hiring sectors include Information & Communication, Financial & Insurance, and Scientific Research & Development.

### EMPLOYMENT STATUS OF GRADUATES WHO PARTICIPATED IN THE FOLLOW-UP SURVEY

64 out of 76 graduates from the Architecture and Sustainable Design pillar participated in the 2018 follow-up survey. These students graduated from SUTD's pioneer batch in 2015. The majority took up SUTD's Master of Architecture programme and participated in the survey upon completion of their practical training. Of those in the labour force, 95.1% secured employment.

The median gross monthly salary among those employed in full-time permanent employment is \$4,000, while the mean gross monthly salary is \$3,945.

SUTD President Professor Chong Tow Chong said: "I am pleased that for the fourth consecutive year, our Graduate Employment Survey results show that SUTD graduates continue to be well sought-after by employers, enjoying high overall employment rates and starting salaries. This is further affirmation that SUTD's multi-disciplinary, design-centric education nurtures our students with strong critical thinking, innovation and problem solving abilities, preparing them well for the jobs of tomorrow. Coupled with overseas exposure and internship experiences, we shape SUTD graduates into industry-, world- and future-ready talents for Singapore."

### GRADUATES FROM CLASS OF 2018



**Joe Ng** graduated with a Bachelor of Engineering in Information Systems Technology and Design and is working as a systems engineer at the Cyber Security Agency of Singapore (CSA), analysing cyber threat intelligence (CTI). His job involves analysing computer log info, known indicators-of-compromise (IOC), trends across known attacks and attempting to find insights from them. Ideally this establishes the Tactics, Techniques and Procedures of threat actors hostile to Singapore, which CSA can then use to defend the nation. Joe decided to join CSA because he was inspired by his SUTD Security Professor Nils Ole Tippenhauer, who was extremely knowledgeable in the field and could easily navigate around any attempts to exploit weaknesses in his code.

He even gave out additional scores for those who managed to break or find loopholes in his code, which "gamified" the studying experience in SUTD significantly. Going forward, Joe hopes to assist Singapore in her drive to become a smart nation through ensuring that all the country's data is untampered and safe from intrusions.



**Hilda Thian** graduated from the Engineering Systems and Design pillar and is working as a senior associate at Changi Airport Group (CAG), under operations management, which includes the interpretation and study of performance data, assessment of slots and counter allocations, as well as the engagement of airline and ground handlers to enhance and upkeep efficiency and passenger experience.

Hilda decided to join CAG as she wanted to make a positive impact on the experiences of travellers while working alongside driven and like-minded peers. The design thinking skills she picked up in SUTD have been helpful in her workplace as these fundamentals of design thinking have taught her the importance of empathising and defining/scoping the problem in all her decision making processes.

## LKYCIC SUPPORTS 1<sup>ST</sup> IMAGINE 2060 CONFERENCE IN SINGAPORE

BY BELINDA YUEN



From left: Dialogue between Prof Chan Heng Chee, Mr Sean Chiao and ESM Goh Chok Tong at the Concluding Session of the Conference

Imagine 2060: Delivering Tomorrow's Cities Together took place at the Asian Civilisations Museum on 25 April 2019. The half-day conference was part of a three-year global series on Water, Air, Land initiated in 2017 and co-organised by Asia Society and AECOM to inspire bold ideas for future cities. This conference, the first of its kind in Singapore, was supported by the Lee Kuan Yew Centre for Innovative Cities (LKYCIC), a research centre at SUTD. It focused on the issue of land, surrounding the question "What lies ahead in 2060 as space runs out?" Approximately 150 delegates, including SUTD Board Members Mr Lim Siong Guan and Mr Sam Goi, attended the conference.

The audience, comprising corporate leaders, diplomatic corps, policymakers, professionals, academics and researchers from think tanks and embassies, universities, private and public sectors, and international organisations like the World Bank heard keynote addresses from Emeritus Senior Minister (ESM) Mr Goh Chok Tong and Minister for National Development, Mr Lawrence Wong. They shared how Singapore actively seeks ways to overcome space constraints to maximise chances for future success.

Two subsequent panel discussions provided in-depth analysis on 'Imagine Life Underground: Impact and Implication for Singapore' and 'Imagine Growing Land: New Models of Productive Use of Land'. The audience joined the discussion with their questions. There was interest to know, for example, whether people were prepared to live underground, whether Singapore could explore and what the impediments were for universities to go underground as was done in Seoul, South Korea. Panel members also shared their views on Green Float, a proposed floating city concept announced in 2008 and planned for construction in 2025.

The conference concluded with a three-way dialogue with ESM Goh Chok Tong, Professor Chan Heng Chee (Global Co-chair, Asia Society and Chairman, LKYCIC) and Mr Sean Chiao (President, Asia Pacific, AECOM), highlighting the respective roles and importance of policy, people and perspective when discussing cities of tomorrow.

## SUTD & CAAS JOINTLY ESTABLISH AVIATION STUDIES INSTITUTE



Prof Chong Tow Chong, SUTD President (left) and Mr Kevin Shum, CAAS Director-General

At the sidelines of the 9 April World Civil Aviation Chief Executives Forum, SUTD and the Civil Aviation Authority of Singapore (CAAS) signed an agreement to establish the Aviation Studies Institute (ASI) to advance air traffic management (ATM) research and development (R&D) in Singapore.

Located within SUTD's campus, the ASI will focus on operational, economic and policy research. This complements and enhances SUTD's focus in aviation research and education, while offering students a macro view of the aviation system and a deeper understanding of its value creation to stakeholders. The research projects aim to benefit the wider aviation community by enabling stakeholders to adopt solutions that can enhance operational efficiency, increase capacity and global interoperability. The ATM tools and policy recommendations developed by the ASI will have a significant impact in Singapore and the ASEAN region, and facilitate dialogue on region-wide

collaborative approaches. For a start, the ASI will conduct research in these four areas:

- Network Capacity
- Airfield Management and Economics
- Airport Connectivity
- Information Sharing and Collaborative Decision Making

Over the next five years, CAAS will provide \$11.6 million to fund the aviation and ATM policy research undertaken by the ASI, as well as lend the expertise of aviation experts for research projects. At the same time, SUTD will provide in-kind contributions of \$5 million, including research manpower and facilities.

"The ASI is a key element of CAAS' larger effort to develop Singapore as a Centre of Excellence for ATM and facilitate the development of safer and more efficient air travel. It will expand the scope of ATM R&D in Singapore to generate insights for improving and transforming our operating models," said Mr Kevin Shum, Director-General of CAAS.

"The ASI represents a major step forward in one of the four major thrusts of SUTD's strategic growth plan. We see Aviation, Healthcare and Cities as three critical domain challenges facing Singapore with the technology of Artificial Intelligence undergirding future advances in all three. All four thrusts build on SUTD's bold advocacy for design innovation. The partnership with CAAS reinforces this vision as the ASI will not only tackle practical problems in the Aviation policy domain but also approach them from a system design perspective and leverage the computational tools of data analytics, optimisation and reinforcement learning," said Professor Chong Tow Chong, President of SUTD.

## DRIVERLESS MOBILITY DEBATE

A Driverless Mobility Debate to better understand Singaporeans' expectations and perceptions of autonomous mobility was conducted at SUTD on 27 April 2019. Organised by TUMCREATE, the Lee Kuan Yew Centre for Innovative Cities at SUTD and Missions Publiques, 60 participants from various backgrounds shared their views across six themes in the day-long discussion.

One participant – a student – reflected on the diversity of views and shared that "it was pleasantly surprising to experience how such conversations between people of different backgrounds can occur". The student said: "For instance, at our table we had a travel tours consultant, an urban planner, a 5G tech expert, a domestic maid agent and a retiree, among others – yet the space allowed everyone to think and share with such openness. Such public facilitation of discourse is critical as society gets more connected and politically involved in national issues, and issues become more complex and interdisciplinary. All in all, I had a most pleasant day and left feeling refreshed and inspired."

Preliminary findings indicate a high level of trust and reliance on the government to lead the transition and regulation of autonomous vehicles in Singapore. The top emerging concerns centred around safety and cost efficiency. Overall, the majority of participants were optimistic about driverless mobility in Singapore and expected benefits such as reduced traffic congestion and more meaningful use of their travel time.



Participants at the Debate

As the Debate will also be held in over 20 cities around Europe, the US and Canada, the data will be analysed and compared across countries and cities. Results will be presented at high level mobility events at national and global levels from September to December 2019.

## SUTD STUDENTS USE VR & AR TO REDEFINE ARCHITECTURE DESIGN

As more and more new technologies are developed, it has become imperative for academic institutions to start making use of these new tools to explore and find new ways to help students learn. SUTD's Architecture and Sustainable Design (ASD) pillar is thus making use of new tools such as Virtual Reality (VR) and Augmented Reality (AR) to inspire and broaden students' learning experience and redefine their understanding of architecture design.

Currently, many firms are using VR and AR technologies as visualisation tools to let clients preview how a building might look and feel before the actual building is constructed. However, this is just one of the more common uses of these technologies.

In one of ASD's core studio classes, Professor Eva Castro has implemented the use of VR and AR technologies under the topic of Digital Archives. Students are tasked with exploring techniques and issues about liberating the archival of thought or ideas from a physical place, and to develop new forms and methods of archival. They will also need to address the relationship between what is "material" and "digital" within the discipline. By setting a specific building type (the digital archive) without a specific site and time, students can experiment on designs without the weight of traditional 'real' parameters, empowering them to explore concepts and tools beyond the norm. To enable others to not just visualise but to envision and experience the concepts and scope of their design, VR techniques are introduced to the students as a means of production.

Said Prof Castro: "VR will not only be used indirectly as a means of phenomenological representation, but as a new tool through which design could challenge basic notions of place, type and



ASD students presented how they used VR and AR at this core studio exhibition

narrative, meaning, questioning the linear-accumulation of commodified experiences of spaces, in time."

ASD student Lucas Ngiam, who was one of the 60 students who presented their work in this core studio exhibition at SUTD on 29 April, said that compared with traditional design methods such as plane drawing and fabricating models, the visual and experiential effects of virtual reality gave him a more "immersive" experience of the space he was designing. It was also easy to test and modify the design repeatedly.

Many external architects and designers were also invited to critique their work. When interviewed, Ong & Ong Pte Ltd group executive chairman Mr Ong Tze Boon said: "For architects, virtual reality technology seems to be a new "drawing board", and many customers hope to "immerse" themselves in the space that designers have come up with. As more and more architects and designers use this technology, it is good for students to master this skill while still in school."

## SUTD ELECTRIC VEHICLE DESIGN CHALLENGE (EVDC) 2019



Over 180 students from various schools participated in the EVDC 2019

To raise awareness and interest in STEM (Science, Technology, Engineering and Mathematics) among youths in Singapore, SUTD and the People's Association co-organised the SUTD Electric Vehicle Design Challenge 2019 from 11 to 12 May at Heartbeat@Bedok.

Youths around 15 years and older were provided with a kart kit designed by students from SUTD's Electric Vehicle (EV) Club. The attached instructions enabled them to assemble a J19 EV, including making their own design modifications. The SUTD students also conducted technical clinics for participating teams to assist and guide them with their assembly. Through this hands-on experience, the youths could get a taste of what engineering and technology are all about and potentially consider a future in this area.

In total, 17 teams made up of over 180 students from various junior colleges and polytechnics participated in this Design Challenge. The winners of the Design Challenge were:

|                           |   |
|---------------------------|---|
| WINNER                    | Eunoia Junior College                       |
| 1 <sup>st</sup> Runner Up | National Junior College                     |
| 2 <sup>nd</sup> Runner Up | Anglo-Chinese School (Independent)          |
| Best Dressed Garage       | School of Science and Technology, Singapore |
| Learning Journey          | Singapore Polytechnic                       |
| Judges' Choice            | Singapore Polytechnic                       |



GOH Mr Chee Hong Tat, Senior Minister of State, Ministry of Trade and Industry & Ministry of Education doing a test drive of the EV

Guest-of-honour for the EVDC, Mr Chee Hong Tat, Senior Minister of State, Ministry of Trade and Industry & Ministry of Education, said, "I am glad that SUTD is using the EV Design Challenge to interest our youths in STEM. The Challenge has allowed our participants to apply their Science and Engineering skills to solve complex problems, giving them a sense of excitement and fulfilment when they successfully assembled their electric vehicles."

Mr Lee Yi Shyan, Adviser to East Coast GRC GROs shared, "We are really honoured to collaborate with SUTD to bring the EV challenge time trial to the heartlands. This is indeed a good opportunity for our residents to come together to bond and bridge, especially to interest more youths in STEM. This out-of-the-box co-creation is in-line with our vision for Heartbeat@Bedok to be a centre of energy, enrichment and fun for the betterment of residents in Bedok and East Coast."

SUTD President, Professor Chong Tow Chong said, "We are grateful to Heartbeat@Bedok for their generosity in helping to co-organise the EV Design Challenge 2019 with SUTD. SUTD's mission is to advance knowledge and nurture technically-grounded leaders and innovators and this Challenge is a good platform for students to gain some hands-on experience of the engineering process. I would also like to commend the SUTD students who worked hard to put together the kart kit that enabled teams to build these EVs, as they have assimilated the design innovation skills learnt at SUTD to bring it to fruition."

This is the third edition of the SUTD EVDC.



SUTD students conducting technical clinics for participating teams

## ANNUAL SINGAPORE 3MT COMPETITION HELD AT SUTD



Participants of the 3MT Competition with Speaker of Parliament, Mr Tan Chuan-Jin

SUTD organised the annual Singapore 3-Minute Thesis Competition (3MT) 2019 on 29 May, where 12 PhD students from four research intensive universities, SUTD, NUS, NTU and SMU, competed to see who could best explain their research thesis simply, clearly and effectively to a non-specialist audience in just three minutes. Mr Tan Chuan-Jin, Speaker of Parliament, graced the event as the guest of honour and delivered the closing speech.

Using the aid of a single, static slide, NTU PhD student Natallia Khaniejo emerged as the winner of the 3MT Singapore competition for presenting her research thesis on 'The Happy Valley: Examining Silent/Silenced frontiers'. She took over the winning crown from John Chan, the SUTD PhD representative in 2018 who was also the co-host of the competition this year.

Meanwhile SMU PhD student Hye Jung Eun was awarded the first runner-up prize for her research presentation titled 'Emphasising Creativity at What Cost?' and SUTD PhD student, Ashaa Preyadharishini Shunmugam received the People's Choice award for her presentation on 'Use of Microorganisms in Bio-MEMS'.

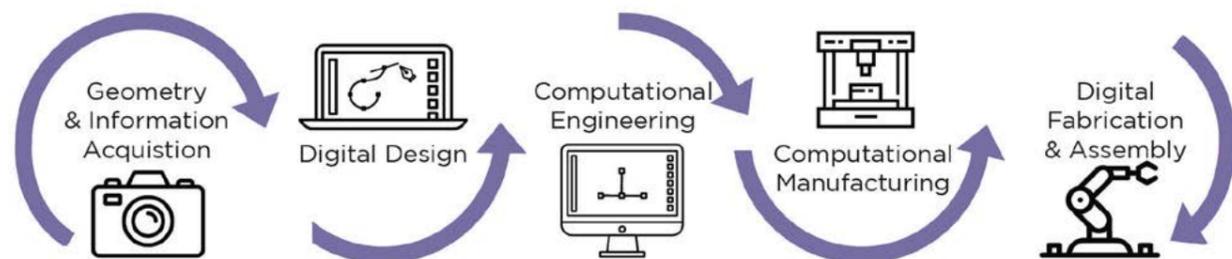
Both Natallia and Hye Jung will represent Singapore at the Asia-Pacific 3MT Competition in University of Queensland(UQ), Australia on 4 October 2019.

"A lot of the work that you put into the research front will have a lot of benefits to society. But you need to get that across to the decision makers, and ultimately, to the people who need to support it. And also to the public so that they can be seized and inspired so that many can follow in your footsteps", said Mr Tan Chuan-Jin, during his closing speech.

Originating from UQ in 2018, 3MT celebrates the exciting research conducted by PhD students and nurtures their critical research communications skills. As it started to gain recognition in numerous universities, a multi-national event was developed and the inaugural Trans-Tasman 3MT competition was held at UQ in 2010. Since 2011, the popularity of the competition has increased and 3MT competitions are now held in over 350 universities across more than 18 countries worldwide.

# TECHNOLOGIES AT THE DMAND RESEARCH CENTRE

BY DAVID W. ROSEN AND LOW HONG YEE



DManD's digital design workflow

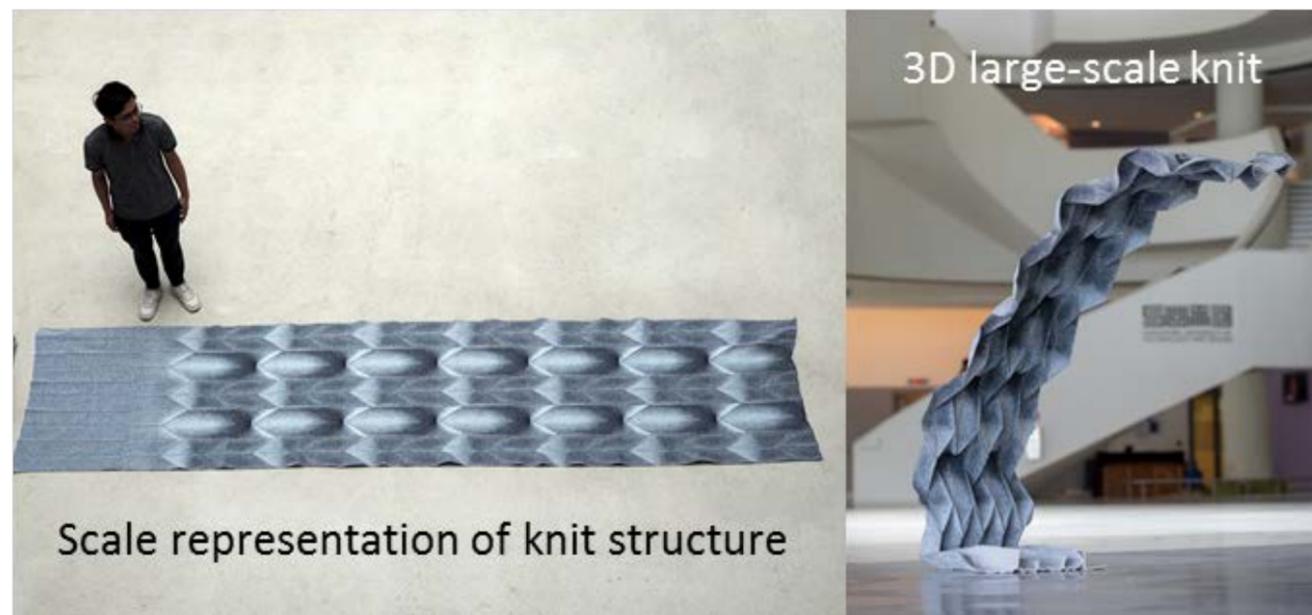
At the Digital Manufacturing and Design (DManD) centre, researchers develop technologies that enable high performance, responsive, shape-shifting devices to be designed, engineered and manufactured. DManD's research strategy embraces the convergence of innovations in design, materials and manufacturing so that designers can explore new design concepts, and exploit integrated, highly efficient digital workflows to speed up product development. This strategic positioning is important as the industry is more ready to adopt such digital workflows, and to take new design ideas and fabrication solutions to cost-effective scaled-up manufacturing.

DManD has four research thrusts: Digital Design, Soft Mechatronics, High Resolution Manufacturing and Large Scale Additive Manufacturing. We will highlight some of our recent accomplishments in Digital Design research.

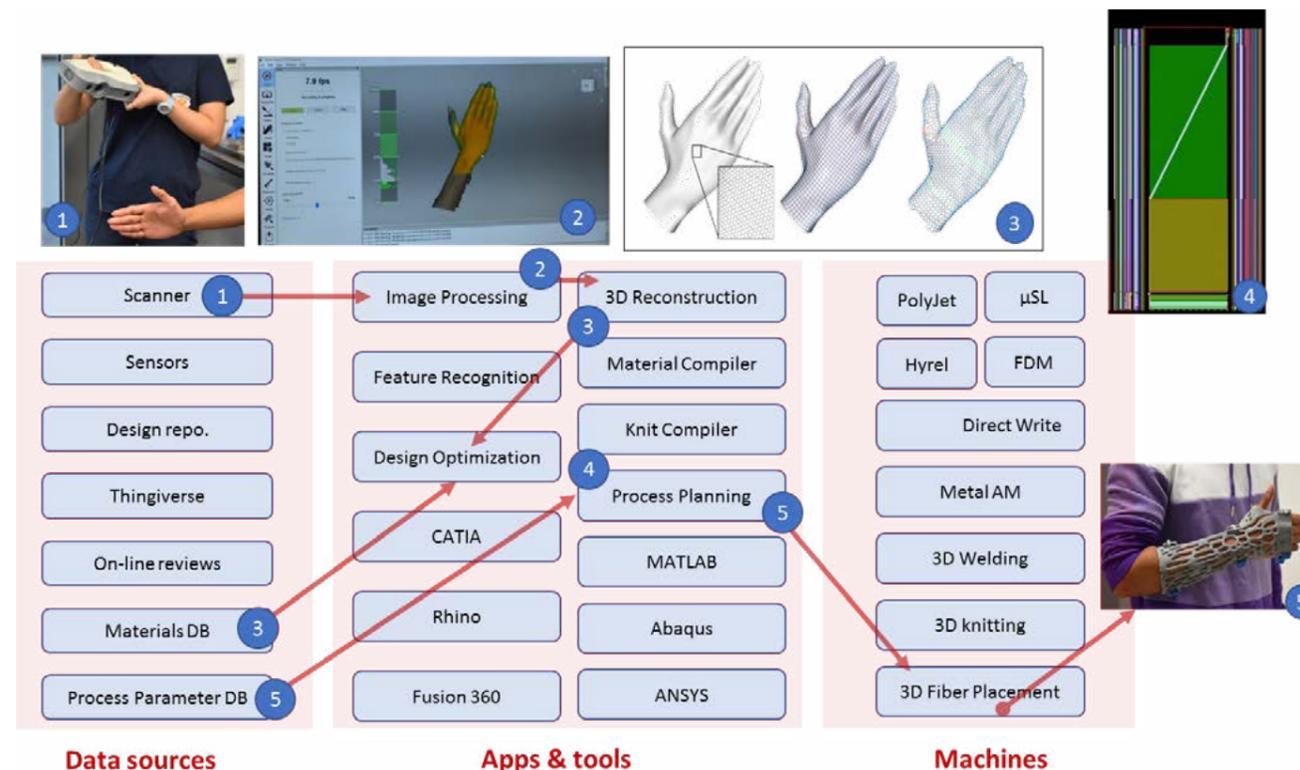
The digital design thrust develops a framework of common methods that merges advanced modelling and simulation techniques with new design search techniques into a computational design optimisation platform. Using this platform, designers can systematically and efficiently exploit the vast design spaces created by digital manufacturing

technologies. DManD is currently developing a cloud-based version of the platform, called the DManD Toolkit. The Toolkit allows other researchers and practitioners to access DManD research results and capabilities, test them, provide feedback and benefit from the research. In the long term, the Toolkit is envisioned to be an environment for configuring digital workflows, executing design and manufacturing projects, and providing a digital design and manufacturing ecosystem for advanced digital engineers.

Unique design capabilities are illustrated by a project on Computer-Aided Design for Additive Manufacturing (CADFAM) that enables the designer to exploit the unique capabilities of additive manufacturing and emerging materials and manufacturing processes. Designers can design artefact geometry and its materials; the CAD system predicts the effects of the manufacturing process on the materials for the specific geometry of the parts. Multiscale composite materials, shape memory polymers and soft elastomers can be incorporated into artefact designs to enable novel and shape-changing devices. For example, custom arm braces have been designed such that it can be 3D printed as flat patterns, but can then change shape to fit the user's arm upon heating to invoke the shape memory effect.



Example of 3D Functional Textiles, for free-standing textile structures using thermo-yarns



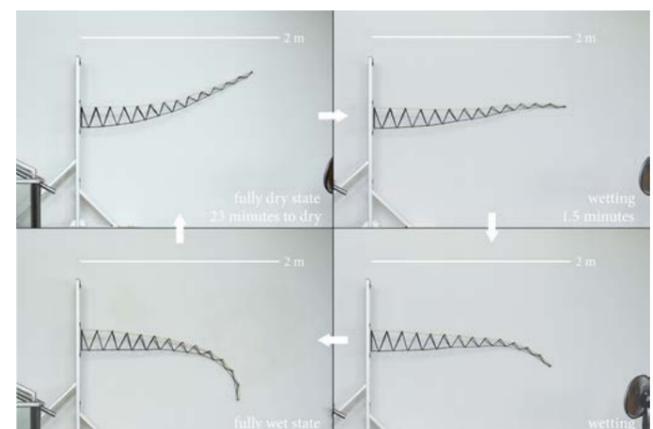
Example of utilising various digital design tools to design, simulate, optimise and manufacture a customisable arm brace

Another interesting technology focuses on 3D technical textiles, utilising whole garment computer numerically controlled (CNC) knitting technology, used for example by shoe companies to knit one-piece uppers. DManD researchers are developing the computational design, optimisation, and fabrication framework to design and engineer novel 3D knitted devices and structures with integrated sensing, communication, and therapeutic capabilities. For example, wearable medical devices that can monitor a patient's condition and provide cooling, heating, massage and other therapeutic actions are being designed.

In the architecture area, DManD researchers are also creating design tools and digital workflows for inventing novel responsive structures that can react to the environment for increased performance and lessened energy input. These

strategies can enable the integration of 'smart', adaptive infrastructure in the urban environment in a sustainable manner. Pending applications include canopies that passively deploy in response to rain to protect pedestrians on a walkway or at a bus stop. Another example being investigated include air-flow-responsive tensile structures that modulate air flow passively (without extra energy), helping to cool people in pavilions.

DManD's emphasis on digital workflows and integration across the product development value chain differentiates the Centre from other research programmes that emphasise research and development on point technologies which are not necessarily integrated with other technologies and workflows.

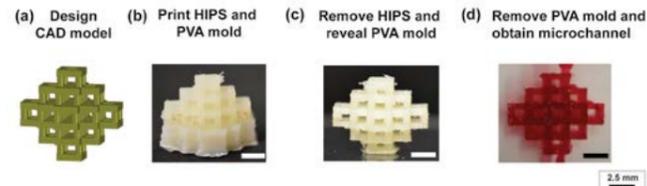


Passively actuated large structures for rain shelter as a specific application.



Tensegrity membrane structures

## 3D PRINTING OF MICROCHANNELS WITH COMPLEX GEOMETRY



Schematic of the four major stages of dual sacrificial molding

Over the last two decades, researchers have applied replica molding to create microchannels with 2D planar geometries. With replica molding, fabrication of 3D microchannels would require precise alignment and laborious stacking of multiple layers. Microchannel geometries such as overhang and helices are difficult to create due to the suspension of the structure by replica molding. However, recent developments in 3D printing and additive manufacturing may change the way microchannels are fabricated.

Led by EPD Assistant Professor Michinao Hashimoto, the research team fabricated microchannels with 3D overhang features by performing sacrificial molding using dissolvable structures. Typically, simple water-soluble mold could be printed by a fused deposition modeling (FDM) printer and then directly embedded in a matrix of microchannels. The team devised a novel process, termed dual sacrificial molding, to fabricate microchannels with overhang and helices using two complementary materials — high-impact polystyrene (HIPS) and polyvinyl alcohol (PVA). HIPS was initially removed in limonene to reveal the PVA mold harboring the design of microchannels. The PVA mold was subsequently embedded in polydimethylsiloxane (PDMS) and removed in water to create microchannels with 3D geometries such as dual helices and multilayer pyramidal networks with multiple overhangs.

The success of dual sacrificial molding relies on the right pairing of the two sacrificial materials and the respective solvents used to remove them. The team profiled the surface of the main material after removal of the support material and discovered that HIPS and PVA adhered well during the process of printing and the solvents used to remove HIPS did not affect the integrity of structures made with PVA.

Principal investigator, Assistant Prof Hashimoto said: “We usually use PVA filament as a support material for FDM 3D printing of acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), among other filaments as it is easily removed by soaking in water. In our work, we reversed the role of PVA filament and used it as a material for sacrificial molding to create microchannels in matrices and hydrogels. We explored compatible support material for PVA within the realm of commercially available filaments so that dual sacrificial molding is accessible to the research communities.”

This work, entitled “Optofluidics: From Fundamental Research to Applications” has been published in the special issue of *Micromachines*. Jason Goh, a PhD candidate at SUTD led the project to publication with other group members.

## DEMYSTIFYING CENTRALISATION IN CRYPTOCURRENCY MINING

Blockchain technology has been considered as the most revolutionising invention since the Internet. Due to its immutable nature and the associated security and privacy benefits, it has widely attracted the attention of banks, governments, technology corporations, as well as venture capitalists.

To participate in the blockchain consensus mechanisms, prospective network nodes – also called miners – need to provide proof of some costly resource. This resource may be computational power in protocols with Proof of Work mechanisms or coins of the native cryptocurrency in Proof of Stake mechanisms.

An integral assumption in the security philosophy of public blockchains is that the network of mining nodes remains sufficiently decentralised and distributed. In the extreme case, sufficiently means that no single entity holds 50% or more of the resources but in practice much more decentralisation may be desired to safeguard the underlying protocol. However, currently available data demonstrates that mining resources are much more centralised than originally thought, leading essentially to a reinvention of our current banking system instead of the intended decentralised digital currency of the future, see Figure 1.

ESD Assistant Professor Georgios Piliouras and Stefanos Leonardos, postdoctoral research fellow at the iTrust Centre for Research in Cyber Security in collaboration with Nikos Leonardos from the National and Kapodistrian University of Athens developed a novel approach to untangle the centralisation phenomena in blockchain mining. They employed the rich economic theory of Oceanic Games, originally devised by the 2012 Nobel Laureate in Economics, Lloyd S. Shapley.

The application of this theory in the currently evolving blockchain ecosystem unveiled incentives both for active and newly entering miners to merge and act as single entities. These observations provide an alternative justification of the observed centralisation and concentration of power in the mining process of major cryptocurrencies. Contrary to common perceptions, they amount to the existence of a negative feedback loop in terms of decentralisation as a core ingredient in public blockchain philosophy and reveal the need for further research in this direction.

For this work, the research team received the Best Paper Award in the 1st International Conference on Mathematical Research for Blockchain Economy.

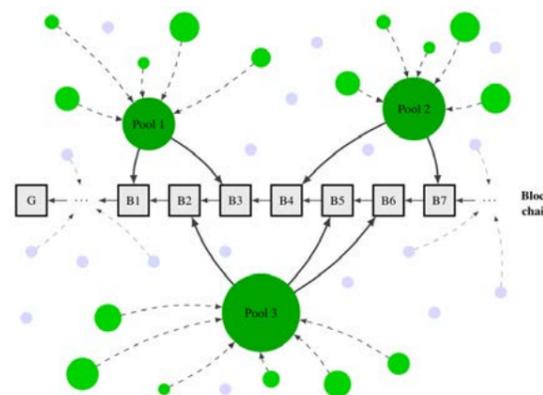


Figure 1. Illustration of centralisation in Blockchain Mining. Several major mining pools dominate the process. The remaining resources are scattered among “Oceanic Miners”.

## PUBLIC LECTURE BY PROFESSOR CLAUDE COHEN-TANNOUJI AT SUTD

BY RUSS CHUA



Prof Claude Cohen-Tannouji (right), with SUTD Associate Prof Roland Bouffanais

Professor Claude Cohen-Tannouji gave a public lecture on “Using Photons for Manipulating Atoms” at SUTD on 23 January, held in conjunction with the Global Young Scientists Summit 2019 organised by the National Research Foundation, Singapore. In his talk, the 1997 Nobel laureate in Physics covered the basic theory of “light amplification by stimulated emission of radiation” (laser), and its wide relevance in empowering countless technologies to date.

Prof Cohen-Tannouji began his talk with how he came to be acquainted with physics, highlighting the importance of his social milieu in his academic journey. Although he initially intended to pursue a research career in mathematics, he subsequently revised this ambition after becoming inspired by the genius of Professor Alfred Kastler who later became his PhD supervisor in École Normale Supérieure. Not long after completing his dissertation in 1962, his supervisor won the Nobel Prize in Physics (1966). This accomplishment was highly motivating for the young academic, who embarked on his research journey and eventually won his own Nobel Prize in Physics (in 1997) “for development of methods to cool and trap atoms with laser light.” In his early years of active research, Prof Cohen-Tannouji also supervised Serge Haroche as his doctoral student, who also became a Nobel laureate in Physics in 2012. Prof Cohen-Tannouji is proud of this history and closely regards the academics he works with as “family”.

Following this, Prof Cohen-Tannouji explained how laser cooling and trapping could be accomplished and the far reaching effects of these findings. In particular, he alluded to its application in producing more stable and precise atomic clocks that could be used in space. He further elaborated that such a project would lead to a more precise synchronisation of atomic clocks in GPS systems.

In his concluding remarks, Prof Cohen-Tannouji also spoke about the importance of scientific endeavours and funding for basic research. Unlike more application specific engineering projects that yield quicker financial returns, basic research is extremely rewarding in the long run. Just as the inventors of laser could not have foreseen its various applications in technology today, Prof Cohen-Tannouji postulated that upstream scientific researchers do not always have intended applications planned in advance. From my perspective as an SUTD alumnus, this lecture was deeply insightful and has provided a better viewpoint towards advancing tomorrow’s technology.

## MASTERCLASS BY MASTER ARCHITECT, PROFESSOR MARIO BOTTA - THE SPACE BEYOND

BY KENDRICK TAY



Prof Mario Botta (seated with raised hands) at a critique session with students

Renowned Swiss architect, Professor Mario Botta gave a Masterclass lecture in SUTD together with a screening of the film Mario Botta, *The Space Beyond* on 15 April. Having the rare distinction of working with many great architects such as Le Corbusier and Louis Kahn, his visit piqued particular excitement among the architectural community, many of whom grew up studying the works of these giants of architecture.

Professor Mario Botta structured the session by giving a thematic introduction to the works of his practice, fascinating the audience with his unique and highly deliberate approach to the crafting of space. The lecture audience were captivated by his stories behind the projects and his intentions as an architect, lending a multi-layered texture to his much beloved works. From his first works at 16, to his latest works of today, each told a story and an experience which he rendered and pursued with a deft touch.

With his rendition of his personal stories behind the projects, shown both in the film and via his personal sharing, the audience also gained a glimpse into the personal side of Mario Botta. His recollections painted a picture of an architect in the relentless pursuit and refinement of sacred spaces, and of finding a space for them in modern society.

All this gave the audience much food for thought, which led naturally to a passionate Q&A session where many challenging questions were posed to both Prof Botta and film director, Loretta Dalpozzo.

SUTD students benefited further from a special session conducted prior to the Masterclass – a closed door session where students had the opportunity to introduce their works which focused on i) interventions at the Uffizi Gallery in Florence (interestingly, a site that Prof Botta had worked on many years ago as part of a competition) and ii) a Landscape Urbanism project focusing on the South China Sea. Prof Botta offered his opinions and ideas about these projects, which were accompanied with the sharing of anecdotes and drawing of parallels with his work. This further led to an exciting interactive session which saw the inter-mingling of ideas between the students’ methodology and the works of an architecture master like Mario Botta, suggesting new possibilities and directions for the students to explore.

The visit by Prof Botta was an inspiration on many levels. His devotion to his craft and relentless pursuit of sacred spaces that underpin his practice were fully brought out in all aspects of the Masterclass, film screening, Q&A and Student Special session, making it an inspiring day of learning for all involved.



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