香港中文大學
The Chinese University of Hong Kong

Innovation for Better Life

2021-2022

Preface
序言

Being a forward-looking comprehensive research university, The Chinese University of Hong Kong (CUHK) pursues excellent innovative research with passion. We compiled in this booklet some of the latest CUHK research results. They are grouped under four categories, namely "Biomedical Sciences and Healthcare Technologies", " Sustainable Development and Green Technologies", "Information and Communication Technologies" as well as" Robotics and Advanced Manufacturing".

Centre for Innovation and Technology (CINTEC) is the technology transfer arm of CUHK under the Faculty of Engineering. We serve as a bridge between the university and the industry, facilitating open communications and industrial collaborations, as well as promoting innovation through technology transfer to the society and the industry.

An electronic version of this booklet is also available online: https://exhibition.cintec.cuhk.edu.hk. Moreover, should you have any enquiries, please do not hesitate to contact us by phone: (852) 3943 8221 or email: enquiry@cintec.cuhk.edu.hk.

Thank you for your interest in the innovations of CUHK.

Prof. WONG Kam-fai
Director
Centre for Innovation and Technology
The Chinese University of Hong Kong

作為一所具前瞻性的研究型綜合大學，香港中文大學(中大)致力追求卓越及創新科研。本刊收錄了多項來自中大不同學院及研究單位的最新科研成果，並因應科研項目的類別，分為「生物醫學及保健科技」、「可持續發展及綠色科技」、「信息和通訊科技」及「機械人及先進製造技術」，以便讀者閱覽。

創新科技中心作為隸屬於中大工程學院的技術轉移部門，是連繫大學與業界的橋樑。我們以促進中大研究團隊與業界的交流與合作為己任，同時亦透過向社會和業界的技術轉移，推動創新。

本刊的電子版本亦同時上載於：https://exhibition.cintec.cuhk.edu.hk，供大家瀏覽。各位如對本刊任何科研項目感興趣或有任何查詢，請與我們聯繫，電話：(852) 3943 8221 及
電郵：enquiry@cintec.cuhk.edu.hk。

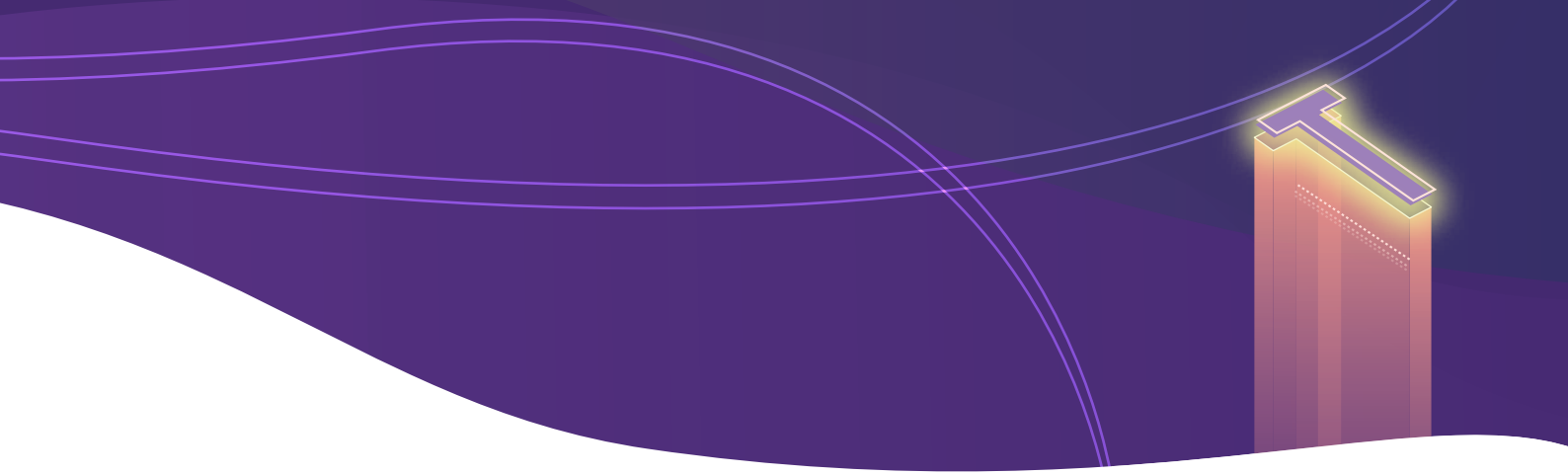
謹此感謝各位對中大創新科研成果的關注。

黃錦輝教授
香港中文大學
創新科技中心主任

Table of Contents
目錄

Biomedical Sciences and Healthcare Technologies
生物醫學及保健科技

Sustainable Development and Green Technologies
可持續發展及綠色科技



Information and Communication Technologies
信息和通訊科技

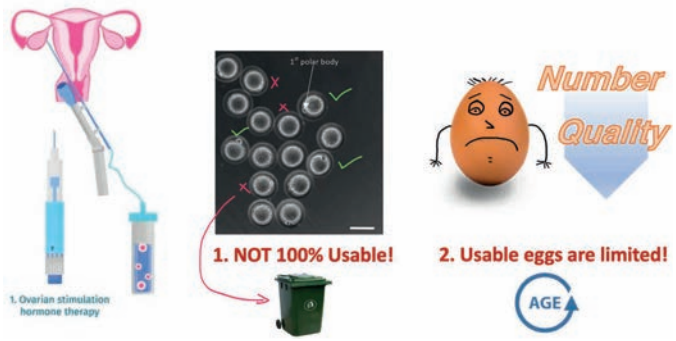
Robotics and Advanced Manufacturing
機械人及先進製造技術

生物醫學及保健科技

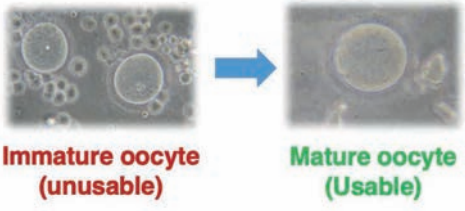
Biomedical Sciences and Healthcare Technologies

Increasing In Vitro Fertilization (IVF) Success Rate with Maturation of Unusable Oocytes

培養未成熟卵母細胞以提高體外受精（IVF）成功率



▲ The low number of usable oocytes in AMA women poses a huge technical challenge in IVF
高齡產婦的成熟卵母細胞數量少，對IVF構成巨大的技術挑戰



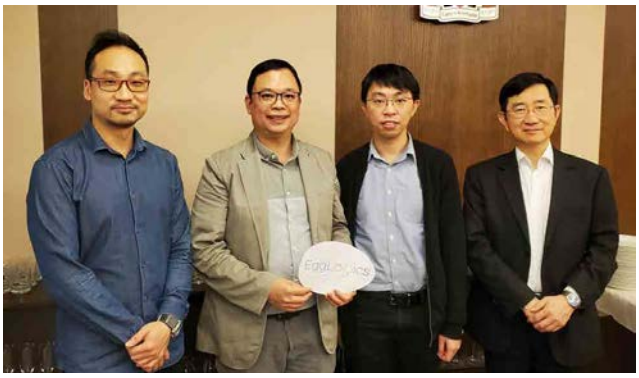
◀ Increase usable oocyte from cell–mediated maturation
以細胞介導增加成熟可用的卵母細胞數量

Over the past 40 years, in vitro fertilization (IVF) success rate has remained poor for women of advanced maternal age (AMA). The poor outcomes are often associated with oocyte quantitative and qualitative decline. To compensate for the poor success rate, AMA women have to undergo multiple IVF procedures, encountering invasive painful operations and the risk of embryo issues. This also inflicts huge financial, physical, and emotional stress. As there are currently no viable solutions, the project aims to develop a novel non–invasive approach to alleviate these stressful experiences by increasing usable oocytes. The animal and human models have shown substantial improvements in reproductive outcomes.

Uniqueness and Competitive Advantages

- First cell–based oocyte improvement
- Natural, not genetic transferred and non–invasive
- Compatible with existing IVF procedure
- A unique device developed for consistent robust performance delivery
- Reduce stresses that follow repeated conventional IVF

▲ A unique device developed for consistent robust performance delivery
為了實現穩定可靠的細胞介導性能而研發的獨特設備



▲ Team members 團隊成員

過去40年間，可能由於卵母細胞質和量下降，高齡（AMA）產婦的人工受孕（IVF）成功率仍然很低。為了成功受孕，婦女必須接受多次試管嬰兒程序，面對多次痛苦的手術和胚胎問題的風險，為自身帶來巨大的財務、身體和情緒負擔。由於沒有可行的解決方案，本項目旨在開發一種新穎的非侵入性方法，通過增加成熟可用的卵母細胞來減少這些痛苦的經歷。動物及人體試驗顯示此方法對受精成功率有顯著的提升。

特點及優勢

- 首次以細胞引導卵母細胞改良
- 自然、無基因轉移及非侵入性
- 與現有的IVF程序兼容
- 獨特的設備實現穩定可靠的性能
- 減少傳統的IVF開支和痛苦

PATENT 專利

1 US patent, 1 European patent and 1 China patent filed
一項美國專利註冊、一項歐洲專利註冊及一項中國專利註冊

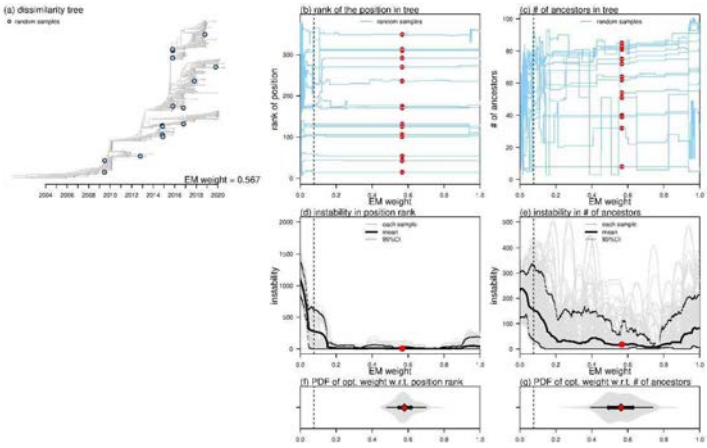
Prof. LEE Tin Lap 李天立教授

School of Biomedical Sciences
生物醫學學院

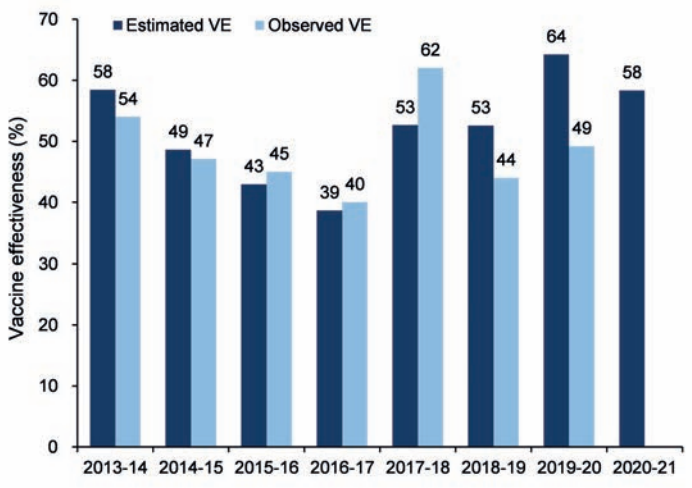
Funding 資助機構 | Research Grants Council, Innovation and Technology Commission, Hong Kong Science and Technology Park
研究資助局、創新科技署、香港科技園

Collaboration 合作夥伴 | Assisted Reproductive Technology (ART) Unit of CUHK, Institute for Tissue Engineering and Regenerative Medicine of CUHK, Department of Biomedical Engineering of CUHK, EggLogics Limited 香港中文大學輔助生育技術中心、香港中文大學組織工程與再生醫學研究所、香港中文大學生物醫學工程學系、優殖有限公司

Virus Mutation Prediction and Vaccine Antigen Design
病毒基因變異預測及疫苗抗原設計技術方案



▲ Virus evolution trajectory and estimation
病毒變異趨勢及估算



▲ Prediction of vaccine effectiveness using genome information
通過生物信息學計算平台估算疫苗有效性

Combining bioinformatics, virology and artificial intelligence, our team developed a robust model that can characterize and predict genetic mutations of viruses. The model could be applied to antigen design to improve vaccine effectiveness (VE), or to accurately estimate the VE of different vaccines in-silico. For instance, when applied to influenza, we could improve seasonal influenza vaccines' effectiveness by 20–40%. The model could also take geographical factors into consideration to provide region-specific antigen designs and VE predictions, assisting vaccine producers and governments around the world make better informed decisions. Besides Influenza, the technology is also transferrable to other viruses.

Uniqueness and Competitive Advantages

- Forwardly-predictive, accurate even when predicted one year in advance for influenza
- Vaccine antigen designs that improve VE
- Accurate VE estimation without the need of additional clinical trials
- Region-specific designs and predictions
- Transferrable to other viruses and vaccines

透過結合生物信息學、病毒學及人工智能，團隊開發出一個可以準確預測病毒基因變異和特點的數據分析平台。平台可應用於抗原設計，提升疫苗有效率；或在接種前準確估算疫苗有效性。例如當用於優化季節性流感疫苗時，疫苗的有效率可提高20–40%。這項技術亦能考慮到地方性的病毒差異，做針對特定地區的抗原設計，或評估疫苗於當地的有效性，協助各地的疫苗生產商、政府及有關組織能作出更優決定。除了流感以外，這項技術還可以應用在其他病毒上。

特點及優勢

- 可預測病毒的未來變異，例如用於流感時，提前一年的預測仍然準確
- 提高疫苗有效性的抗原設計
- 接種前準確估算疫苗有效性
- 可針對不同地區作預測與設計
- 可用於其他病毒及疫苗上

Prof. WANG Haitian Maggie 王海天教授

The Jockey Club School of Public Health and Primary Care
賽馬會公共衛生及基層醫療學院

PATENT 專利

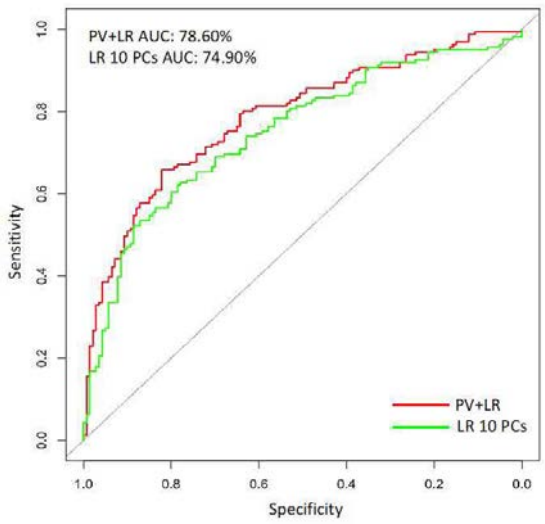
1 Patent Cooperation Treaty (National Phase): China, US, Europe
一項專利合作條約 (國家階段)：中國、美國、歐洲

Funding 資助機構 | University Grants Committee 大學教育資助委員會

Collaboration 合作夥伴 | Beth Bioinformatics Co., Ltd 貝思生物科技有限公司

The technology is exclusively licensed to Beth Bioinformatics. The company is currently in collaboration with pharmaceutical companies regarding vaccines.
此項技術為專屬授權予貝思生物科技有限公司使用。貝思生物已經與多家藥廠簽署合作合同。

Complex Disease Screening Using Human Genome Data
基於基因組信息的複雜性疾病篩查



▲ AUC improvement by our patent technology: Prism Vote. Our patent analytic platform can be applied to any disease whole genome sequencing data to improve prediction accuracy
團隊的專利分析技術提升疾病預測的準確度。系統可用於任何全基因組序列數據。

▲ Could incorporate with 3rd generation sequencing device to provide analysis on the site in the future
技術未來可配合第三代基因測序儀器進行即場測試

Complex disease refers to diseases without identifiable single major cause. Our team chose a couple of diseases currently known to have strong genetic heritability — such as Alzheimer's disease and Schizophrenia — and invented a novel statistical method to account for the effects of genome interactions. Using this method, the team successfully developed a screening test that is significantly more accurate in risk-assessment than existing methods, through analyzing human genome data. Paired along with 3rd generation sequencing, we hope to provide quick and reliable services for primary care, genetic-testing companies and insurance industry in a wide-range screening setting.

Uniqueness and Competitive Advantages

- Better accuracy in risk assessment
- Could incorporate clinical parameters to further increase accuracy
- Tolerant to various format of human genome data sets
- Caters to human genome data of people of Asian ethnicity
- Could be used for other complex disease in the future

複雜性疾病泛指一些成因複雜及沒有單獨明確致病因素的疾病。我們團隊選擇了一些與遺傳因子高度關聯的複雜性疾病，例如阿茲海默症和思覺失調症，並發明了一套新的統計學方法去考量多因子之間的相互作用。透過這個新方式去分析人類基因數據，團隊成功研發出比現有方式更準確的疾病風險評估模型。團隊希望這項技術能夠與第三代基因測序儀器並用，為社區基層醫療、基因測試公司、保險業界等提供可廣泛應用的複雜性疾病風險篩查服務。

特點及優勢

- 更準確的風險評估
- 可於臨床指標加入數據模型，提高準確度
- 可分析不同格式的基因數據
- 更適用於亞洲人種的基因數據
- 技術將來可擴展應用於其他複雜性疾病

Prof. WANG Haitian Maggie 王海天教授

The Jockey Club School of Public Health and Primary Care
賽馬會公共衛生及基層醫療學院

PATENT 專利

1 US provisional patent application; Patent Cooperation Treaty (National Phase): China, US, Europe
一項美國臨時專利申請；專利合作條約（國家階段）：中國、美國、歐洲

Funding 資助機構 | University Grants Committee 大學教育資助委員會

Collaboration 合作夥伴 | Beth Bioinformatics Co., Ltd 貝思生物科技有限公司

The technology is exclusively licensed to Beth Bioinformatics. The company is currently in collaboration with gene-testing companies.
此項技術專屬授權予貝思生物科技有限公司使用。貝思生物目前正與基因檢測公司展開合作。合作模式：共同開發、商用分析服務、雲端平台技術使用授權

Automatic Retinal Image Analysis Technology for Identifying Risk of Autism and Other Chronic Diseases

用於計算自閉症及其他慢性病風險的「全自動視網膜圖像分析」技術

▲ (From right) Ms Maria LAI, Assistant Director; Prof. Benny ZEE, Director of the Centre for Clinical Research and Biostatistics of the Jockey Club School of Public Health and Primary Care at CU Medicine; and Ms Sally CHIU, Educational Psychologist at Schools of Hong Chi Association, which is the partner of this research project.

（右起）中大醫學院賽馬會公共衞生及基層醫療學院臨床研究及生物統計中心副主任黎明寶女士、中心主任徐仲錡教授，以及是次研究合作單位匡智會學校代表教育心理學家趙頌敏女士

▲ Retinal images captured by the non-mydriatic fundus camera can reflect cardiovascular health and brain health.

透過儀器拍攝的「眼底相」，可以反映心臟血管及腦部健康

The Automatic Retinal Image Analysis (ARIA) technology is developed to assess the risk of autism spectrum disorder (Autism). Study results show that autism subjects have significantly larger optic disc diameter and larger optic cup diameter. The sensitivity and specificity of this technology to identify autism were 96% and 91% respectively.

The use of retinal image analysis is non-invasive, fully automatic and relatively convenient. Retinal images can be obtained from very young children to assess their risk of suffering from autism. This technique provides an objective screening method that can be implemented in a community setting and provides an efficient tool to assess the risk before clinical and behavioural assessment.

Uniqueness and Competitive Advantages

- Fast evaluation in a few minutes
- High sensitivity and specificity that reached 96% and 91%
- Non-invasive, fully automatic and relatively convenient

PATENT 專利

Obtained US, China and Taiwan Patents
已獲得美國、中國及台灣地區專利

本項目開發了用於計算自閉症風險的「全自動視網膜圖像分析（ARIA）」技術。研究結果發現，自閉症患者的視盤及視杯直徑明顯增大，而ARIA技術辨識自閉症患者的靈敏度及識別能力分別達96%及91%。

視網膜圖像分析是一種無創、全自動和相對方便的技術。即使是幼兒，也可透過這項新技術分析其視網膜圖像來評估罹患自閉症的風險。此客觀評估技術有望可在社區進行自閉症篩查，成為臨床及行為評估前一種有效的風險評估工具。

特點及優勢

- 可在數分鐘內快速評估
- 靈敏度及識別能力分別高達96%及91%
- 無創、全自動和相對方便

Prof. ZEE Chung Ying Benny 徐仲錡教授

The Jockey Club School of Public Health and Primary Care
賽馬會公共衞生及基層醫療學院

Brain Method to Forecast Infants' Future Language Development

嶄新的腦電圖測試技術以預測嬰兒長大後的語言能力

▲ Prof. Wong said that the test can now be applied to Cantonese and Mandarin speaking communities, while the research team is studying the accuracy of the test on English language development.

黃教授表示，現時收集的測試數據已覆蓋廣東話及普通話的群體，項目正研究對英語語言發展的預測準確度。

▲ Prof. Leung said that most babies can take the EEG test once they are born, which allows parents to learn about their children's potential language problems one to two years earlier than the traditional methods.

梁教授指，一般嬰兒甫出生便可接受腦電圖測試。比傳統測試提早一至兩年識別嬰兒潛在語言問題。

▲ Ms. Chow's daughter conducts the EEG test at CUHK Brain and Mind Institute.

周女士的女兒在中大大腦與認知研究所進行腦電圖測試。

The project has developed a test to predict infants' future language ability by electroencephalography (EEG). With EEG, a method is then devised to forecast language developmental outcomes. By intervening at the earliest possible time, the severity of potential language impairment will be reduced and provide optimised language learning for all children.The predictive models this project constructed using neural measures substantially outperformed models constructed using traditional clinical factors such as birth weight and gestational age. With early intervention, language can be improved, as the nervous system is at its most plastic in the early years. Interventions that are delivered early have higher economic returns than those administered later in life.

Uniqueness and Competitive Advantages

- The way how infant's central nervous system encodes and differentiates speech sounds may effectively predict the language development
- A simple EEG test is the most suitable method for infants with no speaking abilities
- Precise enough to make prediction about an individual child's development

此項目研發了一套嶄新的腦電圖測試技術，綜合並分析腦電圖及語言測試結果，構建一套個人語言發展預測計算程式來預測嬰兒長大後的語言能力，透過早期介入，改善孩子的語言能力或減低語言障礙的嚴重程度。項目利用神經測量數據構建全新的預測模型，其預測表現遠超其他用傳統臨床指標（例如出生時體重及懷孕周數）來計算的模型。年幼兒童神經系統的可塑性最大，早期介入是改善及預防語言障礙的有效方法，而且愈早介入，效果及經濟效益亦愈大。

特點及優勢

- 掌握嬰兒的中樞神經系統如何編寫及區分語音，能夠有效預測早期語言發展水平
- 簡單的腦電圖測試是最適合為未能說話的嬰兒進行測試
- 能夠個別地為每位兒童作出準確的預測

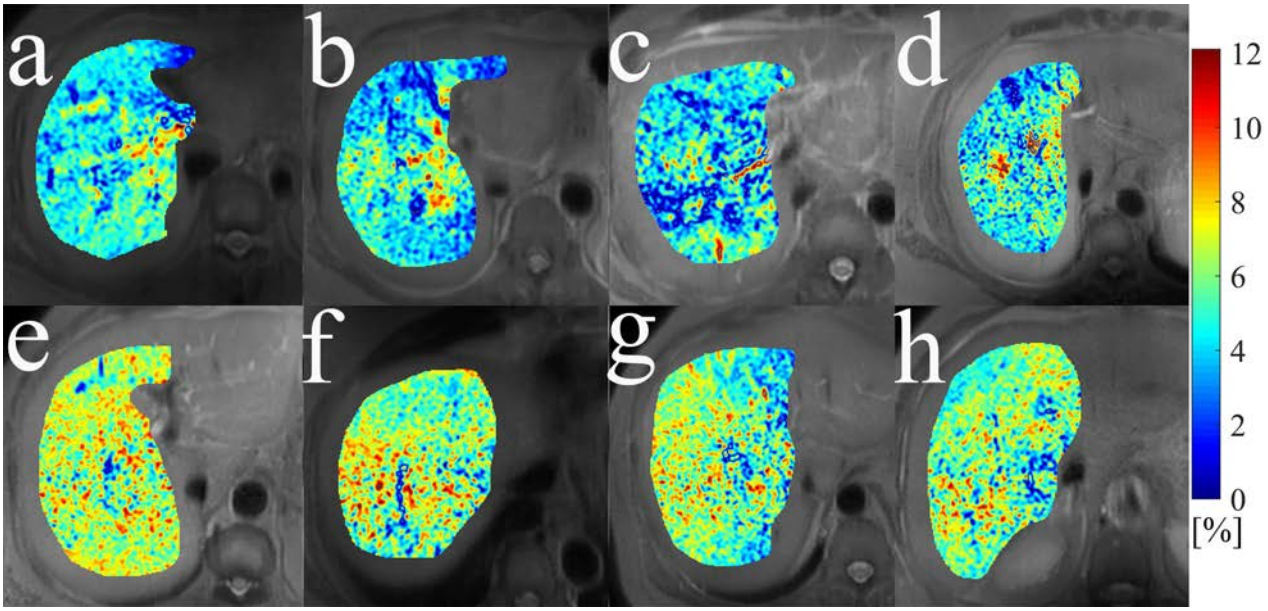
Prof. WONG Chun Man Patrick 黃俊文教授
Department of Linguistics and Modern Languages
語言學及現代語言系

Prof. LEUNG Ting Fan 梁廷勳教授
Department of Paediatrics
兒科學系

Prof. LAM Hung San Hugh Simon 林鴻生教授
Department of Paediatrics
兒科學系

Funding 資助機構 | Innovation and Technology Commission 創新科技署

Non-invasive Diagnosis of Liver Fibrosis
非侵入性肝纖維化診斷



▲ Relative collagen content of the liver of 8 patients measured using our technology: No liver fibrosis (a–d); Early–stage liver fibrosis (e–h)
8位病人透過本技術獲得的相對肝膠原蛋白檢驗圖：沒有肝纖維化 (a–d)；早期肝纖維化患者 (e–h)

This project provides advanced medical solutions for non–invasive diagnosis of liver fibrosis based on MRI and AI technologies. The current gold standard for diagnosis of liver fibrosis is liver biopsy, which is invasive and impractical for screening and treatment monitoring. The existing non–invasive diagnostic techniques still have significant limitations. The project aims to develop a product to fill the gap of diagnosis of liver fibrosis. Our solutions are convenient and easy to operate. The diagnostic value of our technology has been demonstrated in pilot clinical studies.

Uniqueness and Competitive Advantages

- Quantifies liver fibrosis directly rather than indirect stiffness measurement. This reduces the influences from confounding factors and improves the accuracy of detecting early–stage fibrosis.
- Does not require extra hardware and has a convenient workflow. This reduces the cost.

本項目利用磁力共振以及人工智能技術，為非侵入性肝纖維化的診斷提供先進的醫療方案。現時，肝纖維化診斷的最佳方案是利用肝穿刺切片檢查，這個方法具侵入性，對篩查和治療過程的監察來說不實用。現存的非侵入性診斷方式尚有明顯局限。此項目旨在開發一種技術來填補現存診斷方式的漏洞。我們的技術便利且易於操作，它在診斷上的有效性已經在初步臨床實驗上獲得證實。

特點及優勢

- 直接量化肝纖維化的程度，減少混雜因素的影響，並能更準確診斷早期肝纖維化
- 毋須額外硬件，而且工作流程便利，有效減低成本

PATENT 專利

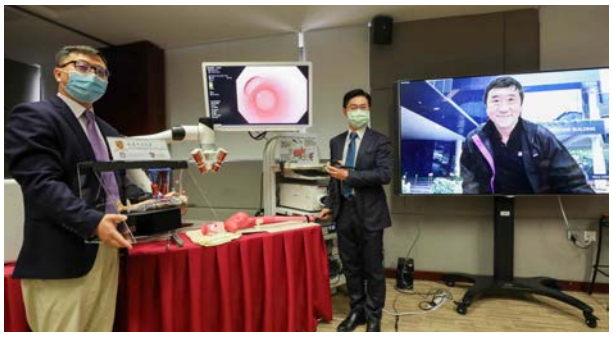
3 USA patents granted, 1 USA patent and 3 China patent applications pending
三項美國專利已經獲得批准、一項美國專利申請及三項中國專利申請

Prof. CHEN Weitian 陳蔚天教授
Department of Imaging and Interventional Radiology
影像及介入放射學系

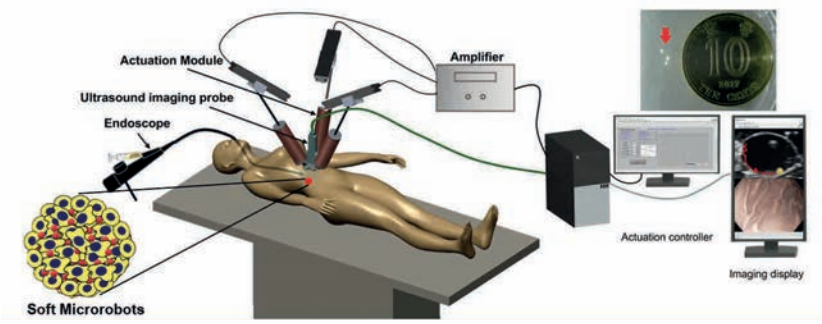
Funding 資助機構 | Innovation and Technology Commission, Hong Kong Science and Technology Park 創新科技署、香港科技園

Biohybrid Soft Microrobots with Rapid Endoluminal Delivery and Imaging

用於體內傳輸的「生物合成軟體微型機械人」



▲ (From left) Prof. ZHANG Li, Prof. Philip CHIU and Prof. Joseph SUNG (zoom image on screen)
(左起) 張立教授、趙偉仁教授及沈祖堯教授
(螢幕上Zoom直播畫面)



▲ Endoscopy–assisted magnetic actuation with a dual imaging system (EMADIS) and stem cell microrobots
雙模成像內鏡輔助磁驅動系統及幹細胞微型機械人

The soft microrobots are mainly composed of stem cells (~98%) and a tiny portion of magnetic particles (~2%), possessing an elastic modulus close to the human brain tissue. The stem cells can be harvested from the host to minimize immune responses during the in vivo delivery. The project has also developed endoscopy–assisted magnetic actuation with a dual imaging system (EMADIS). Endoscope offers "express lane" for soft microrobots to avoid the direct contact with complex physiological environment. The microrobots not only have rapid response and precise targeting capability under the magnetic field, but also show excellent adaptability to the complex surroundings by self–alternating the shape during navigation inside the body. The technology has the potential for treating various diseases in tiny and tortuous lumens which are hard–to–reach or inaccessible by regular medical devices.

Uniqueness and Competitive Advantages

- First to integrate soft microrobots, endoscopy, magnetic navigation and ultrasound imaging for endoluminal delivery
- Greatly extends the reach and functionalities of endoscopy
- "Express lane" for soft microrobots to avoid the direct contact with complex physiological environment and bio–barriers
- Rapid deployment of soft microrobot in tiny & tortuous lumens (~ 1 m in minutes)

這個軟體微型機械人由大量（約佔98%）幹細胞及微量磁性粒子（約佔2%）組成，柔軟度有如人體大腦組織。其幹細胞源自於宿主，因此能大大減低免疫系統的排斥反應。項目亦開發了雙模成像內鏡輔助磁驅動系統（EMADIS）。內窺鏡為軟體微型機械人提供了一個安全的「快速通道」避開複雜的生理環境。機械人於磁場驅動下，不但有快速反應及準確鎖定目標的能力，更可於傳輸過程中變形，以通過體內複雜狹窄的管道，配合實時成像導航技術，能針對一些常規醫療儀器未可觸及的部位進行微創治療。

特點及優勢

- 首次結合軟體微型機械人、內鏡、磁場驅動和超聲波成像，用於體內腔道傳輸
- 能大大擴展內鏡可覆蓋範圍和功能
- 「快速通道」讓軟體微型機械人安全地避開複雜的生理環境和生物屏障
- 用於快速精準遞送軟體微型機械人到人體內微小和曲折的腔內管道 (數分鐘內能遞送約一米距離)

Prof. ZHANG Li 張立教授
Department of Mechanical and Automation Engineering
機械與自動化工程學系

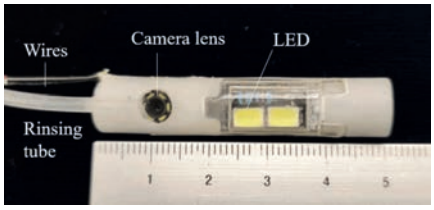
Prof. SUNG Jao Yiu Joseph 沈祖堯教授
Department of Medicine and Therapeutics
內科及藥物治療學系

Prof. CHIU Wai Yan Philip 趙偉仁教授
Department of Surgery
外科學系

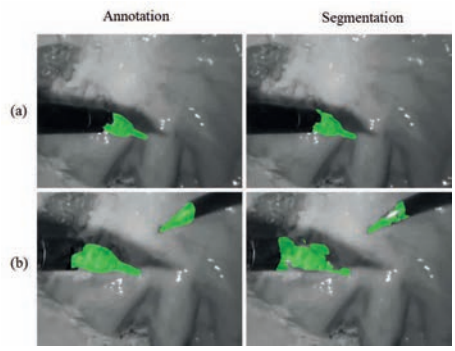
Funding 資助機構 | Research Grants Council, Innovation and Technology Commission
研究資助局、創新科技署

Collaboration 合作夥伴 | Chow Yuk Ho Technology Centre for Innovative Medicine of CUHK, T. Stone Robotics Institute of CUHK, Department of Imaging and Interventional Radiology, CUHK
香港中文大學周毓浩創新醫學技術中心、香港中文大學天石機器人研究所、香港中文大學影像及介入放射學系

Intelligent Magnetic Anchored and Guided Endoscope for Minimally Invasive Surgery
用於微創手術的智能磁錨定內窺鏡



▲ The prototype of magnetic anchored endoscope
磁錨定內窺鏡立體設計模型

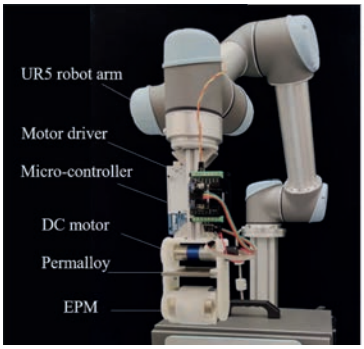


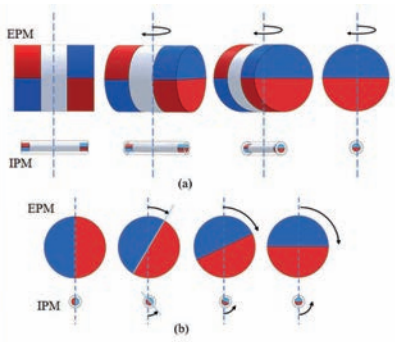
▲ A.I. assisted instrument detection, comparing performance of human (left) and machine (right). Both the single instrument (a) and double instruments (b) cases were explored
人工智能手術工具偵測，比較人類(左) 與 電腦(右)的表現，
包括單個(a)和多個工具(b)

Conventional laparoscopes are not suitable for minimally invasive surgery as they limit the surgeon's field of view and may collide with other instruments. They also occupy much port space and hence bigger incision or additional port is required. Concerning these problems, the project has developed an intelligent magnetic anchored and guided endoscope. The system included a robot arm that controls an external magnet above the patient's chest. The endoscope staying just beneath the chest wall is guided by the magnetic force, providing multiple perspectives for surgeons. An A.I. assisted instrument detection allows this system to track the surgeon's tools. Surgeons can work intuitively without worries of endoscope control.

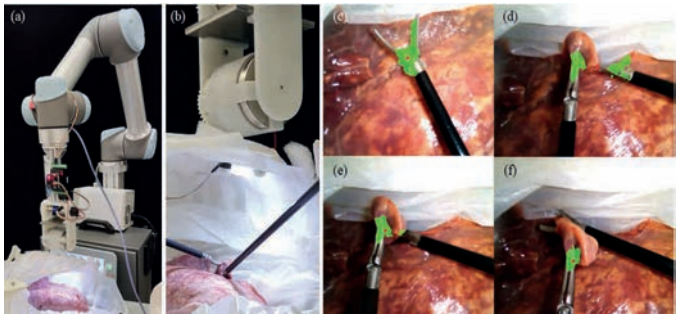
Uniqueness and Competitive Advantages

- More freedom inside patient and better views for surgeons
- Autonomous instrument tracking
- Avoids port crowding, ideal for single port surgery
- Prevents collision with other instruments
- Multiple cameras (multi-view of surgical target)





▲ The robotic magnet controller (Left); illustration of magnetic actuation principle (Right)
控制磁鐵的機械臂(左) 及磁力驅動原理(右)



▲ Lung wedge resection successfully performed using the system. Test completed inside a human chest simulato
以智能系統成功完成肺部組織切除，實驗於人體胸腔模型完成

傳統的腹腔鏡會限制角度和視野，且容易跟其他工具碰撞，亦因為佔用了端口空間而需要更大或更多的創口，故此並不適用於微創手術。有見及此，本項目研發了智能磁錨定內窺鏡。這個智能系統當中包括一個機械臂，它會控制病人胸腔外的磁鐵，從而以磁力引導病人胸壁內的內窺鏡移動，為醫生提供多種視野。系統的人工智能更能幫助自動偵測及追蹤手術工具，醫生無須憂慮內鏡的控制，讓手術更簡化、安全及方便。

特點及優勢

- 在體內更自由地移動，提供更廣闊視野
- 自動追蹤手術工具
- 避免佔用創口，有利單孔手術
- 避免與手術工具碰撞
- 多個鏡頭同時以多角度觀察手術目標

AWARDS 獎項

Gold Award, EMedic Global 2019
2019年 EMedic Global 金獎

Bronze Award, International Exhibition of Inventions Geneva 2021
2021年日內瓦國際發明展銅獎

PATENT 專利

1 US patent granted and 1 China patent granted
一項美國批准專利和一項中國批准專利

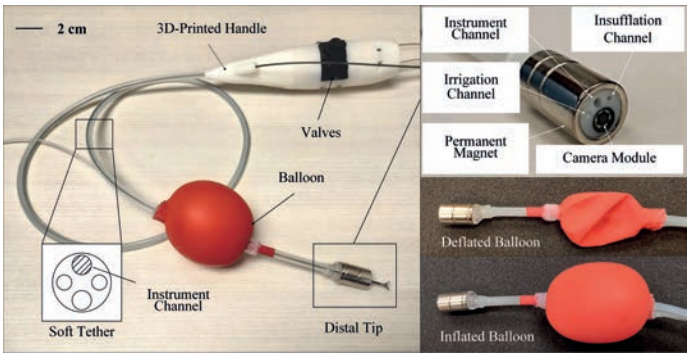
Prof. LI Zheng 李崢教授

Department of Surgery
外科學系

Funding 資助機構 | Research Grants Council, Innovation and Technology Commission 研究資助局、創新科技署

Collaboration 合作夥伴 | Multi-scale Medical Robotics Center 醫療機械人創新技術中心

Electromagnetically Actuated Soft-tethered (EAST) Colonoscope
電磁驅動柔性腸鏡



▲ Prototype of the soft-tethered endoscopic device
柔性內窺鏡設備的原型樣機

Colorectal cancer can be prevented and cured in case of early diagnosis. However, conventional flexible colonoscopes which are most commonly used for colon inspection and treatment still have two major limitations: (i) patient discomfort related to the colonoscopy procedure without sedation; (ii) high skill requirements for endoscopists.

This project proposes and designs an electromagnetically actuated soft-tethered (EAST) colonoscope which is also equipped with regular diagnostic and therapeutic functions. It can achieve painless colonoscopy without sedation due to the active locomotion under external magnetic fields as well as the gentle interaction with the human colon. A system with autonomous navigation and polyp detection based on artificial intelligence is also developed to introduce easy and intelligent manipulation of the colonoscope, which thus reduces the skill requirement and workload of endoscopists, and helps enhance the social acceptance and availability of regular colon inspection.

Uniqueness and Competitive Advantages

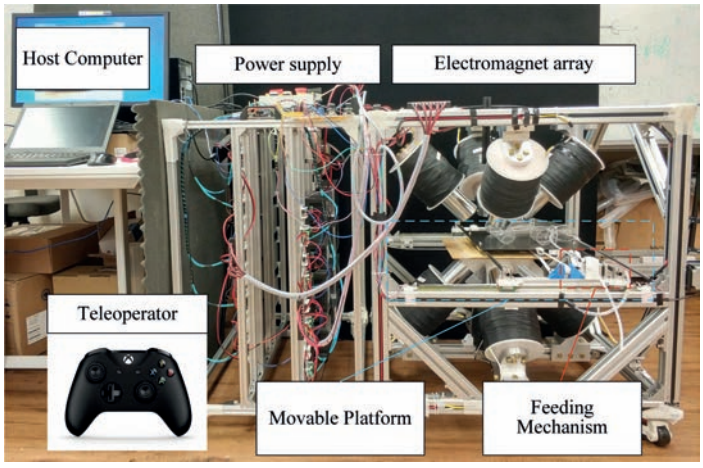
- Equipped with regular diagnostic and therapeutic functions as the conventional flexible colonoscope
- Painless colonoscopy without sedation
- Low skill requirements and workload for endoscopists with easy manipulation and assisted functions of the colonoscope, such as autonomous navigation and poly detection
- High autonomy, enabling rapid colonoscopy and enhancing the availability of the regular colon inspection

大腸癌在早期診斷中是可預防及治癒的。然而，最常用於結腸檢查及治療的常規柔性腸鏡仍有兩個主要缺點：（1）病人在無鎮靜劑的腸鏡過程中會有不適感；（2）腸鏡操作對醫師的技術要求較高。

本項目研發的電磁驅動柔性腸鏡配備了同樣的診查和治療功能。由於磁力驅動及與腸道的溫和交互，該設備無需鎮靜劑即可完成無痛腸鏡檢查。同時，為使腸鏡操作更簡單直接，此項目亦開發了具自主導航功能及息肉檢測功能的智能系統，從而減低內鏡醫師的技能要求和工作量，亦可提高定期大腸篩查的社會接受度和普及度。

特點及優勢

- 配備了與常規柔性腸鏡一樣的檢查和治療功能
- 無需鎮靜劑即可實現無痛腸鏡檢查
- 開發了簡單直接的操作和協助工具，如自主導航和息肉檢測，降低了內鏡醫師的技術要求和工作量
- 高自動化，可實現快速腸鏡檢查，提高定期腸鏡檢查的普及度



▲ Prototype and components of the electromagnetic actuation system for proof-of-concept
作為概念驗證的電磁驅動系統組成部分和原型樣機

AWARDS 獎項

Postgraduate Group Champion & Special Award, Professor Charles K. Kao Student Creativity Awards 2021
2021年高錕教授學生創意獎研究生團體組冠軍及專項

PATENT 專利

1 China patent application
一項中國專利申請

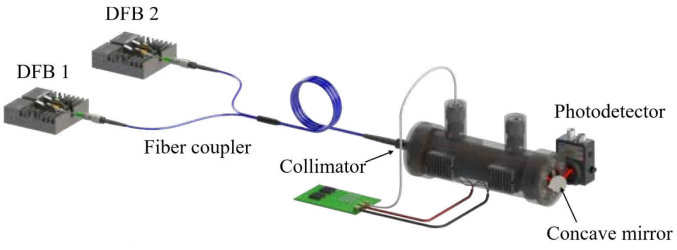
Prof. LI Zheng 李崢教授

Department of Surgery
外科學系

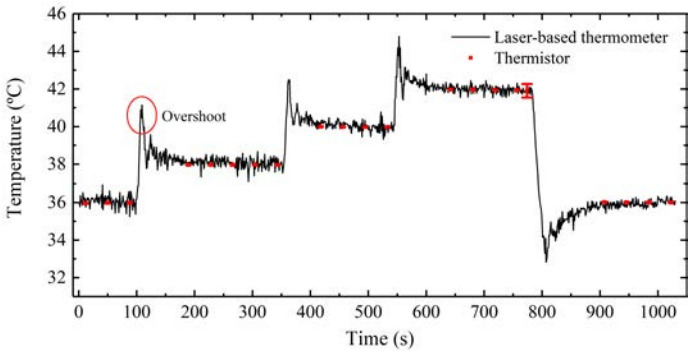
Funding 資助機構 | Research Grants Council, Innovation and Technology Commission 研究資助局、創新科技署

Collaboration 合作夥伴 | Multi-scale Medical Robotics Center 醫療機械人創新技術中心

Laser-based Non-contact Body Temperature Sensor
非接觸式激光體溫計



▲ Laser–based sensor tested in a temperature controllable gas cell
激光溫度傳感器正在用可控溫的氣室進行測溫測試



▲ Temperature measurement results of our laser–based sensor (black line)
溫度測量結果（黑線）

Under COVID–19, there is an urgent requirement for fast and precise temperature measurement. However, the existing contact thermometers are likely to cause secondary infection, while the non–contact ones have low reliability and are easily affected by external environments.

Concerning these problems, a precise and fast optical thermometer based on tunable diode laser absorption spectroscopy is developed for breath diagnostics with relevance to non–contact body temperature measurements.

Uniqueness and Competitive Advantages

- Non–contact measurement
- Fast response (1s real–time)
- High accuracy (< 0.16 ℃ error)
- Active measurement without needs for pre–calibration
- Highly integrated system and intelligent data post–processing program

在新冠疫情下，快速且準確的體溫測量尤其重要。然而，現有的接觸式體溫計有機會造成二次感染，並不安全；非接觸式體溫計測量結果可信度低，且容易受到外界輻射影響。有見及此，本項目基於可調諧二極管激光吸收光譜技術，設計了一款高精度且快速響應的光學測溫計。該體溫計以激光透射過人體呼出的氣體來測溫，可用於非接觸式體溫測量。

特點及優勢

- 非接觸式測量
- 響應速度快（1s實時測量）
- 測量結果準確（誤差小於0.16℃）
- 主動式測量，無需標定
- 高度整合的系統及智能的後置處理程序，可將測溫數據接入其他電子系統

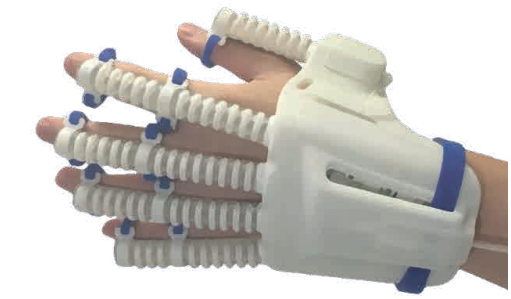
PATENT 專利

1 China patent filed
一項中國專利註冊

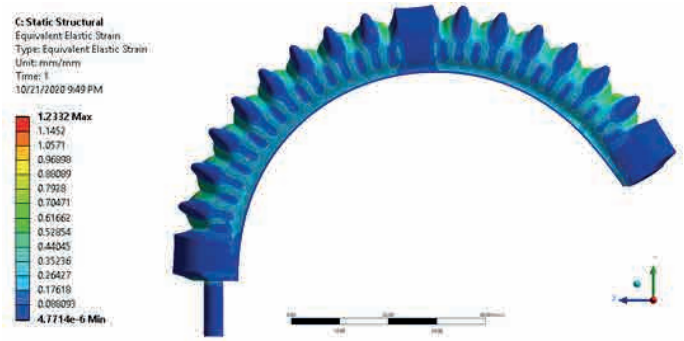
Prof. REN Wei 任偉教授

Department of Mechanical and Automation Engineering
機械與自動化工程學系

Soft Robotic Hand for Stroke Rehabilitation
復康機械手套



▲ Prototype of the Soft Robotic Hand
復康機械手套原型



▲ Computer simulation of the Soft-Elastic Composite Actuator
軟體彈性複合執行器的電腦模型分析

This project provides the portable wearable robotic hand for rehabilitation of patients after stroke. It also integrates the professional rehabilitation guidance and evaluation, enabling the patients to conduct the training at home and complete activities of daily living (ADL) with the device.

The key component of soft robotic hand is our design of Soft-Elastic Composite Actuator (SECA) that includes an elastomer bladder reinforced with fiber wrapping and torque-compensating layers. It is driven by fluidic pressure, which flexion is controlled on fluid pressurization and extension is controlled on depressurization, respectively.

Uniqueness and Competitive Advantages

- Light weight (< 20g), fast production (<15 minutes), low cost (<HKD 500) and it supports 3D printing customization.
- Operation process of SECA is safe and comfortable due to the inherent compliance of soft materials that are like human tissues.
- The powered flexion and extension of body joints upon the wearing of SECA are controlled actively following patients' mind, e.g. surface electromyography (sEMG), motion data, etc.

▲ Prototype of the Control System
控制盒原型

本項目為中風患者們提供便攜式可穿戴復康訓練手套，同時融入專業的康復指導和評估，以支援家中訓練及簡單日常生活活動（ADL）。

復康機械手套的關鍵元件是軟體彈性複合執行器（SECA），當中包括纖維包裹層和扭矩補償層增強的彈性囊。它由流體壓力驅動，可在流體加壓時彎曲，在減壓時伸展。

特點及優勢

- 重量輕（<20克），生產快（<15分鐘），成本低（<HKD 500）並支持3D打印定製
- 採用了類似人體組織的軟體材料，可保證安全和舒適
- 可集成肌電控制（sEMG）以及傳感器，方便患者通過自己的意圖進行主動控制訓練

AWARDS 獎項

Second Prize, The 6th China International College Students' "Internet +"Innovation and Entrepreneurship Competition
二等獎，第六屆中國國際互聯網+創新及創業大賽

Third Prize, The 6th China College Students' Entrepreneurship Competition
三等獎，第六屆「創青春」大學生創業大賽

Silver Award, The 47th International Exhibition of Inventions Geneva
銀獎，第47屆瑞士國際日內瓦發明展

PATENT 專利

1 US patent and 1 China patent applications
一項美國專利及一項中國專利申請

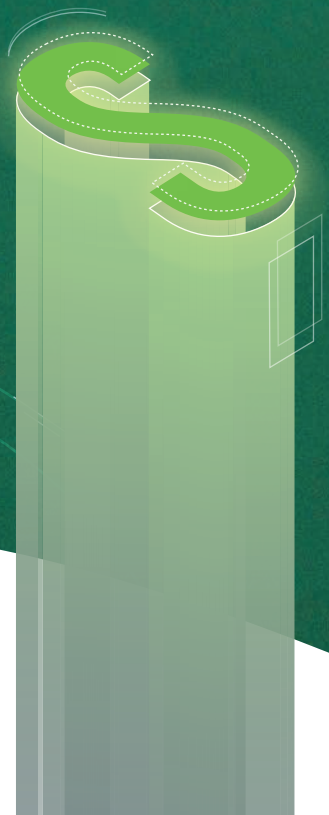
Prof. TONG Kai Yu Raymond 湯啟宇教授

Department of Biomedical Engineering
生物醫學工程學系

Funding 資助機構 | Innovation and Technology Commission 創新科技署
Collaboration 合作夥伴 | Hopebotics Limited 樂希機械人有限公司

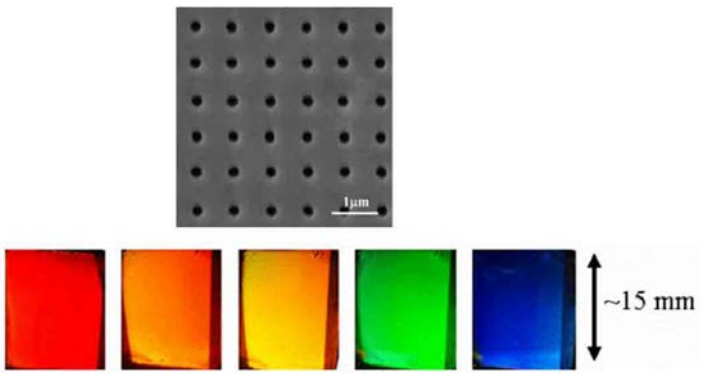
可持續發展及綠色科技

Sustainable Development and Green Technologies



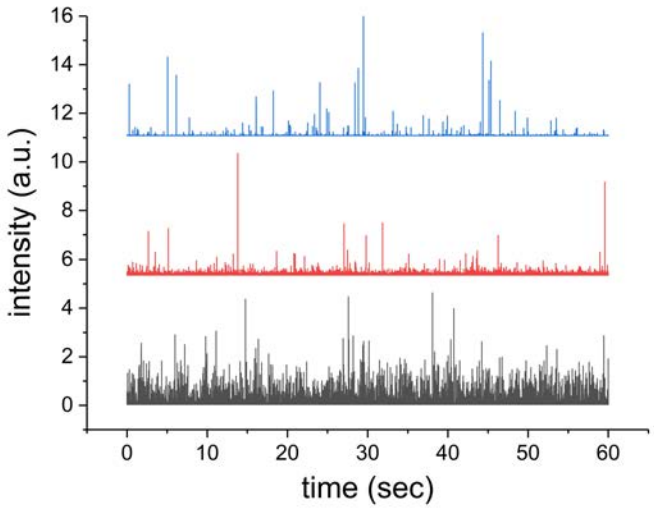
High Sensitive and Selectivity Plasmonic Systems for Ultrafine Particulate Matter (PM) 0.1 and 0.3 Detection

用於檢測超細顆粒物PM0.1和PM0.3的高靈敏度和選擇性等離子體系統



▲ Surface plasmon periodic arrays fabricated by interference lithography.
The large area array, with length ~1.5 cm, is very uniform: when viewed at different angles, the color is almost the same across the entire sample.

干涉光刻技術製成的表面等離子體週期陣列。
長至1.5厘米的大面積陣列非常均勻：在不同角度觀察時，整個樣品的顏色幾乎是相同的。



▲ Real time detection of different PM sizes.
DI water without PM particulates (Top); 0.1 PM particulates (Middle); 0.3 PM particulates (Bottom).

不同顆粒物大小的實時檢測數據。
沒有顆粒物的去離子水（上）；0.1微米的顆粒物（中）；0.3微米的顆粒物（下）

Particulate matter 0.1 and 0.3 are influential to human health and the environment. Particularly, most viruses including COVID-19 have sizes ranging from 0.1 to 0.3 um and are difficult to be detected by current PM sensors. We have developed the plasmon-mediated light scattering effect to improve the performance of PM sensors. Metallic nanostructures at low cost have been prepared and integrated into conventional PM sensors to enhance their efficiency by 10 times, leading to the detection limit lower than 1 μg/m3 for 0.1 and 0.3 particulates.

Uniqueness and Competitive Advantages

- Capable of detecting small PM sizes down to 0.1 um
- Possible integration to current light scattering based PM sensing technology
- Real time detection (less than 5 min)
- Portable and cost-effective

超細顆粒物PM0.1及可入肺顆粒物PM0.3對人類健康及環境有極大影響。包括2019新型冠狀病毒在內的大多數病毒，大小都在0.1到0.3微米的範圍內，但卻難以被目前的顆粒物傳感器檢測到。 此項目利用了等離子體介導的光散射效應來提高顆粒物傳感器的性能，製備低成本的納米金屬結構，並將其納入常規的顆粒物傳感器中，藉此使其效率提高10倍，0.1和0.3 微米顆粒物的檢測限亦因此能降低至1μg/m3以下。

特點及優勢

- 可檢測小至0.1微米的細小顆粒物
- 有機會與目前基於光散射的顆粒物傳感技術結合
- 實時檢測（少於5分鐘）
- 便攜及性價比高

Prof. ONG Hock Chun Daniel 王福俊教授

Department of Physics
物理系

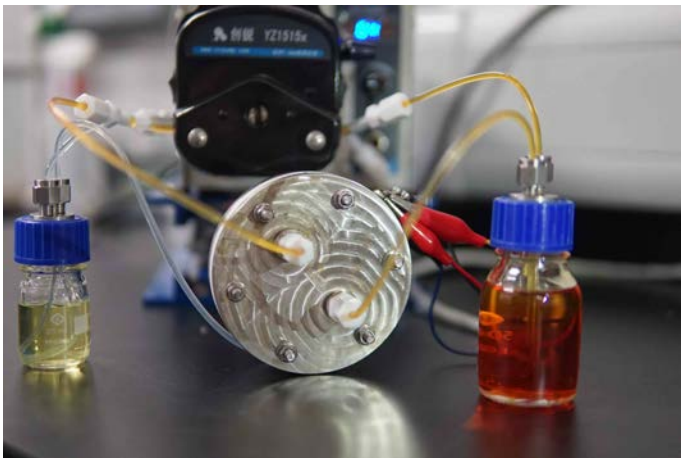
PATENT 專利

1 US provisional patent application
一項美國臨時專利申請

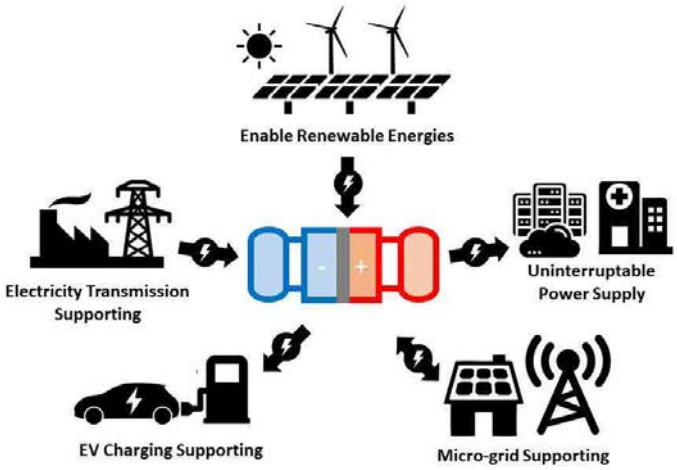
Funding 資助機構 | Innovation and Technology Commission 創新科技署

A Safe, Scalable and Low-cost Energy Storage System for Smart City and Micro-Grid Applications

面向智慧城市及微電網應用的安全、可規模化及低成本的儲能系統



▲ The lab-scale flow battery prototype
實驗室用液流電池原型機



▲ Potential applications of flow battery energy storage devices in smart cities and smart micro-grid
液流電池儲能系統在未來智慧城市和智能微電網中的應用

Advanced energy storage system (ESS) is the crucial technology for the future target of carbon neutralization. Renewable energy sources such as solar and wind power, are naturally unstable. The large-scale utilization of renewable energy requires energy storage systems as the buffer to provide a reliable electricity supply. The objective of this project is to develop an inherently safe, scalable and low-cost aqueous flow battery energy storage system. This flow battery system incorporates advanced electrolytes, electrodes and separators, to provide a safe and economical solution for grid energy storage.

Uniqueness and Competitive Advantages

- Inherently safe, non-toxic and nonflammable
- Low-cost
- Uses eco-friendly materials
- Scalable
- The highly selective ion-selective membrane can improve the cycle-life of the battery

先進的儲能系統（ESS）是實現未來碳中和目標的關鍵技術。可再生能源，如太陽能和風能，具有天然不穩定的特性，其大規模應用需要儲能系統的緩衝，以提供可靠的電力供應。本項目的目標是研發一種安全、可規模化且低成本的水系液流電池儲能系統。此液流電池結合了先進的電解液、電極與隔膜，有望為電網儲能提供安全且經濟實惠的解決方案。

特點及優勢

- CUHK液流電池本質上安全、無毒及不可燃
- 低成本
- 使用環保材料
- 可規模化
- 新型離子交換膜可提高電池壽命

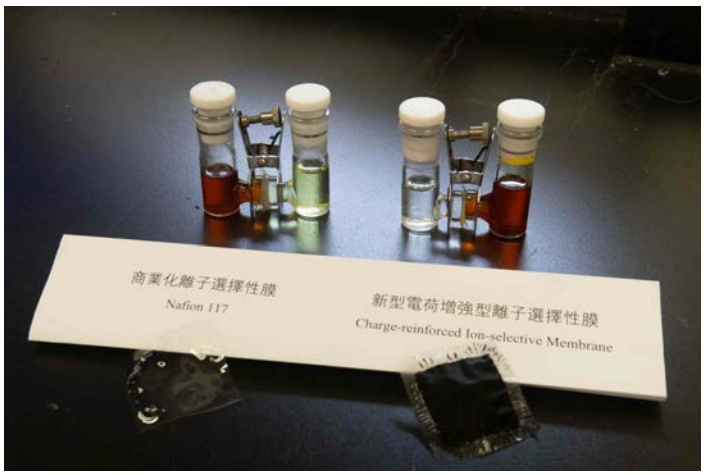
Prof. LU Yi Chun 盧怡君教授

Department of Mechanical and Automation Engineering
機械與自動化工程學系

Funding 資助機構 | Innovation and Technology Commission 創新科技署
Sponsorship 贊助機構 | ITE Engineering Limited, Green Tech Services Limited
Collaboration 合作夥伴 | Electrical and Mechanical Service Department 機電工程署

Polysulfide-based Redox Flow Batteries with Long Life and Low Levelized Cost Enabled by Charge-reinforced Ion-selective Membranes

可用於硫基液流電池的新型「電荷增強型離子選擇性膜」



▲ Crossover comparison between CUHK's charge–reinforced ion–selective membrane (CRIS, right) and commercial Nafion membrane (N117, left)
中大研發的「電荷增強型離子選擇性膜」(右) 及商業化離子選擇性膜N117 (左) 的比較

This project designs a novel charge–reinforced ion–selective (CRIS) membrane for sulphur–based redox flow batteries, with 15 consecutive hours of runtime and over 2,000 hours cycling without obvious capacity decay is developed. The new battery has taken a significant step forward in the practical application of redox flow batteries in grid–scale storage for renewable energy, by resolving the problems posed by its poor lifetime and low cost–effectiveness.

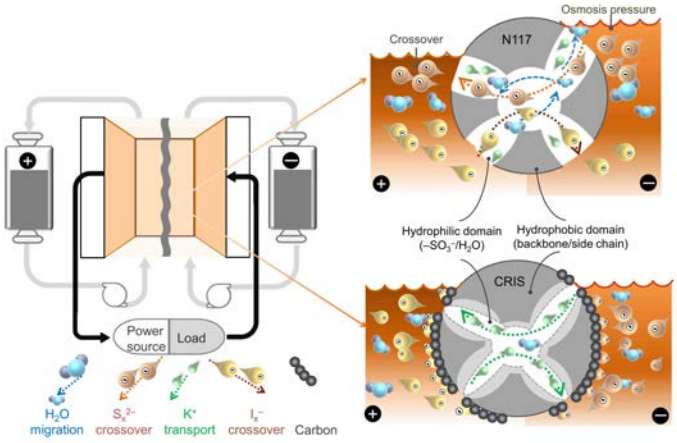
Uniqueness and Competitive Advantages

- Increases the stability and the lifetime of batteries and provides an effective application in grid–scale energy storage devices.
- An ultralow capacity decay rate (0.005% per day), achieving record high cycling stability and calendar lifetime with over 2,000 hours cycling
- The coulombic efficiency is more than 99.9%
- A competitive levelised cost of storage (LCOS) when continuously operated and discharged for more than 15 hours

這項目研發出一款可用於硫基液流電池（以硫化物為材料的液流電池）的新型「電荷增強型離子選擇性膜」（CRIS）。利用新技術，電池在沒有明顯容量衰減情況下，運作時間大幅提高至逾2,000小時，每次充滿電後可持續使用達15小時，解決了這類電池長久以來因使用壽命短、成本高，而未能普及應用於可再生能源大型電網儲能的難題。

特點及優勢

- 提高電池的使用壽命，使其可用於大型電網儲能裝置
- 容量衰減率每天僅為0.005%，即可運作逾2,000小時
- 放電庫倫效率高達99.9%
- 持續放電時長超過15小時後，儲能均化成本亦較低



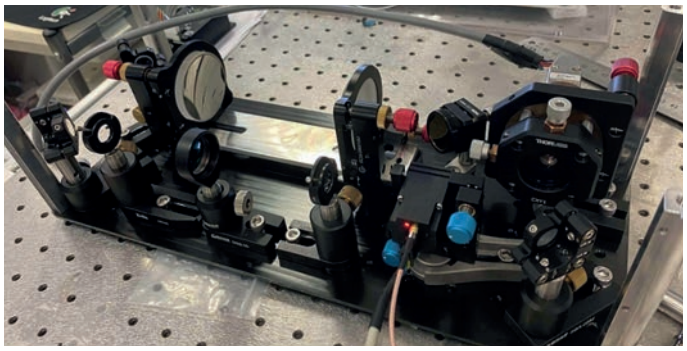
▲ Diagram of a polysulfide–iodide redox flow battery
多硫化物–碘液流電池示意圖

Prof. LU Yi Chun 盧怡君教授

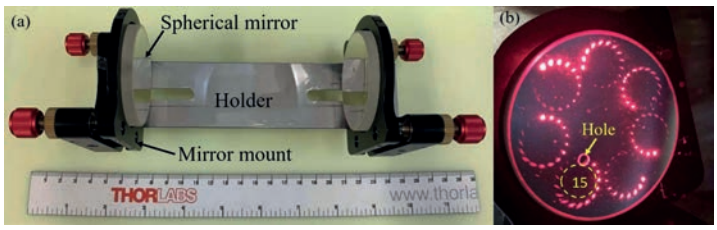
Department of Mechanical and Automation Engineering
機械與自動化工程學系

Funding 資助機構 | Research Grants Council 研究資助局

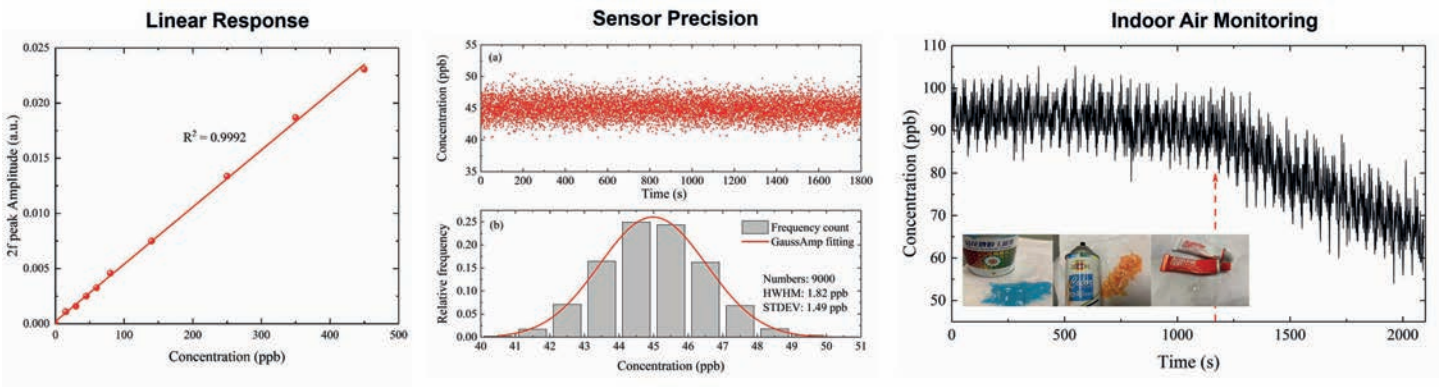
Portable Formaldehyde Sensor with Sub-ppb Sensitivity
便攜式高靈敏甲醛快速檢測儀



Formaldehyde sensor prototype
甲醛激光傳感器原型機



Design of a multipass gas cell
多次反射氣體吸收池設計



Sensor performance
傳感器測試結果

This project developed a battery-driven handheld optical sensor for calibration-free and ultra-sensitive formaldehyde detection. The proposed formaldehyde sensor adopts the recently developed optical method using multipass-assisted wavelength modulation spectroscopy with low cost and low power consumption. The sensor achieves a minimum detection limit of 0.6 ppb at 1 s measurement time and the detection is free of interference from other gases in the ambient environment.

Uniqueness and Competitive Advantages

- Infrared laser absorption sensor
- Ultra-sensitivity (sub-ppb) of formaldehyde
- Ultra-fast (1 second) detection
- Low power consumption (battery driven)
- Portable sensor

本項目研發了一種便攜式光學氣體傳感器，能夠免校準、高靈敏探測甲醛。項目採用了團隊近期研發的免校準激光光譜技術，並已成功搭建一個低成本、低功耗的甲醛探測原型機，最低可探測甲醛濃度0.6 ppb，測量時間1秒，而且測量結果不受環境中其他氣體干擾。

特點及優勢

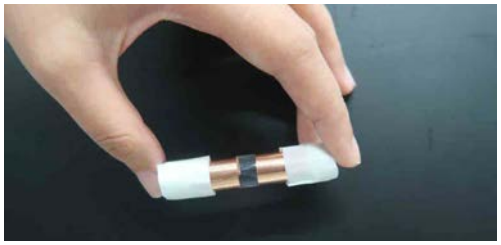
- 紅外激光吸收氣體傳感器
- 超高靈敏度甲醛探測（sub-ppb）
- 超快時間響應（1 秒）
- 低功率電池驅動
- 便攜式系統

Prof. REN Wei 任偉教授

Department of Mechanical and Automation Engineering
機械與自動化工程學系

Funding 資助機構 | Innovation and Technology Commission 創新科技署

Water-tube-based Triboelectric Nanogenerator (WT-TENG)
水管式摩擦納米發電機



▲ This project discovered that by filling half of the tube with water, the output charge is the highest, as was the output voltage after multiple experiments.

經反覆測試，本項目發現只需用水注滿膠管一半，便能輸出最高電壓。

◀ Multiple small WT–TENG units can be easily combined and integrated as one larger unit and realise multiplied electric outputs.

每個WT–TENG單元都可以像積木一樣，拼合成較大型的發電裝置，令電能輸出倍增。

This project developed a water–tube–based TENG (WT–TENG) to convert ocean wave energy into electricity efficiently. Water is encapsulated in a tube of 6 cm long with a diameter of 1 to 2 cm. When waves hit and water moves in the tube between regions of the two electrodes, triboelectrification happens and electric currents can be generated. Taking advantage of the flexibility of water, the WT–TENG can be operated in various modes. Moreover, WT–TENG addresses the problem of low electric charge density of conventional triboelectric nanogenerators (TENG) which is often based on solid/solid contact. Due to the high contact intimacy of water and the tube surface, the output volumetric charge density of the WT–TENG is significantly enhanced, reaching 9 mC/m^3 at a frequency as low as 0.25 Hz, which is the highest recorded among all the existing TENGs for low–frequency energy harvesting.

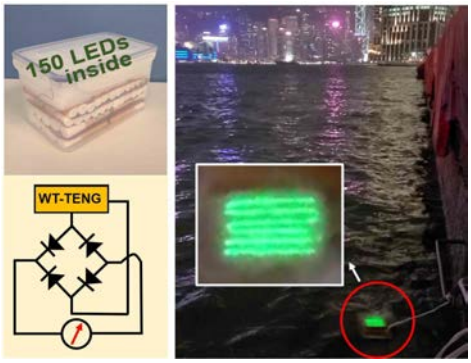
Uniqueness and Competitive Advantages

- Low cost
- Can generate electricity at a low–frequency mechanical motion when operated under rotational mode
- Can be formed into different combinations of units according to the needed output charge
- Reaches the highest volumetric output charge density among all the existing TENGs for low–frequency energy harvesting (9 mC/m^3)

本項目研發的水管式摩擦納米發電機（WT–TENG），能將海浪能量高效轉換成電能。水被封裝在直徑1至2厘米，長度約6厘米的膠管，當波浪的衝擊使水與膠管的電極區域摩擦時，便會產生電流。基於水的流動性，WT–TENG適合在多種運動模式中收集能量。另外，由於水和膠管表面可以緊密接觸，能突破基於固體材料的傳統摩擦納米發電機（TENG）電荷體積密度不足的問題。WT–TENG的輸出體積電荷密度在低至0.25 Hz 的頻率下達到9 mC / m^3，是現有低頻能量收集TENG之中最高。

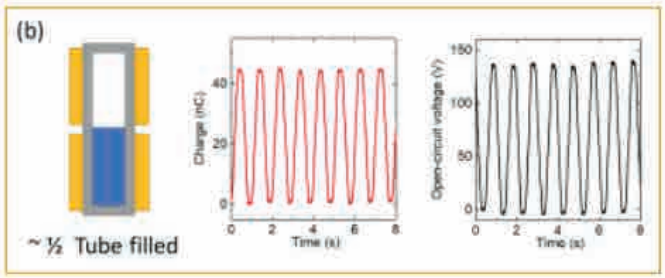
特點及優勢

- 生產成本低
- 即使在低頻率的機械運動下，裝置在旋轉模式下亦能發電
- 可按所需發電量拼合不同單元組合
- 體積電荷密度是現有低頻能量收集TENG之中最高 (9 mC /m^3)



▲ This project places a box with 34 WT–TENG units in the sea to collect ocean wave energy. The peak power generation is enough to drive 150 LED light bulbs.

本項目將裝有34個WT–TENG單元的盒子，放到海面上收集海浪能量，高峰發電量足以推動150個LED燈泡。



▲ 1 unit of WT–TENG can reach the highest electric voltage of 100 to 1 unit of WT–TENG can reach the highest electric voltage of 100 to 150V, while a dry cell only holds 1.5V.

一個單元的WT–TENG最高輸出電壓達100至150伏特，而一般乾電池只有1.5伏特。

Prof. ZI Yunlong 訾雲龍教授

Department of Mechanical and Automation Engineering
機械與自動化工程學系

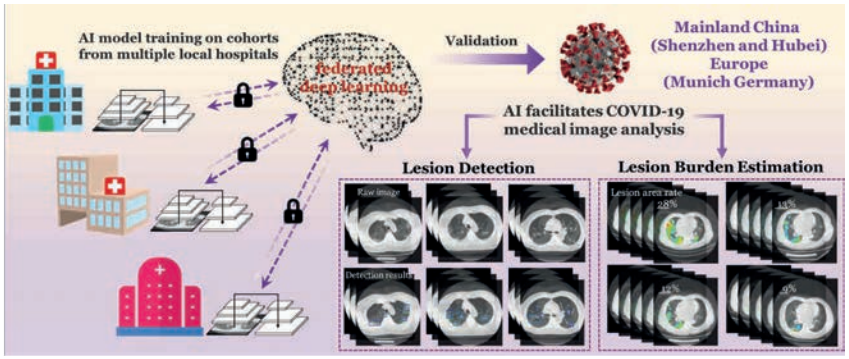
Funding 資助機構 | Research Grants Council, Innovation and Technology Commission, Shun Hing Institute of Advanced Engineering of CUHK, Department of Science and Technology of Guangdong Province
研究資助局、創新科技署、香港中文大學信興高等工程研究院、廣東省科學技術廳

Collaboration 合作夥伴 | City University of Hong Kong 香港城市大學

信息和通訊科技

Information and Communication Technologies

AI System for Detecting COVID-19 Infections in CT Images
用於自動分析新冠肺炎CT影像的人工智能系統



▲ Overview of our AI scheme to develop a privacy-preserving CNN-based model for detecting CT abnormalities in COVID-19 patients with a multinational validation study. The privacy-preserving AI system was developed with CT data from three hospitals in Hong Kong using federated learning, and then the generalizability was validated on external cohorts from Mainland China and Germany.

本項目研發的人工智能（AI）使用聯合深度學習，令醫療中心之間分享數據時患者私隱得到保護。研究成果結合世界各地不同醫療中心的數據，涵蓋三家香港醫院，以及德國和中國內地的醫院。

Using new federated learning techniques, the AI system is trained on multicentre data in Hong Kong without the need to centralise data in one place, thus protecting patient privacy. The established AI system is validated on multiple, unseen, independent external cohorts from mainland China and Europe, showing the potential and feasibility to build large-scale medical datasets with privacy protection, so as to rapidly develop reliable AI models amidst a global disease outbreak such as the COVID-19 pandemic.

Uniqueness and Competitive Advantages

- Can accurately evaluate the CT data in around 40 ms
- Wide validation and applicability on cohorts with various imaging scanners and different demographics show outstanding robustness and generalisability of the established AI model in complex real-world situations
- Rapid and accurate detection of COVID-19 infections in CT images

▲ Case studies with longitudinal CT scans relying on dense scoremaps of lesion regions for lesion burden estimation. The raw images are shown accompanied with dense prediction scoremaps, more hot color denotes higher estimation score. The CT images are chronologically ordered from left to right, top to down, in accordance to the scanning date.

縱向電腦斷層掃描利用密度分數圖來估算病變部位的病變負擔。醫學影像的原片與密度分數圖相互配合，影像顏色偏紅的位置即代表估算分數較高。電腦斷層掃描影像以左至右、上至下的順序按掃描日期的時序排列。

項目採用新型聯邦學習技術，通過香港多家醫院的臨床影像數據對AI模型進行訓練，無需將數據集中在一處，藉以保護病人私隱。項目利用內地和歐洲多個獨立及不可見的外部數據集對訓練後的AI系統進行驗證，展現了在COVID-19的全球爆發中，快速開發高效可靠的AI模型以建立大規模醫療數據集的可行性和巨大潛力，同時保護病人私隱。

特點及優勢

- 僅在40毫秒內即可準確評估整個三維CT影像
- 多中心協作訓練的學習模式能夠偵測各種數據差異及提高模型可靠性，進而在複雜的實際臨床應用中充分發揮AI的效能
- 可快速及準確地自動檢測CT影像上的新冠肺炎（COVID-19）感染病灶

Prof. DOU Qi 竇琪教授

Prof. HENG Pheng Ann 王平安教授

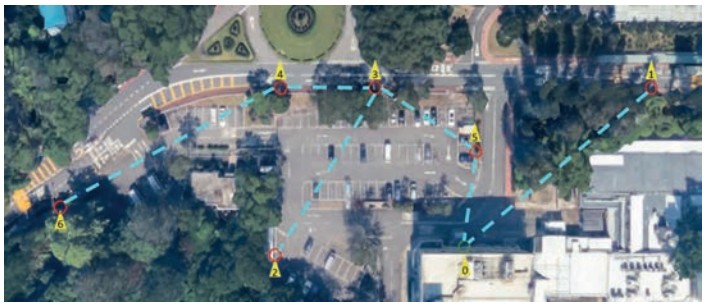
Department of Computer Science and Engineering
計算機科學與工程學系

Dr. SO Yuen Tung Tiffany 蘇宛彤醫生

Prof. YU Chun Ho Simon 余俊豪教授

Department of Imaging and Interventional Radiology
影像及介入放射學系

Real-Time Fog Computing Technologies for Next Generation Smart Lampposts
支持智慧燈柱的實時霧計算技術



▲ The figure shows the smart lamppost node (yellow triangle) deployed in the first phase (Phase I) of the project. The lines in the figure indicate the wireless communication topology of the lamppost, and node 0 is linked to the campus network for public network access.
上圖為項目第一階段部署的節點（黃色三角形），圖中綫條表示燈柱間無綫通信拓撲結構，其中節點 0 鏈接到校園網。

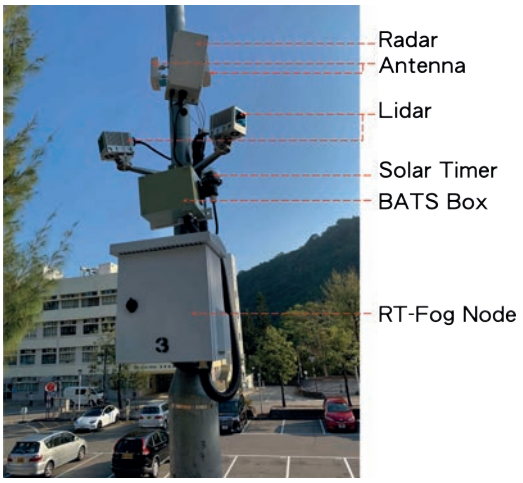
Smart lampposts are widely regarded as the key infrastructure of smart cities, which can realize a range of applications including intelligent transportation, assisted/autonomous driving, real-time monitoring and public safety response, and city-scale public Wi-Fi services. Our goal is to develop the most advanced smart lamppost wireless communication technology based on the batch sparse coding (BATS code) proposed by The Chinese University of Hong Kong, which can achieve high throughput even after dozens of hops of lossy wireless links. Thus our approach avoids the installation and deployment of expensive optical fiber links. The research content of this project includes 1) Real-time fog computing system based on edge nodes of smart lampposts. 2) Multi-hop dynamic routing wireless communication protocol. 3) Vehicle-road collaboration and data fusion in autonomous driving scenarios.

Uniqueness and Competitive Advantages

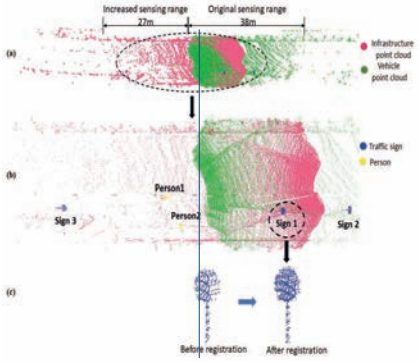
- The smart sensors deployed on the lamppost nodes support a variety of AI applications
- The lamppost testbed developed in the project provides interfaces to deploy a variety of AI applications
- The designed multi-hop communication protocol supports high-bandwidth wireless communication
- Supports the reconstruction of network links under extreme conditions such as interference and noise, and provides stable communication quality
- Wi-Fi applications are deployed on lamppost nodes to provide users with a wide range of wireless communication support

特點及優勢

- 燈柱節點部署的智能傳感器支持多種AI應用
- 開發燈柱測試平台，提供接口部署多種應用
- 多跳通訊協議設計，支持高帶寬無綫通訊，大大降低部署成本
- 支持在干擾、噪音等極端情況下重新構建網絡鏈接，提供穩定的通訊質量
- 燈柱節點部署Wi-Fi應用，給用戶提供大範圍無綫通訊支持



▲ The actual deployment of smart lamppost node
智慧燈柱節點部署實際圖



▲ An example of Lidar point cloud data fusion. In Figure (a), red and green dots represent the Lidar point cloud data on the roadside and smart vehicles, respectively. Through data fusion, it can effectively expand the range of intelligent vehicles' perception of the environment.
智慧燈柱部署的激光雷達點雲數據融合實驗圖，圖(a)中紅色和綠色分別表示路邊和智能車輛上的激光雷達點雲數據。通過數據融合，能有效擴展智能車輛對環境的感知範圍。

智慧燈柱被認為是智慧城市的關鍵基礎設施，可支持智能交通，輔助或自動駕駛，以及城市規模的公共Wi-Fi服務。本項目旨在在香港中文大學提出的分批稀疏編碼（BATS碼）的基礎上，開發最先進的智慧燈柱無線通信技術，經過數十跳有損無線鏈路也可以實現高吞吐量，避免昂貴的光纖鏈路的安裝與部署。 研究內容包括 1) 基於智慧燈柱邊緣節點實時霧計算系統。2)多跳動態路由無線通信協議。 3) 面向自動駕駛場景下的車路協同與數據融合。

Prof. XING Guoliang 邢國良教授

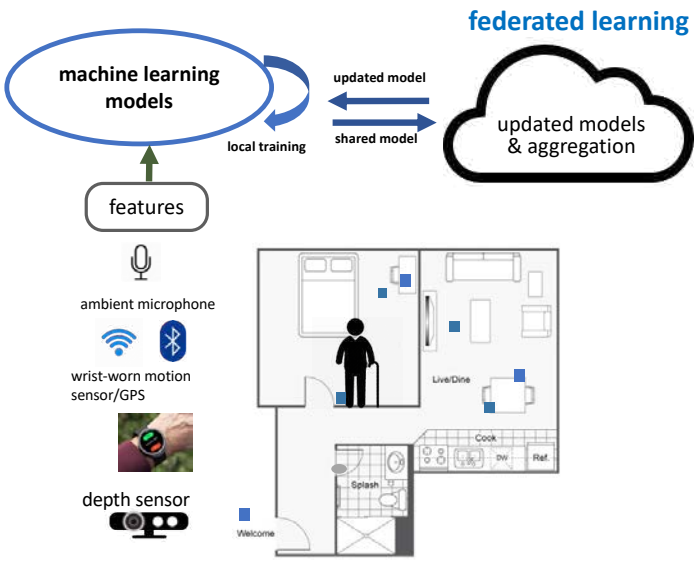
Department of Information Engineering
信息工程學系

Funding 資助機構 | Innovation and Technology Commission 創新科技署

Collaboration 合作夥伴 | Huawei Technologies Co., Ltd. 華為技術有限公司

Machine Learning Technologies for Advancing Digital Biomarkers for Alzheimer's Disease

基於機器學習技術的阿茲海默症數碼生物標記研究



▲ The illustration of the entire framework.
項目完整的框架圖。

Early identification of people at risk of developing Alzheimer's Disease (AD) and timely intervention to slow the onset and progression of AD are crucial.

In this project, we will build an indoor monitoring system that deploys different types of sensors and collect the corresponding data to develop a multi-modal fusion algorithm for daily activities and behavior detection. Besides, we will develop a new federated learning framework, which not only ensures the real-time of related algorithms but also protects users' private data. After that, we will predict and identify individuals who are at a higher chance of developing dementia and provide high-quality feedback to the users.

Uniqueness and Competitive Advantages

- The collected data are stored in the local repositories and are neither being transmitted nor leaked, thus protecting the users' privacy
- Uses depth cameras to collect depth images of users' daily activities, which don't reveal face information
- Provides users with the high-quality early identification of developing AD and timely intervention to slow the progression of AD

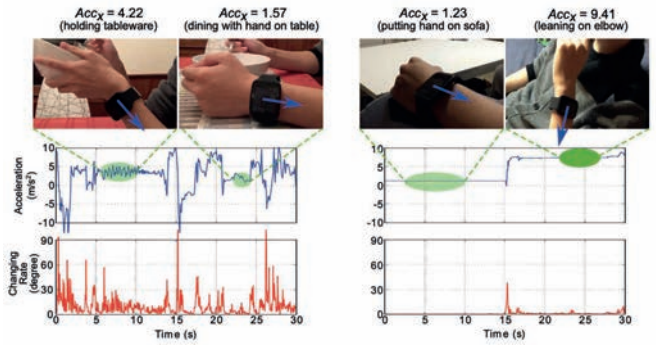
Prof. XING Guoliang 邢國良教授

Department of Information Engineering
信息工程學系

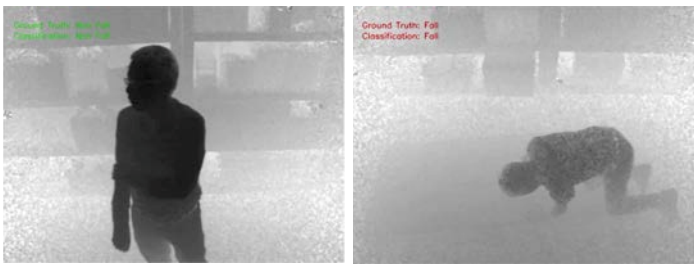
早期監測及介入對緩減阿茲海默症尤其重要，本項目將構建一個室內的智慧健康系統。其會部署多種類型的傳感器，收集不同模態的數據，進而建立一套多模態融合算法來完成日常活動、行為檢測。同時建立一個新型的聯邦學習框架，該框架即可以保證相關算法的實時性，又可以保護用戶的隱私數據。之後項目會預測並識別出那些更容易患老年認知障礙的人並給予他們高質量的治療反饋。

特點及優勢

- 數據會保存在本地數據倉庫，不被傳輸或洩露，進而保護用戶隱私
- 用深度攝像機採集數據，收集的深度圖像不會揭示人臉信息
- 將為用戶提供高質量的早期識別和及時干預，盡可能減緩其病症的進展



▲ Examples of detecting activities using motion features. The left column shows a dining scenario; the right column shows a TV viewing scenario.
使用運動特徵檢測到的活動例子。左欄展示的是進餐場景；右欄為看電視場景。



(a) Non Fall (b) Fall

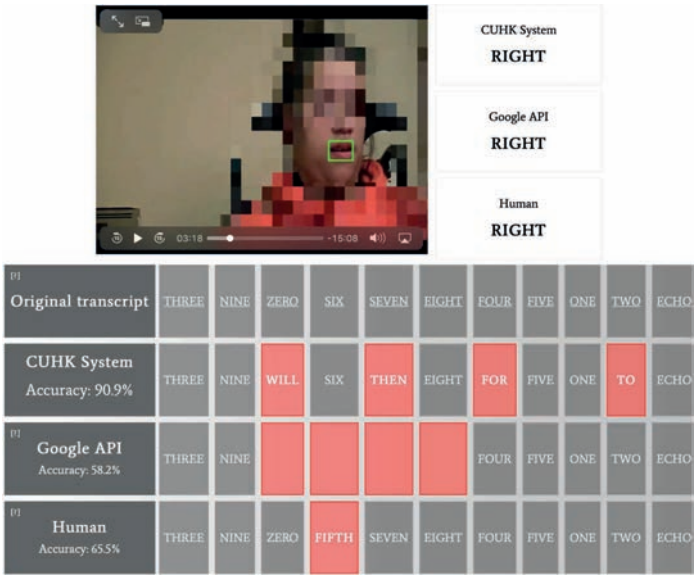
▲ A demo of our fall detection system. (a): The man is standing. Fall has not happened. (b): Fall has happened. Our system can immediately give feedback to the caregiver so that the fallen people can be rescued in time.
跌倒檢測系統的演示。 (a)：人處於站立狀態，跌倒沒有發生。(b)：跌倒發生。系統可以立即地給相關的護理人員反饋，以致於跌倒的人可以及時被救治。

Funding 資助機構 | Alzheimer's Drug Discovery Foundation 阿茲海默症藥物研發基金

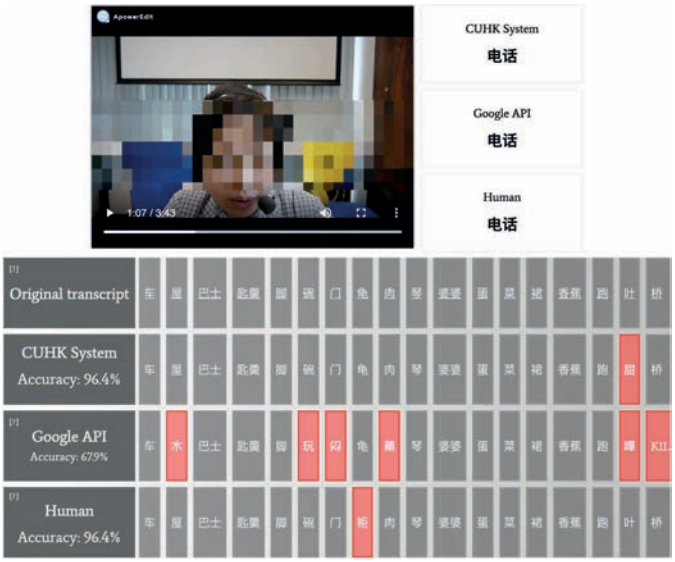
Collaboration 合作夥伴 | The University of Hong Kong 香港大學

A Bilingual Speech Recognition System for the Elderly and Disabled Population with Speech Disorders

面向有言語交流障礙的老齡和殘疾人群的雙語語音識別系統



▲ CUHK English Dysarthric Speech Recognition Demo System
中大英語構音障礙語音識別演示系統



▲ CUHK Cantonese Dysarthric Speech Recognition Demo System
中大廣東話構音障礙語音識別演示系統

This project aims to develop a bilingual speech recognition system that can accurately recognize continuous sentence level Cantonese and English speech inputs from impaired adult speakers with varying forms of speech disorders. The system targets both conversational speech that is essential for daily use, and more formal style speech. The recognition vocabulary covers over 80,000 common and uncommon words. The average recognition error rates will be below half of those obtained using the Google speech recognition engine. This system can aid the communication of the elderly and disabled people with speech disorders, improve their quality of life, social inclusion and the cost–effectiveness of the care they require.

Uniqueness and Competitive Advantages

- Large accuracy improvements over commercial speech recognition systems
- Robust performance across varying forms of speech dysarthria
- Fast user adaptation using minimum data
- Audio–visual disordered speech recognition
- Low published word error rate

本項目旨在研發一個面向有言語障礙老齡和殘疾人群的廣東話及英語雙語實時自動語音識別系統，可準確識別患有各種形式言語障礙的成人患者的連續語音輸入。系統識別內容以廣東話和英語日常生活適用口語為主，並兼顧書面用語，可識別詞庫涵蓋逾八萬個常見及不常見的詞彙，平均識別錯誤率將低於Google語音識別引擎錯誤率的一半。此系統將輔助有言語障礙的老齡及殘疾人群與外界自主交流，提高他們的生活品質及所需的醫護質量和效率。

特點及優勢

- 與商業語音識別系統相比識別準確率大幅提升
- 針對不同形式的語音構音障礙，實現穩健性能
- 以最少的數據快速適應用戶需求
- 視聽覺協同的多模態語音識別系統
- 詞錯率低

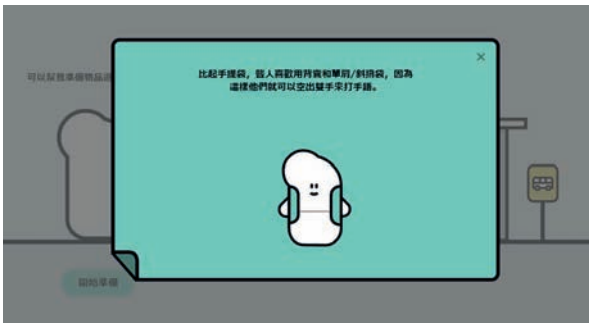
Prof. LIU Xunying 劉循英教授

Department of Systems Engineering & Engineering Management
系統工程與工程管理學系

Funding 資助機構 | Innovation and Technology Commission, Research Grants Council 創新科技署、研究資助局

SignTown — The World First Multi-language Online Sign Language Game with Automatic Sign Language Recognition
全球首個具手語自動識別技術多語言網上手語遊戲「手語村」

▲ The opening screen of the SignTown
「手語村」遊戲的首頁



▲ SignTown provides information about deaf culture in various regions.
遊戲內介紹不同地區的聾人文化

SignTown is a web-based, real-time sign recognition game, where users take control of an avatar to communicate with other characters in sign language to get things done. The game employed an end-to-end open source platform for machine learning, TensorFlow™, to train the sign language recognition model. It enables users to learn and express themselves in sign language and to get feedback about their signing simply with a computer and a webcam. SignTown is designed around various common categories and themes. It also provides information about deaf culture in various regions. Users can enjoy the experience of signing into Hong Kong sign language and Japanese sign language in the game.

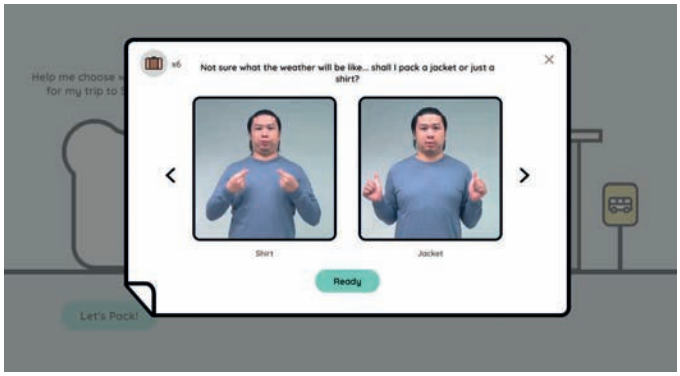
Uniqueness and Competitive Advantages

- Can track facial expressions and non-manual features without the need for special equipment or specific settings
- Can switch between HKSL and JSL in the game
- More accurate results on sign recognition

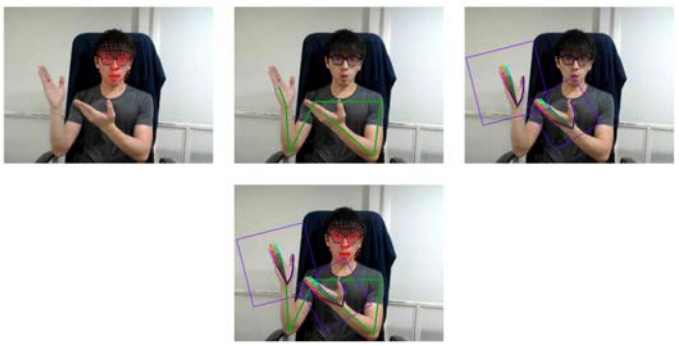
「手語村（SignTown）」是一款網絡實時手語識別遊戲，玩家要控制角色用手語與村民交流來完成任務。此項目運用了機器學習端到端開源平台TensorFlow™技術，用以訓練手語識別模型。玩家能通過電腦和網絡攝像鏡頭學習和嘗試打手語，而人工智能識別系統就會對玩家所打手語的準確度作出回應。「手語村」涵蓋各種日常生活主題，亦會介紹不同地區的聾人文化。玩家可在遊戲內學習及使用香港和日本兩種不同手語。

特點及優勢

- 毋須特殊設備或特定環境，亦能追蹤面部表情和非手控特徵
- 可隨時切換香港和日本兩種不同的手語
- 更準確的手語識別結果



▲ Users collect different items by selecting and performing the sign to the camera.
玩家透過不同的手語來獲取相應的物品



▲ Multiple machine learning models are used to track the phonetic features of sign language.
使用多種機器學習模型來追蹤手語的語音特徵

Prof. TANG Wai Lan Gladys 鄧慧蘭教授

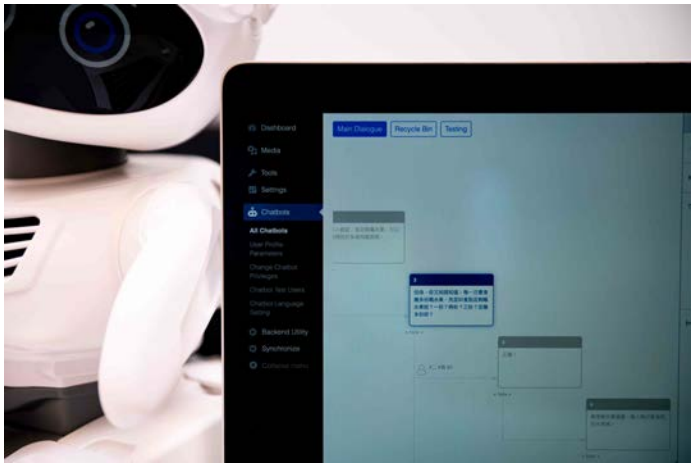
Department of Linguistics and Modern Languages
語言學及現代語言系

Funding 資助機構 | The Nippon Foundation 日本財團

Collaboration 合作夥伴 | The Nippon Foundation, Google, The Sign Language Research Center of Kwansei Gakuin University
日本財團、Google、關西學院大學手語研究中心

A Customisable Multi-turn Chatbot Based on Query-Context Attentions and Few Shot Learning

基於查詢上下文注意和小樣本學習的可定制多輪聊天機器人



▲ A visualisable logic tree for easily customise the chatbot logic without any coding.
可視化的邏輯樹，無需任何編碼即可輕鬆自定義聊天機器人邏輯。

For a chatbot to generate proper responses, it should have both short-term and long-term memories, so that the chatbot can associate the relationship between the past and the current conversation in the response. One of the major challenges in this project is to effectively associate the relationship between a user query and the previous dialogue. We solve this problem by using query-content attentions. In addition, common practice for chatbot training is to feed as much data as the model can take which increases time cost for data collection/annotation and computational cost for model training. To reduce such cost, we employ few-shot learning in chatbot training that requires less data to train a model. Low amount of training data means a significant reduction in the costs related to data collection/annotation and the computational costs.

Uniqueness and Competitive Advantages

- Able to handle multi-turn dialogue
- Able to handle multi-context conversation
- Able to extend to multi-domain based on few shot learning mechanism
- Easily customizable without coding

聊天機器人若要作出正確回應，它應同時具有短期和長期記憶，使機器人在回應時能夠串連過去對話與現時對話的關係。如何有效地關聯用戶查詢和先前對話之間的關係是其中一個主要挑戰，本項目使用查詢上下文注意技術來解決這個問題。此外，訓練聊天機器人的常見做法是盡可能輸入最多的數據，但這會增加數據收集/註釋的時間成本和模型訓練的計算成本。為降低成本，本項目採用小樣本學習來訓練聊天機器人，這方法需要較少的訓練數據，從而顯著降低與數據收集/註釋相關的成本和計算成本。

特點及優勢

- 能夠處理多輪對話
- 能夠處理多語境對話
- 能夠基於少樣本學習機制擴展到多領域
- 無需編碼即可輕鬆定制

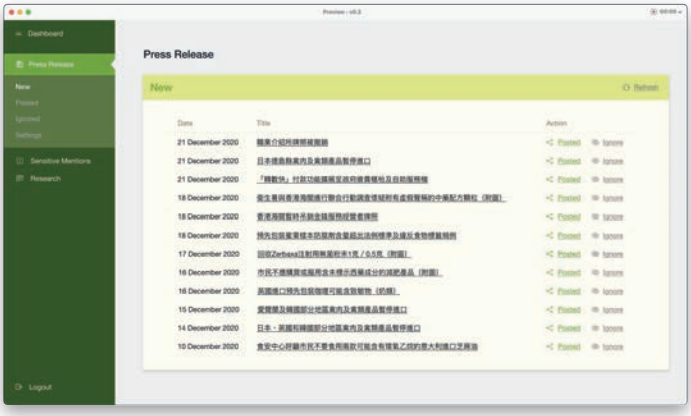
Prof. WONG Kam Fai 黃錦輝教授

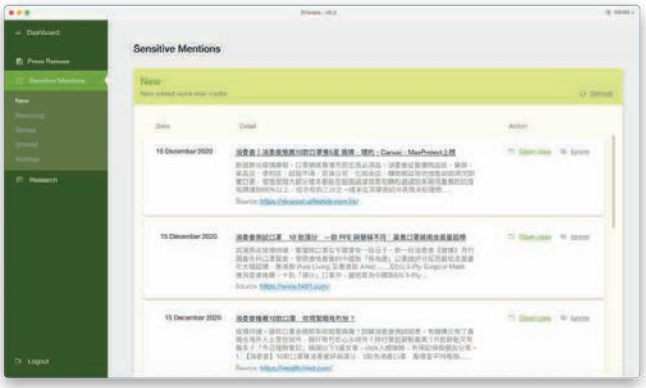
Department of Systems Engineering and Engineering Management
系統工程與工程管理學系

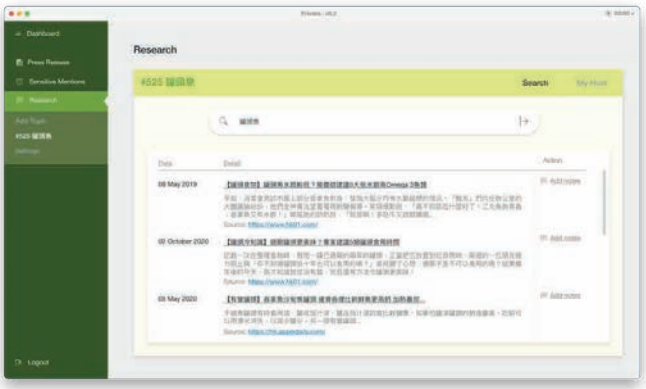
Funding 資助機構 | Innovation and Technology Commission 創新科技署

Soliste – A Social Listening System for Understanding Your Customer

「細聽」 – 仔細了解客戶的社媒聆聽系統







▲ "Soliste" actively listens Government press releases and media reports. It also helps to search and understand what the media is interested in and can let us understand how we may capture the attention of the readers of the media.

「細聽」積極聆聽政府的新聞稿和媒體報導。它還有助於搜索和了解媒體感興趣的內容，使我們理解如何吸引媒體讀者的關注。 ▶

Searching, organizing and summarising what the customers are thinking on the Internet or social media can help companies better understand their potential consumers' interests and needs for tailored marketing strategies. However, such kind of data collection and analysis is labor intensive, time consuming and error prone. In collaboration with the Consumer Council, our project team developed Soliste, an artificial intelligence social listening system which helps analyse consumer data and comments on the Internet.

Uniqueness and Competitive Advantages

- Actively listens what was happening around you
- Consolidates information from multiple sources into one platform for easy information management
- Visualizes topics and trends
- Predicts the impact of the current information
- Notifies the users whenever an interesting news is identified

透過搜尋、整理及分析目標顧客群在網上或社交平台發表的意見，我們一般可以更好地掌握目標顧客群的特性及喜好，從而協助制定相應的營銷策略。然而這種目標顧客群分析一般需要投入大量的資源，導致費時失事。我們的研究團隊早前與消費者委員會合作，研發出一套名為「細聽」的聆聽系統。它通過人工智能程式分析目標顧客群的數據及留言，除了可以減省人手、成本及時間，亦可避免出現錯誤或遺漏重要資料等情況。

特點及優勢

- 積極傾聽周圍發生的事情
- 將多源信息整合到一個平台，輕鬆管理信息
- 可視化主題和趨勢
- 預測當前信息的影響
- 每當發現有趣的新聞時通知用戶

AWARDS 獎項

Silver, International Exhibition of Inventions Geneva 2021
2021年日內瓦發明展銀獎

PATENT 專利

2 patent applications in China
於中國申請2項專利

Prof. WONG Kam Fai 黃錦輝教授

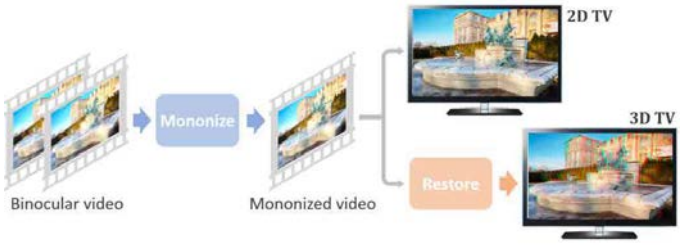
Department of Systems Engineering and Engineering Management
系統工程與工程管理學系

Funding 資助機構 | Innovation and Technology Commission 創新科技署

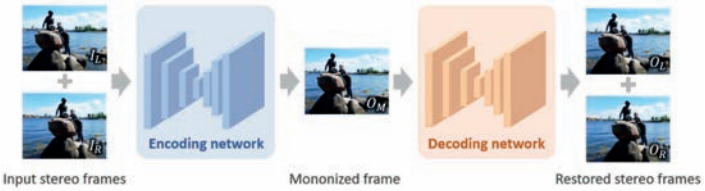
Collaboration 合作夥伴 | Consumer Council 消費者委員會

A Data Compact System for 5G Media Streaming Applications

應用於5G多媒體直播領域的數據壓縮系統



▲ Conceptual illustration of back-compatible binocular videos
立體內容壓縮還原示意圖



▲ Framework of generating and decoding mononized videos
2D內容生成復原架構圖

With the development of 5G technology, the ultra-high speed and super-low latency network will bring many new media applications to industry. For example, 8K + 360 panorama + 3D live video streaming will become possible. We propose to develop a new data compact system for 5G media streaming applications, which could achieve the goal of converting 3D content into 2D format, without losing the 3D information. By developing an artificial intelligence system, we achieve the goal of hiding depth(3D) information in pictorial spaces, so as to be able to recover the 2-D media content into a 3-D media content with no perceivable inconsistency. In terms of practical usage, via compressing the data on the media recording side and recovering on the back end terminals, the transmission efficiency of 5G network could be further improved, which will bring better media streaming visual experience in live broadcast, virtual reality and online education industries.

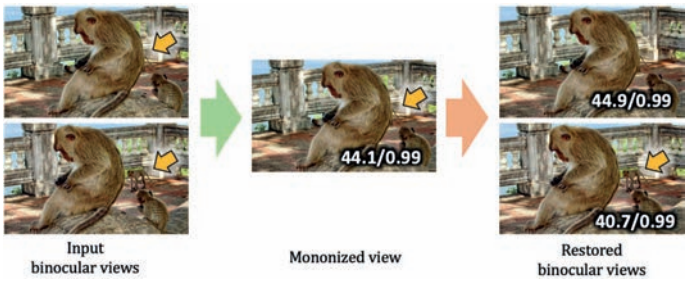
Uniqueness and Competitive Advantages

- Innovative 3D-2D media compact system
- AI based media processing system
- Industry oriented technology
- High quality compact system with efficiency
- 5G applications supported

伴隨著5G技術的發展，「超低時延、超高頻寬」的多媒體創新應用將為社會帶來全新的影視體驗。8K+360全景+3D高清視頻傳輸成為新的可能。我們提出一個創新的人工智能媒體內容處理系統，可實現高清數碼內容的2D-3D無損轉換。通過在前端拍攝壓縮，並在後端恢復的方式，促進超高清內容的傳輸效率，可對直播、虛擬現實和在線教育等領域產生比較大的影響。

特點及優勢

- 創新型3D-2D視頻壓縮系統
- 運用最新人工智能技術的多媒體平台
- 可直接應用於工業界
- 高效能、高質量
- 可用於5G傳播



▲ Visualized result demonstration
可視化結果演示圖

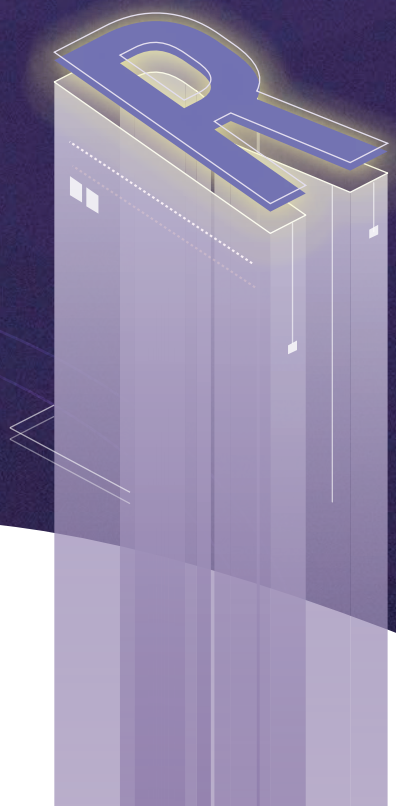
Prof. WONG Tien Tsin 黃田津教授

Department of Computer Science and Engineering
計算機科學及工程學系

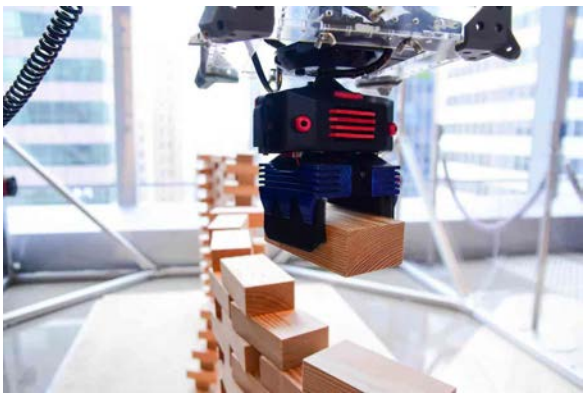
Funding 資助機構 | Innovation and Technology Commission 創新科技署

機械人及先進製造技術

Robotics and Advanced Manufacturing



The Cable-Driven Brick Structure Construction "CU-Brick" System
「CU–Brick」線控砌磚機械人系統



▲ The gripper contains a distance sensor that can be used to detect the location of brick.
夾持器中的距離感測器能探測磚頭的位置

The "CU–Brick" system consists of a gripper end–effector and cable actuators which can be mounted on a range of different environments, from metal frame structures to the walls and roofs of buildings. The design is performed through developed intelligent software. The system will then automatically generate the structure to be built, while keeping the robot within the designated operational region and ensuring the number and location of bricks remain unchanged. It can turn innovative designs into executed complex brick placement operations. With the ability to work 24/7 and error–free, "CU–Brick" can perform the same task with higher precision and consistency compared to the current techniques which are constrained by several factors including building time and costs. It also better addresses the problems of labour costs and worker safety.

Uniqueness and Competitive Advantages

- High portability and convenient setup
- Higher precision
- Can easily execute more complex designs with the same costs
- Different construction materials can be used, including wood, bricks and cement

▲ A cubic frame with 4m each side can build walls about 3m in height.
配置每邊4米長的立方體框架，可以建造一幅3米高的磚牆

CU–Brick系統由一個夾持式末端效應器和電纜執行器組成，可安裝於金屬框架結構或建築物的牆壁和屋頂等各種不同環境。系統會自動砌出由電腦程式運算的設計方案，同時保持機械人在指定操作區運作，確保磚頭數量和位置不變，簡易砌出設計複雜的建築結構。CU–Brick能全天候二十四小時工作，精準度亦比人手操作高，能避免建築質量參差問題。不僅不受建築時間和成本等因素限制，亦能有助減低人手成本、保障工人安全。

特點及優勢

- 便攜及易於安裝
- 精準度更高
- 可以同等成本輕易完成更複雜設計
- 不同建築材料均可應用這套系統，包括了木材、磚塊、水泥

▲ The system calculates the corresponding location of each brick and constructs the design precisely with cables and the gripper.
系統計算每一磚塊對應位置，以纜線和機械夾爪精準完成工程

Prof. LAU Tat Ming Darwin 劉達銘教授
Department of Mechanical and Automation Engineering
機械與自動化工程學系

Prof. FINGRUT Adam
School of Architecture
建築學院

Funding 資助機構 | T. Stone Robotics Institute of CUHK 香港中文大學天石機器人研究所

Multi-functional Prosthetic
多功能義肢

▲ The prosthetic can give easier control of the strokes of the bow to play beautiful and harmonic violin music.
義肢可穩定臂力、讓演奏小提琴時拉弓角度更佳。

The project designed a multi-functional prosthetic to fit users' daily needs. The new design is equipped with a custom made "adapter" which is firmly screwed to the stump and allow quick change of various kind of "tools" to accomplish daily tasks; for example, an extender used to improve contact angle of violin bow to string, and a spatula or spoon used for cooking. A function-based prosthetic is more practical and cost-effective. Thus, "function" will be the primary consideration.

The project proposed to install more flexible and precise movement by adding a motor onto the prosthetic or even making automated adjustments to angles by tracking users' movements.

Uniqueness and Competitive Advantages

- Low cost
- Light material
- Practical and cost-effective

Prof. LAU Tat Ming Darwin 劉達銘教授

Department of Mechanical and Automation Engineering
機械與自動化工程學系

本項目設計出多功能義肢，協助用家進行各種日常活動。新設計包括一個連接義肢的底座，可按需要在底座換上不同配件進行不同活動，例如換上延長工具以演奏小提琴，如要烹調則換上配備鏟鏟或勺子的工具。工具型的義肢較傳統義肢更實用和符合成本效益，因此項目以功能為首要考慮。

為了讓用家做出更靈活精準的動作，團隊下一步將研究在義肢安裝馬達及感應器，透過追蹤用家的動作自動調整義肢的角度，以拓展義肢的功能。

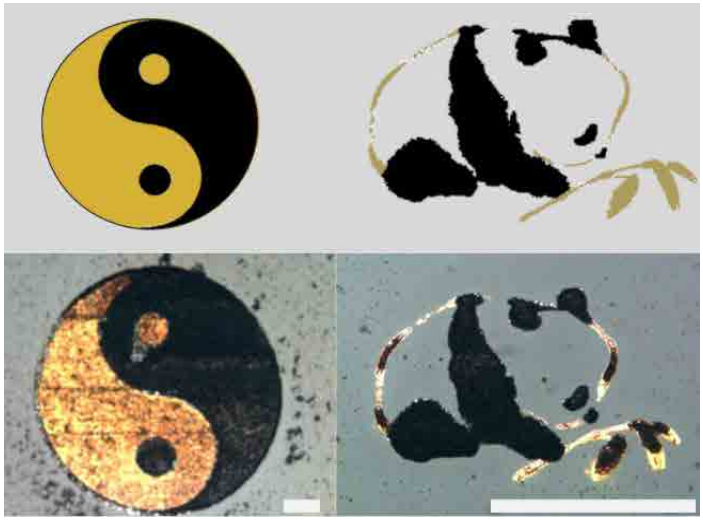
特點及優勢

- 成本低廉
- 質料輕盈
- 實用及符合成本效益

▲ Amputees can use the prosthetic with a spatula attached for cooking.
截肢者可利用配有鏟鏟工具的義肢炒菜。

▲ The computer rendering images of the adapter (top left), tool for playing cards(top right) attaching to the prosthetic and the tool for holding the bow (bottom).
安裝在義肢的底座（左上），用於紙牌遊戲的工具（右上）及琴弓固定工具（下）的電腦繪圖。

“Universal Ink” for Direct Laser Writing
用於光刻領域的「萬能墨水」

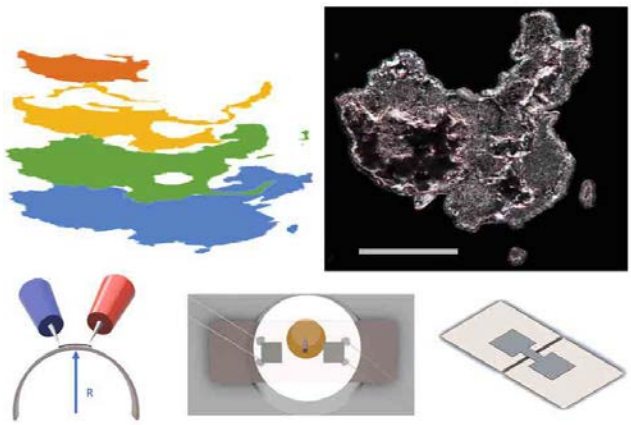


▲ Examples of double metal (platinum and gold) printing. Taichi double fish pattern (left); panda (right) (The scale bar represents 50 μm)
示範用兩種不同金屬（鉑金和黃金）打印圖案。太極標誌 (左)；熊貓圖案 (右)（白色比例尺代表50微米）

Stemming from fundamental physics principles, the research team came up with a brand–new idea for material deposition. They combined the optical tweezer technique and semiconductor photoelectric effect, by introducing semiconductor nanoparticles suspension into metallate solution to form the “universal ink”. The focused laser beam triggers both effects simultaneously and induces chemical reduction reactions on the nanoparticles. The reduced metal particles accumulated on the semiconductor nanoparticles work as “glue” to join each other into a solid structure and attach to the substrate. By changing the focus position, selective deposition at an arbitrary position on the substrate is achieved. Through the change of “ink” recipes, the team realized deposition with various materials on different substrates.

Uniqueness and Competitive Advantages

- Enables fabrication of complex images made of different materials
- Can be realised with simple equipment and be easily adapted everywhere
- Environmental–friendly in terms of its low–cost and recyclability
- Can integrate an optical detection/measurement device with this laser writing platform to monitor the deposition quality in situ

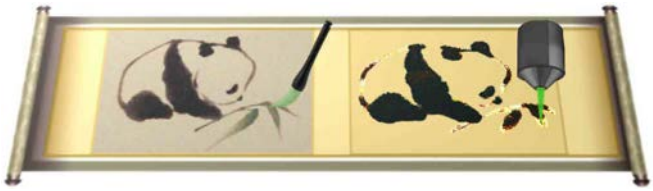


▲ 3D printed topography in iron (top) (The scale bar represents 100 μm); Schematic drawing of flexible devices and the repairing of the circuits (bottom)
3D打印的金屬地形圖 (上)（灰色比例尺代表100微米）及柔性材料及電路修復概念圖 (下)

中大物理系的研究團隊以嶄新的方法進行高精度的材料沉積，研發出「萬能墨水」。「萬能墨水」由不同的金屬鹽溶液加入半導體納米顆粒溶膠製成，再運用光鑷技術和半導體光電子效應，透過激光引發化學還原反應，合成金屬納米顆粒。顆粒會像「膠水」一樣互相黏附，並沉積在晶片基底。只要改變激光的聚焦點，便可選擇金屬納米顆粒沉積位置；墨水中的金屬成分亦可隨意調整，以配合不同晶片的應用。

特點及優勢

- 可用多種材料製作複雜的圖案，增加晶片的應用範圍
- 設備簡單，便於大規模推廣
- 成本低廉，可回收再用，大大減低對環境的污染
- 可配合光學測量/量度儀器，監控金屬結構在沉積過程的精確度和質量



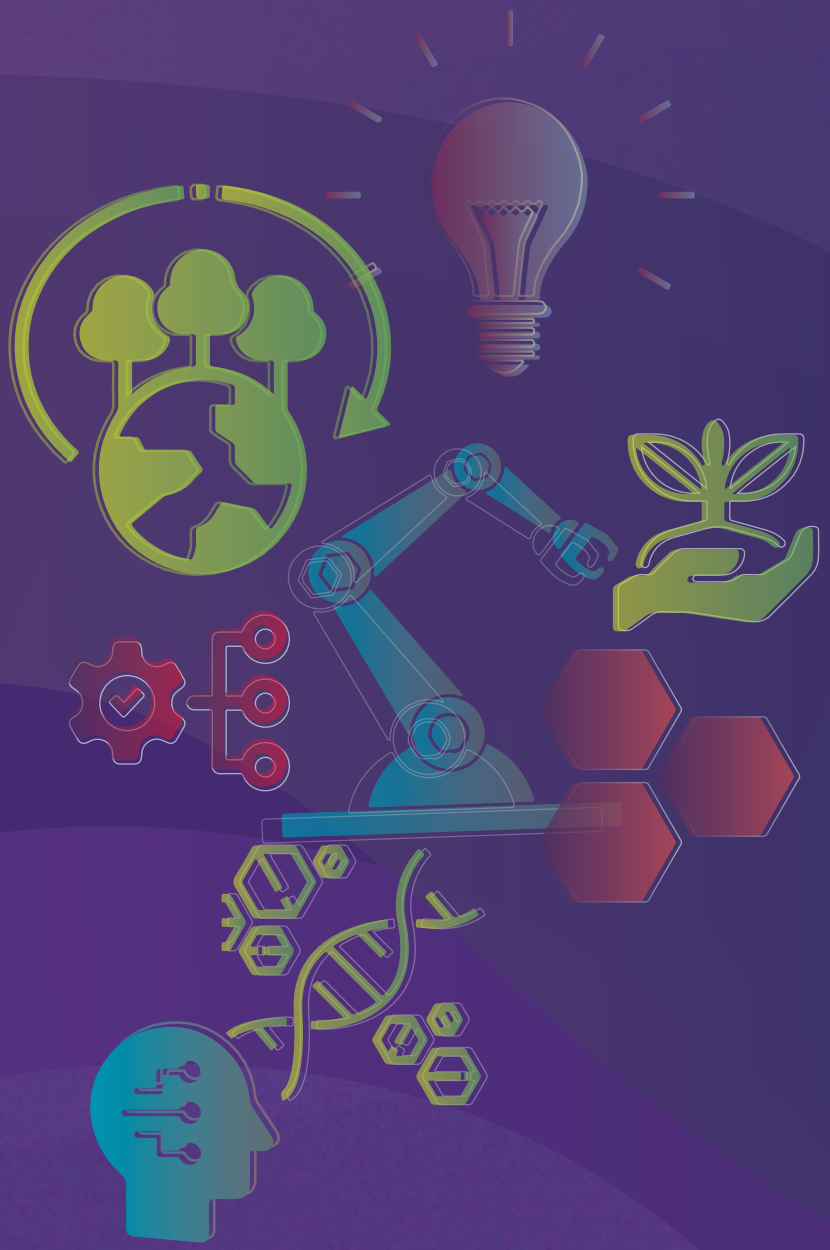
▲ The research team discovers that carbon ink used by traditional Chinese calligraphy and ink painting is one of the best choices as the nanoparticles in this technology
研究團隊發現，傳統書法及水墨畫使用的碳素墨水中的碳納米顆粒，是「萬能墨水」最理想的原材料

PATENT 專利

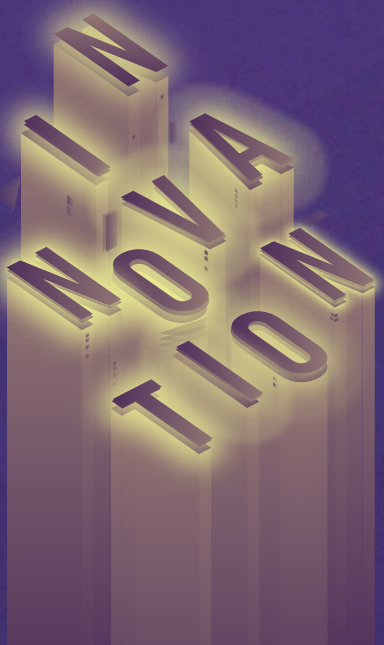
1 European patent, 1 USA patent and
1 China patent granted
一項歐洲專利、一項美國專利及一項中國專利註冊

Prof. YANG Sen 楊森教授

Department of Physics
物理系



CUHK Innovations



Innovation
for Better Life

If you are interested in any of the projects listed, please contact Centre for Innovation and Technology, The Chinese University of Hong Kong.
如閣下對本書內任何科研項目感興趣，請與香港中文大學創新科技中心聯絡。

香港中文大學
The Chinese University of Hong Kong

香港中文大學 創新科技中心
Centre for Innovation and Technology
The Chinese University of Hong Kong

Tel 電話：+852 3943 8221
Fax 傳真：+852 2603 7327
Email 電郵：enquiry@cintec.cuhk.edu.hk
Website 網址：https://exhibition.cintec.cuhk.edu.hk