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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

INNOVATION
FOR BETTER LIFE

2020-2021

香港中文大學
The Chinese University of Hong Kong

PREFACE
序言

"Innovation for Better Life" is the theme of this booklet. Being a forward-looking comprehensive research university, The Chinese University of Hong Kong (CUHK) not only pursues excellent innovative research with passion, but also strives to transfer the fruitful research results into practical form and eventually to be commercialized.

As a technology transfer arm of CUHK under the Faculty of Engineering. Centre for Innovation and Technology (CINTEC) serves as a bridge between the university and the industry, and facilitates open communications and industrial collaborations. We are pleased to share with you some of the latest CUHK research results, which are ready for demonstration or even commercialization. Some are / will be adopted by the government departments or public service units; some are being developed into start-ups.

An electronic version of this booklet is also available online: exhibition.cintec.cuhk.edu.hk/exhibition. 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
Faculty of Engineering
The Chinese University of Hong Kong

「創新為更美好生活」是本書刊的主題。作為一所具前瞻性的研究型綜合大學，香港中文大學(中大)不但追求卓越與創新，還致力把豐碩的研究成果轉化為實用方案，並最終成為商品。

創新科技中心專注中大工程學院的技術轉移工作，目的是向大眾推廣中大的最新研究成果。與此同時，中心積極連繫大學與業界，並以促進中大研究團隊與業界的交流與合作為己任，推動科技轉移。我們很高興與您分享中大今年部份最新的研究成果，這些都是實際成果可以示範操作甚或商品化，當中不少已經/將被政府部門或公營單位採用；有些則正在發展為初創公司。

本刊的電子版本亦同時上載於：exhibition.cintec.cuhk.edu.hk/exhibition，供大家瀏覽。此外，如有任何查詢，請與我們聯繫，電話：(852) 3943 8221 及電郵：enquiry@cintec.cuhk.edu.hk。

謹此感謝各位關注中大的科研成果。

香港中文大學工程學院
創新科技中心主任
黃錦輝教授

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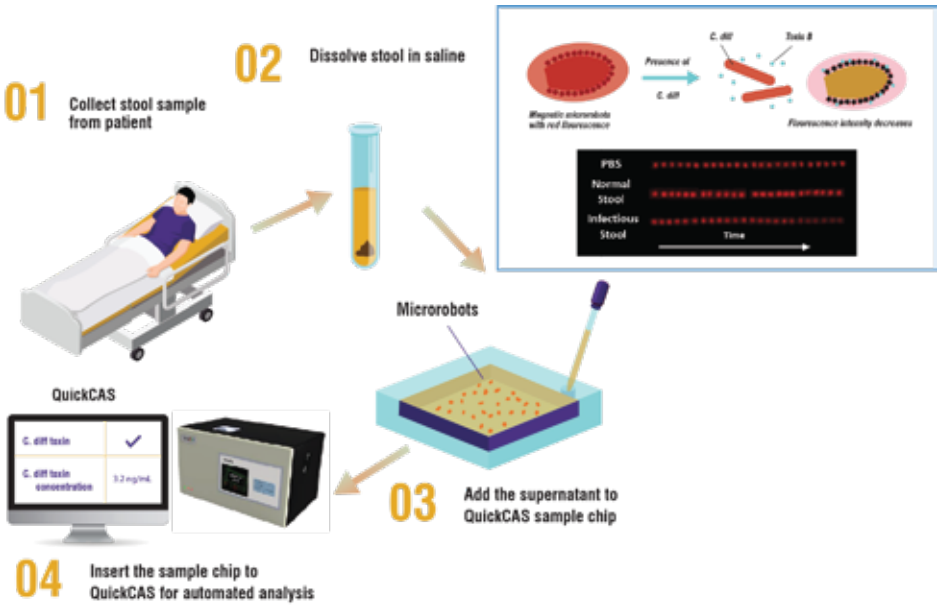
BIOMEDICAL SCIENCES

生物醫藥科學

QUICKCAS: AN EASY-TO-USE ANALYSIS SYSTEM FOR QUICK DETECTION OF INFECTIOUS PATHOGENS IN CLINICAL SAMPLES

QUICKCAS: 一種用於快速分析病人樣本中傳染病病原體的自動化檢測系統



Detection workflow of C. diff with QuickCAS and its detection mechanism
QuickCAS檢測難辨梭菌的流程及檢測原理

Infectious diseases cause 50,000 deaths daily. Early detection is essential for timely treatment and prevention. However, current diagnostic methods face limitations in long reaction time, high costs, or require specialists to conduct labour-intensive procedures. To tackle this, we developed a fast and effortless detection system, which integrates a novel microrobotic sensing probe capable of detecting a specific pathogen with magnetic field and fluorescence. Our first product QuickCAS targets the detection of C. difficile infection, one of the most typical infections in hospitals. This technology has filed a US non-provisional patent and a Chinese invention patent.

世上每天都有超過五萬人因傳染病去世。快速檢測對於及時治療及預防傳染病極為重要。然而，現存的檢測方法一般需要較長的時間、較高成本和需要化驗師進行繁複的程序。有見及此，我們開發了一套全自動的快速檢測系統，當中整合一種創新的微型檢測機械人，以磁場及螢光探測特定的病原體。我們第一代的產品QuickCAS針對檢測難辨梭菌、一種常見的院內感染病原體。此項技術已申請一項美國非臨時專利及一項中國發明專利。

Uniqueness and Competitive Advantages

- Quick detection (15 mins vs 2-4 hours with present protocol)
- Low cost (US$5 vs US$40)
- Fully automated, which does not require specialised manpower for tedious procedures and reduces risk of infection especially during highly infectious pathogen detection
- Prototype system ready to be deployed in hospitals for clinical trials
- Can be applicable to batch and multiplex detection of different pathogens, including* COVID-19, Streptococcus pneumoniae, Salmonella, Pathogenic E. coli. and H. pylori

  *Under development with Department of Microbiology, CUHK

特點及優勢

- 快速檢測 (15分鐘 比 現存方法需時2至4小時)
- 低成本 (5美元 比 40美元)
- 全自動化系統，不需專業人員作繁複程序，亦可減低檢測具高度傳染性之病原體時洩漏受感染風險
- 原型機準備於醫院作臨床測試
- 可擴展至批量及多工檢測病原體，包括* 新冠肺炎、肺炎鏈球菌、沙門氏菌、病原性大腸桿菌及幽門螺旋菌等

  *與香港中文大學微生物學系研發中

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Department of Mechanical and Automation Engineering
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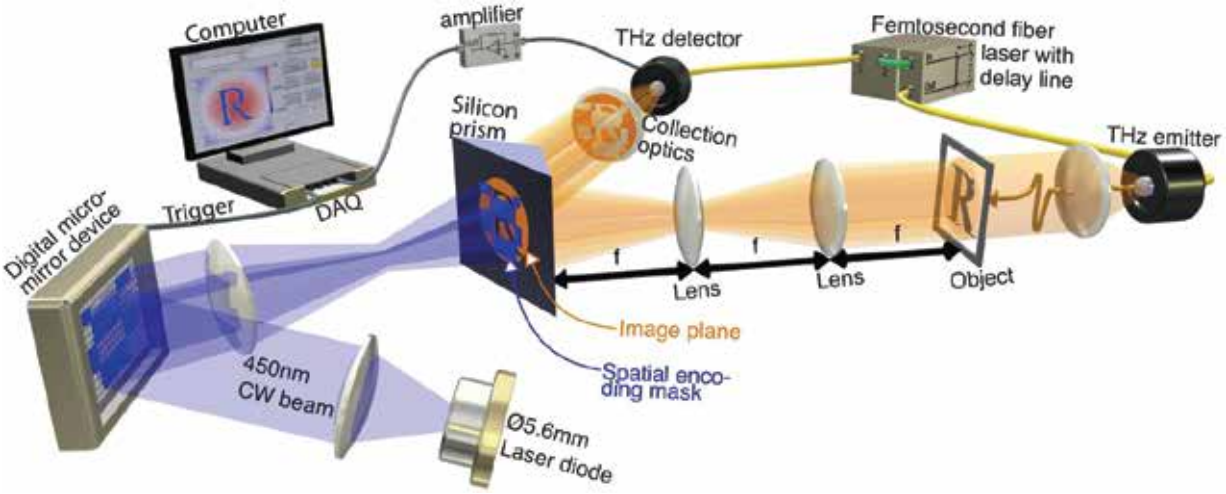
Funded by Innovation and Technology Commission with sponsorship from Tolo Research Limited
由創新科技署資助及Tolo Research Limited贊助

Collaboration with Institute of Digestive Disease, CUHK
合作夥伴為香港中文大學消化疾病研究所

T-RAY CAMERA SPEED BOOSTED A HUNDRED TIMES OVER

太赫茲相機成像速度提升愈百倍



Optical set up for single-pixel transmission imaging of object R
對物體R進行單像素透射成像的光學裝置

Terahertz (THz) radiation, or terahertz radiation (T-rays), sit in-between infrared and Wi-Fi on the electromagnetic spectrum. T-rays have different properties from other electromagnetic waves, most notably they can see through many common materials. Another quality is that the low-energy photons of T-rays are non-ionizing, making them very safe in biological settings including security and medical screening. They are also highly sensitive to water and can observe minute changes to the hydration state of biological matter. This means that diseases perturbing the water content of biological matter, such as skin cancer. However, THz technology is still not widely used in commercial settings for the last 25 years as the cost, robustness and/or ease of use is still lagging behind for commercial adoption in industrial settings.

This project has reached a crucial milestone towards developing single-pixel T-ray imaging technology. Their single-pixel T-ray camera reached 100 times faster acquisition than the previous state-of-the-art, acquiring a 32x32 video at 6 frames-per-second, without adding any significant costs to the entire system or sacrificing the sub-picosecond temporal resolution needed for the most sought-after applications, potentially opening the opportunity for them to be used in non-invasive security and medical screening. We do this by firstly determining the optimal modulation geometry, secondly by modelizing the temporal response of our imaging system for improvement in signal-to-noise, and thirdly by reducing the total number of measurements with compressed sensing techniques.

Future work will focus on improving the signal-to-noise and optimizing the software needed for accurate medical diagnosis, with the ultimate goal being to use single-pixel THz imaging for *in vivo* cancer diagnosis.

太赫茲（THz）輻射，又稱T射線，在電磁頻譜上位於紅外線和無線網絡之間。相比其他波段的電磁輻射，T射線能夠穿透大部分常見材料，而其光子能量較低亦沒有電離能力，不會對活細胞結構產生影響，這使其在無創式檢查方面有巨大的應用潛力。此外，T射線對水份十分敏感，可用於檢測生物樣品的水含量變化，可用作檢測一些會改變生物組織水份的疾病，例如皮膚癌。然而，基於成本、系統穩定性及便利度等因素，T射線在過去25年間仍未能廣泛作商業應用。

本項目在單像素太赫茲(T-ray)成像技術取得突破，我們研發的相機在成像質素不變情況下，成像速度較現有技術提升逾百倍，新研發的相機能以每秒6幀的速度錄製32x32像素影片，而且製作成本並無增加，將為無創式安檢及醫學篩查帶來更安全和便宜的方案。項目主要從三方面來實現該成像速度，包括計算最佳的調整射線方案、提升信噪比、通過壓縮傳感技術減少測量次數。

未來我們會專注於優化單像素T射線相機的信噪比，以及開發用於精確醫療診斷的相機軟件，期望有朝一日可應用於活體癌症診斷上。

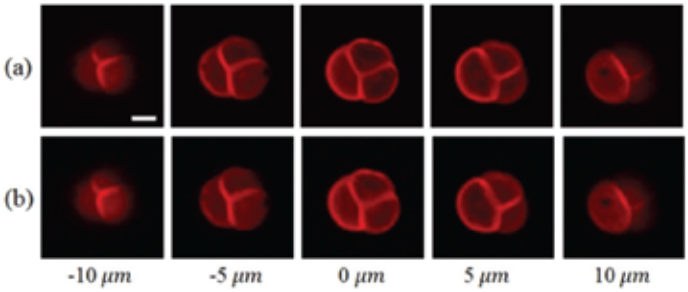
Prof. MACPHERSON Emma
MACPHERSON Emma 教授

Department of Electronic Engineering at CUHK and the Department of Physics at University of Warwick
中文大學電子工程學系及英國華威大學物理系

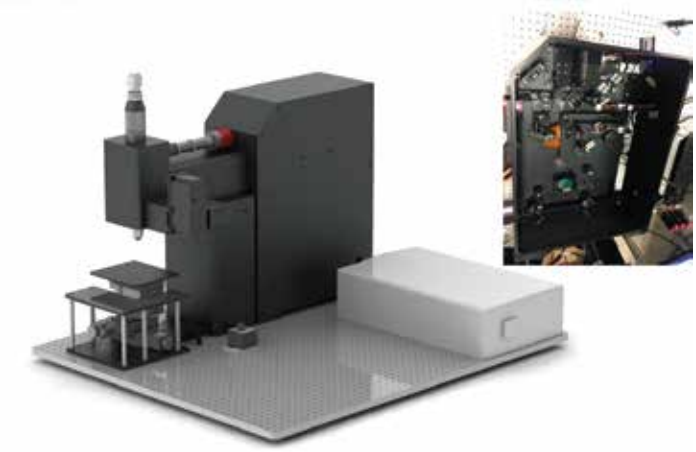
Funded by Innovation and Technology Commission
由創新科技署資助

NOVEL IMAGING APPROACH BRINGS FASTER 3D IMAGING FOR BIOMEDICAL RESEARCHES

全新成像方法提升三維成像速度 促進生物醫學領域研究



We prepared two-photon microscopy images of a pollen grain by using (a) traditional point-scanning and (b) the new compressive imaging approach. The point-scanning imaging time was 2.2 seconds while the compressive imaging time required only 0.55 seconds.
我們使用傳統的逐點掃描（a）和新的壓縮感知方法（b）對花粉分別進行雙光子螢光成像。其中，逐點掃描需2.2秒，而壓縮感知耗時僅為0.55秒。



We have developed a system that increases the imaging speed of two-photon microscopy up to three to five times without compromising resolution. On the left is a CAD model of the compact, custom built, two-photon microscopy system. The free-space optics inside are pictured on the right.
我們已開發基於數碼微鏡陣列的雙光子顯微鏡，可在不影響解析度的情況下將雙光子顯微鏡的成像速度提高三至五倍。雙光子顯微鏡系統的CAD模型如左圖所示，實際系統的內部如右圖所示。

Activities of neurons are generally completed on a time scale of 10 milliseconds, which makes it hard for conventional microscopes to observe these phenomena directly. On the contrary, two-photon microscopy works by delivering ultrafast pulses of infrared laser light to the sample, where it interacts with fluorescent labels to create an image. It is extensively used for biological researches because of its ability to produce high-resolution 3D images up to a depth of one millimeter in a living tissue or to monitoring activities from hundreds of neurons simultaneously. These advantages, however, come with a limited imaging speed of the two-photon microscopy because of the weak fluorescent signal.

To speed up scanning, this project developed a multi-focus laser illumination method that uses a digital micromirror device (DMD). The new approach is able to produce two-photon microscopy images of a 3D sample in one second without sacrificing the resolution, which is at a speed three to five times that of the conventional point-scanning method. The research solves the problem of conventional DMD being unusable to work with ultrafast laser, enabling them to be integrated and used in beam shaping, pulse shaping, and two-photon imaging. We further increased the imaging speed in this research by combining multi-focus scanning with compressive sensing. This approach enables image acquisition with fewer measurements. This is because it carries out image measurement and compression in a single step and then uses an algorithm to rebuild the images from the measurement results. Experiments demonstrated the technique's ability to produce high-quality 3D images with high imaging speeds from any field of view. For example, they were able to acquire 3D images from a pollen grain, in just 0.55 seconds. The same images acquired with traditional point scanning took 2.2 seconds.

由於神經活動一般在十毫秒量級的時間內完成，傳統的顯微鏡難以直接觀察這些現象。與常規顯微鏡比較，雙光子顯微鏡利用匯聚的紅外超快脈衝鐳射在樣品中，與螢光標貼互動以製成圖像，並已經廣泛應用於生物學研究中。雙光子顯微鏡能夠在深達1毫米的活體組織中進行高解析度三維成像，並同時觀察幾百個神經元的活動。然而，由於螢光訊號十分微弱，使雙光子顯微鏡的成像速度受到限制。

為了提升掃描速度，本項目開發了基於數字微鏡器件的多焦點鐳射掃描方法，方法能夠在1秒內即可完成對三維樣品的雙光子螢光成像，速度是傳統點掃描方法的3至5倍，並保持同等的解析度。研究解決了數位微鏡器件無法調製超快鐳射的問題，使之能被集成及應用於超光鐳射光束整形、脈衝整形，以及雙光子成像中。為進一步提升成像速度，我們通過結合壓縮感知演算法與數碼全息顯微鏡。這種方法將圖像測量和壓縮「同步進行」，在較少的測量次數下即可完成圖像採集，隨後使用算法從測量結果中重建圖像。這種方法用於雙光子顯微鏡時，可以將測量次數減少70%至90%。模擬實驗證明了該技術能夠實現高速及高品質的三維成像，例如此方法只需0.55秒對花粉進行三維成像，相比之下傳統的逐點掃描相同圖像則只需2.2秒。

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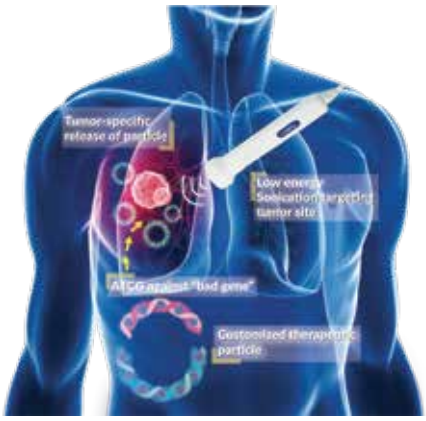
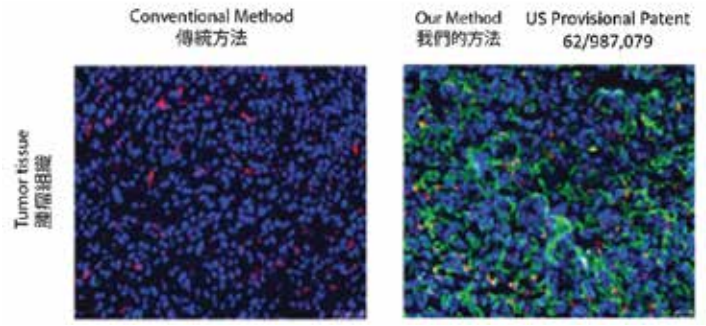
A NOVEL VIRUS-FREE ANTICANCER GENE THERAPY

非病毒性抗腫瘤基因新療法



Outline of virus-free gene therapy system. The customized gene-targeting particles will be administrated via blood stream and released precisely in the tumor tissues by a low energy ultrasound-guided microbubble mediated system.
無病毒基因治療系統概述。定制的基因靶向顆粒通過血流輸入身體，並通過低能量的超聲引導的微泡介導系統在腫瘤組織中精確地釋放出來。



The invention largely improves the tissue-specificity of the gene therapy
發明大幅提升了基因療法的組織標靶性

Cancer treatments remain unsatisfactory to date. Although massive pathogenic genes have been discovered by the rapid growth of bioinformatic and molecular analysis, the lack of their specific inhibitors largely limits their preclinical and translational development. This limitation would be overcome by gene therapy which can permeably delete a specific gene at genomic level, but the use of virus raises safety concerns particularly in the clinical setting. Thus, this project invented a novel virus-free method that can tumor-specifically target any pathogenic gene for inhibiting cancer at transcriptional level in a reversible manner. In the application, a plasmid expressing shRNA specifically for targeting the gene expression at the transcriptomic level is customized, then they are precisely delivered to the tumor tissues using an ultrasound-guided microbubble mediated system. The project has completed tests in experimental cancer models including melanoma, lung carcinoma, hepatoma, and breast cancer, which clearly demonstrate its anticancer efficiency and safety.

在生物信息學和分子分析技術的幫助下，科學家近年已找出多種致癌基因，但由於缺乏針對這些基因的抑制劑，臨床轉化發展受限，現今的癌症治療效果仍然未能令人滿意。儘管通過基因療法可以把基因修改並導入患者體內，惟一般基因療法均使用病毒為載體，存在安全風險。因此，本項目發明了一種非病毒性抗腫瘤基因新療法，制定帶有特定shRNA的轉載體，以超聲微泡系統將目的基因精確地到導入腫瘤組織，在轉錄層面上抑制任何致癌基因。項目已完成黑色素瘤、肺癌、肝癌和乳腺癌等的實驗性癌症模型測試，證明此療法能安全、有效抗癌。

	Conventional method 傳統方法	Our method 我們的方法
Safety 安全性	· Delivery by virus 透過病毒傳遞 · Permanent change 為身體帶來永久影響	· Virus–free 非病毒性 · Reversible 可逆轉
Flexibility 靈活性	· Genomic level 基因組層面 · Cannot target post–transcriptional level 無法針對轉錄後的狀態	· mRNA level 信使核糖核酸層面 · Can design for any new gene isoforms 可因應任何新的基因異構物
Precision 準確性	· Relatively low 相對較低 · Systemic diffuse 擴散到全身 · Affect all tissues 影響所有組織	· High 高 · Tissue–specific 攻擊特定組織 · Release in tumor 只在腫瘤中釋放

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Funded by Innovation and Technology Commission, University Grants Committee, Faculty Innovation Award (Medicine, CUHK), State Key Laboratory of Translational Oncology (CUHK), Guangdong Science and Technology and The Lui Che Woo Institute of Innovative Medicine
由創新科技署、大學教育資助委員會、香港中文大學醫學院創新科研獎、轉化腫瘤學國家重點實驗室（香港中文大學）、廣東省科技廳及呂志和創新醫學研究所資助

HUMAN FETAL STEM CELL SECRETOME CONTAINED MEDICAL DRESSING PROMOTING SKIN WOUND HEALING

載有人胎兒幹細胞分泌物質的醫用敷料促進皮膚傷口癒合

Production of Human Fetal Stem Cell Secretome and Applications
人胚兒來源幹細胞分泌物質體生產過程及應用示意圖

Fetal stem cell secretome is a unique source with high regenerative properties. We invented a powder which contain stem cell secretome and nanoparticles with antiaging and regenerative properties. To cite an example, with a patented manufacturing and quality control process, we invented a medical dressing that contains secretome to promote diabetic skin wound healing. Based on the *in vitro* and *in vivo* study results, the effectiveness of the dressing is remarkable.

人胚兒幹細胞的分泌物質體具有高度促進組織再生的能力。本項目研發出一種包含幹人胚兒細胞分泌蛋白質體及納米顆粒的載體，可以有效對抗細胞衰老和促進組織再生。利用我們的專利保護的生產及質量控制的方法，我們成功載製造出載有人胎兒幹細胞分泌物質的醫用敷料，並證明這種敷料可加速糖尿病足患者的皮膚傷口癒合，在體外和體內的研究結果均顯示其卓越效用。

Uniqueness and Competitive Advantages

- Use of bioreactor to increase the production rate of secretome for 10 times (compared with culture dish)
- Use of PLGA nanoparticle to achieve slow-release in a capsule – smaller dose thus lower cost (much cheaper than commercial golden standard PDGF-BB)
- Easy to store and transport
- A safe form of stem cell therapy in form of off-the-shelf products

特點及優勢

- 使用生物反應器生產分泌物質體，生產率提升10倍（與培養皿相比）
- 採用聚乳酸甘醇酸納米顆粒，有效延緩膠囊釋放時間，減少劑量和降低成本（比業界黃金標準的血小板衍生生長因數更經濟）
- 容易存放及運輸
- 一種新型的「拿來即用」的幹細胞產品，比現有幹細胞產品安全

Patent

2 Patents Filed in China

專利

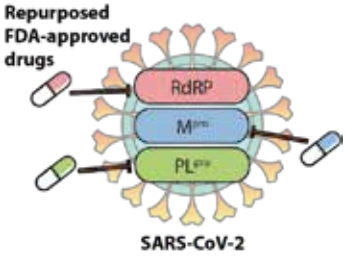
兩項中國發明專利

Prof. LI Gang 李剛教授

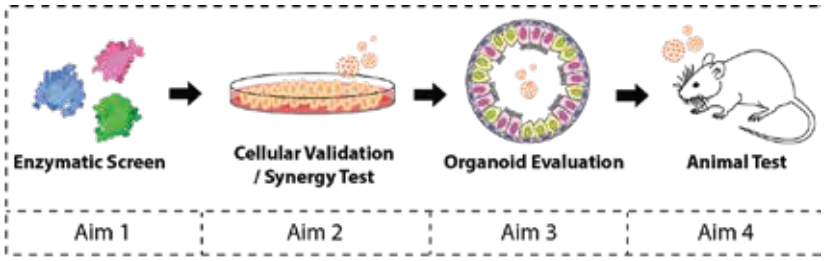
Department of Orthopaedics and Traumatology
矯形外科及創傷學系

DRUG REPURPOSING FOR COVID-19 TREATMENT

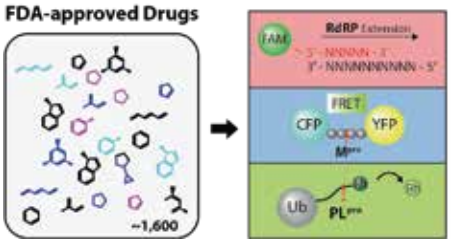
舊藥新用以治療新冠肺炎



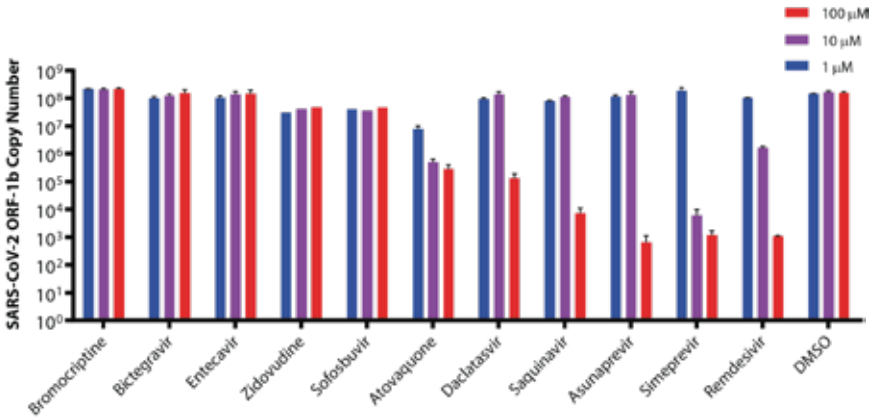
Drug Screening against three different viral proteins to simultaneously inhibit the virus
針對三個病毒蛋白作出藥物篩選以同時對抗新冠肺炎病毒



Drug Screening and evaluation in different models of COVID-19
針對不同新冠肺炎病毒進行篩選及評估



Three biochemical assays for testing the inhibitory activity of 1,600 FDA-approved drugs
三個生物化學測試去斷定一千六百個已知藥物的抑制效果



Results of 10 FDA-approved drugs against viral replication in cellular models
十種已知藥物對病毒在細胞中的抑制作用

The recent outbreak of coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus, is a global threat to human health. However, there are currently no drugs for treating this devastating disease. The existing drug, remdesivir, has only one known protein target and is prone to drug resistance. Using *in vitro* screening and biochemical characterization, we identified the several FDA-approved drugs, such as the hepatitis C virus (HCV) protease inhibitor simeprevir, as promising candidates for treating COVID-19. Simeprevir exhibits a similar suppression efficacy against SARS-CoV-2 viral replication as remdesivir and synergizes with remdesivir *in vitro* which lowers effective dose. Mechanistically, we showed that simeprevir inhibits both of the main protease (Mpro) and RNA-dependent RNA polymerase (RdRP) and this drug has known pharmacokinetics. Our results thus reveal unexpected viral protein targets of this drug and provide preclinical rationale for the combination of FDA-approved drugs and remdesivir for the pharmacological management of COVID-19 patients.

新冠肺炎肆虐全球，但仍然缺乏新冠肺炎治療藥物，而現時用作使用治療的瑞德西韋亦只有一個標靶蛋白，容易產生抗藥性。透過細胞及蛋白實驗，我們發現幾種可以用於治療新冠肺炎的藥物，例如司美匹韋。司美匹韋在細胞實驗展現了媲美瑞德西韋的病毒抑制效果，並與瑞德西韋有協同效應，能降低所需藥量。原理上，司美匹韋能夠抑制病毒的主要蛋白酶及RNA複製酶，其藥物動力學也是已知的。因此，我們不但發現這種藥物有多個蛋白標靶，更初步證實了已知藥物與瑞德西韋的組合可用於新冠肺炎患者上。

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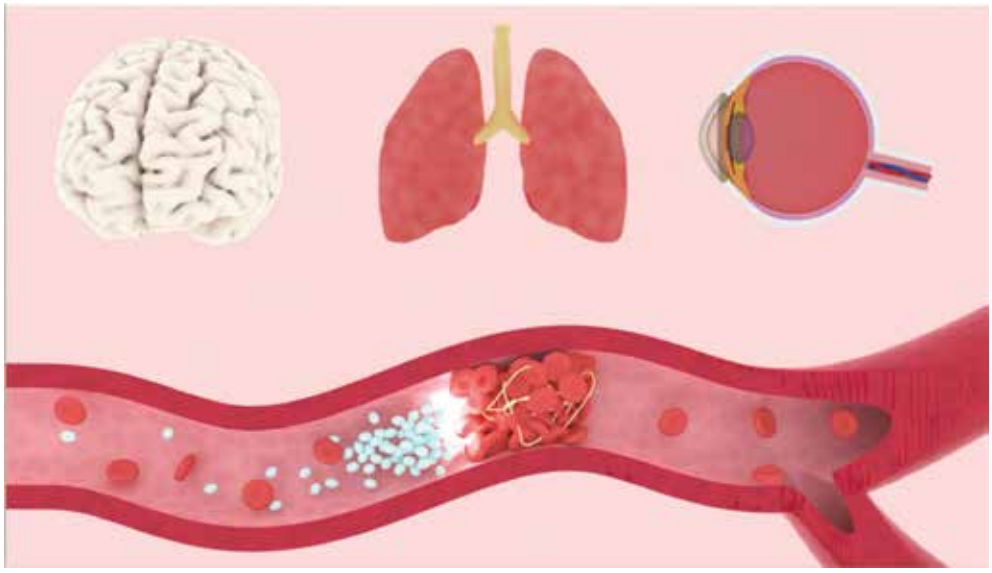
School of Pharmacy
藥劑學院

Funded by The Chinese University of Hong Kong and The Croucher Foundation
由香港中文大學及裘槎基金會資助

Collaboration with The University of Hong Kong, Hong Kong Baptist University, Beckman Research Institute, The Hong Kong Polytechnic University, Goethe University Frankfurt, Academia Sinica and Université d'Aix-Marseille
合作夥伴為香港大學、香港浸會大學、貝克曼研究所、香港理工大學、法蘭克福大學、中央研究院及艾克斯-馬賽大學

NEW STRATEGY FOR THE STUDIES OF MICROROBOTIC SWARMS AND THEIR MEDICAL APPLICATIONS IN HUMAN BODIES

新策略預測仿生微型機械人集群行為　助推進人體醫學應用



A conceptual illustration of microrobotic swarm for active delivery and localised therapy *in vivo*
(Credit: Xingzhou Du from Professor Zhang Li's laboratory)
微納機械人集群在人體內進行遞送及局部治療示意圖
（由張立教授實驗室杜星洲提供）

To apply the microrobotic swarms for medical applications in the human body, the generation and navigation behaviours of microrobotic swarms in bio-fluids, such as blood and vitreous humour, need to be investigated. Different from the relevant research that conducted in water before, this project categorised magnetic active swarms into three types, and individually investigated the generation and navigation behaviours of two types of the swarms in bio-fluids. The influences of bio-fluids, such as different viscosities, ionic strengths and mesh-like polymeric structures on microrobotic swarms were studied. A new strategy has been subsequently proposed to select the optimised swarms in different bio-fluids based on their physical properties.

The good agreement between the prediction and the experimental results fully validated the strategy. In high-viscosity fluids (such as the vitreous humour inside the eyeball), medium-induced particle swarms are more stable; while in fluids with high ionic strength (such as the gastric acid inside the stomach), magnetic field-induced swarms have better performances. It is also notable that both types of microswarms can be generated in the blood plasma and the whole blood. We are currently exploring the opportunities of using the microrobotic swarm for the minimally invasive treatment in vascular system as well as in the other confined and hard-to-reach regions inside the human body. Meanwhile, the electromagnetic system for autonomous control of the microrobotic swarm at the human scale are being developed.

如要將微型機械人集群應用於人體醫學應用，應先充分了解它們在生物流體（例如血液及眼球內的玻璃體等）中的形成和運動行為。有別過往在水中進行的的研究，本項目將磁性活動集群分為三種類型，分別研究了兩種類型的活動集群在生物流體中的形成和運動行為，並系統地分析了生物流體的粘度，離子強度和內部高分子形成的孔隙結構等各項物理特性對微型機械人集群的影響，從而總結並提出了一套新穎的策略，用於預測不同種類微型集群機械人在各種生物流體中的行為。

我們通過多次實驗，成功驗證了該策略的可行性。在高粘度生物流體體系中（比如眼球的玻璃體），基於流場生成的磁性粒子集群會較為穩定；而在高離子強度的液體中（比如消化道的胃酸），基於磁場生成的集群的表現會更好。在血漿和血液中，上述兩種類型的微機械人集群都可以生成和按指令運動。項目正在進一步探索微納機械人集群在醫療上的應用，如在血管和人體內其他狹小空間內的介入式治療，並會研發相應的磁場生成和控制系統。

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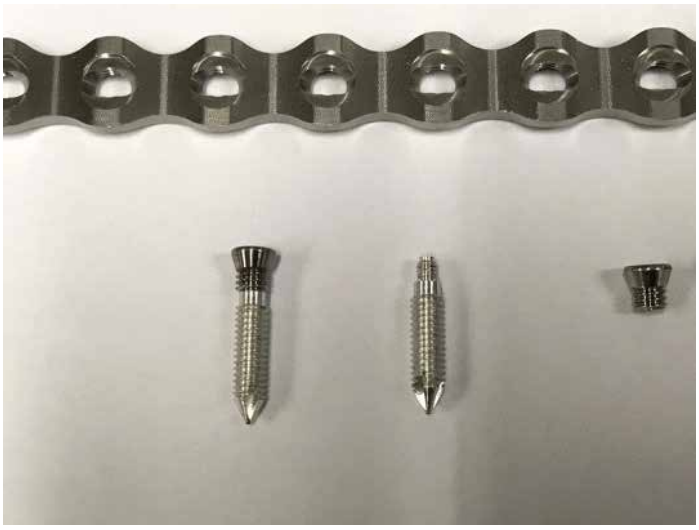
Funded by Research Grants Council, Innovation and Technology Commission, and the Research Sustainability of Major RGC Funding Schemes from CUHK
由研究資助局、創新科技署及中大研究事務委員會資助

NOVEL MAGNESIUM-BASED IMPLANTS FOR FRACTURE HEALING AND STEROID-INDUCED OSTEONECROSIS

用於骨折癒合和治療類固醇引致骨壞死的新型含鎂混合植入物



The fabricated locking plate and hybrid screw
鈦及鎂混合釘骨板組合

The screw with new design did not break off, compared to previous design, after the screws were completely inserted into the tibia of goat
與舊設計相比，新設計的螺絲釘在完全鑲入山羊脛骨後並沒有斷裂

Prof. QIN Ling 秦嶺教授

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Funded by Innovation and Technology Commission and Research Grants Council
由創新科技署及研究資助局資助

Collaboration with Zoltrix Material International Limited
合作夥伴為昶盛物料應用製品有限公司

CUHK research team has developed a novel hybrid system of Magnesium-containing implant for fracture fixation to enhance the healing quality by incorporating biodegradable Magnesium (Mg) into the conventional implants. Titanium-Magnesium plate-screw hybrid fixation system has been produced and tested in small animal model. Our result indicates that the system is a promising solution for clinical applications, especially for elderly patients with osteoporotic fracture. In this project, we have further modified the design of hybrid fixation system.

Locking plate and screws are introduced in current project instead of dynamic compression plate to maximize the osteogenic potential of Mg ions during degradation of Mg-based screws, via a novel periosteum-dependent mechanism, to promote bone formation and facilitates fracture healing. Surface modifications will be performed on the surface of Titanium (Ti) implants to have adequate mechanical properties for human applications.

中大團隊研發了一種專為骨折固定而設計的新型含鎂植入物混合系統，將可生物降解的鎂融合在常規植入物中以促進骨折修復。鈦及鎂混合釘骨板組合已在小動物模型進行測試，證明此系統是可於臨床應用的有效解決方案，尤其在治療老年骨質疏鬆引致的骨折。我們此次進一步改善混合固定系統的設計。

我們在本期項目中採用鎖定骨板和骨釘，取代動力加壓骨板，通過創新性骨膜依賴性機制，在最大程度上發揮含鎂螺絲釘在降解過程中釋放的鎂離子的促成骨作用，以促進新骨形成。同時，我們將對鈦骨板進行表面處理，以獲得足夠的力學強度滿足臨床使用需要。

Uniqueness and Competitive Advantages

- Sufficient and desired mechanical strength for fracture fixation
- Enhancement of fracture healing
- Modifications based on commercially available implants
- Validated in large animals

特點及優勢

- 為骨折固定提供所需的力學強度
- 促進骨折癒合
- 基於市面上現有的植入物作修改
- 已在大型動物模型中進行測試及驗證

NOVEL MAGNESIUM - BASED COMPOSITE DEVICE FOR TREATMENT OF STEROID - INDUCED OSTEONECROSIS OF FEMORAL HEAD

用於治療類固醇引致股骨壞死的新型鎂基髖部空心支架複合裝置

Mg-based stent with holes in the shaft for injection of bone cement to repair osteonecrosis in the femoral head in emu
透過帶孔純鎂支架複合裝置注射骨水泥，用於修復鴯鵒的股骨頭壞死

Core decompression, the classic preservation treatment for steroid – associated osteonecrosis (SAON), only addresses biological environment of the necrostic head and cannot treat the collapse caused by the biomechanical failure of the femoral head. Prof. QIN Ling and his research team in CUHK have developed a Mg-based composite device of magnesium hip stents, with the rational of supporting the subchondral plate during structural reconstitution of the underlying cancellous bone, which can augment core decompression. Besides, the injectable bone cement may fill the gap through the holes on the perforated and cannulated stent, to maintain, consolidate and strengthen the support of the implant. In accordance with previous studies Mg ions released from the Mg-based implants during in vivo degradation may prevent the femoral head collapse. This device has been validated on large animal model of the bipedal emu.

髓芯減壓術是治療由類固醇引致股骨頭壞死的傳統方法，但這種方法只能針對壞死股骨內的生物環境，卻未能有效處理股骨的力學性能失效和塌陷。為解決這個問題，中大團隊開發了一款新型鎂基髖部空心支架複合裝置，它有效增強髓芯減壓的力學效應，適當地在軟骨下骨結構重建時支撐軟骨下板。另外，注射型骨水泥可透過裝置內的空心支架孔進行間隙填充，以達到維持、鞏固並加強植入物的支撐效果。根據早前的研究，鎂基植入物在人體內降解過程中會釋放出鎂離子，可防止股骨塌陷。此裝置已在雙足大型動物（鴯鵒）上進行試驗。

Uniqueness and Competitive Advantages

- Supporting the subchondral plate during structural reconstitution of the underlying cancellous bone, while filling the gap to augment mechanical strength
- Protecting against avascular necrosis and ischemia-reperfusion injury
- Preventing further collapse of femoral head via osteogenesis and angiogenesis effect

特點及優勢

- 在軟骨下骨結構重建過程中支撐軟骨下板，同時填充間隙以增強力學強度
- 對缺血性壞死和缺血再灌注損傷有保護作用
- 促進骨與血管生成，可防止股骨頭進一步塌陷

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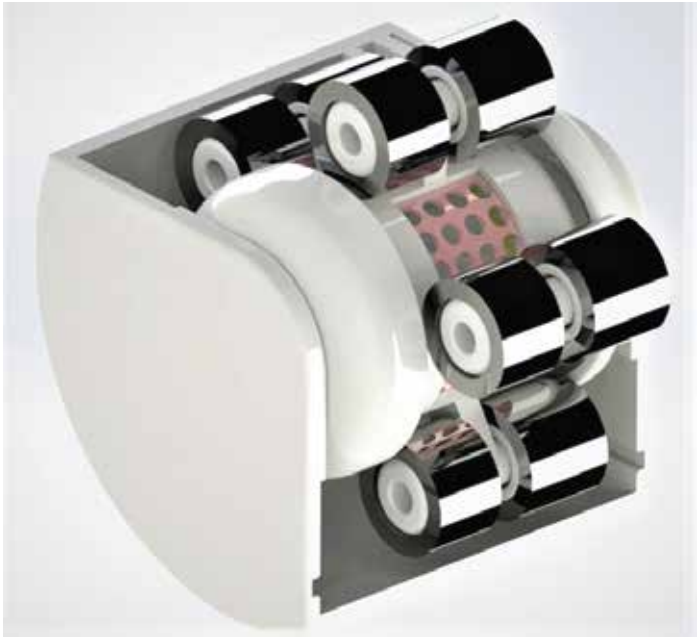
Funded by Theme-based Research Scheme of Research Grants Council
由研究資助局主題研究計劃資助

SMART THERAPEUTIC DEVICE FOR KNEE OSTEOARTHRITIS

智能膝關節炎治療儀

First generation of smart therapeutic device for knee osteoarthritis
第一代智能膝關節炎治療儀



Core components of the device
治療儀的核心組件

Many elderly suffer from knee osteoarthritis and related degenerative diseases. However, due to limited medical resources and population ageing, patients have to wait for months for physiotherapy treatment in hospital. To provide elderly a safe, reliable and effective personalized physiotherapy, our team has developed an easy-to-use smart therapeutic device for prevention and treatment of knee joint degeneration diseases. By combining low-level laser therapy, heat therapy, massage and AI technology, the device is a promising solution to relieve pain, stimulate musculoskeletal and promote joint tissue regeneration.

不少長者患有膝關節炎和相關的退化性疾病。但是，由於醫療資源有限和人口老齡化，患者必須等待多月才能在醫院進行物理治療。因此，我們開發了一種易於使用的智能膝關節炎治療儀，結合低強度激光、熱療、深層肌肉刺激及人工智能（AI）技術，為長者提供安全可靠和有效的個人化方案，以舒緩痛楚、刺激肌肉骨骼和促進關節組織再生，預防和治療膝關節症狀。

Uniqueness and Competitive Advantages

- World's first patented home medical therapeutic device to provide treatments on the popliteal fossa
- 3-in-1 rechargeable device with medical grade low-level laser therapy (LLLT), FDA approved thermotherapy, and deep tissue stimulation (compression roller) to promote tissue repairing, blood and lymphatic circulation, and reduce inflammation
- Equipped with AI technology offering auto-adjustment, such as speed, pressure, temperature, energy output of laser therapy and treatment duration
- Tested on 43 elderly participants in a 2-month clinical trial and achieved comparable results with clinical instruments in hospitals

特點及優勢

- 全球首個專利的家用膝關節醫療設備
- 具有醫用低強度激光，符合FDA規格的熱療和深層組織刺激（按壓與滾輪）的三合一充電式設備，可促進組織修復、血液和淋巴循環，並減少炎症
- 配備AI技術，自動調整治療儀的速度、壓力、溫度、激光治療的強度和治療時間
- 已進行兩個月臨床實驗，共43名長者參與，證明能有效治療膝關節炎症狀，效果媲美醫院臨床儀器

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Collaboration with MTcure Biotech Limited
合作夥伴為鎂天健康生物科技有限公司

Award: Gold Medal, 46th International Exhibition of Inventions Geneva

獎項： 第46屆日內瓦國際發明展金獎

AR + SENSOR + THERAPIST : AUGMENTED REALITY REHABILITATIVE TRAINING WITH REAL-TIME THERAPIST GUIDANCE AND SENSOR-EMBEDDED TOOLS

「AR實時指導治療師」結合「智能訓練工具」的復康訓練

The platform provides instant training instructions to users
智能復康訓練平台能即時指示用家進行訓練

Upper and lower limb exercise instruction and daily training report
上肢及下肢訓練指示及日常報告

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Department of Biomedical Engineering
生物醫學工程學系

Funded by CUHK Jockey Club HOPE 4 Care Programme
由中大賽馬會凝聚希望計劃資助

Physical Therapists (PTs) and Occupational Therapists (OTs) are striving to provide the best therapeutic exercises to patients, while applying numerous tools to facilitate their routine training. With a growing aging population worldwide, the demand for high quality rehabilitation will continue to increase. We therefore developed AR + Sensor + Therapist, a platform providing automated rehabilitative training with advanced AR technology and sensor-embedded rehabilitation tools to support therapists effectively.

物理治療師和職業治療師都致力於為患者提供最佳的復康治療，他們同時會使用多種工具來促進日常訓練。隨著全球人口老化增長，對於高質素復康訓練的需求將會持續增加。因此，我們開發「AR實時指導治療師」結合「智能訓練工具」的復康訓練的智能復康訓練平台，透過先進的AR擴增實境技術和在各色復康器材中嵌入智能感應器， 有效支援治療師的工作。

Uniqueness and Competitive Advantages

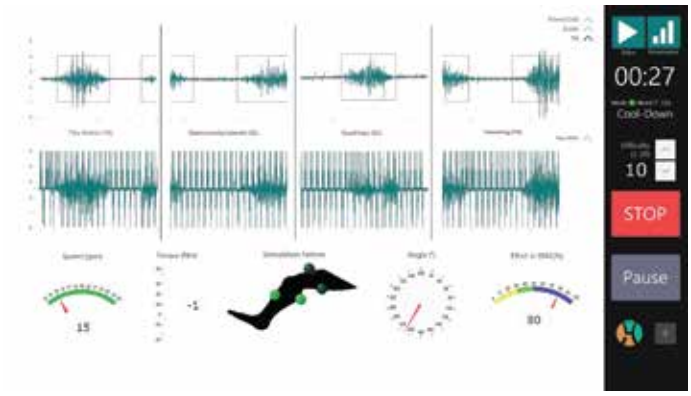
- Large variety of innovatively training activities designed by therapists with special sensor-embedded physiotherapy tools, more than 45 activities are provided
- Matches well with current routine training in clinics/hospitals
  Users can train at home/community centres by themselves under supervision
- Personalized training is designed, assembled and monitored by therapists
- 3D whole body tracking technology
- Instant, objective AR, visual and audio instructions
- User performance evaluation and intelligent scoring system
- Currently in use in 7 elderly/rehabilitation centres, and will be expanded to 14 in 2020, 40 in 2021-2022

特點及優勢

- 由治療師進行設計，提供超過45個多元化的創新復康訓練；復康器材中嵌入特別設計的智能感應器
- 無縫銜接目前診所 / 醫院的日常操作
- 用家可在治療師的遠程指導下，自行在家居 / 社區中心進行訓練
- 個人化訓練（由治療師設計、整合和監督）
- 3D全身動作捕捉技術
- 即時、客觀的AR擴增實境指示和反饋
- 用家表現評估及智能評分系統
- 現時已在7間長者/復康服務中心使用，2020年將擴大到14間，2021-2022年將擴大到40間

INTERACTIVE CYCLING SYSTEM WITH NEUROMUSCULAR ELECTRICAL STIMULATION FOR LOWER LIMB REHABILITATION

電刺激復康互動單車



Electromyographic (EMG) signals collected on the surfaces of four lower limb muscles
收集使用者下肢的肌電信號

Neuro-Muscular Electrical Stimulation (NMES) motor-assisted cycling system
電刺激復康互動單車

50 scenery videos from 29 different countries are provided
提供來自29個不同國家50多個風景視頻

Our Neuro-Muscular Electrical Stimulation (NMES), motor-assisted cycling system is designed for persons recovering from stroke or other lower limb functional disabilities. Electromyographic (EMG) signals collected on the surfaces of four lower limb muscles (i.e. Quadriceps, Hamstring, Gastrocnemius, and Tibialis Anterior) are used to modulate the cycling speed and neuro-muscular electrical stimulation intensity through a closed-loop control system, in which the adjustment will be based on quality of the user's muscle contraction patterns. The system could facilitate motor and brain re-learning for the recovery of motor function.

電刺激復康互動單車專為中風或其他下肢功能障礙康復者而設計，過程會收集使用者下肢的肌電信號(即股四頭肌、腘繩肌、腱、腓腸肌和脛骨前肌)。根據使用者的肌肉收縮時產生的肌電強度，系統會調節電機的轉速，並會以合適的電脈衝強度來刺激目標肌肉收縮，使其產出動力並協助持續的踩單車運動。這康復鍛煉不僅可以強化肌肉，還可訓練大腦重新學習肌肉協調。

Uniqueness and Competitive Advantages

- Real-time algorithms are used to determine whether the targeted lower limb muscles are activated by the user's voluntary intention at the correct cycling phase.
- Users with different muscle strengths and qualities can use our NMES cycling system, as EMG thresholds and maximum stimulation intensities are both individually adjusted.
- Therapists can choose any combination of the four lower limb muscles that requires active participation during the rehabilitative training.
- Smart filtering and data processing algorithms within our closed-loop control are used to remove stimulation artifacts and to improve surface EMG signal quality.
- More than 50 scenery videos from 29 different countries are provided, and the video speed can be modulated with the cycling speed to enhance user experience.
- Currently in use in 7 senior/rehabilitation centres, and will be expanded to 14 by 2020

特點及優勢

- 實時顯示並確定使用者是否自主地使用正確的下肢肌肉進行訓練
- 系統的肌電閾值和最大刺激強度可根據使用者的下肢肌肉狀況而設定
- 治療師可針對使用者的需要選擇不同的肌肉組合作訓練
- 有效過濾及消除不必要的信號，並改善表面肌電信號的質量
- 提供來自29個不同國家50多個風景視頻，並可以互動單車的車速來調節視頻速度以增強用戶體驗
- 目前全港有7間日間復康中心使用，到2020年將擴大至14間

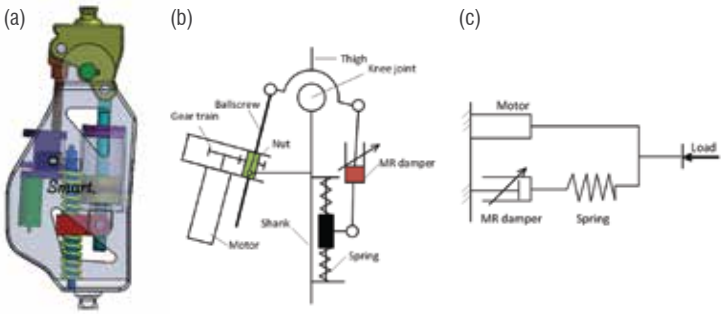
Prof. TONG Kai Yu Raymond 湯啟宇教授

Department of Biomedical Engineering
生物醫學工程學系

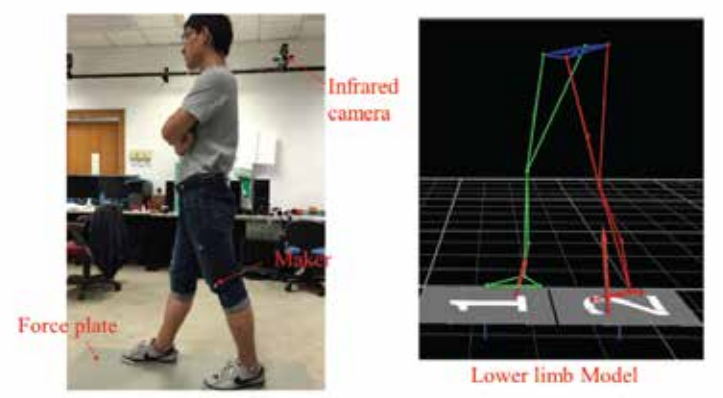
Funded by CUHK Jockey Club HOPE 4 Care Programme
由中大賽馬會凝聚希望計劃資助

SELF-POWERED SMART PROSTHETIC KNEE

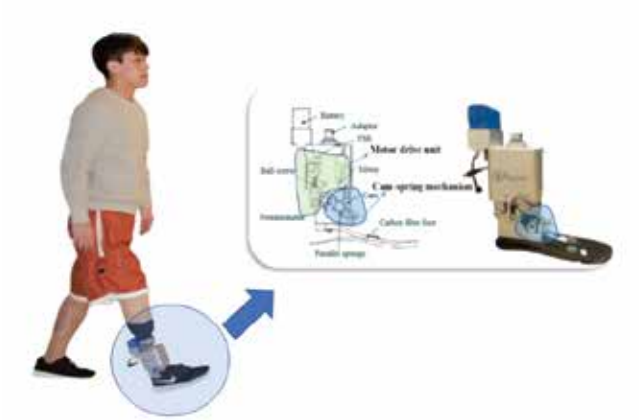
自供能智能膝關節義肢



(a) 3D Model of the smart prosthetic knee 智能膝關節義肢3維模型
(b) Geometric configuration of the prosthesis 義肢的幾何結構
(c) Model of the actuator in the smart prosthetic knee 智能義肢的驅動器模型



Measurement of human knee dynamics by a motion capture system
動態捕捉系統用於測量人體膝關節動力學特征



Below-knee amputee walking with the powered ankle-foot prosthesis
膝下截肢者穿戴動力踝足義肢行走

Prosthetic knees are the devices for helping trans-femoral amputees to regain locomotion ability. When compared with passive prosthetic knees, quasi-passive and powered prosthetic knees with the ability to govern the motion of prostheses can significantly improve the stability and safety, at the same time enable exceptionally natural and effortless gait, even on difficult terrains. However, the mobile power source constrains the development and widespread use of these type of prostheses in terms of limited endurance and inconvenient daily charging. In this project, to handle the power source issue, we propose a self-powered smart prosthetic knee. In another project targeting the needs of below-knee amputee, experimental results indicated that our powered ankle-foot prosthesis when compared with widely used passive prostheses can reduce users' metabolic cost by 15% and improve the symmetry of users' gait, reducing the users' effort required for walking.

膝關節義肢是一種用於幫助膝上截肢者重獲運動功能的醫療輔助裝置。與被動義肢相比，具有自身運動控制功能的半主動及主動義肢能明顯提高佩戴者的行走穩定性和安全性，同時讓他們能在複雜困難的地形上輕鬆行走。然而，現有的移動電源設計限制了這兩類義肢的發展和廣泛應用。為解決電源問題，這項目研發出可以自動供電的智能主動膝上義肢。於另一個針對膝下截肢者需要的動力踝足義肢項目中，臨床測試顯示，這新穎設計相比被動踝足義肢，穿戴者的能量消耗降低達15%，同時有效提高步態對稱性，減輕行走負擔。

Uniqueness and Competitive Advantages

- Design with the consideration of motion and biomechanics
- An actuator consisting of smart materials, a DC motor, a MR damper, and springs is designed for driving the prosthesis, in which the energy consumption can be reduced significantly
- Energy harvesting technologies are employed in the prosthetic knee, solving the limitation of batteries and inconvenient daily charging
- The design of our ankle-foot prosthesis has been filed as a US patent (granted) and a China patent application

特點及優勢

- 配合人體膝關節的運動和生物力學特徵
- 驅動器採用智能材料、直流馬達、磁控阻尼器和彈簧機制，有效降低義肢的功耗
- 採用能量回收技術，擺脫電池的束縛及免於頻繁充電
- 動力踝足義肢項目已申請了美國專利（已授權）和中國專利

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Funded by Innovation and Technology Commission
由創新科技署資助

Partners include Tai Po Hospital and Prince of Wales Hospital
合作夥伴包括大埔醫院及威爾斯親王醫院

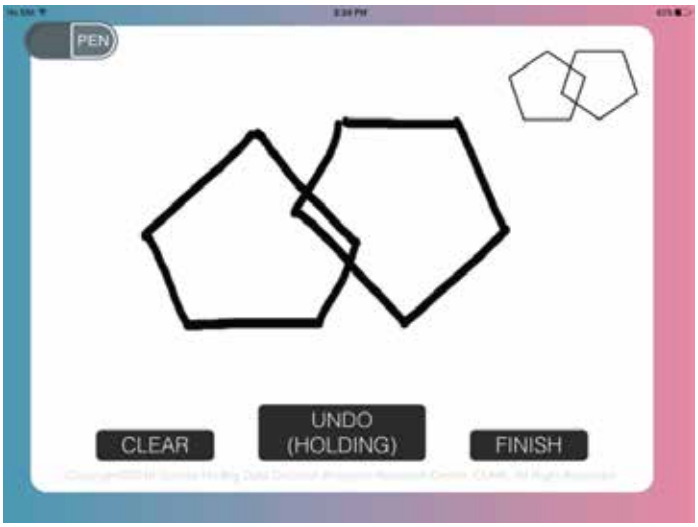
- Gold Medal, 46th International Exhibition of Inventions of Geneva
- Champion, Prof. Charles K. Kao Student Creativity Awards (Postgraduate Group)

- 第46屆日內瓦國際發明展金獎
- 高錕教授學生創意獎-研究生組冠軍

DEMENTIA SCREENING IN 30 SECONDS WITH AUTOMATED DIGITAL DRAWING PLATFORM

認知障礙症30秒快速篩查：電子繪畫平台

The drawing platform was used in community screening programs targeting the aged population
繪圖平台用於針對老年人群的社區篩查計劃



Drawing a simple figure to detect risk of dementia
繪畫一個簡單的圖案來檢測罹患認知障礙症的風險

Patent

USA - 1 Filed
China - 1 Filed

專利

於美國及中國註冊

Prof. TSOI Kam Fai Kelvin 蔡錦輝教授

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

Funded by The Office of Research and Knowledge Transfer Services (ORKTS), CUHK
由香港中文大學研究及知識產權服務處資助

With the rapidly growing population of elderly and rising life expectancy, the incidence of dementia amongst elders is rapidly increasing. Although there is currently no cure for dementia, early detection of cognitive impairment can greatly delay the onset of the disease. Current pen-and-paper methods of dementia screening, such as MMSE, is time consuming and labour intensive, as well as requires the supervision of healthcare professionals. However, our newly developed software utilizes artificial intelligence to quickly analyze real-time drawings of users through clinically validated models, in order to analyze brain activity and screen for dementia.

隨著人口老齡化加快和人類平均壽命的增長，認知障礙症的新發病例不斷增加。目前尚無治癒認知障礙症的方法，但儘早發現認知障礙可延緩癡呆症的發作。現在的認知障礙症篩查例如MMSE等紙筆測試需要由專業醫護人員監督進行，人力及時間需求都很大。我們研發的軟件利用人工智能實時分析用戶的繪畫行為，從而根據當時的大腦活動數據篩查認知障礙症。

Function

- Screen for risks of dementia through simply drawing activities
- Analyze screening results and provide follow-up recommendations

Product Features

- Highly accurate AI analysis based on real-time responses
- User-friendly, cost effect, and does not require the supervision of healthcare professionals
- Time efficient (Takes roughly 1-2 minutes, as opposed to 20-30 minutes using traditional pen-and-paper screening methods)
- Can be integrated into various settings (e.g. kiosks) and different softwares (e.g. mobile app or website)

功能

- 繪畫簡單圖像，偵測認知障礙症風險
- 根據篩查結果作相對應跟進

產品特色

- 運用人工智能，實時分析腦部反應，準確度高
- 簡單易用，無需醫護人員協助
- 方便快捷(繪畫平台檢測需時1-2分鐘，而傳統認知障礙檢測需時20-30分鐘)
- 可應用於任何硬件及軟件 (流動應用程式或網站)

HEALTHCAP 拍健

THE ONLY HEALTH MANAGEMENT PLATFORM IN HONG KONG CAPTURING HEALTH DATA WITH A SNAPSHOT OF MOBILE DEVICES

全港唯一利用流動裝置拍攝功能記錄健康數據的平台

One click to record your blood pressure readings
一鍵記錄血壓數據

Report and dashboard to empower individuals and their family members for self-monitoring
以健康報告和圖表等形式推動個人及其家庭成員作自我監察和管理健康

For more information, please visit www.healhtcapture.com.hk
如欲了解更多，請瀏覽 http://www.healthcapture.com.hk

Available on the App Store
GET IT ON Google Play

Download Now
立即下載

Prof. TSOI Kam Fai Kelvin 蔡錦輝教授

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

Funded by The Office of Research and Knowledge Transfer Services (ORKTS), CUHK
由香港中文大學研究及知識產權服務處資助

HealthCap is a mobile App that serves as a chronic disease management platform, providing a convenient way to log and manage blood pressure data. Users can record their health data with a simple snapshot using the cameras on their mobile devices. Equipped with state-of-the-art image recognition techniques, utilizing advanced optical character recognition (OCR) technology as well as deep learning, HealthCap can instantly recognize and record blood pressure data taken on a blood pressure monitor. Applying the big data analytic engine developed by the research team of The Chinese University of Hong Kong, HealthCap is able to analyze blood pressure records and provide comprehensive and insightful health reports to its users.

拍健應用程式為一個慢性疾病管理平台，為記錄和分析血壓數據提供了便利的方法。用家只需使用流動裝置的相機快門，即可把血壓紀錄上傳至雲端。拍健使用先進的光學字符識別技術及深度學習技術的圖像識別系統捕捉和記錄血壓計上的讀數，並透過中大研究團隊研發的大數據平台來分析用家的血壓數據，提供個人健康評估。

Function

- Capture and convert blood pressure data into digital format with a snapshot using mobile phones (or mobile devices)
- Analyze blood pressure data, report blood pressure risk alerts and provide health summaries and reports
- A “one-to-many” application platform to support blood pressure record management across multiple use in one single account

Product Features

- Compatible with most blood pressure monitors available in the market, even non-Bluetooth enabled ones
- Useful health reports endorsed by professors in the Faculty of Medicine from the Chinese University of Hong Kong for providing insightful health data for medical practitioners
- One versatile application meeting the needs of individuals, families, clinics and institutions
- Extended supports to both blood pressure and blood glucose management with the HealthCap Premium version

功能

- 突破傳統血壓記錄方法，利用流動裝置拍攝功能記錄血壓狀況
- 分析血壓數據，預設血壓風險提示功能，提供圖表及健康報告
- 「一對多」智能管理平台，支援一名用戶為多名用家管理血壓紀錄

產品特色

- 適用於傳統血壓計，無需額外花費購買裝置
- 健康報告獲香港中文大學醫學院教授認可，有助醫護人員更了解個人身體狀況
- 適用於個人、家庭、醫療及長者服務機構作健康管理之用
- 拍健（加強版）同時支援血壓及血糖紀錄

JOCKEY CLUB COMMUNITY eHEALTH CARE PROJECT

賽馬會e健樂電子健康管理計劃

The older adult measured health data at eHealth station at elderly centre
長者於長者中心內的電子健康站量度健康數據

Older adults enjoyed using health devices at elderly centre under the instruction of staff
在職員指導下，長者於長者中心內使用健康設備

Prof. WONG Yeung Shan Samuel 黃仰山教授
Prof. TSOI Kam Fai Kelvin 蔡錦輝教授
The Jockey Club School of Public Health and Primary Care
賽馬會公共衞生及基層醫療學院

Prof. WOO Jean 胡令芳教授
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香港中文大學老年學研究所

Initiated and funded by The Hong Kong Jockey Club Charities Trust
由香港賽馬會慈善信託基金策劃及捐助

Partners include CUHK Jockey Club Institute of Ageing, the Senior Citizen Home Safety Association and 23 participating Non-Governmental Organizations ("NGOs")
合作夥伴包括香港中文大學老年學研究所、長者安居協會及23間非政府組織

The population in Hong Kong is ageing, and the number of older adults with chronic conditions will continue to grow. The project is the first territory-wide elderly care support project which integrates health management technology, community care and professional support. We aim at promoting preventive healthcare among the older adults and empowering them in health management. Besides, the project aids the transformation of elderly centres into community hubs on healthy ageing and to pioneer digital health solutions through a new developed digital portal.

香港老年人口持續增長，長期病患者人數日趨增加。本計劃透過全港首個結合電子健康管理技術、社區關懷及由專業團隊跟進的服務模式，冀望提升長者的健康管理能力，促進長者保健安康。計劃同時協助長者中心成為首個了解長者健康和社會需要的接觸點，並透過大數據分析本地長者的健康狀況和模式。

Uniqueness and Competitive Advantages

- Tele-care Programme: regular health measurement of blood pressure, blood glucose and weight
- Nursing caring call and regular outreach visits by a multi-disciplinary team (nurses, health workers, social workers)
- Older adult participants - Members can log in to the eHealth station and conduct regular measurement at the elderly centres with smart cards
- Health data is transferred to nursing team by cloud technology for proactive monitoring and follow-up
- Digital health portal and devices to keep track on participants' blood pressure readings, BMI, physical function and cognitive capability
- Examine possible health risks of the older adults and find out the association between daily health readings and the long term health-status

特點及優勢

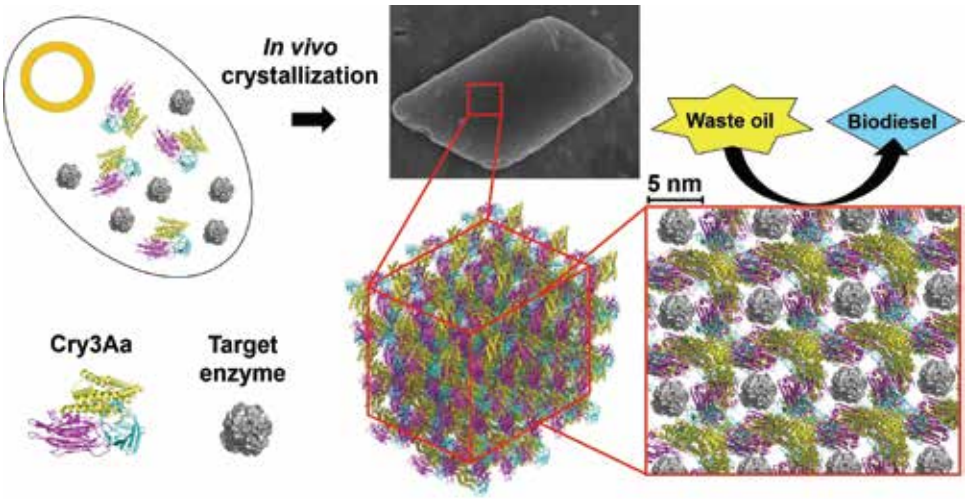
- 遠程健康關懷服務 - 定期量度血壓、血糖和體重
- 跨專業團隊 (護士、保健員及社工) 提供關愛電話跟進服務及定時外展探訪
- 長者能透過智能卡在長者中心登入電子健康站
- 透過雲端技術傳送健康數據到護士團隊作監察和跟進
- 協助監察參加者的血壓、身高體重指數、身體活動能力及認知能力
- 檢視長者的潛在健康風險並找出日常健康指數和長遠健康狀況的相互關係

ENVIRONMENTAL & GREEN TECHNOLOGIES

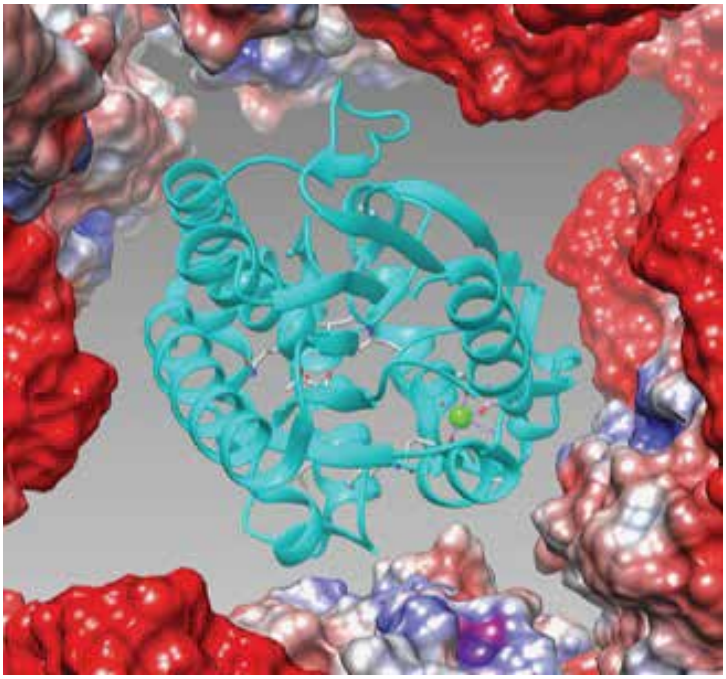
環保和綠色科技

NOVEL TECHNOLOGY FOR GENERATING BIOCATALYSTS FOR BIODIESEL PRODUCTION

從細菌生產生物催化劑新技術



Schematic showing how Cry3Aa crystals produced in bacteria cells trap an enzyme
在細菌細胞內產生的Cry3Aa晶體，將生物酶藏於晶體孔隙中



Close-up view of an enzyme molecule trapped inside the Cry3Aa crystal pore
藏於Cry3Aa晶體孔隙中的生物酶

Biodiesel is an emerging renewable fuel commonly used in blends with petroleum diesel, which produces less pollutants than traditional pure diesel. It is typically produced from cooking oil, in which requires rigorous pretreatment resulting in water pollution. Enzymes can also act as a catalyst to produce biodiesel. In fact, enzymes generate less waste and require lower temperatures than traditional base catalysts. Unfortunately, in their current state, enzymes are too expensive to compete with base catalysts. This is because enzymes require tedious purification procedures and subsequent immobilization to be easily recycled and reused.

This project developed a novel method to overcome these hurdles. The approach involves trapping enzymes in protein crystals produced naturally in bacteria, and then isolating these crystals in a single step. This greatly simplifies the isolation procedure and reduces cost. When an enzyme and a special protein called Cry3Aa were produced together in the same bacteria cell, the resulting crystals contained millions of copies of the enzyme trapped inside the pores. These crystals could be easily isolated and applied to produce biodiesel. Importantly, entrapment of this enzyme inside the Cry3Aa crystals made it much more stable, allowing it to be used in multiple cycles of biodiesel production from waste cooking oil.

生物柴油是新興的可再生燃料，與傳統柴油混合使用，可降低引擎廢氣排放。生物柴油由各種食用油脂加以處理而成，傳統提煉方法過程涉及加熱等程序，亦會產生廢水污染問題；另一種提煉方法則使用酶作催化劑，這種方法所產生的污染較少，但由於製作酶催化劑成本高、且要經過繁複的純化及固定化過程，導致酶催化生物柴油未能成為主流。

本項目發現可以利用蛋白質結晶的特性，將細菌合成的酶固定在晶體內，只需一個簡單步驟便能將晶體分離提取，大大簡化分離程序，降低成本。當一種名為Cry3Aa的特殊蛋白質與酶於同一細菌細胞內合成，這些Cry3Aa晶體便會將數以百萬計由細菌生產的酶分子收藏於其小孔內，尤如一個「酶收納袋」。這些晶體能保護具有活性的酶分子免於提取過程中受破壞，方便純化。而固定在蛋白晶體內的酶更為穩定，可以重覆使用於廢食油轉為生物柴油的催化過程。

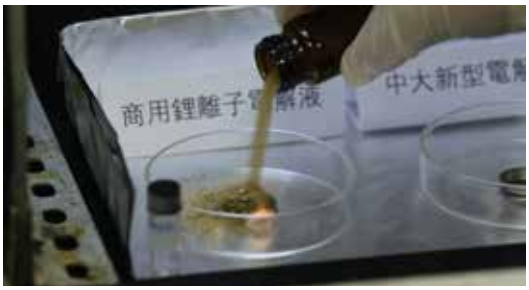
Prof. CHAN Michael Kenneth 陳文博教授

School of Life Sciences
生命科學學院

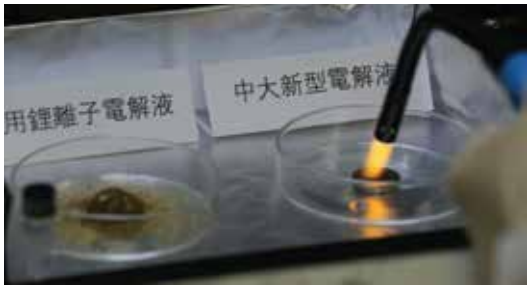
Funded by the Research Grants Council and Innovation and Technology Commission
由研究資助局和創新科技署資助

NOVEL AQUEOUS ELECTROLYTE ENABLES STABLE AND NON-FLAMMABLE AQUEOUS LI-ION BATTERIES

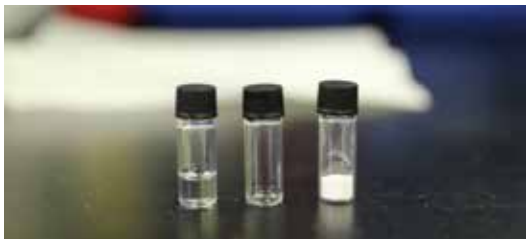
新型電解液為非易燃水系鋰離子電池提供穩定輸出



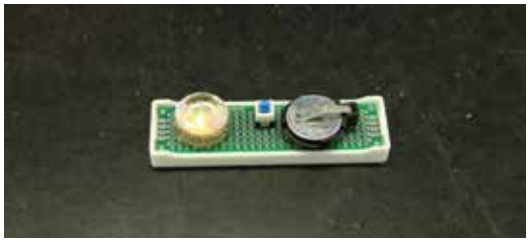
Organic Li-ion electrolyte ignites into flames
鋰離子電池有機溶液在燃燒



Molecular crowding electrolyte proved to be fireproof
中大新型電解液通過燃燒安全測試



Ingredients of CUHK molecular crowding electrolyte. PEG (left), pure water (middle), lithium salt (right)
中大新型電解液的成份有聚乙二醇（左）、純水(中)、鋰鹽(右)



LED light powered by a molecular crowding battery prototype
由中大新型水系鋰離子電池原型供電的發光二極體

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

Funded by Research Grants Council
由研究資助局資助

Electronic devices and gadgets are indispensable parts of our modern life. As a result of the rechargeable characteristics and stable energy output, Li-ion batteries have become the heart of these electronics. However, they still heavily rely on toxic and flammable organic electrolytes to produce power, and the serious safety hazards remain unsolved. In contrast, aqueous Li-ion batteries are non-flammable, but they have been suffering from low energy-density issues. Existing approaches to improve the output often involve the use of a large amount of expensive and toxic Li-ion salts to stabilise water molecules, which raises the issues of cost, toxicity and environmental sustainability.

Building on our previous research on aqueous Li-ion batteries, this project provides a new aqueous electrolyte for safe, low-cost and eco-friendly energy storage. We use poly (ethylene glycol) or PEG to replicate "molecular crowding" in the electrolyte, in which the activity of the water solvent is reduced. PEG is a water soluble polymer that can be easily incorporated into aqueous batteries. Using this novel stabilisation agent, a $LiMn_2O_4$ cathode and a $Li_4Ti_5O_{12}$ anode, we successfully e nhanced the performance of the batteries.

現今電子設備已成為生活中不可或缺的一部分，而鋰離子電池也因為供電穩定和可重複使用而成為電子產品的核心要素。然而，鋰離子電池的有機電解液仍然含有毒性及高度易燃，有機會引發致命事故。近年有研究利用水系電解液取代傳統有機電解液以解決易燃問題，但是電池受限於水電解，電壓和能量密度低。另外，利用高濃度鋰鹽來穩定水系鋰離子電池的方法會令成本大增及有高毒性的問題。

本項目在水系鋰離子電池的研究基礎上，研發出一種更安全、低成本、更環保的新型電解液。為取代高濃度鋰鹽或離子化合物，我們利用一種名為「聚乙二醇」的水溶性聚合物，有效在電解液擬造出「分子擁擠」現象，以抑制水分子活性。另外，設計以錳酸鋰（$LiMn_2O_4$）為正極、鈦酸鋰（$Li_4Ti_5O_{12}$）作負極材料，成功地在低鹽濃度的情況下提升電解液性能。

Uniqueness and Competitive Advantages

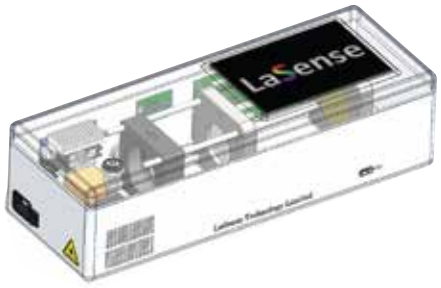
- Expanded the aqueous electrolyte stability window to 3.2 Volts
- Demonstrated stable battery operation for delivering a high energy density of 75-100Wh per kg over 300 cycles
- The operational voltage can be further improved to over 4.0 Volts with gel coating
- The common side reactions in aqueous Li-on batteries (hydrogen / oxygen evolution reactions) are virtually eliminated
- A flammability test was conducted to prove the fireproof characteristics of the novel electrolyte, significantly improving the safety of Li-ion batteries

特點及優勢

- 穩定電壓視窗擴大到3.2伏特
- 經過300次充放電，能量密度穩定在每公斤75至110瓦特小時
- 透過凝膠包覆最高電壓更可達到4.0伏特
- 消除水系鋰離子電池的常見問題，包括析氫/氧的化學反應
- 接觸明火後不會燃燒，大幅提高安全性

HIGH-SENSITIVE GAS SENSING AND CONTROL SYSTEM
高靈敏度氣體傳感和控制系統

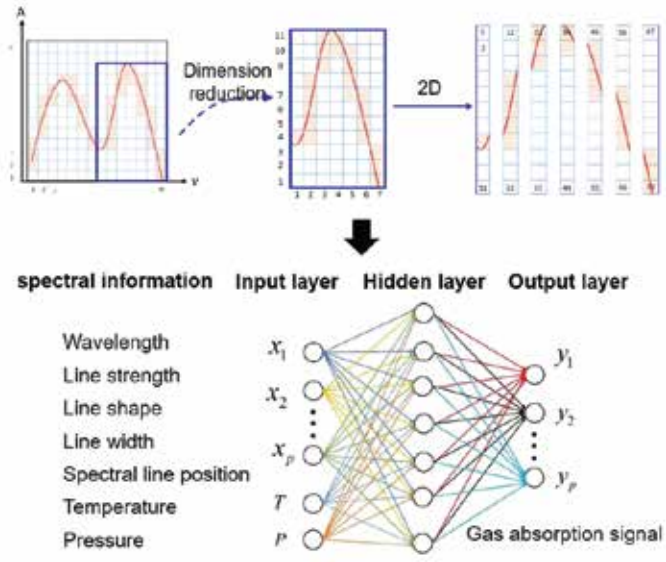
EFFECTIVE REAL-TIME DETECTION AND MONITORING OF GASEOUS POLLUTANTS
高效的氣體污染實時監測及控制方案



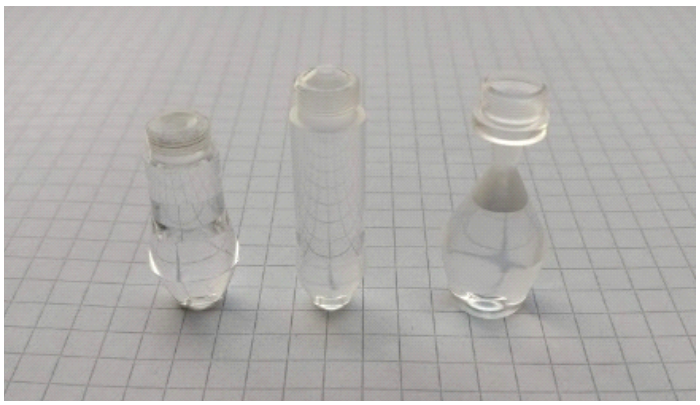
Overall sensor system
傳感器系統整體圖

Back view of sensor
傳感器背面

Packaged sensor
氣體傳感器



AI machine learning spectral analysis
AI機件學習光譜分析



Ultra-light optics with 3D printing
3D打印的超輕光學器件

Industrial processes, such as thermal power generation and petrochemical production, involve emission of harmful gaseous chemicals and a growing number of companies are taking corporate environmental responsibility to take initiatives in monitoring, controlling and preventing pollutant emission. To enable timely and effective detection of gaseous pollutants in the industrial processes, we have developed a high-sensitive gas sensing and control system. It combining advanced laser spectroscopy technology (TDLAS and photoacoustic) and AI algorithm. The system provides the type, concentration, temperature and pressure of multiple gas components such as CO, NOx, NH_3, SO_2 in a complex environment in real time. It also gives feedback to the control terminal through wireless transmission.

許多工業如熱力發電行業和石化行業，均會在工業過程中產生多種不同的有害氣體污染物，愈來愈多企業主動承擔社會環境責任，採取積極措施監測污染物信息、進而控制污染物排放。為了向工業過程提供及時有效的污染氣體信息，我們研發了一套高靈敏度氣體傳感和控制系統。該系統利用最新激光光譜技術，結合人工智能算法，提供CO, NOx, NH_3, SO_2等多種主要氣體的類型、濃度、溫度、壓力等實時信息，並通過無線傳輸技術反饋到控制端。

Our system provides

- Simultaneous detection of multiple target gases generated by thermal power plants, industrial boilers and oil companies
- Ultra-high sensitivity required in industrial processes (sub-ppb)
- Real-time online sensing (response time < 3 s)

我們的發明提供

- 熱電廠、工業鍋爐和石油公司產生的多種目標氣體同時檢測
- 合乎工業過程需要的超高靈敏度 (sub-ppb)
- 實時在線檢測 (響應時間 < 3 s)

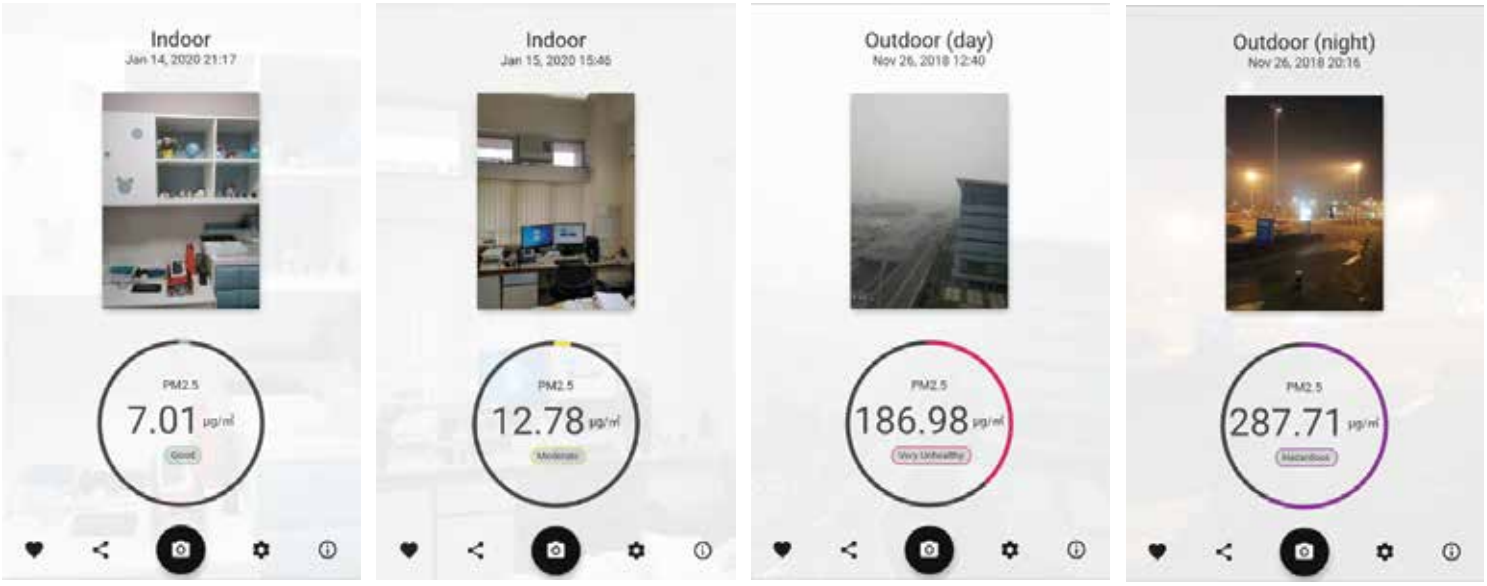
Prof. REN Wei 任偉教授

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

Funded by Innovation and Technology Commission
由創新科技署資助

PHOTOAIR: MEASURING INDOOR AND OUTDOOR PM2.5 WITH A MOBILE PHONE

PHOTOAIR: 以智能手機量度室內外PM2.5細懸浮微粒濃度



PhotoAir can measure PM2.5 concentrations indoor or outdoor, day or night
PhotoAir可全日量度室內外的PM2.5細懸浮微粒濃度

By simply taking a photo using a mobile phone, PhotoAir can measure PM2.5 concentrations indoor or outdoor, day or night in real time regardless of weather conditions. These functions are achieved through the development of advanced computer vision and artificial intelligence algorithms in the light of physical optics to extract complex features embedded in the photo accounting for different illumination attenuations. With real-time alerts on pollution levels and forecasting tools, users can then keep track of their exposure to PM2.5 to make informed travel plans by avoiding heavily polluted areas.

不論日夜和各種天氣狀況，只要擁有一部配備攝影功能的智能手機，即可透過PhotoAir軟件輕鬆獲得即時室內外PM2.5細懸浮微粒濃度資訊。受惠於電腦視覺及人工智能算法的發展，先進科技讓軟件可在不同光度的照片中以物理光學進行分析，從而獲取複雜的數據。根據軟件內的即時空氣污染警報和預測工具，用戶可紀錄他們曝露於PM2.5細懸浮微粒的時間並提前計劃行程，避開高污染地區。

Uniqueness and Competitive Advantages

- Indoor or outdoor; day or night
- Real-time
- 90% accuracy
- Simple and convenient to use

特點及優勢

- 室內、室外；日間、晚間
- 即時
- 90%準確度
- 使用方法簡單方便

Patent

1 Patent Filed in China

專利

一項中國專利

Prof. HUANG Bo 黃波教授

Department of Geography and Resource Management
地理與資源管理學系

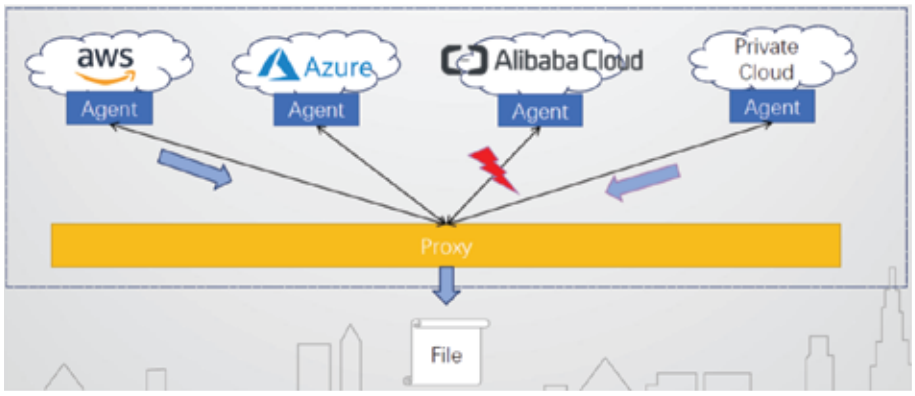
INFORMATION & COMMUNICATION TECHNOLOGIES

信息和通訊科技

SOFTWARE-DEFINED NETWORK-CODING-BASED STORAGE FOR GEO-DISTRIBUTED CLOUD DATA CENTERS

基於軟件定義網絡編碼存儲模式的地理分佈式雲數據中心

nCloud provides scalable storage by striping data across multiple nodes (servers) .
nCloud將數據分佈式儲存於多個終端(伺服器)，提供可擴展的數據儲存。



With our multi-cloud strategy, nCloud ensures data availibilty and reliability against unexpected cloud failures and vendor lock-in.
採取跨雲端技術，即使面對雲端失效或供應商鎖定的情況，仍能保持數據的可用性和可靠性。

Enterprises increasingly support hyper-scale data storage in production, yet providing performance and reliability guarantees for big data storage remains a non-trivial challenge. We propose a software-defined network-coding-based cloud storage system, called nCloud, that supports geo-distributed cloud data center storage with storage efficiency, performance, and fault tolerance in mind. nCloud adapts the network coding theory to specifically target major performance-critical operations. Its novelty is to address the hierarchical nature of geo-distributed cloud data centers, such that it first computes partially encoded results from the data stored in each local data center, followed by aggregating the partial encoded results across multiple data centers to obtain the final encoded data. We envision that our project findings will benefit the big data storage industry in general. nCloud supports applications including backup and archival storage, document management, virtual disk management *etc*.

企業在生產環境中逐漸支持超大規模數據存儲，然而如何保障大數據存儲的性能和可靠性依然是一個重大挑戰。我們提出了一個基於網絡編碼的軟件定義雲存儲系統nCloud，以支持地理分佈式雲數據中心存儲，並兼顧存儲效率、系統性能和容錯能力。nCloud將網絡編碼思想用於主要的性能相關操作。它的創新性在於將地理分佈式雲數據中心的層級特性與網絡編碼理論相結合，即首先在本地數據中心對數據進行局部編碼，隨後聚合多個數據中心的局部編碼數據，從而得到最終編碼數據。我們預期此項目的發現將有益於大數據存儲產業。nCloud支持檔案備份和存儲、文檔管理、虛擬磁盤管理等。

Uniqueness and Competitive Advantages

- High storage efficiency
- High repair performance
- Security guarantees
- Scalability for geo-distributed environments
- Software-defined storage management

特點及優勢

- 高存儲效率
- 高效數據修護性能
- 安全保證
- 地理分佈式環境的擴展性
- 軟件定義存儲系統管理

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

Funded by Innovation and Technology Commission
由創新科技署資助

Collaboration with Unissoft Technology Co. Ltd. Microsoft Hong Kong Limited, Hong Kong Telecommunications (HKT) Limited and Huawei Technologies Noah's Ark Lab
合作夥伴包括紫晟科技有限公司、微軟香港有限公司、香港電訊有限公司、華為技術有限公司諾亞方舟實驗室

A BREAKTHROUGH IN PHOTONIC INTEGRATION FACILITATING HIGH-SPEED OPTICAL COMMUNICATION

突破性光子集成研究　實現高速光通信

The research team of Prof. SUN Xiankai (1st right) and Prof. TSANG Hon Ki (2nd left)
孫賢開教授(右一)及曾漢奇教授(左二)的研究團隊

The ever-increasing growth in data traffic requires more powerful transmission networks. The conventional optical communication is based on total internal reflection, creating a high-refractive-index channel, for the light wave to propagate. Bound states in the continuum (BICs) refer to a type of wave that can coexist with continuous waves without any radiation loss. Applying BICs in photonic integrated circuits enables low-loss light guidance in low-refractive-index channels on high-refractive-index substrates, lowering the cost and the complexity of processing.

This research revealed a way to use light to convey large rates of data in advanced optical chips. We applied the aforesaid concepts on an etchless lithium niobate integrated photonic platform and has successfully confined light without adopting the high-refractive-index channel. The BIC concept makes it unnecessary to invent new high-refractive-index polymers to form waveguide channels on the high-refractive-index substrate or etch the substrate in order to guide light in channels in the substrate. To further increase the data transmission capacity, optical multiplexing technologies are used to transmit multiple channels of data in parallel. By making use of carefully engineered high-order BICs on a planar lithium niobate substrate, we demonstrated the viability of the BIC concept for use in high-capacity optical communication links by using different spatial modes for mode-division multiplexing. With this new technology, we can obtain an aggregate data rate of 160 Gb/s per wavelength light carrier on the lithium niobate platform.

互聯網世界的數據流量與日俱增，有必要建立傳輸容量更大的網絡以滿足通訊需求。傳統的光通訊技術是基於全內反射的光學現象，利用高折射率通道來傳輸光子。連續區束縛態是指一種能夠與諸多連續波共存而不會有輻射損耗的傳輸模式。在集成光路中利用連續區束縛態，能夠在高折射率物料上產生低折射率通道，減低加工複雜程度及成本，卻仍保持光導低損耗。

本項研究利用連續區束縛態技術製作芯片，把相關概念應用於無刻蝕鈮酸鋰平台上，成功利用低折射率通道傳輸光子，實現芯片上低損耗光通訊，不再需要依靠開發高折射率聚合物或蝕刻底基等高成本的方法去製作高折射率光導通道。為了進一步提升數據傳輸能力，我們亦探討透過光復用技術，讓不同數據在同一通道內互不干擾地傳輸。這個設計的高階連續區束縛態可用於平面鈮酸鋰底基上，利用通道內不同的空間模式實現了模分復用，印證了將連續區束縛態用於高容量光通信的可行性。借助這項新技術，我們可以在鈮酸鋰平台上實現每波長光載波160 Gb/s的總數據傳輸率。

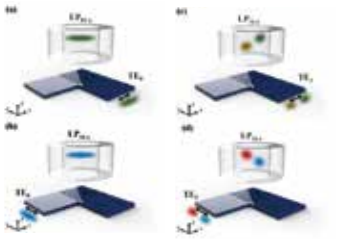
Prof. SUN Xiankai 孫賢開教授

Prof. TSANG Hon Ki 曾漢奇教授

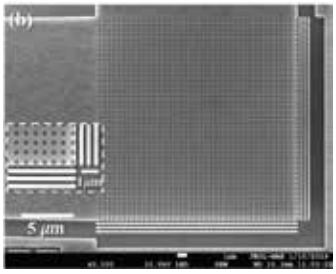
Department of Electronic Engineering
電子工程學系

MULTIMODE WAVEGUIDE GRATING COUPLERS FOR MODE DIVISION MULTIPLEXED HIGH CAPACITY SILICON PHOTONICS TRANSCEIVERS

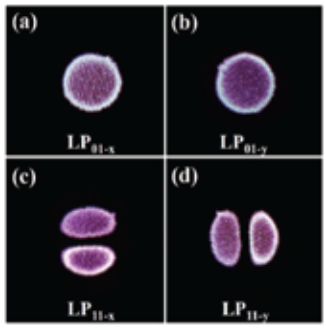
用於模分複用大容量通信矽光子收發器的多模波導光柵耦合器



Schematic diagrams of simultaneous launch of 4 modes into a step-index few-mode fiber (FMF) via the novel subwavelength waveguide grating. (a) LP01−xmode, (b) LP01−ymode, (c) LP11−xmode and (d) LP11−ymode.
通過新型亞波長波導光柵將4個模式同時發射到階躍型少模光纖的示意圖。(a) LP01-x模式，(b) LP01-y模式，(c) LP11-x模式和 (d) LP11-y模式。



Scanning electron microscope image of the fabricated multimode grating coupler with a zoom-in view shown in the inset.
製作的多模光柵耦合器的掃描電子顯微鏡圖像，放大視圖如插圖所示。



Output field profiles of the step index few mode fiber when LP01−x, LP01−y, LP11−x and LP11−y are selectively launched by the multimode waveguide grating coupler.
當多模波導光柵耦合器有選擇地發射LP01-x，LP01-y，LP11-x和LP11-y模式時，階躍型少模光纖的輸出場分佈。

Patent 專利

2 US patents filed
2項美國專利

Prof. TSANG Hon Ki 曾漢奇教授

Department of Electronic Engineering
電子工程學系

Funded by National Natural Science Foundation of China /Research Grants Council Joint Research Scheme (2015-2019) and General Research Fund, Research Grant Council of Hong Kong (2021-2023)
國家自然科學基金委員會與香港研究資助局聯合科研資助基金(2015-2019)和香港研究資助局優配研究金(2021-2023)

Mode division multiplexing in few-mode or multimode optical fibers is one of the most promising emerging technologies which can enable optical fiber interconnects to increase their data transmission capacity and bandwidth density. Current 400Gb ethernet standard optical transceivers use 4 lasers at four wavelengths, each supporting 50Gbaud PAM-4 modulation. This is not scalable to 1.6Tb/s as it becomes too expensive to use 16 lasers in a transceiver. Besides, mode division multiplexing in multimode fibers is currently impractical because of the difficulty to selectively excite different modes with the large volume produced silicon photonic transceivers.

We have developed a new type of multimode waveguide grating coupler which will enable the use of mode division multiplexing in multimode optical fibers. A direct optical interface between multimode fiber and a silicon photonic transceiver is also developed, in which will enable mode division multiplexing in multimode fibers for high capacity short-reach data communications. The technology will enable the next generation optical ethernet to attain 800Gb/s or possibly 1.6 terabit/s capacity with a single wavelength silicon photonic transceiver interfaced with multimode fibers. We have already demonstrated this technology with few-mode fibers and are currently developing advanced designs for use with standard multimode fibers.

少模或多模光纖中的模分複用是增加光纖互連數據傳輸容量和帶寬密度的最有效新興技術之一。現時400Gb乙太網的標準光收發器會使用4個波長的激光器，每個激光器支援50Gbaud PAM-4調制，但因使用16個激光器的成本高昂，所以無法擴展到1.6Tb/s。另一方面，目前大量生產的矽光子收發器有局限，他們不能選擇性地激發多模光纖的不同模式，所以在多模光纖中使用模分複用技術難於實踐。

本項目開發了一種突破性的新型多模波導光柵耦合器，亦在多模光纖和矽光子收發器之間設計了直接光學接口，令多模光纖中的模分複用成為可能，實現大容量短距離數據通信。技術能讓下一代光乙太網通過多模光纖接口的單波長矽光子收發器，達到800Gb/s或1.6Tb/s的容量。這項技術已經在少模光纖中進行驗證，目前我們正開發可用於標準多模光纖的進階設計。

Uniqueness and Competitive Advantages

- A new technology with US patent filed
- Avoids the need for fiber photonic lanterns which will cause additional cost and consume valuable space in the data centers
- Allows direct multimode fiber interface to the silicon photonic transceiver without the need for any fiber break-out box
- Simply doubles the capacity of current 400Gb ethernet to 800Gb/s with multimode fiber transmission; Further increases to 1.6Tb/s are possible with the use of additional spatial modes in the fiber
- Applications include high capacity data center optical interconnects and 5G backhaul transceivers

特點及優勢

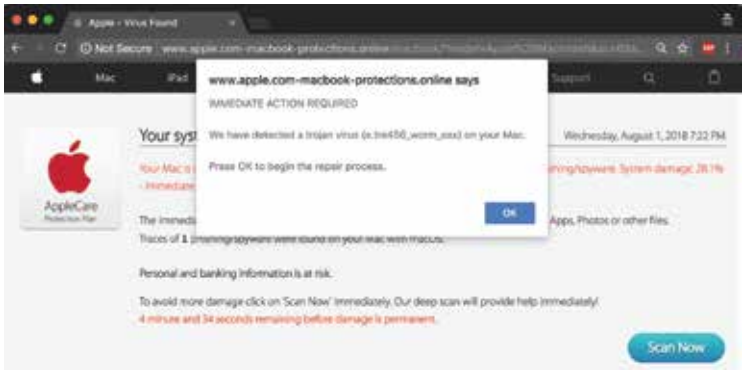
- 已申請美國專利的全新技術
- 避免消耗光纖光子燈籠結構，減少額外成本和數據中心的寶貴空間
- 無需任何光纖轉接盒，讓多模光纖接口直接連接至矽光子收發器
- 簡單地將400Gb乙太網的多模光纖的傳輸容量增加一倍達到800Gb/s；利用光纖中的其他空間模式，可以進一步提高通信容量到1.6Tb / s
- 可應用在大容量數據中心光互連及5G回傳收發器上

NOVEL BROWSER-BASED ANALYSIS FRAMEWORK OBSERVER

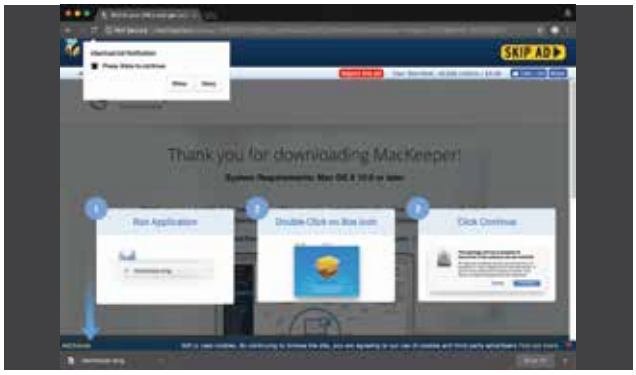
瀏覽器分析系統OBSERVER

DETECTING MALICIOUS CLICK INTERCEPTION AND MITIGATING WEB SECURITY THREAT BY THIRD-PARTY CODE

首創追蹤第三方惡意點擊攔截　減輕網絡安全威脅



Victim users can be directed to fake antivirus pages
受害用戶可被引導到偽造的防病毒頁面



Victim users can be directed to drive-by download pages
受害用戶可被引導到路過式下載頁面

A click is the prominent way that users interact with content on the World Wide Web (WWW). Malicious third-party advertisers or hackers expose web users to a security threat by injecting malicious JavaScript code to intercept user clicks and trick them into visiting untrusted web content. Attackers aim to intercept genuine user clicks to either launch ad click frauds by fabricating ad click traffic, or to send malicious commands to another website on behalf of the user (e.g., to force the user to download malwares). This project developed a browser-based analysis framework – Observer, which is able to detect three different techniques for intercepting web user clicks. Different from previous researches that mainly considered the type of click interceptions launched by malicious first-party websites, Observer addresses this research gap, in which it considers the various click interceptions launched by third-party JavaScript code.

It is acknowledged that web behaviour caused by third-party JavaScript code is difficult to record and analyse. Observer detects third-party click interceptions by extending the browser to collect the behaviour at runtime and thoroughly analysing the click-related behaviour. Using Observer, we analysed Alexa top 250K websites, and detected 437 third-party scripts that intercept user clicks on 613 popular websites, which in total receive around 43 million visits on a daily basis. In particular, though click interception, these scripts could trick users into visiting 3,251 untrusted unique uniform resource locators (URLs) controlled by third parties. Over 36% of them were related to online advertising. Further, some click interception URLs led users to malicious content such as scamwares. This demonstrates that click interception has become an emerging threat to web users. Our research team has released the source code of the framework publicly to help web browsers detect malicious click interceptions and alert users about the malicious behaviour to protect them from being exposed to malicious content.

The research identified three categories of click interception techniques

1. Modifying the destination URL of hyperlinks to lead users to malicious websites upon clicks.
2. Adding click event listeners to manipulate user clicks.
3. Visual deception, for example, by creating web content that is visually similar to first-party content, or displaying transparent elements on top of the web page. The former will trick users into clicking third-party element, and the latter enables the transparent elements to capture all user clicks on first-party content. Consequently, the users can be led to a page controlled by the attackers.

Prof. MENG Wei 孟瑋教授

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點擊是用戶與萬維網（World Wide Web, WWW）上內容進行互動的主要方式。不良第三方廣告商或駭客在網頁中加入惡意JavaScript代碼來攔截瀏覽者點擊，欺騙他們訪問不受信任的網頁，令網絡用戶安全受到威脅。攻擊者攔截真實的用戶點擊，製造廣告點擊流量以進行廣告點擊欺詐，或以用戶的身分向其他網站發送惡意指令，例如迫使用戶下載病毒程式。為了偵測此點擊攔截行為，本項目研發出瀏覽器分析系統Observer（觀察者），可檢測三種用於攔截網絡用戶點擊的不同技術。有別於以往針對由第一方網站發起點擊攔截的研究，Observer可以應對可由第三方JavaScript代碼發動的各種點擊攔截，針對全新領域。

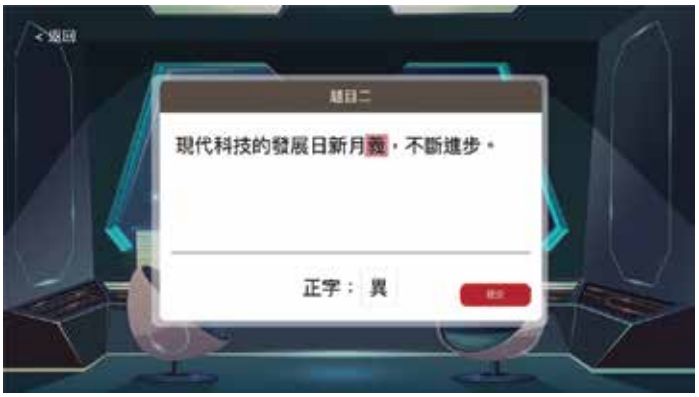
眾所周知，由第三方JavaScript代碼啟動的網頁行為是很難用作記錄和分析的。Observer系統通過擴展瀏覽器以收集運行時的行為，針對點擊相關的行為作徹底分析，以此來檢測第三方的點擊攔截行為，保障用戶免受這些惡意攻擊威脅。我們利用Observer分析了Alexa（全球網站排名計算系統）首25萬個網站，在其中613個受歡迎網站（每日總瀏覽量約4,300萬人次）上發現有437個第三方代碼在攔截用戶點擊。這些代碼通過攔截用戶點擊可誘騙用戶訪問3,251個被第三方操控的不受信任的網址，其中逾36%與在線廣告有關，另有部分點擊攔截網址會將用戶引向惡意內容如詐騙軟件，說明點擊攔截已成為網絡用戶的新興威脅。我們的團隊已公開Observer系統源代碼，協助網絡用戶檢測惡意的點擊攔截，並就此惡意行為發出警告，保障他們免遭惡意網站的影響。

本研究確認了點擊攔截技術的三大類型

1. 更改超連結的目標網址，當用戶點擊時將其引導至惡意網站。
2. 通過新增監聽事件（Event Listener）來欺騙用戶點擊。
3. 視覺矇騙，例如模仿第一方網站內容製作網頁，欺騙用戶點擊由第三方杜撰的元素，或以透明介面覆蓋整個版面，攔截用戶對第一方內容的所有點擊，將用戶帶到由攻擊者控制的網頁。

DRILL-EASY – AN AI-BASED LANGUAGE LEARNING SYSTEM

「知易行難」– 基於人工智能的語言學習系統



Interface of online Chinese language learning system "Drill Easy"
「知易行難」線上中文學習系統的界面

Drill-Easy is an online Chinese language learning game for primary and junior secondary students. It is based on the award-winning artificial intelligence technology at the 47th International Exhibition of Inventions of Geneva. The EdTech system, in the form of a game, can auto-compose corresponding proofreading exercises for users at different grades, and auto-correct the answers submitted by students in real-time. Students can practise through e-learning channels and get immediate feedback from teachers. Furthermore, through big data analysis, students' progress and performance will be clear at a glance, and effective language learning can be achieved easily.

「知易行難」是一款為小學及初中學生而設的線上中文學習系統。基於第47屆日內瓦國際發明展獲獎的人工智能技術，此教學系統以遊戲形式為不同年級的用戶自動編寫相應的校對練習，並實時批改答案。學生可以通過電子學習渠道進行練習，獲得即時反饋；教師亦可透過大數據分析，輕鬆掌握學生的進展和表現，達至有效的語文學與教。

Uniqueness and Competitive Advantages

- Promote students' correct use of Chinese vocabulary through proofreading exercises
- Reduce the workload of teachers, who can focus on teaching
- Immediate feedback instead of waiting feedbacks from teachers
- Performance tracking via big data analysis
- Adopted by a local online learning platform serving thousands of students

特點及優勢

- 通過改正病句、錯別字練習，提升學生對中文詞彙的正確使用能力
- 減輕老師的工作量，讓他們專注於教學
- 可獲得即時反饋而不用等待教師批改
- 通過大數據分析紀錄績效
- 系統已被本地線上學習平台採用，為數千名學生提供服務

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Department of Systems Engineering and Engineering Management
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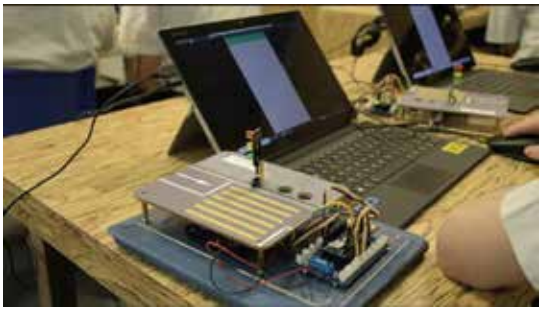
JOCKEY CLUB COMMUNITY CARE AND STEM IN ACTION PROJECT

賽馬會社區關懷與創意教育實踐計劃

Students learn programming in the Project's curriculum of "STEM Education".
學生於計劃的「STEM教育」課程中學習編程

Students learn about barrier free facilities in our community for people with visual impairment in the Project's curriculum of "Social Service Education"
學生於計劃的「社會服務教育」課程中了解為視障人士而設的無障礙社區設施



Through programming, students can read real-time data of smart traffic light model connecting to the Internet of Things (IoT)
學生通過編程讀取已連接物聯網的智能交通燈模型的實時數據

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由香港賽馬會慈善信託基金捐助

Collaboration with Lok Sin Tong Yu Kan Hing Secondary School and Hong Kong Institute of Educational Research of CUHK
合作夥伴包括樂善堂余近卿中學及香港中文大學香港教育研究所

As STEM-related innovations become an integral part of the 21st Century, promoting the innovation and technology ecosystem via STEM education in secondary schools becomes a vital educational strategy. The **Jockey Club Community Care and STEM in Action Project** maximizes the opportunities of students and schools to apply the latest STEM knowledge and skills within the community. Besides, the project supports junior form students' creativity and innovative ideas and induces a sense of social responsibility via a quadripartite professional partnership among the university, schools, social service organizations and entrepreneurs in Hong Kong.

Interactions with socially disadvantaged elderly groups not only enables students to gain a deeper understanding of the actual livelihood needs of these groups, but further develop respect and care towards their elderly family members and the underprivileged within the community. The community beneficiaries will gain care and support when their daily practical issues are solved by our students' innovative ideas and STEM-related products. We hope that after students' involvements with this project, they will become inspired to continue innovating new products for the community in the future. Allowing secondary school students to access our university's innovative STEM resources help unleash their creativity. This also allows students to have an authentic learning platform and gain new insights into how technology can be deployed towards designing innovative products. Furthermore, the mentorship programme enables secondary school students to benefit from coaching and guidance by university undergraduate mentors who possess practical experience and tertiary-level knowledge in engineering.

隨着與STEM相關的革新成為21世紀不可或缺的一部分，在中學裏藉着STEM教育來推廣創新與科技生態系統已成為一項重要的教育策略。**「賽馬會社區關懷與創意教育實踐計劃」**增加學生和學校在社區應用最新STEM知識和技能的機會，並通過連結大學、學校、社會服務機構及企業等專業合作伙伴，支持初中學生的創意和創新構思，並培養學生的社會責任感。

參與計劃的學生有機會與弱勢長者社群交流，深入了解長者的生活需要，學習尊重和關心家中的長輩，以至社會中的弱勢社群。通過交流，學生能夠從中受到啟發，以創新構思和STEM相關產品為弱勢社群解決日常實際問題，在將來繼續為社區研發新產品。學生除了可以使用大學的創新STEM資源，幫助他們發揮創意，也能透過具真實情境的學習平台，開擴眼界，了解如何運用科技設計產品。此外，科創指導計劃讓初中學生能在具備工程實踐經驗和大專知識的本科生導師的指導下受益。

Uniqueness and Competitive Advantages

- Students could learn about the latest CAM/CAD technologies and production cycles in the commercial sector
- By learning the IoT hardware development platform in our project, students gain practical skills and knowledge of the fast-paced 21st century's building blocks
- Students will be equipped with technologically innovative skills and knowledge such as IFTTT, coding, and programming
- Students could gain knowledge in 3D drawing and 3D printing, which enable students to transform their innovative STEM ideas into prototypes and products

特點及優勢

- 學生可學習最新的CAM/CAD（電腦輔助設計與製造）技術和商界的生產週期
- 藉着IoT（物聯網）硬件開發平台，學生能獲取實務技巧和知識，奠定基礎
- 掌握如IFTTT、編碼、編程等科技創新的知識和技能
- 學習3D繪圖和3D打印知識，助學生把創新的科創意念轉化為原型和產品

ROBOTICS & AUTOMATION

機械人及自動化科技

SELF-POWERED SMART WATCH AND WRISTBAND ENABLED BY EMBEDDED GENERATOR

用於實現自供電智能手錶和手環的嵌入式發電機

Front view of the prototype
原型正視圖

Prototype embedded in a watch case
原型可嵌入手錶中

The limited battery life of smart watches and wristbands remains a pain point. We designed an embedded and compact electromagnetic generator so that these wearable gadgets can be self-powered. Applications include pedometer, sleep monitoring and GPS. Unlike existing products, the invention uses a novel magnetic frequency-up converter and harnesses the kinetic energy of human motion. A converter transforms the low-frequency arm swing to achieve desirable output power.

有限的電池使用時間一直是智能手錶和手環的應用痛點。針對這個問題，我們設計出一個可嵌入穿戴設備的小巧型磁力發電機，讓這些設備可自動發電，以支援計步器、睡眠監控及GPS定位等功能。與現有產品不同，這個發明採用新型磁力升頻器，能有效收集人體動作所產生的動能，從而在低頻率的手臂擺動中仍能轉化出理想的輸出功率。

Uniqueness and Competitive Advantages

- 4x output power and 10x power density compared with existing technologies
- Improves energy conversion efficiency by eliminating mechanical friction
- Avoid damage caused by impact force, saving maintenance or replacement
- Compact and easily embedded in variety of wearable electronics

特點及優勢

- 比現有技術提高 4 倍輸出功率和10倍功率密度
- 減少機械性摩擦，提升能量轉換效率
- 降低因撞擊造成的損壞風險和維修更換的需求
- 小巧的嵌入式設計可廣泛應用在穿戴設備上

Patent

1 China and 1 US patent applications

專利

1個中國專利與1個美國專利申請

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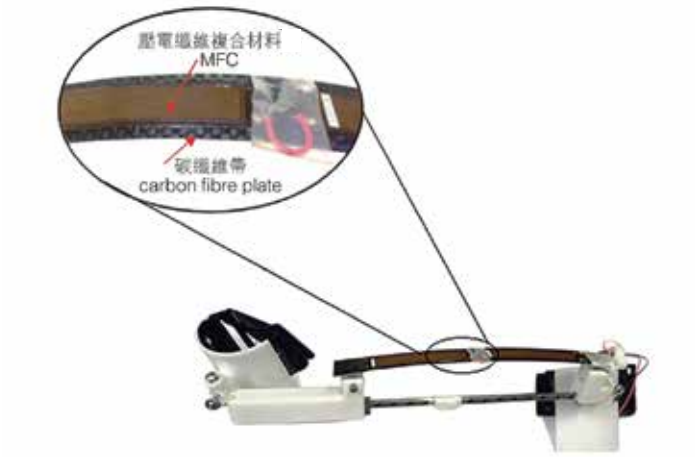
Funded by Research Grants Council
由研究資助局資助

HARVESTING ENERGY FROM WALKING HUMAN BODY

極輕便人體動能採電系統

The energy harvester only weighs 307g
整套系統僅重307克，非常輕便



Lightweight macro-fibre composite (MFC) and carbon fibre plate are the materials used in the harvester
系統採用壓電纖維複合材料及碳纖維帶等材料

Energy harvesters are traditionally heavy and create burden in the energy capture process. This smart materials-based energy harvester enables wearable electronic devices. Made with a lightweight macro-fibre composite, it captures energy from motion of the human knee, deforming piezoelectric transducers to generate electricity. Walking 10,000 steps at normal speed is enough to power a smart wristband for the whole day.

過往在人體動能發電時都需要使用笨重、累贅的電力採集系統，而本項目利用壓電纖維為材料，研發出輕便的可穿戴型電力採集裝置。人體膝蓋於步行時會自然彎曲及伸直，壓電纖維在折合和彎曲的過程中會透過壓電換能器將動能轉化成電能。以正常速度步行10,000步便足以為智能手環提供整天的電力。

Uniqueness and Competitive Advantages

- Light (307g only) and easy to wear/take off
- No extra metabolic burden to users
- Can power wearables especially for hikers, e.g. pedometers, health monitors, GPS
- Can be embedded into garments for sportswear

特點及優勢

- 輕量(只有307克)及易於穿戴和脫下
- 不會造成額外體力負擔
- 特別適合配備穿戴型電子產品的遠足人士，如計步器、健康監測儀和全球定位系統(GPS)等
- 可應用於運動服裝上

Patent

1 US patent and 1 China patent applications

專利

1個美國專利與1個中國專利申請

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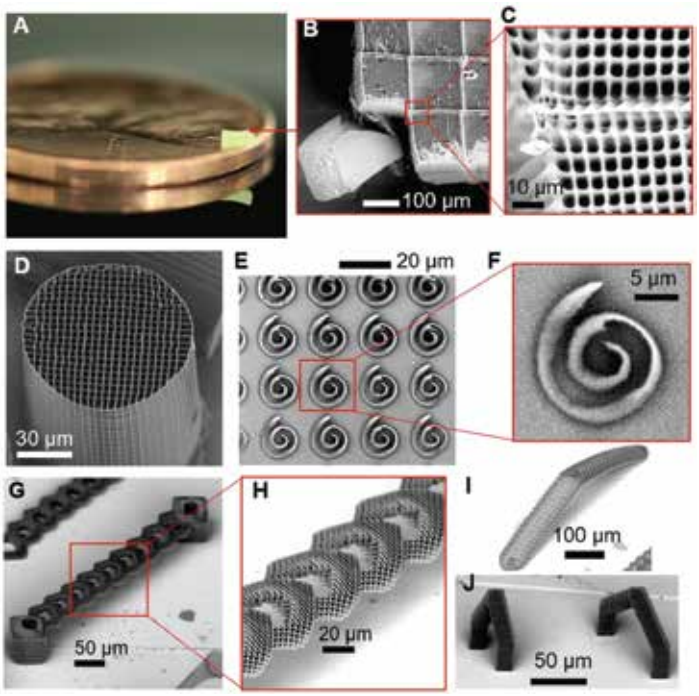
Department of Mechanical and Automation Engineering
機械與自動化工程學系

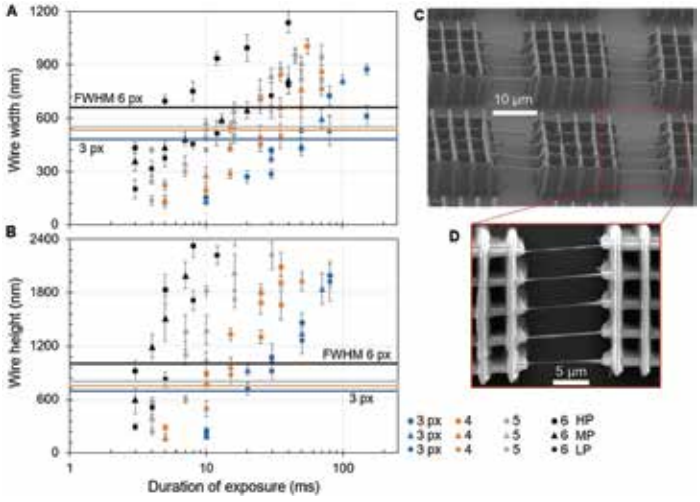
Funded by Innovation and Technology Commission
由創新科技署資助

FEMTOSECOND PROJECTION TWO-PHOTON LITHOGRAPHY BOOSTS 3D PRINTING SPEED BY UP TO 10,000 TIMES

飛秒鐳射投影技術將3D打印速度提高萬倍



Printing of complex 3D structures with submicron resolution via FP-TPL
FP-TPL打印技術以亞微米（即submicron，1微米以下）的精密度打印複雜的3D結構



Printed nanowires demonstrating nanoscale resolution of FP-TPL
FP-TPL技術打印的納米線，展示150納米級的精密度

Ultraprecise 3D printing technology is a key enabler for manufacturing precision biomedical and photonic devices. However, the existing printing technology is limited by its low efficiency and high cost. The conventional nanoscale 3D printing technology, i.e., two-photon polymerisation (TPP), operates in a point-by-point scanning fashion. As such, even a centimeter-sized object can take several days to weeks to fabricate. The process is time-consuming and expensive, which prevents practical and industrial applications. To increase speed, the resolution of the finished product is often sacrificed.

This project develops the "Femtosecond Projection Two-photon Lithography (FP-TPL)" printing technology, which overcomes the challenging problem by exploiting the concept of temporal focusing, where a programmable femtosecond light sheet is formed at the focal plane for parallel nano-writing; this is equivalent to simultaneously projecting millions of laser foci at the focal plane, replacing the traditional method of focusing and scanning laser at one point only. What makes FP-TPL a disruptive technology is that it not only greatly improves the speed (approximately 10 – 100 mm^3/hour), but also improves the resolution (~140 nm / 175 nm in the lateral and axial directions) and reduces the cost (US$1.5/$mm^3$). This new technique substantially increases the printing speed by 1,000 - 10,000 times, and reduces the cost by 98%. Besides, due to the slow point-scanning process and lack of capability to print support structures, conventional TPP systems cannot fabricate large complex and overhanging structures. The FP-TPL technology has overcome this limitation by its high-printing speed, i.e., partially polymerised parts are rapidly joined before they can drift away in the liquid resin, which allows the fabrication of large-scale complex and overhanging structures.

FP-TPL technology can benefit many fields; for example, nanotechnology, advanced functional materials, micro-robotics, and medical and drug delivery devices. Because of its significantly increased speed and reduced costs, the FP-TPL technology has the potential to be commercialised and widely adopted in various fields in the future, fabricating meso- to large-scale devices.

高精度立體3D打印技術，是製造精密醫療及科技器件的重要驅動力，惟現有技術效率低且成本高，窒礙普及應用。常見的3D高精度打印技術（即雙光子聚合系統，簡稱TPP），原理是以鐳射光串逐點寫入，再分層製造，即使是小型器件也要花上數天以至上星期掃描打印，過程費時及昂貴，也限制了這項技術在大規模生產中的應用。若要提升速度，則往往要犧牲成品的精密度。

本項目克服了上述難題，研發出「飛秒鐳射投影雙光子聚合光刻」（Femtosecond Projection Two-photon Lithography, FP-TPL）3D打印技術，突破性地利用新聚焦方法，同時投影100萬個光點，形成整個光平面，以取代傳統將鐳射光集中於一點的做法。新技術下，打印速度增加至每小時10至100立方毫米，還可將精密度提升至140 x 175 納米，成本更降至每立方毫米1.5美元。打印速度提升數千至一萬倍，並降低打印成本達98%。另外，TPP系統採用的點掃描技術由於動作緩慢且缺乏打印支撐結構的能力，無法製造大型複雜的懸垂結構。FP-TPL則克服了這個限制，它的高速打印能力可迅速將液態樹脂中部分聚合的零件在漂移之前連接在一起，從而製造複雜及大型的懸垂或倒勾結構。

FP-TPL技術適用於高端納米科技、先進材料、醫療用微支架及藥物傳輸技術的研發。並且由於其顯著提升了速度和降低成本，在未來可能被更廣泛的應用於各個領域，打印中型或大型器件，極具商業應用潛力。

*mm=毫米 μm=微米, submicron=亞微米 nm=納米 fs =飛秒

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合作伙伴為美國「勞倫斯利佛摩國家實驗室」