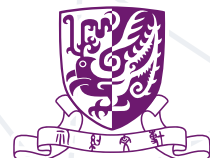




Innovation

For Better Life

2018 - 2019



香港中文大學

The Chinese University of Hong Kong



■ PREFACE 序言

Being a forward-looking comprehensive research university, The Chinese University of Hong Kong (CUHK) pursues excellent innovative research with passion. Centre for Innovation and Technology (CINTEC) is pleased to share some of the latest CUHK research results with you, which are contributed from various faculties and research units, such as Faculty of Education, Faculty of Engineering, Faculty of Medicine, Faculty of Science, Institute of Space and Earth Information Science, etc.

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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

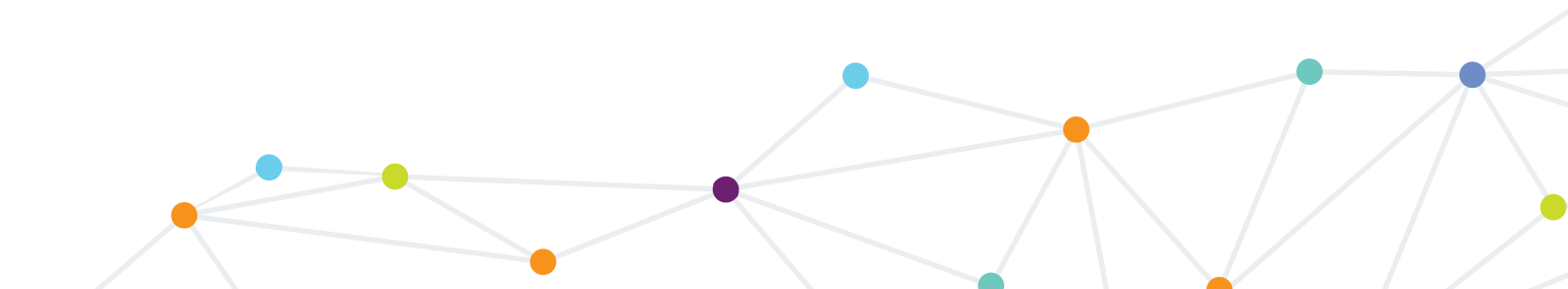
作為一所具前瞻性的研究型綜合大學，香港中文大學（中大）擁抱熱情追求卓越的創新科研。創新科技中心樂意與您分享其中部份的最新研究成果，它們來自中大多個不同學院及研究單位，包括教育學院、工程學院、醫學院、理學院、太空與地球信息科學研究所等。

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，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。

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謹此感謝您對中大創意發明的興趣。

香港中文大學
創新科技中心主任
黃錦輝教授



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Biomedical
Sciences

生物醫學科學



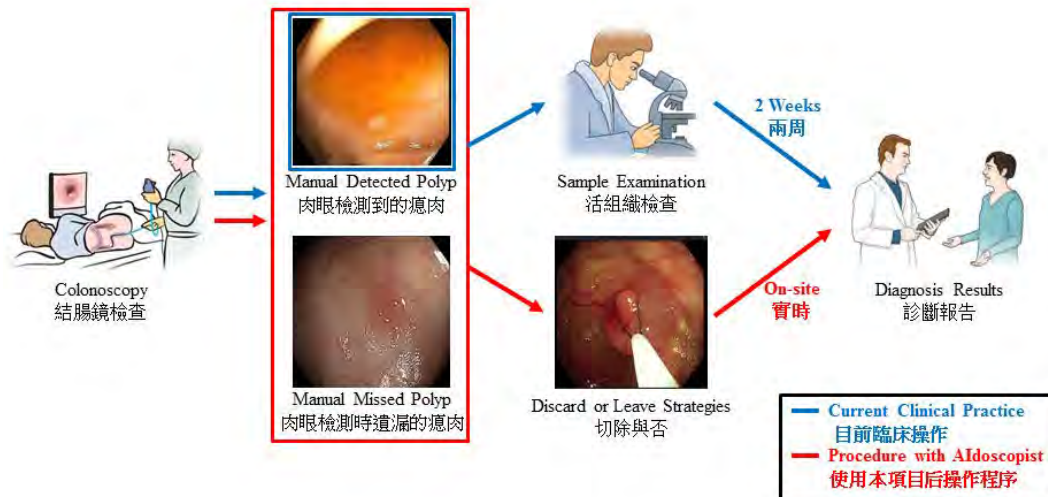
Aldoscopist: A Real-Time Computer-aided Diagnosis System for Cancer Screening during Colonoscopy



用於結腸鏡癌症篩查的實時計算機輔助診斷系統

Colonoscopy is one of the most effective ways to prevent colorectal cancer. It allows doctors to examine the colonic wall for polyp(s) and remove those that are adenomatous. Nevertheless, two major difficulties are encountered by endoscopists during colonoscopy: namely missed polyps and misclassified polyps. To solve the issues, we develop a real-time computer-aided diagnosis system for polyp detection and classification during colonoscopy. The system, named Aldoscopist, displays the diagnosed result of each polyp to doctors in real time and assists doctors in making instant decision of whether a polyp should be resected or not. The ultimate goal is to make colonoscopy a safer and more cost-effective procedure.

結腸鏡檢查是預防結直腸癌最有效的方法之一。醫生可以通過檢查結腸壁的瘻肉並去除腺瘤樣病變的組織。然而，內鏡醫師在結腸鏡檢查時遇到兩個主要困難：即遺漏不明顯的瘻肉和對瘻肉出現病理誤判。為了解決這些問題，中大的研究團隊開發了一套人工智能實時計算機輔助診斷系統，用於結腸鏡檢查時的瘻肉檢測和病理類型分類。這個名為Aldoscopist的系統能實時向醫生顯示每個瘻肉的診斷結果，並協助醫生決定是否切除瘻肉。系統的最終目標是使結腸鏡檢查更安全，提升醫療效率之餘，同時有助減輕成本。



Colorectal cancer screening with the proposed artificial intelligence diagnosis system
實時人工智能結直腸癌篩查系統

- Built with advanced deep learning method and incorporated both spatial and temporal information in the prediction model
- 用先進的深度學習和遷移學習算法融合來搭建，能同時分辨非瘻肉、非腫瘤性瘻肉和腫瘤瘻肉三類圖像
- Tested with full colonoscopy videos collected from 300 patients and achieved comparable results with a group of endoscopists
- 已完成在300名患者的結腸鏡視頻中進行離線測試，並達到與內鏡醫師相約的分辨率
- Evaluated on two patients for real-time processing and displaying the results
- 對兩名患者進行臨床測試，證明能達到實時的分析速度

Prof. POON Chung Yan Carmen
潘頌欣教授

Prof. MAK Wing Chung Tony
麥穎忠教授

Prof. WONG Hei Sunny
黃曦教授

Prof. LAU Yun Wong James
劉潤皇教授

Endoscopy Centre,
Department of Surgery
外科學系內鏡中心

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Hong Kong

由創新科技署及香港研究資助局資助



Automatic Screening of Primary Cervical Cancer

Using deep learning technology to automatically detect suspected cell malformation in digitalized cervical smear

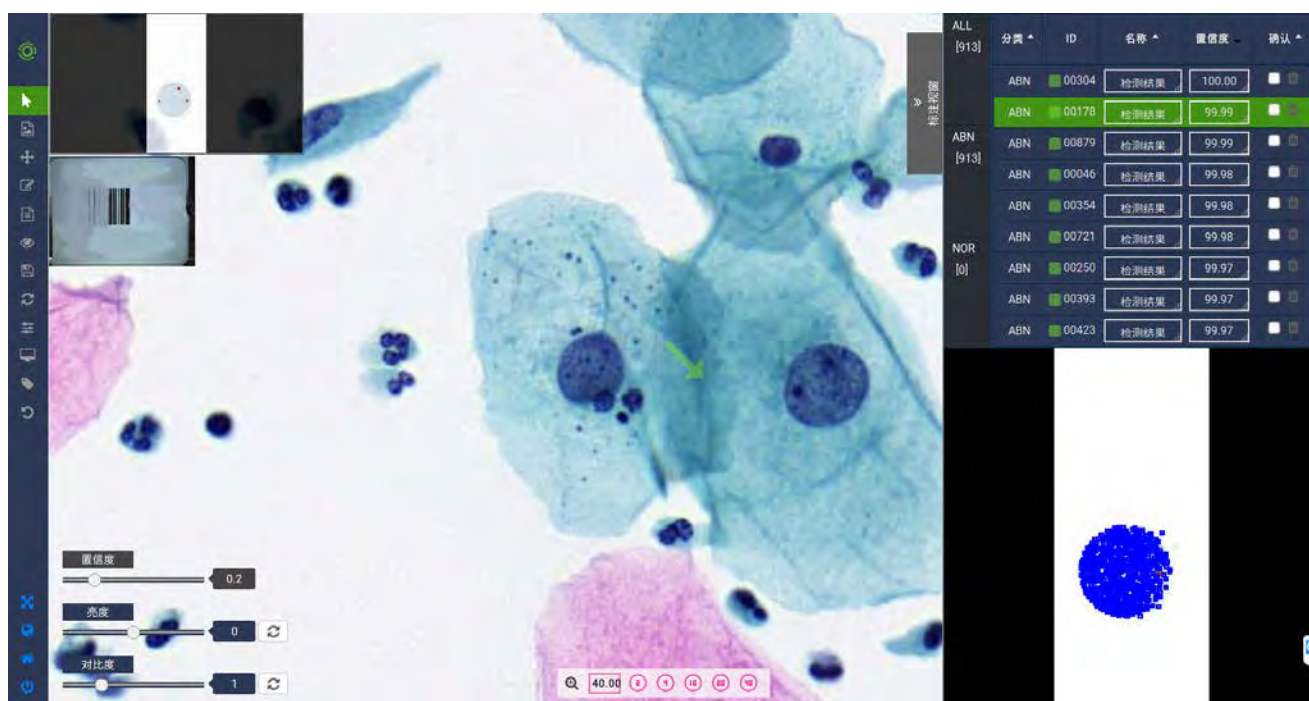


早期宮頸癌的自動化篩查

基於深度學習技術從數碼化的宮頸細胞塗片自動篩選疑似病變細胞

Cervical cancer is one of the most common cancers in women. Screening is the only way to detect and cure cervical cancer at the early stage. Therefore, we design a novel deep-learning-based method with convolution neural network to detect suspected cell malformation in cervical smear. Screening of digitalized cervical smear will be beneficial to precancerous cervix detection, prevention and treatment of cervical cancer.

宮頸癌是女性最常見的癌症之一。雖然如此，只要通過篩查，宮頸癌是目前唯一可於早期發現便能治癒的婦科癌症，因此，我們提出基於深度學習技術的自動化解決方案，利用卷積神經網絡，從數碼化的宮頸細胞塗片中篩選疑似病變細胞，有助發現宮頸癌前病變，防治宮頸癌。



Detection and visualization of cancerous cells

癌細胞的檢測及可視化

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

Funded by Technology Start-up
Support Scheme for Universities (TSSSU)
由大學科技初創企業資助計劃資助

Collaboration with CluserTech Ltd and Bayer
合作夥伴包括聯科集團及拜耳

- The system is built based on the convolution neural network of deep learning technology for Thinprep Cytologic Test (TCT) detection of cervical cancer
- 本技術是基於卷積神經網絡、針對宮頸癌液基薄層細胞檢測Thinprep Cytologic Test (TCT) 的深度學習技術
- Cervical cancer is screened by automatically detecting suspected cell malformation with subtypes classified in digitalized cervical smear
- 本系統會自動對數碼化宮頸細胞塗片中的疑似病變細胞，進行篩選和亞型分類



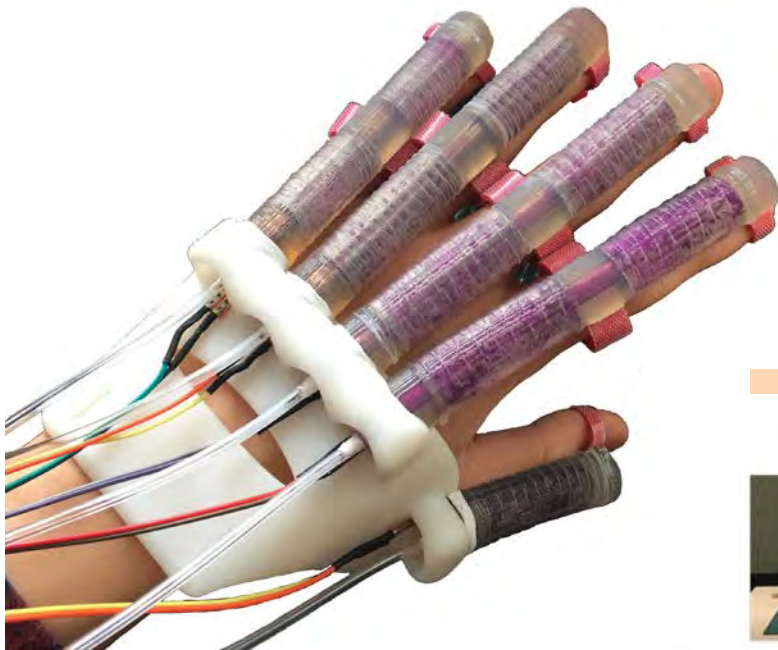
3D-Printed Soft Robotic Hand for Rehabilitation

3D打印軟體復康機械手



Stroke has been the leading cause of disability around the world. Almost every 40 seconds there will be a new stroke case. The 3D-Printed Soft Robotic Hand is designed for stroke-induced disability and hand disability rehabilitation. It can be tailor-made to fit each patient's hand. This light-weight robotic hand facilitates both flexion and extension of fingers with spasticity and assist the hand function rehabilitation training. It provides a personalized and affordable solution for stroke rehabilitation training.

中風是全球引致殘障的主因之一，每約40秒便有一個中風個案。3D打印軟體復康機械手是專為中風人士和手活動障礙人士設計的復康工具，可根據患者手部尺寸度身訂造。這款輕巧的軟性機械手可以協助患者屈曲和伸展手指，幫助患者改善手部活動能力，為患者提供一個可個人化和價格實惠的復康訓練方案。



Third generation of Soft Robotic Hand
第三代軟體復康機械手



A stroke survivor grabbing towel with
3D-Printed Soft Robotic Hand
中風患者使用3D打印軟體復康機械手抓毛巾

- Soft Robotic Hand can be personalized for patients, from children to adults, according to the size of their fingers and palms
- 軟體機械手根據患者手指和手掌的尺寸度身訂造，不論兒童或成年患者均可使用
- Making use of the latest silicone printing technology, our soft elastomer-based actuators support patients to control their hand muscles and effectively facilitate hand function recovery
- 結合最新矽膠列印技術，我們的軟膠製驅動器能輔助患者控制他們的手部肌肉，有效協助手部機能復康
- To facilitate the relearning of upper-limb function, the Hand is intention-driven using electrogram signals from the brain to the muscles
- 軟體機械手使用肌電意念控制技術，會因應患者的活動意欲協助完成手部動作，讓患者重新學習如何使用大腦控制手部肌肉，促進上肢活動的康復

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 Research Fund and
T Stone Robotics Institute
由中大研究基金及天石機械人研究所
資助



Novel Hybrid System for Fracture Fixation

Innovative Degradable Magnesium-containing Implant for Long Bone Fracture Fixation

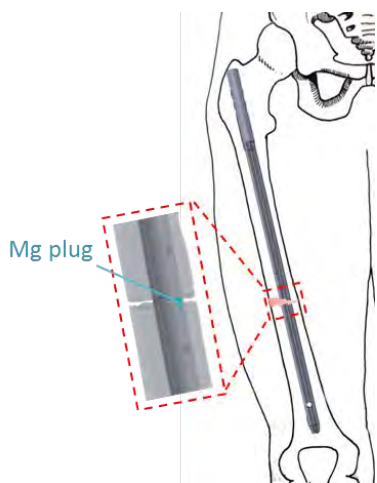
新型骨折固定混合系統

用於長骨骨折固定的創新型可降解含鎂內植物



Fractures take a long time to heal completely. Patients often have conditions, such as osteoporosis, that leads to decrease in healing potential. Our novel hybrid system of Magnesium-containing implants provides an innovative solution to improve the healing process and shorten the healing duration. The implant consists of a modified implant, such as intramedullary nail (IM nail) or compression plate with drill holes, and self-locking Magnesium (Mg) plugs. These implants are designed based on modifications on commercially available implants to allow incorporation of Mg components. Mg-containing orthopaedic implants would release Mg ions which can stimulate and facilitate fracture healing.

骨折需要很長時間才能完全癒合。病人往往患有其他疾病，如骨質疏鬆，會減慢骨折癒合過程。我們的新型混合系統使用可降解含鎂內植物，提供一種創新的方案來改善癒合過程並縮短癒合時間。透過加入鎂金屬成分的內植物，將自鎖固定的鎂材料置入改良的傳統內植物，如髓內釘和壓縮接骨板的孔隙中，改進市場上現有的金屬植入物。鎂內植物在生物分解過程中會釋放鎂離子，從而促進骨折修復。



Schematic diagram of the hybrid system after surgery: Mg plug is close to the fracture site which the released Mg ions would be distributed to the surrounding tissue and promote fracture healing

手術後植入混合系統的示意圖：鎂內置物鄰近骨折部位，釋放出的鎂離子會分佈於周圍組織，促進骨折癒合



(a) CAD model of modified IM nail; (b) Prototype of the hybrid IM nailing system with insertion of Mg plug; (c) Mg plug

(a) 改良的髓內釘模型；(b) 原初設計的髓內釘混合系統，鎂內置物置於其中；(c) 鎂內置物

Prof. QIN Ling
秦嶺教授

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

Funded by Research Grants Council of
Hong Kong
由香港研究資助局資助

- Novel patented technology
- 新型專利技術
- Incorporating Mg with the conventional implants can enhance the healing quality of fracture
- 通過結合鎂與傳統內植物提高骨折的治療質量
- The degradation of Mg plug promotes bone formation and facilitates fracture healing
- 鎂內植物在體內降解可促進骨的形成和骨折癒合
- Our system enhances healing in patients with diaphyseal fracture, especially for those with conditions that lead to decrease in regeneration potential
- 我們的系統能幫助骨幹骨折的病人，特別是同時患有其他疾病而導致骨折癒合緩慢的病人於創傷後的癒合過程



Smart Running Anklet Wearable

智能跑步腳帶



Running is a very popular sport. However, the injury risk is very high (around 70% per year). Currently, the industry uses video analysis and instrumented treadmill to assess runners' gait. Video analysis is subjective and a lot of intrinsic parameters such as force, energy and impact cannot be measured; instrumented treadmill is available to measure these parameters but at a very high cost. Therefore, we develop a smart running anklet wearable to provide a cheaper, easier and accurate solution for physiotherapy clinics, gyms, running coaches and runners.

Our product can measure more than 10 biomechanical parameters and provide real-time scientific biofeedback to reduce injury risk, improve running efficiency and endurance through smart sensor and cutting edge AI technology. We empower distance runners to run faster, further and injury-free by providing customized suggestions and personalized training plan.

跑步是一項非常受歡迎的運動，但受傷風險非常高（每年約為70%）。運動業界目前大多使用視頻分析或可測量步態的跑步機來為跑手評估跑姿。不過，視頻分析無法測量跑步時的力學參數，依賴教練的主觀判斷；而可測量步態的跑步機雖然可量度詳細參數，但成本高昂。因此，我們開發了智能跑步腳帶，為物理治療診所、健身房、跑步教練及跑手提供更便宜，方便和準確的解決方案。

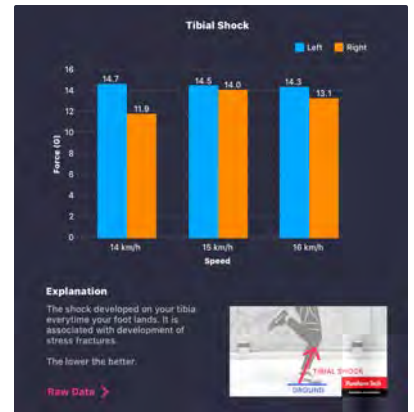
我們的智能跑步腳帶利用人工智能技術實時測量超過10種生物力學參數，並分析用戶的受傷風險，跑步效率和耐力，同時提供個人化的建議和訓練計劃幫助跑手跑得更快、更遠。



Smart Running Anklet Wearable
智能跑步腳帶



App showing the breakdowns of the running gait
顯示分析報告的應用程式



Scientific analysis in the app
科學化的跑姿分析

- Measure more than 10 running related biomechanical parameters such as force, energy loss
- 測量超過10種生物力學參數，如撞擊力、能量損失
- Analyze running injury risk and diagnose key issue in running form that leads to injury and poor performance
- 分析用戶跑姿中會引致受傷和表現不佳的關鍵問題，提升跑步表現和降低受傷風險
- Provide clinically proven biofeedback targeted to the problematic area that can reduce injury risk by over 60%
- 提供經臨床實驗證實的生物反饋技術，可將受傷風險降低60%以上

Prof. CHEUNG Chi Kwan Vincent
張智鈞教授

Mr. CHEUNG Man Fai Ben
張文斐先生

School of Biomedical Sciences
生物醫學學院

Funded by Technology Start-up Support Scheme for Universities (TSSSU)
由大學科技初創企業資助計劃

Collaboration with The Hong Kong Polytechnic University and The City University of Hong Kong
合作夥伴包括香港理工大學及香港城市大學

Portable Laser-Vibration Therapeutic Device

便攜式激光振動治療儀



Population ageing has become a serious global issue. Many elderly suffer from various health problems, such as arthritis and joint pain. Our project is to develop a portable and user-friendly medical device for prevention and treatment of knee joint degeneration diseases. The laser-vibration therapeutic device consists of three technologies: low-level laser therapy, vibration and heat therapy, which can help individuals to relieve pain, promote blood and lymph circulation, and conduct simple treatment at anytime. The device will be used for clinical rehabilitation in hospital. It can also be applied to people who need to sit for a long time, such as at home, in the office or during long-distance flight.

人口老化是全球面對的嚴重問題。許多老年人都患有不同的健康問題，如關節炎和關節疼痛等。這項目旨在開發一種容易使用的便攜式激光振動治療儀，以預防和治療膝關節退化性疾。它由三種技術組成：弱激光治療，振動按摩和熱療，可幫助使用者緩解痛楚、促進血液和淋巴循環，並隨時進行簡單治療。這裝置將應用於由醫院提供的臨床康復治療，亦適用於需要在家中、辦公室或長途飛行等長時間坐下的人士。



Prof. QIN Ling

秦嶺教授

Mr. ZOU Li

鄒力先生

Department of Orthopaedics and
Traumatology

矯形外科及創傷學系

Funded by Technology Start-up Support

Scheme for Universities (TSSSU)

由大學科技初創企業資助計劃資助

The Portable Laser-Vibration Therapeutic Device is small and light-weight (170g). It covers three treatments of retrogression which can improve the treatment efficiency.

便攜式激光振動治療儀體積細少和輕巧(只重170克)，包含三種退行性病變的治療功效，能有效地提高治療效果。

- Laser Therapy: use high range laser and low range laser which can provide low-level laser therapy
- 激光治療：使用不同波長的醫用激光以提供弱激光療法
- Vibration: provide physical therapy and strengthen musculoskeletal joints
- 振動按摩：提供物理治療和增強肌骨關節
- Heat Therapy: maintain the temperature at around 42 degree Celsius which is recommended by the U.S. Food and Drug Administration for medical rehabilitation
- 熱療：維持在美國食品藥品監督管理局建議的攝氏42度熱力以促進醫療康復



Portable Quantitative Phase Microscope 便攜式定量相位顯微鏡

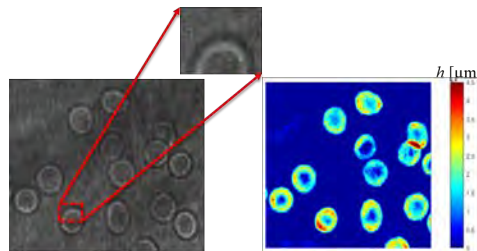


Quantitative phase microscope (QPM) techniques have become an important modality for quantifying live cell morphology and precision material (e.g. semiconductor) metrology. However, conventional QPM is expensive, especially for those in underdeveloped areas. The sensitivity of current microscopes is poor when measuring transparent or thin samples. Additionally, most current portable microscopes require an external camera, thus they are not compact at all. To solve the problem, CUHK research team develops a new portable and versatile QPM system. It can measure the dynamical deformations of both transparent and reflective samples by combining both reflection mode and transmission mode into one system. Current system has a lateral resolution of $1\ \mu\text{m}$, field of view of $50\ \mu\text{m} \times 50\ \mu\text{m}$, and height sensitivity of 2nm .

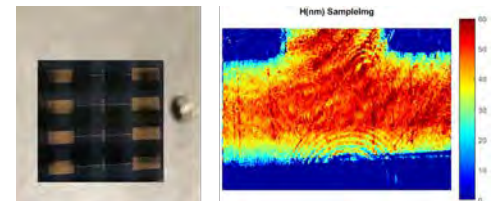
定量相位顯微鏡 (QPM) 技術已成為一種定量測量活細胞形態和精密材料 (如半導體) 形態的重要方式。不過,傳統的定量相位顯微鏡價格高昂,特別是對於落後地區來說,而測量透明或纖薄樣品時,現有的定量相位顯微鏡靈敏度不佳,加上,目前大多數便攜式顯微鏡都需要外置鏡頭,實則並不輕便。針對以上問題,中大研究團隊開發了一種新型便攜式多功能定量相位顯微鏡系統。通過將反射模式和透射模式組合到一個系統中,本系統可以測量透明和反射式樣品的動態變形。目前,系統具有 $1\ \mu\text{m}$ 的橫向解析度, $50\ \mu\text{m} \times 50\ \mu\text{m}$ 的視場和 2nm 的高低距離靈敏度。



Portable quantitative phase microscope prototype
便攜式多功能定量相位顯微鏡系統原型



Red blood cell testing result
檢測紅細胞的結果



Semiconductor chip testing result
檢測半導體晶片的結果

- Our system uses a special interferometry technique to greatly eliminate noise influence, thus, it can realize higher sensitivity and measurement resolution
- 本系統採用特殊的光學干涉技術,大大消除噪聲影響,因而可達至更高的靈敏度和測量解析度
- Not only high precision, low cost, our system is also compact in size (weighs less than 1 kg), portable, and it can be further miniaturized and automated in future
- 不但測量精度高、製造成本低,同時輕巧(重量少於1公斤)、便攜,將來更可進一步小型化和自動化
- Our system is versatile. For example, it is able to detect defects in semiconductor chips, characterize micro-/nano-fabricated structures, image biological cells and tissues, etc. Even to be potentially used for blood screening in underdeveloped areas
- 用途廣泛,例如檢測半導體晶片缺陷、表徵微/納米製造結構、生物醫學細胞和組織成像等,甚至可用於落後地區的血液檢測

Prof. ZHOU Renjie
周仁杰教授

Department of Biomedical Engineering
生物醫學工程學系

Collaboration with ASM Technology HK Ltd.
合作夥伴為香港先進科技有限公司



Diagnosis of Malaria in Saliva via a new Biomarker: The Activity of Plasmodium Topoisomerase I

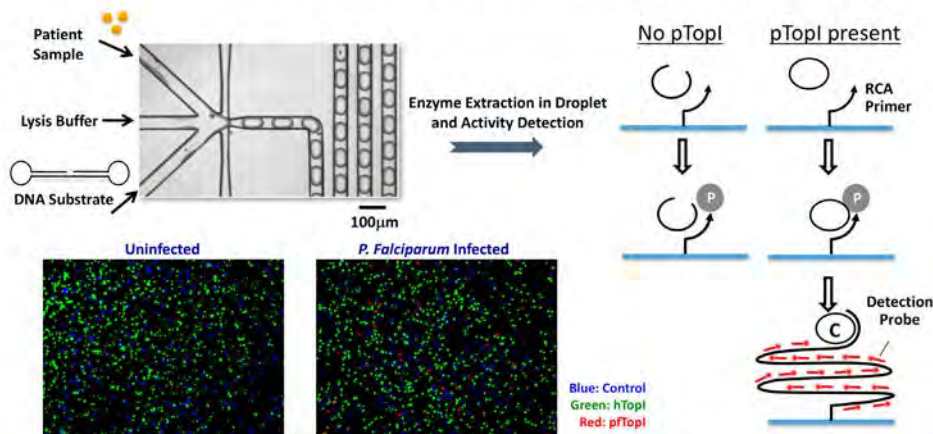
利用唾液樣品診斷瘧疾： 一種新的生物標記物 — 瘧原蟲拓撲異構酶的活性



Infectious disease represents a major threat to global health causing millions of human lives often due to late diagnosis and inefficient treatment. Many of the currently prevalent diagnostics methods are not preferred in the clinics because they rely heavily on pre-amplification or post-separation steps. Motivated by the appeal of a sensitive, yet easy-to-assay, diagnostic approach, we have been working on a new biomarker, the activity of pathogen expressed DNA-modifying enzymes, for the diagnostics of infectious diseases. By using non-invasive saliva as a sample, we develop a malaria point-of-care diagnostic kit to reduce duration of diagnostic process and enhance efficiency. The technology can be applied in diagnostics of malaria and other infectious disease.

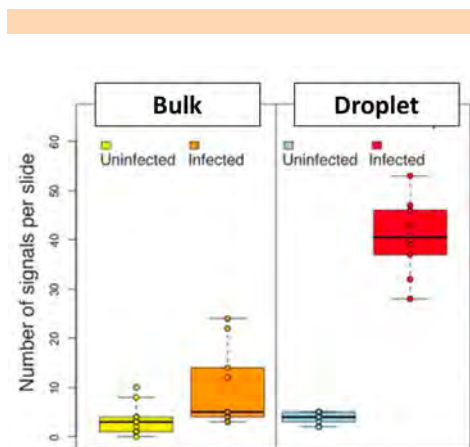
由於診斷延誤和治療效率低下，傳染性疾病仍是全球急需解決的問題。許多目前主流的診斷方法十分依賴於預擴增或後分離等處理步驟，耗時長且效率低。針對此問題，我們研究開發了一種新的生物標記物 — 病原體表達DNA修飾酶的活性，以應用於傳染性疾病的診斷。利用非侵入性的唾液樣品，我們開發了即時檢測瘧疾的診斷工具，以減少診斷時間並提高效率。這技術可應用於瘧疾及其他傳染病檢測。

Malaria Diagnostics via Plasmodium Topoisomerase (pTopI)



Schematic of malaria diagnostics via plasmodium topoisomerase

通過瘧原蟲拓撲異構酶診斷瘧疾的概要圖



Prof. HO Yi Ping Megan
何亦平教授

Department of Biomedical Engineering
生物醫學工程學系

Funded by Danish Research Council and
CUHK Start-up Fund

由丹麥國家基金委項目及中大啟動基金資助

Collaboration with Aarhus University, Denmark
合作夥伴為丹麥奧胡斯大學

- Pathogen specific enzymatic activity as a novel biomarker for malaria diagnostics
- 針對活體病原菌做檢測
- Effective extraction and well-preserved enzymatic activity by confined reaction in picoliters droplets
- 有效率的提取專一性高的病原菌酶作為生物標記物
- Catalytic reaction of enzymes offers an intrinsic amplification and significant improved detection sensitivity
- 利用酶催化反應的特性放大信號，無須後處理
- High species specificity
- 物種特異性高
- Ultrasensitive detection (0.06parasites/mL)
- 超靈敏檢測 (每毫升0.06寄生物)
- Diagnostics based on saliva and direct pathogen detection
- 基於唾液和活體病原體檢測的診斷





Link Between 'Fuz' Protein Level and Neurological Disorders

New Treatment Paths for Neural Diseases

Fuz蛋白水平與神經系統疾病之關係

為治療神經系統疾病提供新研究方向

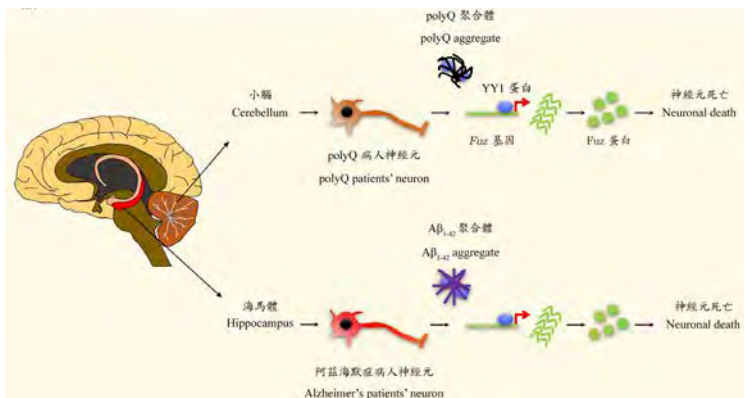


Spinocerebellar ataxia type 3 (SCA3) is the most common form of dominantly inherited ataxia. SCA3 patients often present problems with gait and balance, blurred vision, and speech difficulties. The symptoms are progressive, and to date SCA3 remains an incurable disease. Our research team has recently discovered a novel pathogenic mechanism of the new function of Fuz protein in inducing neuronal death for a group of rare genetic neuronal disorders, known as polyglutamine (polyQ) diseases, including spinocerebellar ataxias and Huntington's disease.

Improper folding of a protein may result in cellular malfunctioning and lead to diseases. Misfolded disease proteins (polyQ protein aggregates) are detected in the deteriorating neurons of SCA3 and other polyQ disease patients. SCA3 polyQ protein aggregates perturb the function of Yin Yang 1 protein (YY1). In neurons, YY1 functions as a repressor of Fuz protein (Fuz). When the function of YY1 is compromised, the expression level of Fuz will increase. Once it exceeds 2.5 times the normal level, it will trigger apoptosis, cause cell death in neurons and eventually lead to neural diseases.

小腦萎縮症三型在顯性遺傳的小腦萎縮症中是最常見的，患者常表現出步態不穩、無法保持平衡、視線模糊及語言困難的症狀，這些症狀會隨著病情惡化而加劇。然而，至今仍未有治療小腦萎縮症三型的有效方法。中大科研團隊最近發現了一類罕見神經系統疾病——聚谷氨酰胺疾病（簡稱polyQ疾病）的致病機制，包括小腦萎縮症與亨廷頓舞蹈症，首次確認Fuz蛋白在誘導神經元死亡方面的新功能。

在人體內，蛋白質錯誤摺疊會令細胞功能將產生障礙，導致神經元功能受損。在小腦萎縮症三型與其他polyQ疾病中，錯誤摺疊的疾病蛋白（polyQ蛋白聚合體）被發現存在於退化的神經元中。小腦萎縮症三型的polyQ蛋白聚合體會影響Yin Yang 1 (YY1) 蛋白的功能。在神經元中，YY1蛋白具抑制Fuz蛋白的作用，當YY1 蛋白的功能受到損壞，Fuz蛋白的表達水平便會升高，一旦超出正常水平的2.5倍時，會導致神經元死亡，引發神經系統疾病。



This finding demonstrates the function of Fuz in inducing neuronal death
此項發現闡明了Fuz蛋白在誘導神經元死亡方面的新功能



Prof. Edwin Chan (2nd left, front row) and his research team
陳浩然教授（前排左二）及其研究團隊

- Our finding shows that the expression level of Fuz also increased in Alzheimer's disease
- 研究結果顯示在阿茲海默症中同樣出現Fuz蛋白表達水平上升的情況
- Fuz-mediated apoptosis pathway plays some common roles in neurological disorders
- Fuz介導的細胞凋亡通路也存在於某些常見的神經系統疾病當中
- We are now investigating the involvement of Fuz in other disease conditions, and finding compounds that can bring Fuz upregulation back down to a normal level
- 我們會繼續研究Fuz蛋白與其他疾病的聯繫，同時也正在尋找一些化合物，可以使升高的Fuz蛋白表達水平重新恢復正常
- This research will be a novel therapeutic direction toward polyQ and Alzheimer's diseases and make contributions to the advancement of biomedical science research in neural disease biology
- 研究成果可能為治療polyQ及阿茲海默症提供新的方向，有助推進神經疾病領域中生物醫學方面的研究

Prof. CHAN Ho Yin Edwin
陳浩然教授

School of Life Sciences
生命科學學院

Funded by CUHK Gerald Choa Neuroscience Centre, Research Grants Council of Hong Kong and Chow Tai Fok Charity Foundation
由中大蔡永業腦神經科學中心及香港研究資助局及周大福慈善基金資助

Supported by Hong Kong Spinocerebellar Ataxia Association
獲香港小腦萎縮症協會支持



Biogenesis and Function of EXPO and Autophagosome in Plants

植物EXPO和自噬體細胞器的生物起源與功能

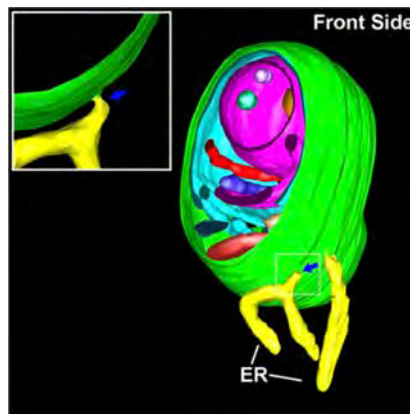
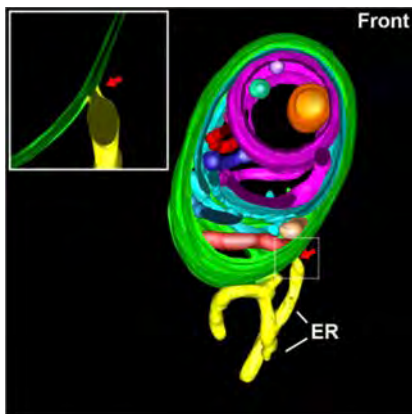


Autophagy is a well-defined catabolic mechanism whereby cytoplasmic materials are engulfed into a double-membrane structure termed autophagosome. Autophagy plays an essential role in quality control of proteins and organelles, and protects the cell against pathogen infection or other unfavorable conditions. During autophagy, autophagosome engulfs and delivers proteins into the lysosome or vacuole for degradation and recycling.

Our recent research programs have made a significant contribution towards our understanding about unconventional protein secretion (UPS)-mediated protein traffic and autophagosome biogenesis in plants. For example, using the Arabidopsis Exo70E2 (AtExo70E2) as a marker for exocytosis, we discovered a novel organelle termed EXPO (Exocyst-positive Organelle) and a new UPS unique in plants. EXPO regulates protein secretion of the cell in order to release antibacterial agents to the plant surface to protect it against bacteria, viruses and infections.

自噬作用是一種分解代謝機制，代表細胞質物質被吞噬到稱為自噬體的雙膜結構中。自噬在控制蛋白質和細胞器品質中有重要作用，可保護細胞免受病原體感染或其他因素影響。在自噬過程中，自噬體會吞噬蛋白質，並將其運送到溶酶體或液泡中以進行降解和循環再造。

我們最近的研究在非常規植物蛋白質分泌輸送和自噬體生物起源方面取得突破性進展。例如，透過使用擬南芥 Exo70E2 (AtExo70E2) 作為胞吐作用的標記物，我們發現了一種名為 EXPO (Exocyst-positive Organelle) 的新細胞器。EXPO 可以調節一種植物中獨有的新非常規植物蛋白質分泌，釋放抗菌劑至植物表面，抵禦細菌、病毒及外來傳染物入侵。



3D transmission electron microscopy (3D TEM) is used to reconstitute the 3D organization of abnormal autophagosomal tubular structures in atg9 mutant

根據斷層掃描電子顯微鏡數據重組的3D模型展示atg9突變體植物中不正常的自噬體管狀

3D tomogram models show direct connection between the abnormal autophagosomal tubule (green) and the Endoplasmic reticulum (ER) membrane (yellow)

3D 模型展示了自噬體小管 (綠色) 與內質網膜 (黃色) 直接相連的關係

Prof. JIANG Liwen
姜里文教授

School of Life Sciences
生命科學學院

Funded by Research Grants Council of
Hong Kong
由香港研究資助局資助

- Both EXPO and autophagosome play important roles in regulating plant growth and development as well as plant response to environment
- EXPO和自噬體在調節植物生長發育以及對環境的反應中擔當重要角色
- Contribution to our understanding about organelle biogenesis and function in plants
- 幫助植物研究界對植物細胞器的生物合成和功能的理解
- Potential application in biotechnology for improving human health
- 對促進人類疾病研究的生物技術有潛在的應用價值

The tomogram models derived from our research are converted into 3D animations to be viewed in Virtual Reality (VR). We have developed a mobile app which users could explore 3D plant organelles in a stimulating cell environment.

我們將研究所得的斷層圖模型轉換為3D動畫，並開發了一個手機應用程式，讓用戶透過虛擬現實 (VR) 探索3D植物細胞器。



App Store



Google Play

14



Environmental
and Green
Technologies

環境和綠色技術

High-Quality Metal Nanoparticles

高質量金屬納米顆粒



The surface area per weight of nanoparticles is much greater than larger particles. It allows nanoparticles to be more reactive to other materials. In this project, we have applied high-quality gold and silver nanoparticles for ultrasensitive drug detection and fabrication of smart windows.

Ultrasensitive Drug Detection

We develop a convenient, cost-effective solution with high accuracy to monitor the concentration of toxic ingredients by fabricating substrates that are deposited with these nanoparticles. Nanoparticles can significantly and precisely magnified the surface-enhanced Raman spectroscopy (SERS) signals of any detected drugs to identify their concentration. Our approach towards the ultrasensitive detection of drugs can be generalized to the detection of any harmful chemical substances that can be detected by Raman spectroscopy.

Smart Window Applications

We combine gold and silver nanoparticles with Vanadium Oxide to construct transparent substrates that can control the transmission of near-infrared radiation (NIR) as well as room temperature. The size and shape of our high-quality nanoparticles can be precisely manipulated to maximize their ability of interaction with light. Similar principle can be applied in solar cells to enhance the transmission of NIR and improve the efficiency.

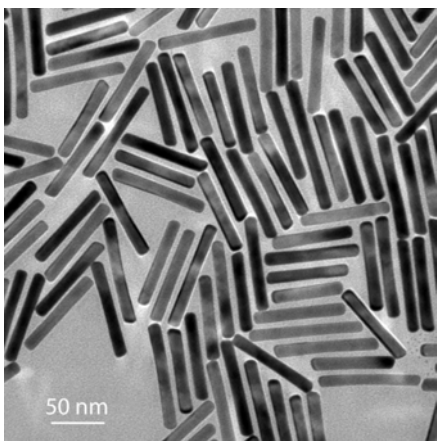
納米顆粒的表面面積（以每單位重量計算）遠大於較大的顆粒，令納米顆粒對其他材料有更靈敏的反應。在這個項目，我們把高質量的金、銀納米顆粒應用於高精度的藥物檢測以及製造智能窗戶。

高精度毒品檢測

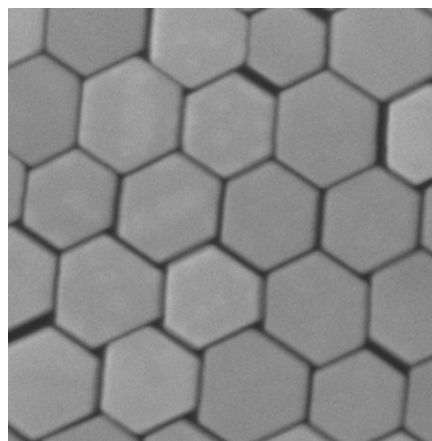
我們開發了一個方便、低成本、高精確度的檢測方法，能檢測任何能被拉曼信號偵測的有害化學物質。透過將高質量的金、銀納米顆粒散布於基底上，納米顆粒能夠有效並精準地增強散佈於基底上的檢測物質的拉曼信號，並以其拉曼信號的強度去探測物質濃度。

智能窗戶應用

我們亦透過結合金、銀納米顆粒和二氧化鈦去製造一種可以控制近紅外線輻射穿透率的透明基底，從而控制室內溫度。我們的技術可以精確控制納米顆粒的大小和形狀，把它們與光的相互作用最大化。類似的原理可用於增強太陽能電池的近紅外線輻射穿透率以提高電池效率。



Long gold nanorods
長型金納米棒



Gold nanoplates
金納米六角板

Prof. WANG Jianfang
王建方教授

Department of Physics
物理系

- Cost-effective detection of toxic ingredients in food and common drugs with high accuracy, such as malachite green, heroin, cocaine, amphetamine and ketamine
- 提供高成本效益、高精確度的檢測方法去檢測食物中的有害物質以及社會常見毒品，例如孔雀石綠、可卡因、海洛英以及安非他命
- Control of the transmission of NIR for smart windows to maintain the room temperature at a comfortable level
- 控制智能窗戶的近紅外輻射穿透率以維持舒適的室內溫度
- Available for mass production at non-cleanroom environment
- 可在非無塵室環境中大量生產



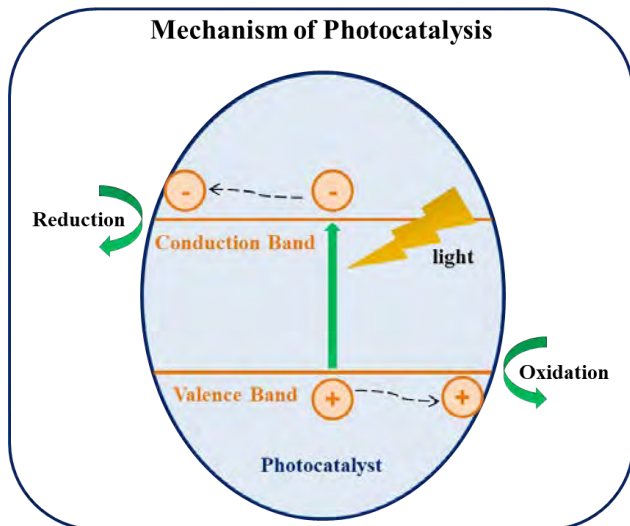
Transparent Photocatalytic Thin Films for Self-Sterilizing Facilities and Devices

用於自動滅菌裝置的透明光觸媒薄膜



Facilities such as door handles and elevator buttons in urban spaces are constantly touched and show high levels of bacterial contamination. With the advancement of touch screen and display technologies, interactive touch system also becomes a part of our city. Adhesion and growth of germs on the frequently touched surfaces are critical to the spread of infectious diseases. We have been working on the incorporation of transparent photocatalytic thin films into frequently touched facilities and devices. These thin films are able to harvest both light originated from the devices and indoor light/sunlight for automated photocatalytic and antibacterial effects without affecting the original function and appearance of the facilities or devices. Application of photocatalytic thin film on the facilities would be beneficial in minimizing the spread of germs around the area.

在人流多的地方，門柄和升降機按鈕等設施是各種細菌和病毒的溫床。隨著觸控螢幕的發展和顯示技術的進步，互動輕觸螢幕亦已經成為這個城市的一部分。病原體會粘附在物件表面上生長，有機會傳播疾病。我們正研究將透明光觸媒薄膜應用在各種公共設施和裝置上。這些薄膜不但能運用來自裝置的光以及室內照明的燈光或室外的太陽光，以達到自動的光催化和殺菌效果；並且不會對設施或裝置自身的功能和外觀造成影響，能夠有效降低病菌播的風險。



Mechanism of photocatalysis
光催化作用的原理



Photocatalysts as powders and thin films
光觸媒粉末和薄膜

- Automatic sterilization
• 自動消毒
- Long-lasting
• 長效
- Reduced use of harmful or irritating disinfectants
• 減少有害或具刺激性消毒劑的使用
- Applications: self-sanitizing door handles, elevator buttons, screen protectors for touch screen kiosks, etc.
• 用途：自潔門柄、升降機按鈕和輕觸式螢幕資訊站等

Prof. YU Chai Mei Jimmy
余濟美教授

Dr. CHAN Ka Long Donald
陳家朗博士

Department of Chemistry
化學系

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



Large Scale Glacier Mass Balance Survey in High Mountains Asia

Mapping High Mountain Asia Glacier Dynamics with Bistatic Interferometry and SAR Imagery Classification



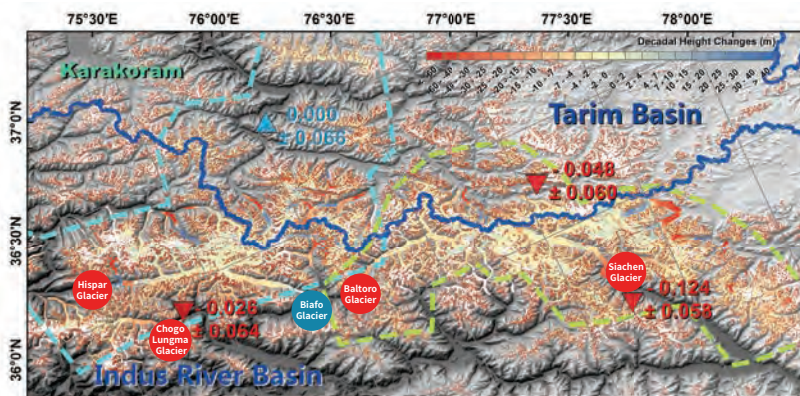
「高亞洲地區」冰川大範圍質量平衡精確測量 使用雙站雷達干涉測量及雷達影像分類技術測量高亞洲冰川動態

Glaciers, as an important part of the cryosphere, play an essential role in climate change. The largest number of low-latitude and high-altitude glaciers in the world are located in 'High Mountain Asia' (HMA), including the Tibetan Plateau, the West Kunlun, the Karakoram, the Hindu Kush and Pamir. Due to inaccessibility and high cost, in-situ observations have been performed only on less than 1% of the glaciers in this region. We recently conducted the world's first large scale glacier mass balance survey based on remote sensing methods in the western part of HMA.

This project applied multi-mission satellite earth observation to invest vast glaciers in HMA. Bistatic synthetic aperture radar (SAR) images are used to form topography and to map decadal glacier height changes by comparing with the terrain data collected in 2000. This research helps scientists understand more about the 'Karakoram anomaly'. The dataset provides important references for hazard prevention, such as glacier lake outburst flood, glacier surging and glacier calving.

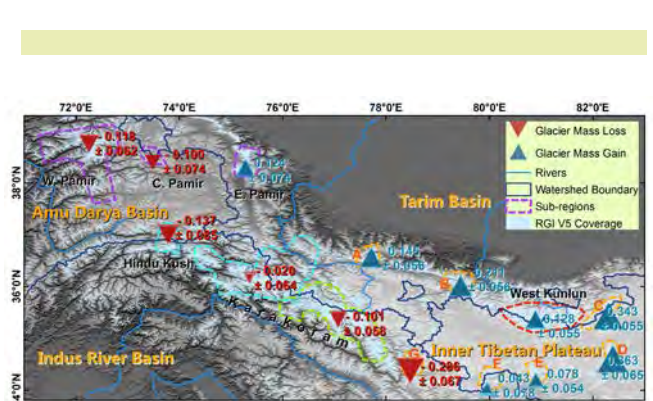
冰川作為全球冰凍圈的重要組成部分，在氣候變化中扮演了重要角色。「高亞洲地區」擁有全球最大的低緯度高海拔冰川，包括青藏高原、西崑崙，喀喇崑崙、印度庫什及帕米爾高原等。由於嚴酷的環境和高昂的費用，該地區只有少於1%的冰川進行過實地考察。我們近日對「高亞洲地區」西部的山脈冰川進行了國際上首次大範圍精確測量。

本項目使用多源衛星觀測資料對高亞洲大範圍冰川進行普查，採用雙站雷達干涉測量技術及雷達影像構建冰川地形並與2000年的地形數據對比，分析2000至2014年間冰川厚度變化。研究有助科學家進一步了解「喀喇崑崙異常」現象，同時為預防冰湖潰決、冰川躍動、冰崩等災害提供重要參考。



Glacier height changes at decadal scale in the Karakoram during 2000-2014. The blue line indicates main ridge of the Karakoram and also the divide between the Indus River basin and Tarim Basin

喀喇崑崙2000至2014年間冰川十數年尺度厚度變化。藍線為喀喇崑崙主山脊線，同時也是印度河流域及塔里木流域的分界線



Glacier mass balance of the Karakoram and its surroundings during 2000-2014 (in terms of m w.e. (water equivalent) yr-1)

2000至2014年間喀喇崑崙及周邊區域冰川質量平衡 (水當量·米/年)

Prof. LIN Hui
林瓊教授

Institute of Space and Earth Information Science
太空與地球信息科學研究所

Funded by Research Grants Council of Hong Kong
由香港研究資助局資助

Collaboration with University of Leeds, Institute of Tibetan Plateau Research and Institute of Remote Sensing and Digital Earth of Chinese Academy of Sciences

合作夥伴包括利茲大學、中國科學院青藏高原研究所及遙感與數字地球研究所

- Unlike optical remote sensing which can be affected by clouds and high albedo, radar technique applied in this project is not affected by cloudy weather and also better in observing upper accumulation zones of glaciers which are difficult to observe with optical techniques
- 相比光學遙感方式，我們採用的雷達遙感技術不但受雲層遮擋影響，亦不會被冰川的高反射率影響，能更準確觀測冰川上游地區
- Technique innovated in this project has been applied to other continental glaciers and to form high precision digital elevation models
- 本項目所使用技術已應用於其他地區的冰川觀測及構建數碼化的高精準度高地地形
- Scientific outputs provide essential data for regional climate, glaciology, glacial-hydrology researches, and the prevention of glacier-related hazards
- 相關成果為區域氣候、冰川學、冰川水文學和防治冰川災害等研究提供重要的觀測資料



New Generation Ligand – Perovskite Inks for Photovoltaics (PV) and Light-Emitting Diode (LED)

用於太陽能板、發光二極管的新一代配體 — 鈣鈦礦墨水

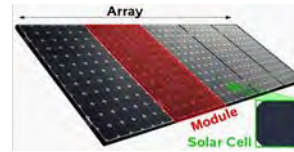
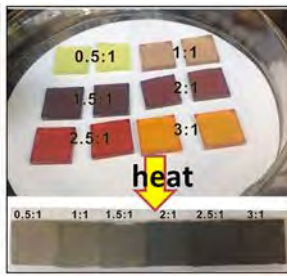
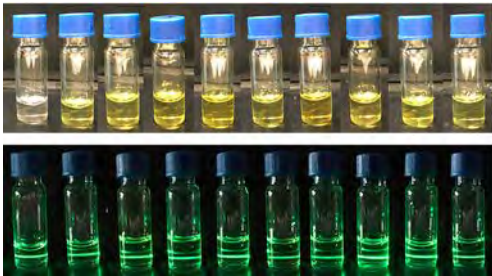


Solution processed perovskite is a new generation thin film technology with solution inks for photovoltaics (PV) and light emitting diode (LED), suitable for application using printing and coating techniques. The world record photoelectric conversion efficiency (PCE) of perovskite-coated PV lies between silicon solar cell (first generation, 26.7%) and thin film solar cell (second generation, ~22%). The luminescent properties, i.e. colour tunability and external quantum efficiency (EQE), of perovskite-based LED are comparable to those of OLED. However, due to its instability, the widespread commercialization of perovskite solar cells is hindered.

We developed a series of ligand-perovskite inks using “non-stoichiometric acid-base reaction (NABR)” that reduce the efficiency-stability-scalability-cost gap of PV/LED devices by half. The inks can be coated on substrates regardless of whether they are rigid or flexible with high throughput. It can be fabricated easily into scalable, flexible and ultrathin films, which is more competitive than nonelastic silicon solar cells. This ligand-perovskite ink technology is promising to be cost-efficiently utilised in the future PV/LED market and would be of great interest to PV/OLED companies as perspective strategies for future development.

鈣鈦礦墨水是用於太陽能光電系統 (PV) 和發光二極管 (LED) 的新一代薄膜技術，只需簡單的溶液加工即可製成鈣鈦礦太陽能電池。鈣鈦礦太陽能電池的光電轉換效率於短短數年間已大幅提升，雖暫不及第一代矽晶型電池（約26.7%），但已超越第二代矽薄膜電池（約22%）。鈣鈦礦LED的發光性能，不論是顏色可調性還是外部量子效率，亦可與有機發光二極體 (OLED) 媲美。然而，因為該類物料的不穩定性，鈣鈦礦太陽能電池一直未能普及化。

我們開發的新一代鈣鈦礦墨水配體，使用「非化學計量比的酸鹼反應」(NABR) 合成方法，能有效增進鈣鈦礦材料的穩定性，製造高效率、低成本、高穩定的鈣鈦礦PV/LED設備。鈣鈦礦材料可輕易製造出硬性或具柔韌性、可捲曲的超薄太陽能板，其應用性比堅硬、缺乏彈性的矽太陽能電池更廣，因此在太陽能電池、LED市場中有很大的發展潛力。



Solution inks for PV and LED
用於太陽光電系統、發光二極管的鈣鈦礦墨水

- The use of the ink depends on the fabricated device and the in-detail parameters can be customised, for instance, 500nm thick film for high performance PV solar panels and 50-100nm for LED devices
- 鈣鈦礦墨水可因應不同裝置及參數製備，例如，500nm的薄膜適用於高性能PV太陽能板；50-100nm的薄膜適用於LED裝置
- The gas-solid reaction process and areactor developed by the team was able to fabricate large-area perovskite thin film ($5 \times 5 \text{ cm}^2$) with dense structure, which substantially fostered their potential in commercial applications
- 團隊設計的氣固反應過程和反應器，能夠製備出緻密的大面積鈣鈦礦薄膜 ($5 \times 5 \text{ cm}^2$)，大大增加了鈣鈦礦電池的面積，向商業化生產所需要求大大邁進一步
- Advantages include the low-cost raw material, simple packaging technology, high power conversion efficiency and switchable PV-LED functions
- 優點包括低成本原材、簡單的封裝技術、高光電轉換效率和PV-LED切換功能

Prof. XU Jianbin
許建斌教授
Prof. YAN Keyou
嚴克友教授

Department of Electronic Engineering
電子工程學系

Funded by Research Grants Council of Hong Kong
由香港研究資助局資助



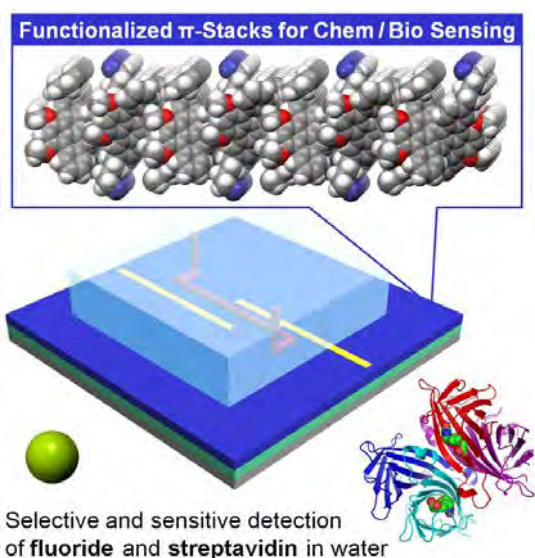
New Electronic Sensor for Detection of Chemical and Biological Species

檢測化學和生物物質的新式電子傳感器

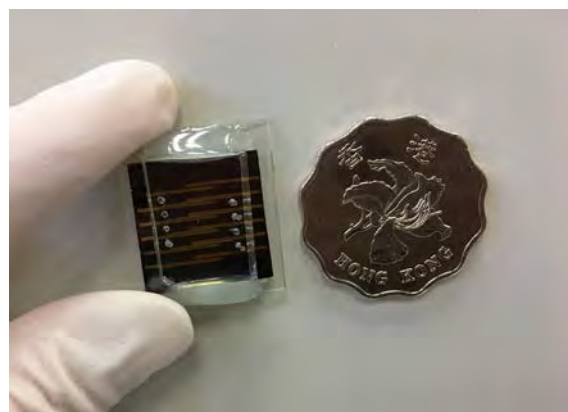


Organic thin film transistors are the basic components of soft, low-cost, wearable organic electronic devices. By combining sensory electrical output with easy device fabrication, sensors based on organic field-effect transistors (OFETs) can be integrated into biocompatible, wearable and implantable electronic devices. However, one challenge for tailoring organic semiconductors in OFET-based sensors is that introduction of reactive or binding sites usually impairs charge transport pathways. In view of this, CUHK research team synthesized hexabenzoperylenes with different functional groups. The unique self-assembly of hexabenzoperylenes allows introduction of a variety of functional groups to organic semiconductors without sacrificing charge transport pathways. The research outputs provide a novel solution to manufacture OFET-based sensors for highly selective and sensitive detection of chemical and biological species.

有機薄膜電晶體是組成柔軟、低成本、可穿戴有機電子設備的基本元件。基於有機薄膜電晶體的傳感器可以把化學反應或生物間的相互作用轉換為電子信號，並集成到具生物相容性的可穿戴電子設備中。但是，如何在有機半導體材料引入反應基團或結合位點而不破壞其導電能力是一大難題。有見及此，中大研究團隊設計及合成了帶有不同功能基團的六苯並花衍生物，並在其晶體結構中發現了一種罕見的分子堆積方式。這些六苯並花衍生物具有獨特的自組裝結構，可以向有機半導體材料引入各種功能基團而不破壞電荷傳輸的途徑。研究成果為基於有機薄膜電晶體的化學和生物傳感器提供了一個全新的解決方案，實現高選擇性、高靈敏度的化學和生物檢測。



Schematic drawing of the sensor with the unique self-assembly structure of organic semiconductors
傳感器原理圖及獨特的有機半導體自組裝結構



Size of the sensor is similar to that of a coin
傳感器的大小與硬幣相若

Prof. MIAO Qian
繆謙教授

Department of Chemistry
化學系

Funded by Research Grants Council of

Hong Kong
由香港研究資助局資助

- Can be customized to detect specific chemical and biological species in aqueous solutions by tailoring hexabenzoperylene molecules through chemical synthesis
- 透過化學合成來修飾六苯並花分子可以訂製不同的傳感器，檢測水溶液中的特定化學與生物物質
- Demonstrate high selectivity and sensitivity to detect fluoride and streptavidin (a protein) down to a concentration of 1×10^{-6} M and 3.6×10^{-11} M respectively
- 測試時對氟離子和鏈霉親和素（一種蛋白質）表現出很高的靈敏度和良好的選擇性，能檢測的濃度分別低至 1×10^{-6} M 和 3.6×10^{-11} M
- Potential applications for food quality control, environmental monitoring and medical diagnosis
- 可應用於食品質量控制、環境監測和醫學診斷



Information and
Communication
Technologies

信息和通訊科技

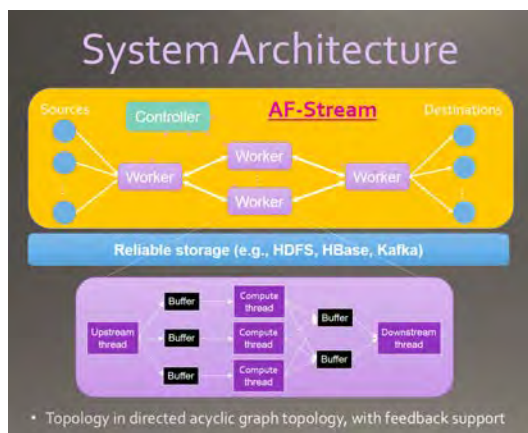
A Tunable Fault-Tolerant Distributed Stream Processing System for Big Data Online Analytics

支持在線分析大數據的可調度容錯分佈式流處理系統

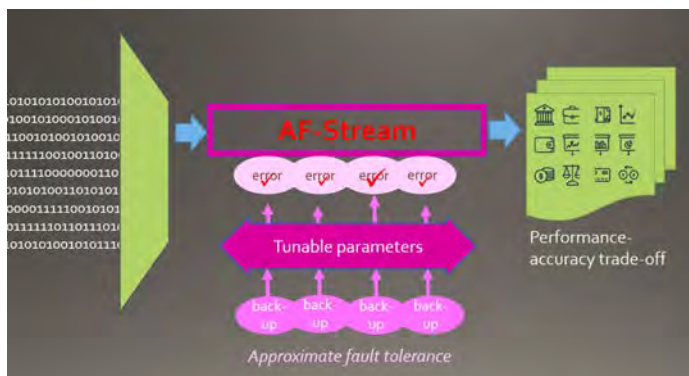


Conventional big data analytics systems (e.g., MapReduce, Dryad, Spark) are designed to work in an offline, batch-based manner originally. All data needs to be available in advance and will be processed as a whole. However, data is often generated continuously and needs to be processed in real time, for instance, network traffic data in telecommunication environment. To solve the problem, CUHK research team develops AF-Stream, the novel big data online distributed stream processing system. It provides a high-performance, fault-tolerant, and generic analytics platform for various analytics applications, such as data synopsis, stream database queries, and online machine learning. AF-Stream realizes a novel concept called approximate fault tolerance, which reduces the number backup operations to mitigate performance overheads for fault tolerance maintenance, while ensuring that the stream processing errors upon failures are bounded. To address diverse application needs, AF-Stream can easily tune the trade-off between performance and accuracy with only few parameters. Therefore, our technology is able to process more data and faster than other systems without fault tolerance.

傳統的大數據分析系統(例如MapReduce, Dryad, Spark)最初設計為以離線,基於批量處理的方式工作,需預先提供所有數據,並作整體處理。但是,大數據通常是連續生成的,需要實時處理,例如電信網絡的流動數據。為了解決這個問題,中大研究團隊開發了一個全新的大數據在線分佈式流處理系統AF-Stream,為各種如數據概要、流數據庫查詢及在線機器學習等分析應用提供一個高性能、容錯、和通用的分析平台。AF-Stream實現了一個新的概念「近似容錯能力」,透過減少備份操作的次數以減輕容錯維護的性能開銷,同時限制因在發生錯誤時所產生的流處理誤差。為解決不同的應用需求,AF-Stream可以很容易透過少量參數以調整性能和準確度之間的取捨,因此比其他沒有容錯能力的系統,能更快地處理更多數據。



System architecture of AF-Stream
AF-Stream的系統結構



AF-Stream can easily tune the trade-off between performance and accuracy with only few parameters
可以很容易透過少量參數以調整性能和準確度之間的取捨

Prof. LEE Pak Ching Patrick
李柏晴教授

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 Huawei Technologies,
Noah's Ark Lab
合作夥伴為華為技術有限公司 諾亞方舟
實驗室

- Goal: large-scale, real-time analysis on continuous, unbounded data streams
- 目標: 大規模實時分析連續無限的數據流
- Applications: network measurements (e.g., anomaly detection, flow size distribution, failure diagnosis), data mining and machine learning (e.g., frequent pattern mining, classification, regression, prediction)
- 應用: 網絡測量(例如異常檢測、流量分佈、故障診斷)、數據挖掘及機器學習(例如頻繁模式挖掘、分類、回溯、預測)
- Users: telecommunication, IT service operators, big data analytics industry
- 目標用戶: 電信、資訊科技服務營運商、大數據分析行業

Development of Empirical Mode Decomposition-Candlestick for FinTech Applications

結合經驗模態分解技術的陰陽燭圖表研發及金融科技應用

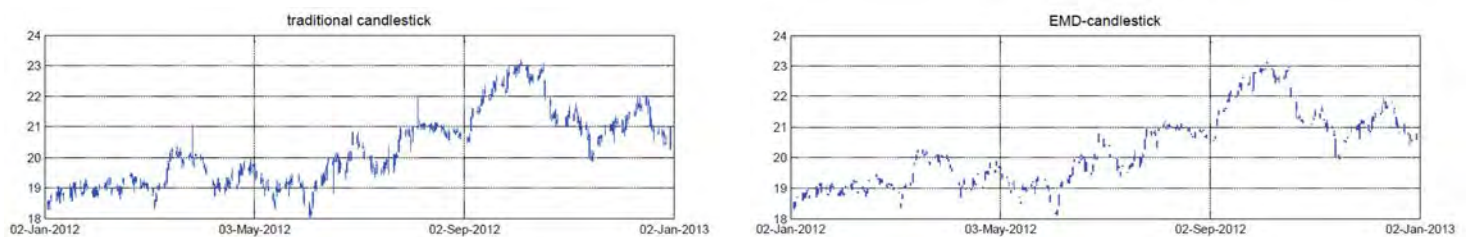


Candlestick is a summary of the daily performance of the underlying stock and is completely determined by the open price, close price, daily high, and daily low. Most technical analysis tools of stock market use it as a building block. However, the noise within the intraday level may affect the use of the four prices as a summary. Therefore, we employ empirical mode decomposition (EMD) methodology to clean up the intraday market data and form a new EMD-candlestick.

EMD-candlestick can replace traditional candlestick in a wide range of financial data analysis. For example, it can serve as the signal generators in technical trading strategies, including moving average, relative strength index, and intraday and inter-day trading rules. Compared with traditional candlestick, empirical results show that technical trading strategies are more profitable if EMD-candlestick is used. EMD-candlestick for FinTech applications can facilitate financial practitioners, algo-traders and investors to develop trading strategies.

陰陽燭是對應股票每日表現的總結，取決於開盤價、收盤價、每日高點和每日低點。股票市場中大多數技術分析工具都是建基於此。但是，日內交易中包含了不少雜訊，會影響以上四類價格作為總結的穩定性。因此，我們採用經驗模態分解技術(EMD)，去除每日市場數據中的雜訊，形成EMD陰陽燭。

EMD陰陽燭可以於多種金融數據分析中取替傳統陰陽燭，例如，在技術交易策略中為移動平均、相對強弱指數以及日內和日間交易規則等產生訊號。研究結果顯示，使用EMD陰陽燭技術交易策略的盈利會比運用傳統陰陽燭的高。EMD陰陽燭的金融科技應用可協助金融從業員、量化交易及一般投資者制定交易策略。



Traditional candlestick (left) and EMD-candlestick (right) of a stock from 4 January 2012 to 31 December 2012

使用傳統陰陽燭 (左) 及EMD陰陽燭 (右) 顯示某上市公司由2012年1月4日至12月31日的股價

- Profitability of our EMD-candlestick model significantly outperforms those using traditional candlestick
- EMD陰陽燭模型的盈利能力明顯超過只使用傳統陰陽燭的交易策略
- Our model acts as a low pass filter to filter out the noise from the intraday stock prices
- 以低通濾波器的形式去除每日股價變動中的雜訊
- By applying deep learning technology on the technical indicator signals generated from EMD-candlestick, we can formulate technical trading strategies for users
- 透過把深度學習技術應用在EMD陰陽燭所產生的技術指標訊號上，我們可為用戶制定技術交易策略

Prof. CHAN Honfu Raymond
陳漢夫教授

Department of Mathematics
數學系

Collaboration with CASH Algo Finance
Group Ltd.
合作夥伴為時富量化金融集團



Seamless Visual Sharing with Colour Blind People

Allow individuals with Colour Vision Deficiency (CVD) to share the same visual content with normal-vision audiences simultaneously

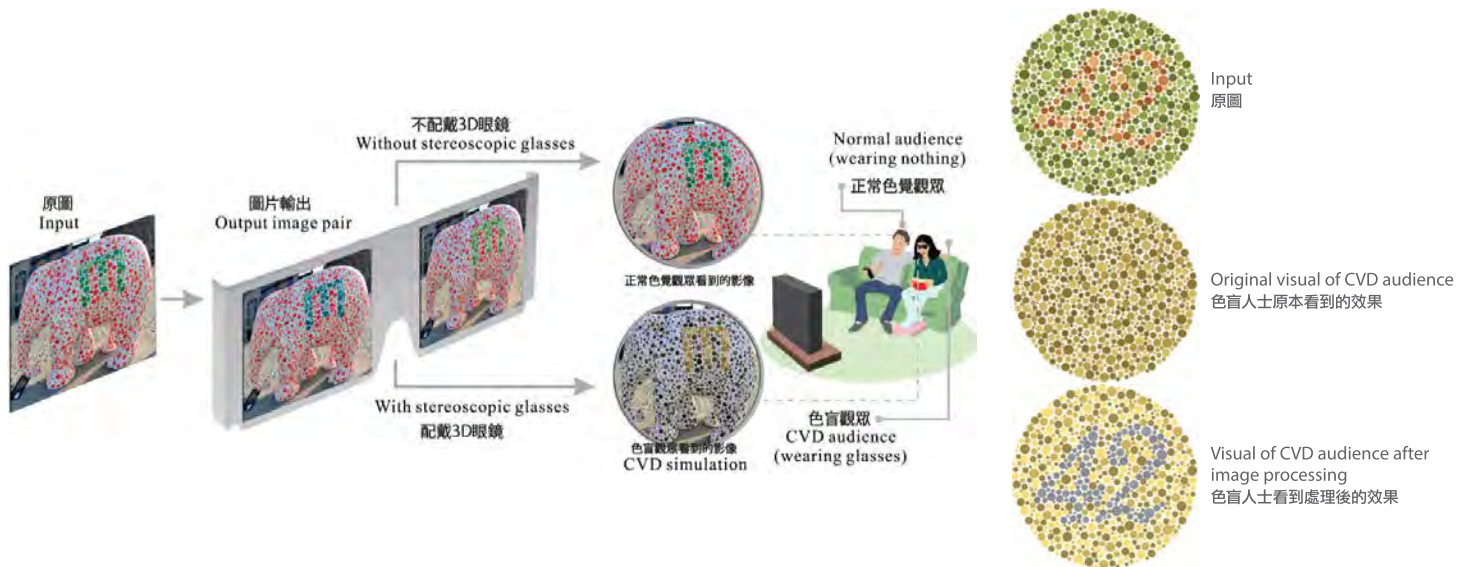


色盲人士視覺共享系統

讓色盲人士與正常色覺人士共享視覺內容

Approximately 250 million people suffer from color vision deficiency (CVD). There exist methods that help colorblind people to distinguish colors via changing the colors in the original images/videos. It is, however, not practical in sharing scenario where there are both CVD and normal vision audiences. Making use of stereoscopic display which offers users two visual experiences (with and without wearing stereoscopic glasses), we propose the very first system that allows CVD and normal-vision audiences to share the same visual content simultaneously. A mobile application is also developed for CVD audiences to distinguish visual content in daily life.

世界上有大約兩億五千萬的色盲人士，現存一些協助色盲人區分顏色的技術，但都需要改變原圖的顏色，當觀眾裡同時有色盲人士和正常色覺人士，這些技術就不適用了。我們利用了3D顯示器的兩個不同觀影模式（戴上3D眼鏡和不戴3D眼鏡），開發了首個讓色盲人士和正常色覺人士共享視覺內容的系統。與此同時，我們使用相關的技術開發了一個流動應用程式，以幫助色盲人士在日常生活中區分顏色。

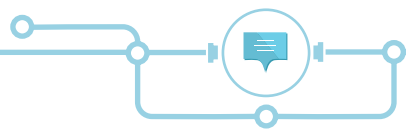


Prof. WONG Tien Tsin
黃田津教授

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

Funded by Innovation and Technology
Commission and Research Grants Council
of Hong Kong
由創新科技署及香港研究資助局資助

- Can be applied in all 3D visual display device e.g. home TVs, movie theaters, mobile screens
- 可應用於各種3D顯示設備，例如家庭影院、電影院以及手機等
- CVD audiences wearing stereoscopic glasses will be able to distinguish the originally indistinguishable colors when presented with computer synthesized binocular images; while normal-vision audiences (without stereoscopic glasses) view the monocular images which are visually no difference from the original image
- 色盲人士透過3D眼鏡觀看由電腦產生的雙目影像，就可以分辨原本分辨不到的顏色；而正常色覺人士不配戴3D眼鏡直接觀看屏幕上的單目影像，會看到和原圖沒有色彩差別的圖像
- Not only enhancing the image colour instantly captured by the device camera for CVD audiences, the mobile application also allows normal-vision audiences to understand the vision of CVD by simulating the visual experience
- 流動應用程式不但可實時改善設備所攝錄的影像色彩，協助色盲人區分顏色，更可模擬色盲人士所看到的影像效果，讓正常色覺人士感受色盲人士的視覺
- Our method is extensively evaluated via multiple quantitative experiments and user studies, with convincing results obtained in all test cases
- 量化評估及用戶測試證明我們的技術提供穩定滿意的效果



AI Based Color Image Compression Platform

AI技術驅動的彩色圖片壓縮平台



With the advancement of digital photography technology, the demand for cloud and local storage space is increasing. Image processing technology nowadays can convert color images into grayscale ones and greatly reduce the storage space required, however, original colour cannot be restored once an image is converted to grayscale. We therefore develop a color conversion system based on convolutional neural network. The system provides an innovative method to synthesise invertible grayscale, which offers color-to-gray conversion and grayscale-to-color restoration, to fully restore the original colour of grayscale images. It can be applied in image processing industry and cloud storage applications.

隨着數碼攝影技術的發展，雲端和本地存儲空間的需求日益增加。現時的影像處理技術可以把彩色影像轉換為灰階，大幅減少所需要的存儲空間。然而，一但把影像轉換到灰階，便無法完全恢復其原始色彩。有見及此，我們開發了一個基於卷積神經網絡的色彩轉換系統，不但可以把影像從彩色轉換為灰階，更能把灰階影像準確地恢復回彩色。相關算法可以應用於圖片處理行業以及網絡雲端存儲應用。



- We propose a color-encoding learning model which consists of an encoding network to convert a color image to grayscale, and a decoding network to invert the grayscale to color
- 我們提出一種顏色編碼的學習方案，將原始圖像中的色彩信息編碼為合成灰階，以及將灰階變回彩色的解碼方法
- The color image recovered by the system is visually the same as the original image
- 利用系統恢復的彩色影像會和原圖沒有色彩差別
- Cloud and local storage space can be greatly reduced as the images are significant compressed using AI-based grayscale generation and color recovery technology
- 通過使用基於人工智能的色彩去除和恢復技術，數據可以得到進一步的壓縮，從而節省雲端和本地的存儲空間

Prof. WONG Tien Tsin
黃田津教授

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

Funded by Research Grants Council of
Hong Kong
由香港研究資助局資助

Smart Drainage Technology for Wireless, Continuous and Large-Scale Flood and Gas Monitoring

無線智慧排水實時監測系統



The complexity of urban drainage systems and blockages may impose difficulties and dangers in performing an on-site inspection and detection of hazardous gases such as sulfur dioxide and methane in real-time, and even increase the risk of flooding associated with adverse weather conditions. The underground has been an extremely challenging environment for establishing a reliable wireless sensing network. Making use of the manhole cover as a part of the antenna of the communication module for transmitting sensor data, our team developed a first-to-its-kind wireless network for the smart drainage system to provide real-time information on drainage performance, the concentration of gases and water level.

Through the wireless signal transmission and big data analysis, the smart drainage system enables frontline staff to take proper and timely action on gas emission, illegal wastewater discharge, and blockage. The system offers a creative and intelligent solution to city's drainage management and promotes smart city development in Hong Kong with minimal installation costs and software requirements.

現代都市的地下渠道環境變化錯綜複雜，如何在極具挑戰性的地下環境建立可靠的無線傳感網絡一直是一個困難的課題。渠道當中的氣體，如二氧化硫、沼氣等有可能對前線人員的安全帶來威脅，而渠道阻塞則隨時可能在暴雨來襲時造成大面積的水浸。針對以上問題，我們利用沙井蓋為傳輸天線的一部份，研發出無線智慧排水系統，實時監測地下渠務管道的狀態，包括沙井內水位及氣體的變化。通過無線網絡傳送的數據及大數據分析，工程人員可及時得到關於氣體溢出、非法排放污水、淤塞等方面的資訊，有效預防氣爆或水浸災害、發現異常環境污染源、研究水位及流速的變化。系統使用成本相宜的軟硬件，為地下渠道管理提供一個創新、有效的解決方法，有助香港發展成為智慧城市。



Prof. Wu Keli (right) and his research team
吳克利教授(右)與其研究團隊成員



Wireless underground devices installed in manholes
於沙井安裝的無線探測裝置

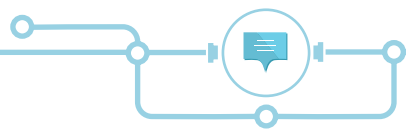
Prof. WU Keli
吳克利教授

Department of Electronic Engineering
電子工程學系

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

Collaboration with Drainage Services Department and Logistics and Supply Chain MultiTech R&D Centre
合作夥伴包括渠務署及物流及供應鏈多元技術研發中心

- Each underground device in the current system could be equipped with up to 5 different sensors to monitor the concentration of hydrogen sulfide (H₂S), sulfur dioxide (SO₂), methane (CH₄), the change of water level, and to detect the opening status of the manhole cover
- 每個裝置可配備五個不同的傳感器：分別監測硫化氫(H₂S)、二氧化硫(SO₂)、甲烷(CH₄)、水位變化及沙井蓋開關狀態
- The manhole cover used to be a conventional obstacle to the propagation of wireless signals due to the metal shielding effect, but the team has changed its nature to an adaptably tuned antenna for a low-frequency communication system so that the collected sensor data can be sent back from a device inside a manhole to the based stations on a rooftop
- 研究團隊突破傳統思維方式，不將沙井蓋視為障礙，反而把其變為自適應天線的一部分，將數據透過無線網絡傳送至位於大廈天台的基站
- The team has developed a very low power gas sampling device for gas sensors to prolong their lifetime while operating in a very humid and collusive underground environment to improve the durability and energy efficiency
- 研究團隊設計了一個低耗能全密封式微型氣體分析裝置，能有效地改善氣體傳感器在潮濕、惡劣環境下的耐用性和效能



Smart Landslide Detection System

智能滑坡監測系統



Mountainous terrain covers 60% of the land area of Hong Kong, and landslides may happen under conditions of continuous rainfall. Civil Engineering and Development Department of Hong Kong SAR Government has been building rigid concrete barriers and flexible wire-mesh fence along the hillside to protect the residential area below. However, these barriers are often located at remote area, making it difficult to perform onsite checks for accumulation of debris and determine if debris exceed the capacity limit of barriers. Our smart landslide detection system provides real-time monitor of terrain conditions, and real-time alerts to the authorities concerned. The sensing devices are designed to monitor water level, detect any impact when landslide debris hits the barrier wall, measure the debris accumulation level inside the barrier, and detect any inclination of the wire-mesh fence. The system performs steadily under extreme weather conditions, demonstrating its ability to immediately notice any landslide activity and protect residents.

香港有六成土地為天然山坡，在持續降雨的情況下有機會觸發山泥傾瀉。有見及此，香港特別行政區政府土木工程拓展署在靠近民居的山坡上興建泥石壩或防護網，保護山坡附近居民的人身安全。然而，防護設備通常位處偏遠地方，難以進行實地檢視泥石堆積物會否超過防護設備的承受能力。我們的智能滑坡監測系統能實時監測山體滑坡情況，並向有關單位發出泥石衝擊的警告訊號，功能包括監察水位，感應雜物的撞擊，測量防護設備內的碎片堆積情況以及量度防護網的受壓情況。系統在惡劣的天氣下仍然運作如常，表現理想，能夠即時提供泥石流出現狀況，保障居民的人身安全。



- Low power consumption
- 低耗能
- Low cost
- 低成本
- Real-time detection of landslide impact on barriers
- 實時監測山體滑坡情況對防護設備的影響
- Durable and reliable
- 耐用可靠
- Flexible for deployment
- 部署靈活
- Effective detection and monitoring system to protect lives and properties
- 有效地保護市民生命和財產的檢測和監測系統

Prof. LAM Wai
林偉教授

Prof. CHENG Chun Hung
鄭進雄教授

Mr. CHAN Kwong Tim
陳廣添先生

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

Collaboration with Civil Engineering
and Development Department
合作夥伴為土木工程拓展署



Knowledge and Education Exchange Platform (KEEP)

知識與教育交流平台 (KEEP)

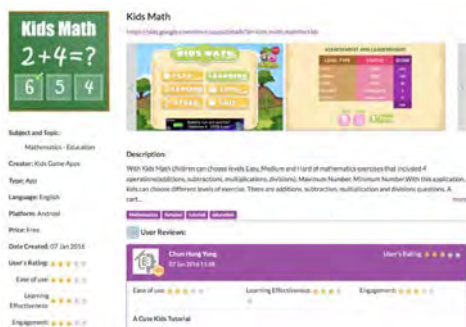


The higher education sector has been facing with the growing need to integrate technology into teaching and learning. A wealth and wide range of digital resources have been produced in recent years by their teachers. These resources, targeting at different users, ranges from learning objects on topics in specific disciplines that cater for the needs of a small groups of students in a single class, functionality tools that benefit all students in one institution, to courses offered in the platform as Mass Open Online Course (MOOC) that attract learners around the world.

To enable efficient access to these resources, Knowledge and Education Exchange Platform (KEEP) is introduced as a one-stop education cloud, such that all the resources, particularly those developed by local educators can be easily showcased, shared, searched, and made accessible to target users. KEEP also supports innovative paradigms and communities establishment for teaching and learning through its interactive knowledge sharing functions and data analytics.

在高等教育界，整合資訊科技和教學領域的需求持續增長。近年教育界已製作了非常豐富和廣泛的電子資源。這些資源包羅萬象，從專門為不同的用戶群組制定的學習單元，到小班教學工具，以至大規模開放線上課堂。

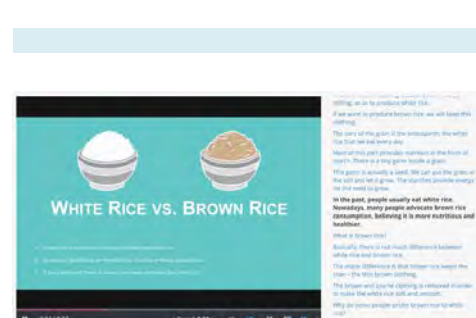
為善用以上資源，我們建立出知識與教育交流平台 (KEEP)，以提供一站式的教育雲，整合各類型的教育資源，特別是本地教育工作者所建立的資源，方便用戶展示、分享與檢索。透過其互動知識分享及數據分析功能，師生可實踐嶄新教學方法，並建立教學社群。



KEEPCatalog



KEEPSearch



KEEPCourse

Key features of KEEP:

KEEP主要功能包括：

- KEEPCourse: Easily create online courses and practice flipped classrooms to enhance learning effectiveness
- KEEPCourse : 教師可以簡便地創建網上課程，以翻轉課堂模式，提升學習效果
- Dashboard: A hub for data analytics where you can know the teaching effectiveness and student engagement for improving the teaching method
- Dashboard : 分析教學數據，了解課程內容效用及學生參與狀況，以持續改進教學
- KEEPoll: A real-time web and mobile polling service to increase student engagement and improve teaching quality
- KEEPoll : 結合網上和流動存取的實時投票系統，增加師生互動，提升學生的學習興趣和改善教學質素
- KEEPCatalog: A showcase collection of the best-in-class tools and apps for teaching and learning
- KEEPCatalog : 集合各類教學工具及應用程式，協助教師授課，亦輔助學生吸收知識及完成課業
- KEEPSearch: Search smartly for education resources and information
- KEEPSearch : 簡易、有效地找出教學所需的資源及資訊

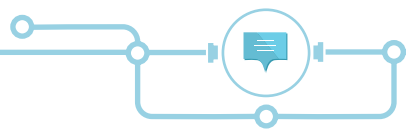
Prof. KING Kuo Chin, Irwin
金國慶教授

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

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City University of Hong Kong, Hong Kong Baptist
University, Lingnan University and The University of
Hong Kong

合作夥伴包括香港教育大學、香港理工大學、
香港科技大學、香港城市大學、香港浸會大學、
嶺南大學及香港大學



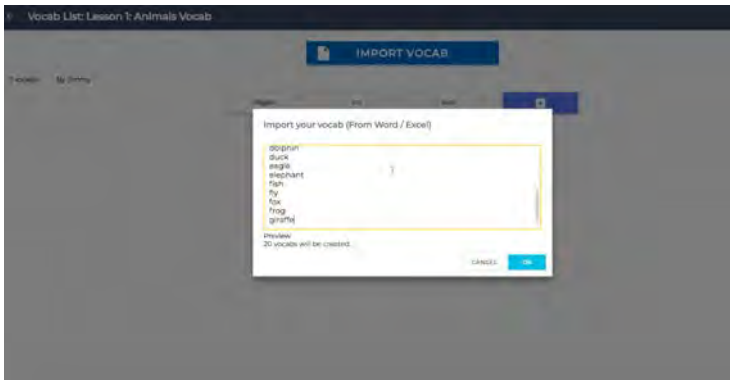
Gamification of English Vocabulary Learning

英語詞彙學習遊戲化



Owing to the insufficient opportunities for English communication in daily life, oral English is often a major challenge for students. Harnessing the mobile technology and artificial intelligence (AI), we have developed a gamified English vocabulary learning platform for students to practice the pronunciation of English words. In accordance with the teaching curriculum and students' English proficiency, teachers can create various vocabulary lists on the platform. Then, students can conduct the gamified vocabulary pronunciation exercises with their mobile phones anytime and anywhere.

由於在日常生活中使用英語交流的機會不足，英語會話往往是學生的一項重大挑戰。本中心透過利用流動科技和人工智能(AI)研發了遊戲化英語詞彙學習平台，目標是幫助學生練習英語詞彙的發音。教師可以根據教學課程和學生的英語水平來製定不同的詞彙表，讓學生可以隨時隨地使用手機進行詞彙發音練習遊戲。



An easy-to-use platform for teachers to import vocabularies
教師可通過簡單易用的學習平台加入詞彙表



Students can practice English pronunciation through a mobile game
學生可透過手機遊戲練習英語發音

- Offer students a user-friendly and engaging gamified learning environment for practicing English vocabulary pronunciation
- 為學生提供一個易於使用和有趣的遊戲化學習環境練習英語詞彙發音
- Encourage students to read aloud English words
- 鼓勵學生大聲朗讀英語詞彙
- Increase students motivation in learning English
- 提高學生學習英語動力
- Promote students' motivation in English learning
- 提高學生學習英語動力
- Provide teachers with an authoring tool for tailor-making vocabulary lists for their students
- 為教師提供製作教材工具，為學生度身訂造詞彙表
- Support anywhere-anytime learning
- 支持隨時隨地學習
- Allow teachers to efficiently assess individual students' learning performance
- 協助教師有效地評估每位學生的學習表現

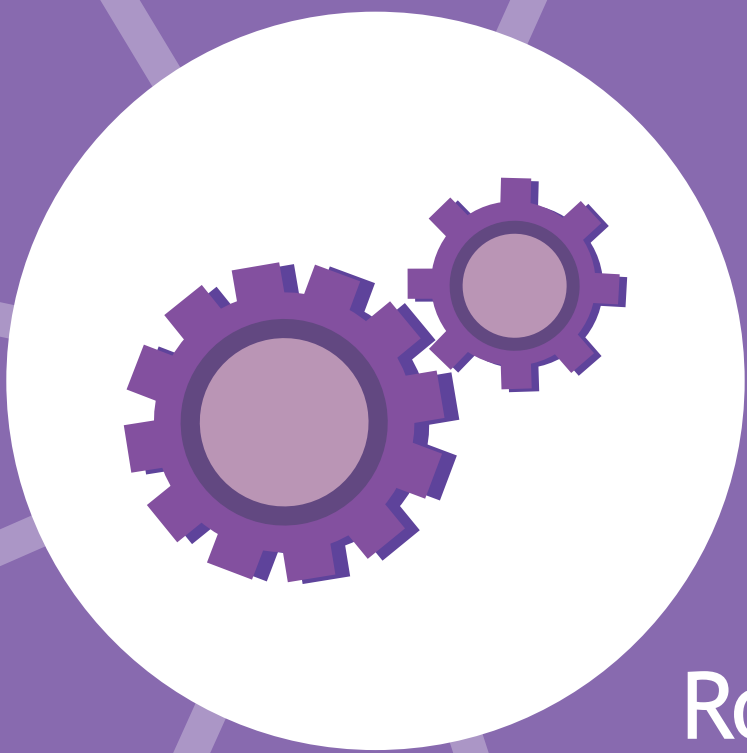
Prof. JONG Siu Yung Morris
莊紹勇教授

Mr. LUK Tsun Hin Eric
陸晉軒先生

Mr. WONG Kin Kwan
黃建鈞先生

Edputation Lab, Centre for Learning
Sciences and Technologies, Department
of Curriculum and Instruction
課程與教學學系學習科學與科技中心
Edputaion實驗室





Robotics and
Automation

機械人及
自動化技術

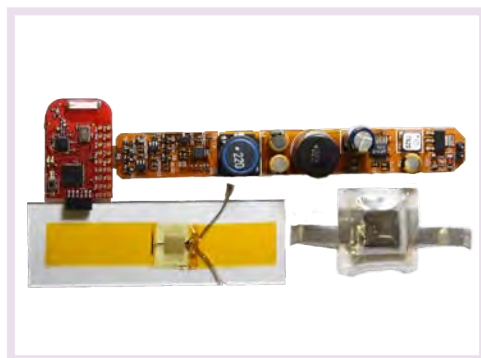
Integrated Thermal Energy Harvesting and Storage for Autonomous Wireless Sensor Network

用於自主無線傳感器網絡的熱能收集與電存儲集成系統

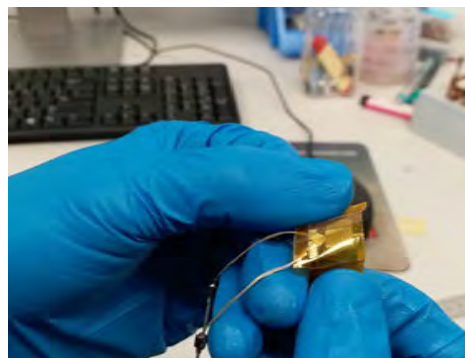


Wireless sensor networks (WSNs) are widely applied in our daily life, e.g. area monitoring, health care monitoring, air pollution monitoring etc. Development of autonomous WSNs requires efficient integration of energy harvesting and storage technologies. Replacement of WSNs' batteries can be difficult as they are often of large-scale and it may also disrupt the continuity. Therefore, we develop an integrated technology that can convert low-grade heat that naturally exists in buildings (e.g. solar heating, pipe lines, generators) to electricity to sustainably power autonomous WSNs. In this project, integration of flexible, wearable thermal energy harvesting and storage are developed by (1) integrating thermoelectric devices and rechargeable batteries using intelligent power management, and (2) by thermogalvanic devices.

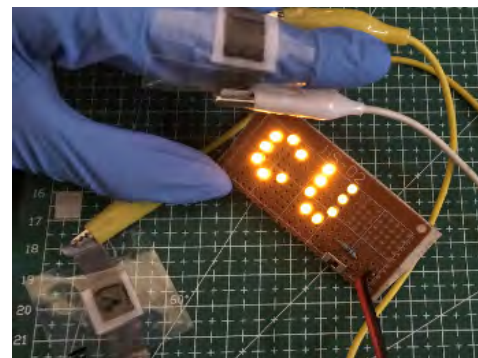
無線傳感器網絡(WSNs)廣泛應用於我們的日常生活當中，例如環境監測、健康監測、空氣污染監測等。自主無線傳感器網絡的發展需要有效地集成熱能收集及電能儲存。因為WSNs很多都很大型，要更換WSNs的電池是一件艱鉅的工作，而且更換時亦可能中斷了監測的連續性。我們開發出一種集成技術，以智能能源管理系統及熱電裝置構建可彎曲及可配戴的熱能收集和電能儲存，將建築物內自然存在的低端熱能(例如：太陽能加熱、熱管道、發電機餘熱等)轉化為電能，以供自主無線傳感器網絡持續使用。



Device prototypes of the system
系統各個裝置原型



Flexible thermoelectric device for thermal harvesting
用作收集熱能的可彎曲熱電裝置



Flexible intercalation based battery for energy storage
用作電能儲存的可彎曲鋰離子電池

- Novel technology from the development of thermoelectric device and rechargeable battery, to the design of power management circuit
創新的熱電器件、可再充電電池及能源管理系統電路設計
- Improve the system reliability of WSNs
提升WSNs系統性能
- Reduce the labor and cost associated with replacing hundreds or thousands of batteries used in the WSNs
減低更換WSNs內成千上萬電池的人力物力及成本
- Enhance overall building efficiency by transforming waste heat into useful power source
廢熱開發轉為有效能量能夠提升整體建築效能
- Potential applications for building management, wireless sensors development, smart city
可應用於大廈管理、無線傳感器系統、智能家居

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

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合作夥伴包括麻省理工學院及香港科技大學

Development of a High-speed Stealth Laser Dicing System based on Multi-depth Bessel Beams

基於多深度貝塞爾光束群的高速激光切割系統



Conventionally, semiconductor wafer dicing is performed by blade dicing or laser ablation dicing, where materials are mechanically removed or pulverized in the cutting path, causing issues such as debris, contaminations, or damage to the devices etc. CUHK research team develops a new high-speed stealth laser dicing (SLD) system for processing wafer based on simultaneous application of pulsed Bessel beams at different depths of a wafer.

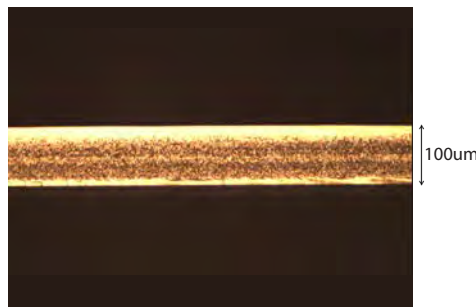
SLD refers to a process that utilizes a laser beam to introduce defects inside a semiconductor wafer for separating it into many small pieces with better resolution, higher precision and speed. Moreover, enhanced process compatibility, and minimized contamination and damage to the wafer are also the advantages.

在傳統的工業技術上，半導體晶片是以刀片或激光消融的方法來進行切割的，原理是把切割路徑中的材料機械地去除或粉碎，導致產生碎屑，污染或損壞晶片等問題。中大研究團隊研發出創新的高速隱形激光切割系統 (SLD)，基於脈衝貝塞爾光束，同時進行多深度半導體晶片切割。

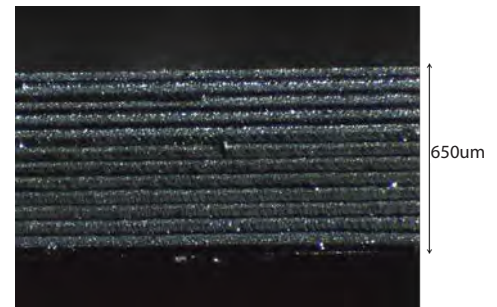
隱形切割是指利用激光聚焦在半導體晶圓內部，晶圓內部形成變質層，通過擴展膠膜以將其分割成晶粒的切割法。此方法能達致更好的分辨率，以及更高精度和速度。此外，隱形切割不但能增強切割的兼容性，而且能把對晶圓的污染和損壞減至最低。



SLD prototype (including software, optical system and motion system)
隱形激光切割系統原型 (包括軟件、光學和運作系統)



Cross section of 100µm wafer diced by the dicing system prototype
用本切割系統原型切割出來的晶圓橫切面



Dicing result in 650µm thick silicon wafer
650µm厚的矽晶片切割效果

Prof. CHEN Shih Chi
陳世祈教授

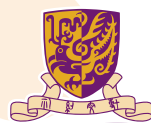
Department of Mechanical and
Automation Engineering
機械與自動化工程學系

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Commission
由創新科技署資助

Collaboration with SAE magnetics (HK) Ltd.
合作夥伴為新科實業有限公司

Why Bessel beam?
為什麼用貝塞爾光束?

Bessel beam is a "non-diffracting" beam, where its transverse intensity profile does not vary as it propagates, making it the ideal laser beam to perform laser cutting. We applied multiple Bessel beams to perform the laser dicing process in parallel, achieving higher throughput with both nanosecond and femtosecond lasers. With the new beam, the SLD modified layer is many times thicker by one pass. 貝塞爾光束是一種「非衍射」光束，其橫向強度分佈不隨其傳播而變化，使其成為激光切割的理想激光束。我們利用納秒和飛秒激光器，並以多個貝塞爾光束同時進行激光切割，而且貝塞爾光束能一次性產生更大範圍的變質層，使激光切割更高效。



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

If you are interested in any of the projects listed, please contact
Centre for Innovation and Technology
The Chinese University of Hong Kong

如閣下對目錄內任何科研項目有興趣
請與香港中文大學創新科技中心聯絡

+852 3943 8221

+852 2603 7327

enquiry@cintec.cuhk.edu.hk

www.cintec.cuhk.edu.hk/exhibition

