香港中文大學
The Chinese University of Hong Kong

Innovation for Better Life

2015 - 2016

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Preface 序言

Centre for Innovation and Technology
Facilitating Technology Transfer of the University

Centre for Innovation and Technology (CINTEC) serves as a bridge between the University and the industry. It facilitates communications and collaboration between CUHK research teams and the industry, as well as promotes innovation through technology transfer to the society. To facilitate industrial collaboration, CINTEC contributes to:

- Identify common interest of the industry and our faculty members in order to establish collaboration and / or technology transfer.
- Serve as a focal point of contact and interface to the industry:
  - Manage industrial enquiries to screen for potential technology transfer opportunities and to direct enquiry to appropriate faculty members;
  - Recruit and liaise with industrial sponsors or collaborators for applied research projects.
- Facilitate negotiation for technology transfer projects.
- Pool up a central knowledge base in technology transfer.
- Advance students' innovation and entreprenureship.

創新科技中心
促進中大技術轉移

香港中文大學的創新科技中心，是連繫大學與業界的橋樑，促進中大研究團隊與業界的交流與合作，同時亦透過向社會和業界的技術轉移，推動創新。為了促進與業界的合作，中大創新科技中心協助：

- 發掘業界與教學人員都感興趣的創新技術領域，從而建立合作和技術轉移的機會。
- 成為工程學院與業界的聯絡點:
  - 接受業界對本校創新科技的查詢，從而尋找知識轉移的機會，以及向學院成員轉介合適的合作夥伴；
  - 為應用科研項目尋找業界的合作或贊助，並與他們保持聯繫。
- 促進技術轉移項目的談判。
- 建立知識轉移的知識庫。
- 推進學生的創意及創業精神。

Being a forward-looking comprehensive research university, CUHK undertakes a wide range of research programmes in many subject areas. In this booklet, CINTEC compiled some of the latest CUHK research results from various areas, for your easy reference.

In recent years, people's concern upon medical and health related topics is rising. CUHK's mission is to serve the needs and enhance the well-being of the citizens of Hong Kong, China as a whole, and the wider world community. Biomedical Sciences logically falls into one of our 5 Focused Areas. A full range of research results in assessment, diagnosis, treatment, surgery, rehabilitation as well as Chinese medicine, integrative medicine, etc. are covered in this booklet, illustrating a comprehensive picture of how CUHK provides caring of our health.

CINTEC is pleased to share these excellent research results with you. If you have any enquiries, please feel free to contact us.

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，中大研究項目包羅萬象，遍及各個學科。創新科技中心編修部份來自多個不同範疇的最新科研成果於本刊物內，以供參閱。

近年，人們對有關醫療、健康課題的關注度不斷提升，而中大的使命，是要滿足香港、全中國，以至世界各地人民的需要，並為人類的福祉作出貢獻。因此，生物醫學科學被列為中大五大重點研究領域之一。而本刊物也全方位涵蓋包括評估、診斷、治療、手術、復康，以及中醫與中西醫結合等等的科研成果，呈現出中大如何廣泛地關顧大眾的健康福祉。

創新科技中心樂意與您分享這些卓越的科研成果。如您有任何查詢，歡迎與我們聯絡。

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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生物醫藥科學
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Novel Bioactive and Degradable Magnesium Screw with Polymer Coating for Osteoporotic Fracture Fixation
用於骨質疏鬆骨折固定的具有生物活性及聚合塗層的新型可降解鎂螺絲釘

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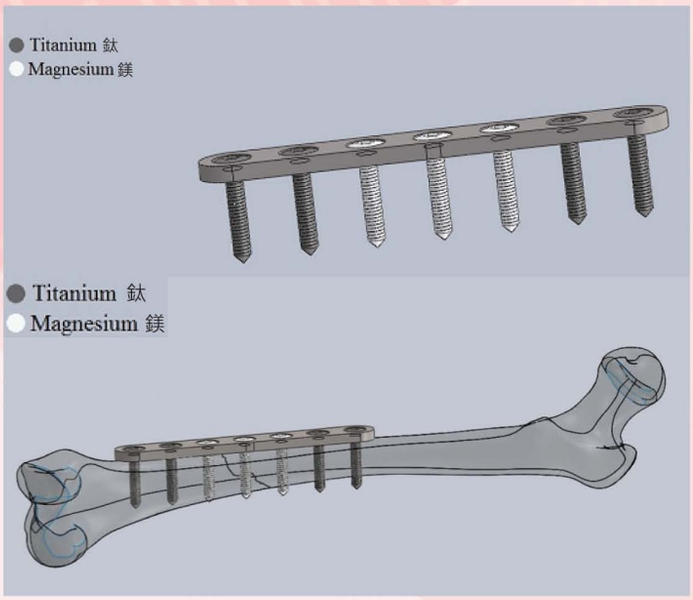


Titanium screws and magnesium screws for fixation
結合鈦螺絲釘以及鎂螺絲釘的固定板

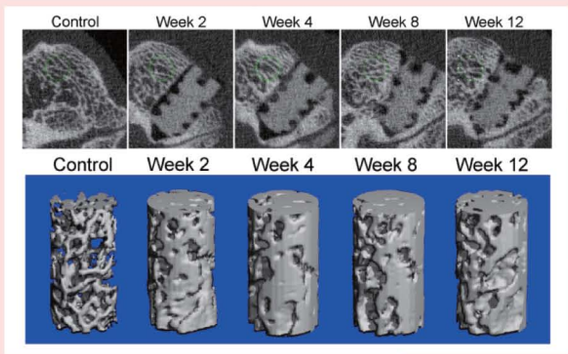
Fracture healing, especially in elderly patients, is very difficult in clinical orthopaedics due to osteoporosis. Current commercially available medical devices and implants for orthopaedic applications are made of permanent metals such as stainless steel and titanium (Ti), which are rigid and have much higher Young's modulus than osteoporotic bone, inducing effect of stress shielding to the fractured bone. This phenomenon accelerates bone loss and may lead to unstable fixation. The healing process of osteoporotic fracture is also much slower because of the decrease in both number and function of bone stem cells in both bone marrow and periosteum. A longer time for fixation is hence required. In case of unstable fixations or risk of infections, a second operation will be required to remove the fixation device/implants, posing huge impact on patients, families and our healthcare system. In view of the above problems, we have developed the polymer coated degradable magnesium (Mg) screw.

Uniqueness and Competitive Advantages:

- Mg has similar mechanical properties to bone. It promotes bone formation and stimulates the periosteum to form new bone. These effects are beneficial to callus formation in fracture healing.
- To address the problem that Mg degrades over time, we coat the Mg with a thin layer of polymer to delay the contact between the Mg and body fluid and hence postpone the degradation of Mg. Our in vivo implantation experiment demonstrated that, after four weeks, the uncoated Mg pins had a volume loss of over 80% while that for coated ones is only 30%.
- We combine the coated Mg screws with the currently clinical locking plate system that is made of titanium to form novel biological fixation system. This fixation construct can be easily modified and individualized for clinical applications.

Applications:

- Fixation for fragility fractures, trauma, sports injuries, or other musculoskeletal injuries. It is especially desirable for osteoporotic fracture repair.



Release of Mg ions stimulates bone formation
鎂離子的釋出可促進骨的形成

骨折治療是臨床骨科面對的一項艱鉅挑戰，常於老年病人身上發生的骨質疏鬆問題，令骨折的治療變得更加困難。現在廣泛使用的骨折固定金屬植入物大多是由不銹鋼以及鈦等不會降解的金屬製成，它們的剛度和彈性模量比骨質疏鬆的骨骼高很多，導致應力遮擋的問題。這個問題會加速骨丟失，導致固定不穩。而骨質疏鬆病人的骨幹細胞活性和數量比正常低，骨折癒合得比較緩慢，因此需要較長時間的固定。如果出現固定不穩或感染的問題，就可能需要進行二次手術將骨折固定植入物取出，對病人、家屬以至整個醫療系統帶來極大影響。針對上述問題，我們研發出聚合塗層可降解鎂螺絲釘。

特點及優勢：

- 鎂具有近似骨的力學性能，可以促進骨的形成以及刺激骨膜形成新的骨組織，加速骨痂形成，提高骨折的癒合能力。
- 針對鎂會降解的問題，我們在鎂的表面塗覆一層聚合物塗層，延緩鎂與體液的接觸，從而延緩降解。體內植入實驗顯示，植入四周後，沒有塗層和有塗層的鎂棒體積減少分別是80%和30%。
- 我們將有塗層的鎂螺絲釘和現行的鈦固定板結合，形成一種新型的固定與促進癒合裝置，此裝置只需經過簡單的調整與改裝，就可作為臨床使用。

應用：

- 提供固定作用以治療脆性骨折、創傷、運動傷害以及其他骨骼肌系統損傷，其益處對骨質疏鬆骨折更為顯著。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/mg-screw-for-fracture-fixation

Design Automation of Customized Jigs for Bone Tumor Surgery
個人化骨瘤手術夾具的自動化設計技術

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Department of Mechanical and Automation Engineering
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王昌凌教授

Funded by Innovation and Technology Commission
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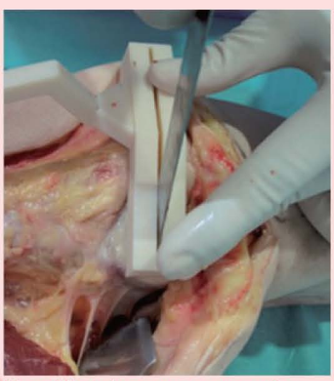
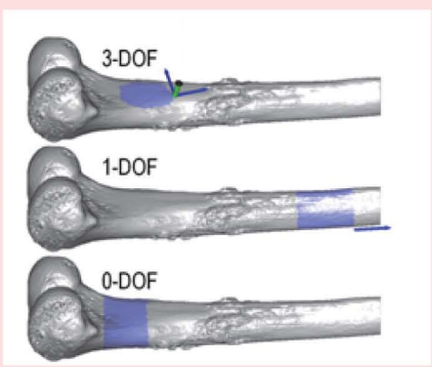
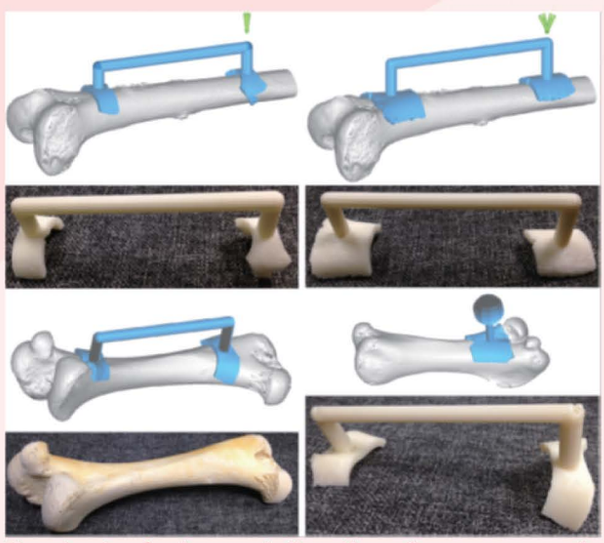
Collaboration with Prince of Wales Hospital
合作夥伴為威爾斯親王醫院



Use of jig in bone tumor resection
使用夾具進行骨瘤切除手術



Surface regions with zero degree-of-freedom of slippage are detected automatically by our system
我們的系統自動尋找出擁有零滑動自由度的表面區域



The unique interface between the jig and bone allows surgeon to easily position the jig on the bone precisely
夾具與骨頭之間的獨特連接面，讓醫生可以輕易地將夾具精準穩妥地放在骨頭表面

Jig is a custom-made fixture tool that allows technicians to precisely perform cutting on hard materials. During cutting, the cutting tool will be fixed at desired position by the jig, so that errors can be minimized. Jigs are also used in bone tumor surgery, in which surgeon will have to remove the part of bone with tumors with high precision. Each jig has to be customized for patient. Doctors will make a 3D model of the patient's bone with the help of CT scan, and then, with trials and errors, design a jig with the optimal interface. Such process is very complicated as well as time-consuming.

In view of this, CUHK is developing techniques to automate the design of customized jigs for bone tumor surgery. Our system automatically detects the bone's surface regions which present unique signatures for making the customized jig with the help of kinematic surface analysis. Then, the regions with zero degree-of-freedom of slippage are used as the interface between the bone and the jig, so that the surgeons can easily match a customized jig on the bone in the right position and orientation. As a result, the planned cutting path integrated with the jig can be accurately performed during bone resection.

Uniqueness and Competitive Advantages:
- Our system simplifies the current manner of computer navigation in bone surgery and provides a practical method to integrate navigation and surgery planning into a customized jig, which can be uniquely positioned onto the surface of patient's bone by interface matching.
- Customized jigs can be automatically designed and fabricated with the help of our prototype system.

Applications:
- Osteoma surgery

夾具是一個讓技師能夠精準地切割堅硬物料的固定工具，能夠確保刀具在切割期間保持在正確的位置，以把誤差減至最小。在骨瘤手術中，醫生需非常精準地把帶有腫瘤的骨塊切除，因此也應用到夾具來幫助。每個夾具都必須為病人度身訂造，醫生先為病人進行電腦掃描，立體打印出骨頭模型，然後反覆設計夾具，以找出最適當的連接面，過程十分繁複費時。

有見及此，中大開發了一套個人化骨瘤手術夾具的自動化設計技術。系統透過對骨頭模型進行運動學分析，自動找出能夠用來製造個人化夾具的獨特表面區域，並利用此滑動自由度為零的區域表面作為夾具與骨頭的接觸面。這樣，醫生便可以輕易地將夾具固定在正確位置和方向，並在已計劃好的切割位置精確地施行骨瘤切除。

特點及優勢：
- 此技術大大簡化了目前骨瘤手術中使用的電腦導航技術，並提供了將電腦導航與手術規劃融為一體的方法，讓夾具可以通過接觸面匹配精準地放置到需要施手術的骨頭上。
- 我們的系統可以自動設計和生產出個人化的骨瘤夾具。

應用：
- 骨瘤手術

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/jigs-for-bone-tumor-surgery

A Novel Tumor Vasculature Homing Peptide for Diagnosis and Therapy for Colorectal Cancer
一種可用於結直腸癌診斷和治療的腫瘤血管靶向多肽

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School of Biomedical Sciences
生物醫學學院
曹之憲教授

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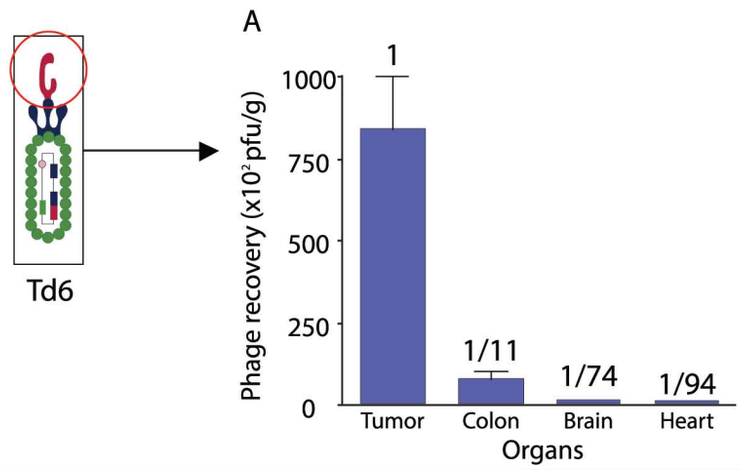
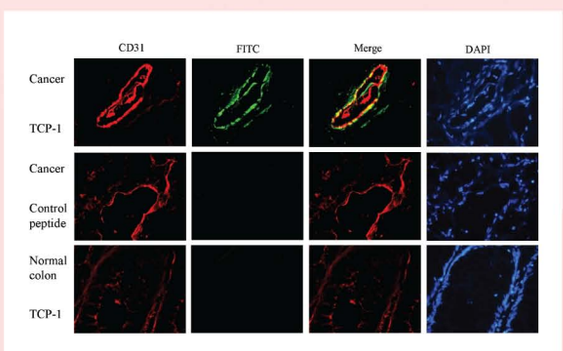
Td6 phage shows a strong homing ability to tumor

Appeared most frequently
Displayed a peptide consisting of 7 amino acids
Termed **TCP-1**



A phage-display library was used to screen for peptides targeting tumor blood vessels in mice. TCP-1 was found to be selective in colorectal tumors than other normal organs.
我們從噬菌體展示庫篩選出能夠標靶老鼠腫瘤血管的多肽，發現TCP-1能夠特異性地結合結直腸腫瘤而非其它正常器官。



TCP-1 peptide has a strong binding capacity to the blood vessels of human colorectal tumors but not to the normal colon.
TCP-1　多肽對人類結直腸癌血管有很強的結合能力，但不會與正常的結直腸結合。

ColoRectal Cancer (CRC) remains one of the most prevalent forms of cancer with an increasing trend in Asia including mainland China and Hong Kong. Our study demonstrated that a peptide could selectively bind to the vasculature of colorectal tumors in animals and humans. There was no similar homing capacity to normal tissues. The peptide acts as a carrier for different imaging contrasts or anti-cancer drugs and holds great potential as targeting agents for the diagnosis and therapy for CRC.

Current diagnosis methods for CRC are either invasive or with low sensitivity. Thus, a non-invasive and accurate method of detecting CRC is needed. Therapy wise, chemotherapeutic drugs not only kill cancer cells but also damage other normal proliferating cells in the body leading to myelosuppression, diarrhea or alopecia, etc. Moreover, long-term drug treatment requires multiple dosages which allow cancer cells to acquire multidrug resistance. To overcome these problems, drugs targeting tumor blood vessels would have advantages over traditional chemotherapy with better efficacy but less systemic toxicity and drug resistance after treatment.

Uniqueness and Competitive Advantages:
- Targeted delivery of imaging substances or anti-cancer agents to CRC tumors
- Targeting tumor blood vessels with prominent therapeutic efficacy at lower doses
- No observable immune responses or systemic toxicity after repeated dosages
- Readiness to make with a wide range of therapeutic conjugates at low cost

Applications:
- Non-invasive diagnosis and targeted therapy for CRC

結直腸癌是常見的癌症之一，其發病率在亞洲地區包括中國大陸和香港持續上升。我們的研究發現了一個多肽，能夠特異性地與小鼠及人結直腸癌血管結合，而不會與正常的組織結合。這一多肽可以作為成像物質或抗癌藥物的靶向傳輸介質，在結直腸癌診斷和靶向治療方面具有巨大的開發潛力。

目前結直腸癌的診斷方法有兩類，其一為侵入性，而非侵入性的，則有靈敏度不足的問題。因此，我們需要尋找一種無創、準確性高的結直腸癌檢測方法。而治療放面，使用癌症化療藥物在殺死腫瘤細胞的同時亦會殺傷正常細胞，常導致如骨髓抑制、腹瀉、脫髮等副作用。同時，長期用藥可能導致多藥耐藥性。因此，使用靶向腫瘤血管藥物可帶來更好的療效，同時能避免系統毒性和耐藥性的發生。

特點及優勢：
- 能夠將成像物質及多種抗腫瘤介質靶向性地傳輸到結直腸腫瘤
- 因具有腫瘤血管靶向性，連接抗癌藥物後在較低的劑量亦具有顯著治療作用
- 多次給藥後多肽本身沒有產生免疫原性及毒性
- 可連接多種抗癌介質，合成價格低

應用：
- 結直腸癌的無創檢測及靶向治療

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/Homing-peptide-for-colorectal-cancer

New Horizons in Integrative Medicine - Evaluation of the need of Chinese Medicine Services for Stroke Patients through Big-Data Analysis
中西醫結合醫學新里程 - 透過大數據分析評估中風病人對中醫服務的需求

Prof. WU Che Yuen Justin
胡志遠教授

The Hong Kong Institute of Integrative Medicine
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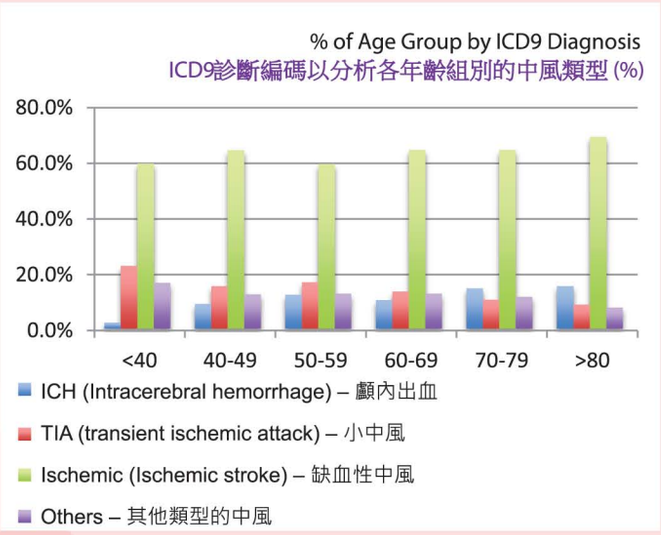
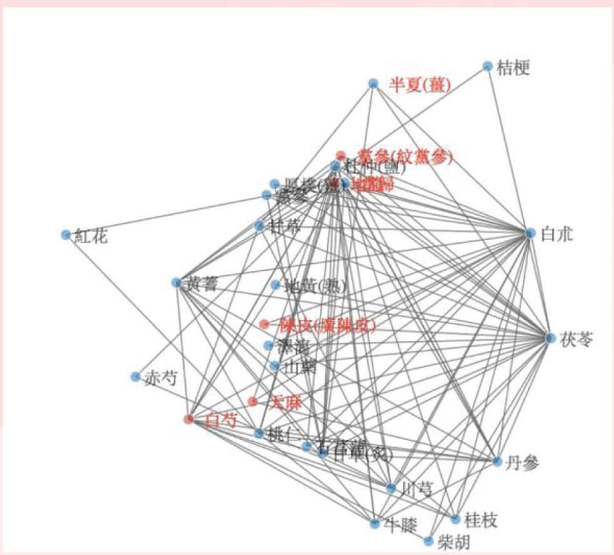


Distribution of common types of stroke stratified to age groups among 3766 stroke patients admitted to the Prince of Wales Hospital from 2010-2012.
就威爾斯親王醫院於2010至2012年期間因腦中風入院的3766名病人個案，根據其年齡組別各中風類型的分佈情況

Acute stroke has been the leading cause of hospitalization and mortality in Hong Kong. The neuroscience team of The Hong Kong Institute of Integrative Medicine (HKIIM), Faculty of Medicine, The Chinese University of Hong Kong, is dedicated to explore strategies to maximize stroke recovery for the betterment of our patients, caregivers, society, and healthcare system. Since February 2014, HKIIM has collaborated with the Chinese Medicine Department of Hospital Authority (HACMD), and the Traditional Chinese Medicine informatics team (iTCM) of the School of Information Technologies, The University of Sydney (USYD), to investigate the integrative medical practices of strokes patients. The project aims to explore the clinical and hospital records of more than 3,000 acute-stroke patients with the use of data-mining techniques, so as to set up a platform such that the complex relationship between herbs, acupoints, Chinese medicine (CM) diagnoses, syndromes, treatment approaches, and interactions with medications can be analyzed, and the association with clinical outcomes, such as mortality or readmissions, can be assessed.

This pilot project was the first study to link patients' disease information (without name and identity) from Western medicine and Chinese medicine for complex data driven analysis. The Institute foresees, once the data-mining platform of stroke is consolidated, it will be a blueprint for exploring complex relationships between herbs, drugs, acupoints, and CM syndromes, treatment methods of other diseases. This knowledge discovery platform will be conducive to the further development in integrative medicine for Hong Kong as follows:

- Putative efficacious and effective herbal formulae for further R&D projects;
- Integrative Medicine service model development relevant to policy makers and clinicians.



Herb co-occurence network graph constructed based on 100 most common herbs used in stroke rehabilitation
100種最常用於中風復康治療的中草藥使用網絡圖

在本港，急性腦中風為引致入院和死亡的主要原因。香港中文大學醫學院香港中西醫結合醫學研究所的腦神經科團隊遂研究改良現行中風復康治療服務，希望加快患者康復，令患者及其家人、護理人員、社會及醫療制度等得以受惠。自二零一四年二月起，香港中西醫結合醫學研究所與醫院管理局中醫藥部門（HACMD）及悉尼大學訊息科技學院的科研隊伍合作，分析中風病人使用中西醫結合醫學治療的概況。是項研究利用數據挖掘技術（data-mining techniques）分析逾三千名急性腦中風患者的臨床及醫院記錄，目標是建立一個數據分析平台，用於以探討中藥、穴位、中醫診斷、臨床症狀、治療方案及藥物相互作用等複雜關係。此平台亦可以用來評估一些臨床數據，例如中風死亡率或再入院比率等，與上列資料的關聯性。

此項先導計劃是首次有研究就病人西醫及中醫疾病記錄(並不涉及病人姓名及身份等資訊)等複雜數據，作出系統化的分析。研究所預料在訂立「中風數據分析資料庫」後，此平台便可應用於分析其他疾病於中藥、西藥、穴位、中醫診斷、治療方案等方面的複雜關係。這個新開拓的知識平台，將有利於本港進一步發展中西醫結合醫學治療，包括：

- 透過平台確立出具療效及實用性的中藥藥方，有助日後的中醫藥科研；
- 根據科研數據，發展出一套可供決策者、西醫及中醫醫療團隊參考的中西醫結合臨床治療模式。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/Integrative-medicine-for-stroke

A Nanoparticle-based Platform for Detection of MicroRNAs in Living Stem Cells
於活幹細胞內檢測微RNA的納米顆粒平台

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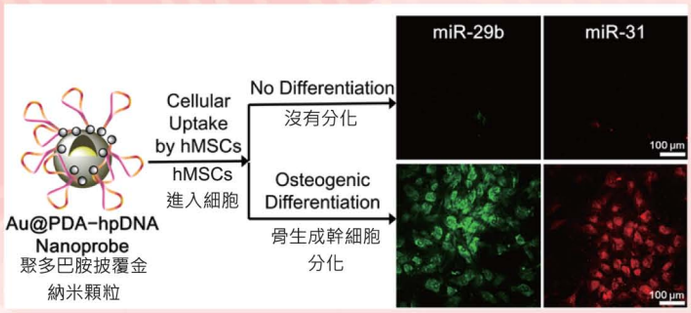

Stem cell research is one of the most fascinating areas of contemporary biology with its potentials to transform human health worldwide. Conventional methods for the analysis of biomarkers related to stem cell differentiation require a large number of cells as well as cell lysis. Such requirements lead to the unavoidable loss of cell sources and preclude real-time monitoring of cellular events. Besides, the poor transfection efficiency of stem cells has made stem cell studies even more challenging.

We report the successful detection of microRNAs (miRNAs) in living human mesenchymal stem cells (hMSCs) by using polydopamine-coated gold nanoparticles (Au@PDA NPs). The PDA shell facilitates the immobilization of fluorescently-labeled hairpin DNA reporter strands (hpDNAs) that can recognize specific miRNA targets. The gold core and PDA shell quenches the fluorescence of the immobilized hpDNAs, and the subsequent binding of the hpDNAs to the target miRNAs leads to the dissociation from Au@PDA NPs and the recovery of fluorescence signals.

Au@PDA NPs do not require the aid of transfection agents to enter stem cells, allowing for intracellular detection of miRNA. Upon the cellular uptake of these nanoprobes, we observe intense and time-dependent fluorescence responses from two important osteogenic marker miRNAs, namely, miR-29b and miR-31, only in hMSCs undergoing osteogenic differentiation but not in undifferentiated hMSCs. Our results demonstrate the capability of our nanoprobes for monitoring the differentiation status of hMSCs (i.e., differentiating versus undifferentiated) via the detection of specific miRNAs in living stem cells.

Uniqueness and Competitive Advantages:
- Detection inside living cells
- Stable fluorescence signals
- Sequence-specific detection of miRNAs
- Sensitive detection inside stem cells

Applications:
- Investigation of the dynamics of stem cell differentiation
- Identification and isolation of specific cell types
- High-throughput drug screening

幹細胞研究可以為人類健康帶來深遠的改變，因而成為現今生物學界炙手可熱的研究範疇。以現存的方法去分析與幹細胞分化過程相關的生物標記，需要大量細胞樣本，並須把細胞樣本殺掉。這些方法無可避免地損耗幹細胞樣本，而且不可能實時監察活細胞的活動。此外，幹細胞的轉染效能非常低，大大增加了幹細胞研究的難度。

我們利用聚多巴胺披覆金納米顆粒(Au@PDA NPs)，成功在活人類間質幹細胞(hMSCs)內進行微RNA(miRNAs)檢測。納米顆粒最外層的聚多巴胺能有效地把帶有熒光標記的髮夾DNA (hpDNA)探針固定於納米顆粒的表面，用以檢測特定的微RNA序列。基於 Au@PDA NPs 獨特的光學性質，金納米顆粒和聚多巴胺皆能把固定於納米顆粒表面的熒光hpDNA探針之熒光猝滅。當與特定的微RNA序列結合，原來固定於 Au@PDA NPs 表面的熒光探針會離開納米顆粒的表面，探針之熒光便會隨之亮起。

Au@PDA NPs 不需要細胞轉染劑的輔助就能自然地進入幹細胞，有助於檢測活細胞的微RNA。miR-29b和miR-31是用以檢測成骨分化之生物標記，把載有miR-29b和miR-31的熒光hpDNA探針放進hMSCs後，我們發現正進行成骨分化的幹細胞相比於沒有進行成骨分化的幹細胞展示出更強的熒光信號。我們的實驗結果充分證實 Au@PDA NPs-hpDNA 探針能檢測活幹細胞內的微RNA，有助監察幹細胞的分化過程。

特點及優勢：
- 活細胞內的檢測
- 穩定的熒光信號
- 能檢測特定的微RNA序列
- 幹細胞內的靈敏檢測

應用：
- 研究幹細胞分化的過程和動態
- 鑒別及離析特定的細胞種類
- 高效地篩查藥物

Slow Degrading Hyaluronic Acid Hydrogels for Osteoarthritis
治療關節炎的緩慢降解透明質酸水凝膠

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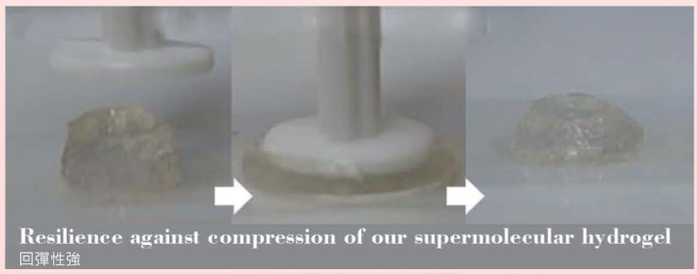
Funded by Innovation and Technology Commission
由創新科技署資助

Collaboration with Prince of Wales Hospital
合作夥伴為威爾斯親王醫院



Osteoarthritis (OA) is characterized by progressive degradation of articular cartilage in limb joints such as knees and hips. Which can lead to significant pain and restricted mobility. Patients with severe OA may even have to use wheelchairs. Currently, a mild form of treatment is the injection of lubricants such as hyaluronic acid (HA) to soothe the joint pain. HA has been reported to be effective in pain relief and improving joint-motion in OA patients with their lubricating and anti-inflammatory properties. However, existing HA injection solution degrades quickly and requires frequent injections. This causes great inconvenience and unnecessary expenses to patients.

To address the above issue, we have developed injectable and slow-degrading biopolymers-derived hydrogels for clinical and veterinary (racehorses, pets) cartilage repair.

Uniqueness and Competitive Advantages:
- Injectable, suitable for minimally invasive surgery
- Fit into the irregular cartilage defects tightly
- Good bio-adhesion on cartilage
- Easy to prepare in operation room
- Able to load and control release of small molecule drugs
- Resilient mechanical properties
- Good biocompatibility
- Self-healing capacity
- Promote recruitment of endogenous cells
- Suitable for the delivery of stem cells
- Low cost

Applications:
- Our proposed HA hydrogels are ideal vehicles for delivering protein drugs and cells to assist treatments of human and animal arthritis and a variety of other diseases including spinal cord injury, intervertebral disc herniation etc.

骨關節炎是由肢體關節(例如膝關節和髖關節)的慢性軟骨組織退化所導致，可導致嚴重痛楚，影響活動能力，嚴重骨關節炎患者甚至需要使用輪椅代步。現時一種比較溫和的治療方法是注射如透明質酸水的潤滑劑以舒緩關節痛。透明質酸具潤滑及抗炎特性，有效為骨關節炎患者減輕痛楚以及改善關節活動。但由於現行使用的透明質酸的降解速度很快，患者需要經常接受注射，既不便又昂貴。

針對以上問題，我們開發了一種以生物聚合衍生物為材料並能延緩降解的注射用透明質酸水凝膠，以供臨床以及動物（賽馬、寵物）關節修復使用。

特點及優勢:
- 可以注射，適合微創手術使用
- 能夠緊密地填補形狀不規則的軟骨缺損
- 對軟骨組織有更強的生物粘性
- 在手術中容易處理
- 可以載入及釋放細小的藥物分子
- 回彈性強
- 良好的生物相容性
- 能夠自我復原
- 促進內原細胞的補充
- 適合作為幹細胞的載體
- 低成本

應用:
- 我們的水凝膠是蛋白質類藥物和細胞的理想載體，可應用於治療臨床以及動物骨關節炎，以及脊髓損傷、腰椎間盤突出症等疾病。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/ha-hydrogels-for-osteoarthritis

Virtual Environment for Training Percutaneous Renal Access
經皮腎穿刺訓練虛擬環境

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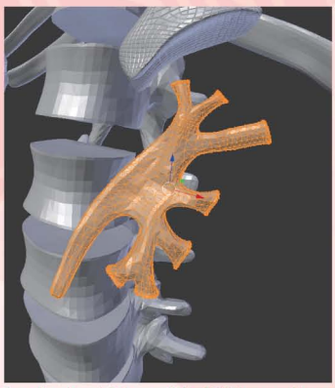
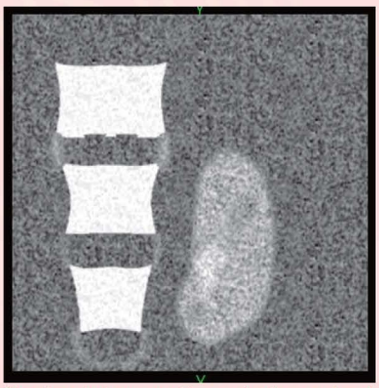
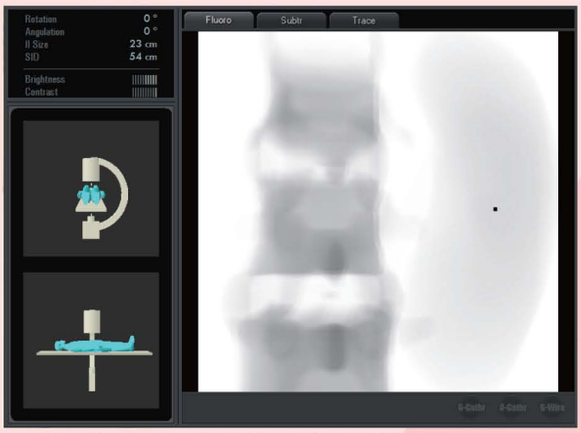
Collaboration with Olympus HK & China Ltd and Beijing BeideStar Technology Development Ltd
合作夥伴包括奧林巴斯香港中國有限公司及北京貝德思達科技發展有限公司



Synthesized 3D model of Kidney calyces
腎盞三維合成模型



Simulated ultrasound image in the renal region
模擬在腎區中的的超聲圖像



Simulated fluoroscopic imaging in the renal region
模擬在腎區中的X光透視成像

Percutaneous nephrolithotomy (PCNL) is a surgical procedure to remove stones from the kidney by a small puncture incision (less than 1 cm) through the skin. One of the most difficult & challenging portions of the procedure is to create the tract between the kidney and the skin, namely the percutaneous renal access. In this project, we aim to develop a virtual reality training system for medical professionals in both training and skill validation of percutaneous renal access skills.

In order to perform a percutaneous access aptly, surgeon should have a good mastery of surgical anatomy in kidney as well as related imaging techniques. Our virtual environment can provide good training on how variations of kidney in different patients is related to the surrounding organs; this can educate trainee on how to avoid injury to other organs under an expandable database of patient cases. Moreover, the training platform can provide unlimited number of trials for planning the skin-kidney tracks under simulated imaging, including ultrasonography and fluoroscopy; truly no harm to patients.

Uniqueness and Competitive Advantages:

- 3D anatomical model reconstruction, data fusion, interactive visualization and physiological condition modeling (e.g. color Doppler indication, respiration), physically modeling of medical devices (e.g. guidewire or catheter), intuitive human-computer interfacing, and multi-sensory feedbacks.
- Comprehensive learning modules with simulated ultrasonic as well as fluoroscopic views, in real-time, for learning complex percutaneous renal access procedures like nephrostomy tube placement, percutaneous nephrolithotomy etc.

Applications:

- Trainee surgeons can acquire a thorough understanding of the importance of different calyces puncture, and eventually be able to differentiate upper pole and lower pole punctures through repeated practice.

經皮穿刺腎結石移除術是一種通過皮膚小穿刺切口（約1厘米）從腎臟移除腎石的外科手術。手術過程其中一個最困難的部分是創建皮膚和腎臟之間的通道（此過程稱為經皮腎穿刺）。在此項目中，我們的目標是研發一個虛擬現實訓練系統，以培訓及驗證專業醫療人員的經皮腎穿刺技能。

要適切地進行經皮腎穿刺，外科醫生必須熟練掌握腎臟的外科解剖學知識，以及相關的醫學成像技術。本虛擬現實系統的可擴展資料庫儲存了大量不同病例，讓實習醫生可以學習不同患者的腎臟差異與周邊器官的關連，從而避免對其他器官造成損傷。此外，培訓平台可以提供無限量的成像訓練 (包括超聲和透視造影)，讓實習醫生在無需危害到病人的前提下，試驗創建皮腎通道。

特點及優勢：

- 3D解剖模型重建、數據融合、交互式可視化和建模（如彩色多普勒徵兆，呼吸作用）、生理條件物理建模的醫療設備（如導絲或導管）、直觀的人機介面和多感官的回饋。
- 全面的學習模塊、實時模擬的超聲波以及透視造影圖，讓實習醫生學習複雜的經皮腎穿刺手術，如造瘻、取腎結石等。

應用：

- 實習醫生可以透徹理解以不同切面穿刺的重要性，在反覆練習下學會分辨上桿和下桿穿刺。

US-MRI Fusion Based Targeted Prostate Biopsy System
融合超聲圖像與磁共振圖像的前列腺靶向穿刺活檢系統

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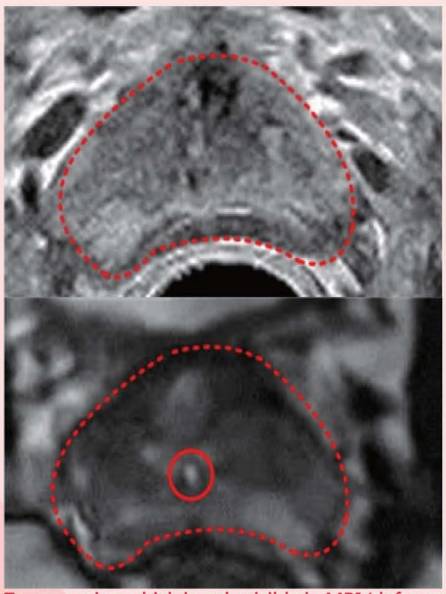
Funded by Innovation and Technology Commission
由創新科技署資助



Tumor region which is only visible in MRI (deformed) can be registered with ultrasound for steering biopsy
在磁共振成像（變形後）與超聲圖像配準後可用作腫瘤活檢之引導

Prostate cancer is the one of most common noncutaneous cancers in the world. To yield the best treatment outcome, early detection is crucial. Although transrectal ultrasound (TRUS)-guided biopsy is widely used for diagnostic confirmation, the low image quality of TRUS leads to a high false-negative rate. Hence, the registration and fusion between preoperative MR images and real-time TRUS images deems to be a necessary and crucial issue to be resolved for more informative visualization guidance in the biopsy procedure.

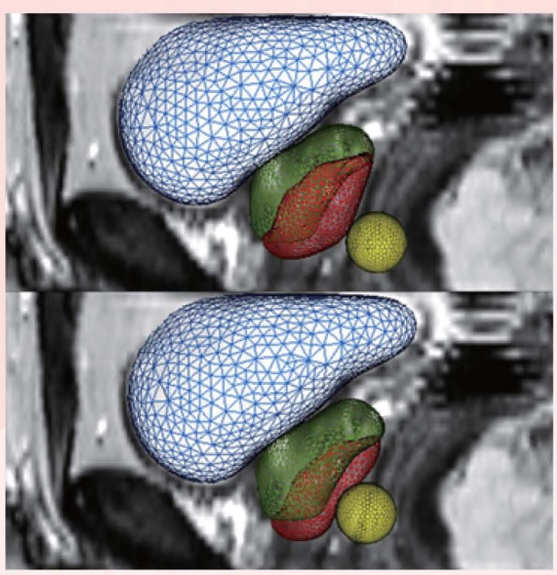
To improve the accuracy of targeted biopsy guidance, we developed a planning and intraoperative guidance system which enables fusion of preoperative MR images and real-time TRUS images for targeted biopsy guidance. We also developed the planning and training system so as to improve the clinical feasibility.

Uniqueness and Competitive Advantages:

- This is an integrated solution with systematic planning, training and intraoperative guidance functions.
- We proposed a non-rigid MR-TRUS registration method based on the prior knowledge of the patient-specific biomechanical deformation. The registration method is further implemented using GPU-based acceleration approach to ensure the real-time advantage of our system for intraoperative guidance.
- The system provides a patient-specific diagnosis to improve safety, accuracy and robustness of clinical prostate biopsy, as well as an efficient and safe solution to improve the ability of physicians to conduct targeted prostate biopsy.

Applications:

- Our training system can be used to train junior doctors for ultrasonic interventions at large and medium-sized hospitals, medical schools, and medical training institutions etc.



Simulated deformation of prostate under pressing of transrectal ultrasound probe
模擬經直腸超聲探頭按壓下的前列腺變形情況

前列腺癌是男性生殖系統最常見的惡性腫瘤，及早診斷是治療的關鍵。經直腸超聲(TRUS)引導的穿刺活檢是前列腺癌診斷的「金標準」，但受TRUS圖像的解析度所限，經常出現假陰性結果。因此，開發融合TRUS圖像與磁共振圖像(MRI)的前列腺靶向穿刺系統對於提升穿刺引導效果具有重要的臨床意義。

為了提高靶向穿刺的準確度，我們開發了一個能夠將術前之MRI診斷信息與術中之TRUS圖像融合的計劃和術中引導系統。我們亦開發了一個訓練系統，以提高系統的臨床易用性。

特點及優勢：

- 這是一個集計劃、訓練和術中引導為一體的解決方案。
- 我們提出一種基於軟組織形變的實時非剛體配準算法，並且利用GPU對算法進行加速，以保證術中引導的實時性。
- 系統為前列腺疾病患者提供個人化的醫療，改善了手術的安全性、穿刺精度和成功率，同時提供了一種安全高效的方式去培訓醫護人員施行前列腺新型靶向穿刺手術的技巧。

應用：

- 我們開發的訓練系統可應用於大中型醫院、醫學院和醫療培訓機構等，以培訓超聲介入實習醫生。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/prostate-biopsy

Robotic Assistant in Hysterectomy
子宮切除手術輔助機械人

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Collaboration with Soon Luck Industrial Limited and
The Cathay A.I. Robotics Corporation Limited
合作夥伴包括生祥實業有限公司及恒睿智能技術有限公司

Prototype of Hysterectomy Robotic Assistant
子宮切除手術輔助機械人原型

Hysterectomy is the most commonly performed gynecological surgical procedure. In laparoscopic hysterectomy, an assistant has to position and deform the uterus with a tool throughout the procedure, which lasts more than 90 minutes, to expose the anatomical structures in the surgical field. The task is tedious and labour-intensive, and very often the assistant cannot manipulate the uterus into an optimal position that meets the surgeon's need. This not only slows down the surgical procedure but also increases the risk of injury to adjacent organ structures.

In view of the above problems, we developed a compact and low-cost robotic assistant for hysterectomy.

Uniqueness and Competitive Advantages:
- The robot takes up the uterus positioning task which is traditionally performed by a human assistant. This improves the precision of the task and saves valuable manpower in the operating theater.
- Surgery safety is highly guaranteed by both a uniquely designed passive mechanisms as well as an energy-based motion/force controller.
- This customized design demonstrates the elegant combination of the actively and passively controlled joints, while is of low cost.
- It also provides a friendly foot-controlled interface for the hand-busy surgeon to directly manipulate the uterus.

Applications:
- Total laparoscopic hysterectomy

子宮切除是最常見的婦科手術。進行微創子宮切除手術時，助手往往需於逾90分鐘的手術過程中，以儀器控制子宮的位置及形狀，將組織結構顯露出來以進行手術。此工作既乏味且費人手，而助手亦經常未能按醫生要求控制子宮位置。這不但影響手術進度，還很可能傷及周邊器官。

針對以上問題，我們研發了一台精簡而低成本的子宮切除手術輔助機械人。

特點及優勢：
- 機械人取替了手術助手執行控制子宮位置的工作，提高了手術的準確性，並節省了手術室裡寶貴的人力資源。
- 專門設計的被動式保護機制和能量定限運動操作器，確保了手術的安全性。
- 我們的設計將主動和被動控制的關節巧妙地組合，且成本便宜。
- 醫生更可用腳去操作簡單易用的介面，以控制子宮的位置和形狀，同時以雙手進行手術。

應用：
- 腹腔鏡子宮切除手術

Robotic Assistant for Sinus Surgery
鼻竇手術輔助機械人

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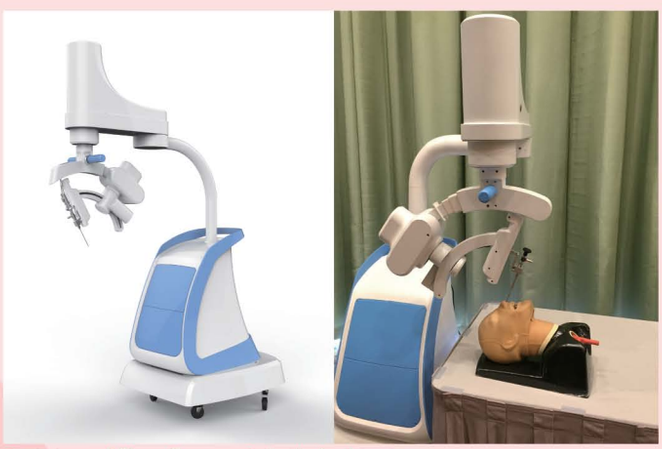
Funded by Research Grants Council of Hong Kong
由香港研究資助局資助

Collaboration with City University of Hong Kong
合作夥伴為香港城市大學



Prototype of Sinus Surgery Robotic Assistant
鼻竇手術輔助機械人原型

Functional endoscopic sinus surgery (FESS) is a surgical treatment of sinusitis and nasal polyps, which involves the removal of diseased or obstructive sinus tissue to restore natural sinus drainage. To carry out such surgical operations in the nasal cavity, a surgeon needs to use one hand to manipulate an endoscope camera and the other to manipulate surgical tools. This one-hand approach limits the surgeon's dexterity during the procedure, where in order to conduct two-hand operations, an assistant surgeon is needed to assist manipulating the camera. This task is tedious and demanding, while often the assistant might not be able to manipulate the camera according to the surgeon's needs.

To solve the above problems, we designed a robotic surgical assistant that can semi-automatically manipulate the camera during FESS to release the hand-busy surgeon from the camera manipulation task to conduct two-hand operations.

Uniqueness and Competitive Advantages:
- The robot is designed to semi-automatically manipulate the camera during FESS, a demanding task traditionally performed by the surgeon himself/herself or an assistant.
- To command the motion of the camera, we developed a new IMU-based control interface which is directly attached to the surgeon's foot. This hand-free interface allows the surgeon to conduct two-hand operations while retaining direct control of the camera, improving the efficiency and safety of FESS.

Applications:
- Functional Endoscopic Sinus Surgery

功能性鼻內窺鏡手術(FESS)是一個治療鼻竇炎和鼻息肉的手術，透過清除病變或堵塞的鼻竇組織，恢復鼻竇的正常流通。進行該項鼻腔手術時，醫生需要用一隻手操作內窺鏡，再用另一隻手操縱手術工具。醫生在手術過程中的靈活性因單手操作手術工具而受到限制，如果要雙手操作手術工具，則需要一個助手來專門操作內窺鏡。這項工作乏味費力，而助手往往未能夠完全因應醫生的需求控制鏡頭。

為解決上述問題，我們設計了一個可以在FESS中半自動控制內窺鏡的輔助手術機械人，讓醫生可以騰出原本控制內窺鏡的手來雙手進行手術。

特點及優勢：
- 機械人可以在FESS中半自動地控制內窺鏡，代替了醫生或助手去做這項費勁的工作。
- 我們研發了一種基於慣性測量單元的新型人機操作接口，可固定在足部讓醫生去控制內窺鏡的移動。這種不需用手操作的方式，讓醫生可以雙手做手術的同時直接控制內窺鏡，改善了手術的效率和安全性。

應用：
- 功能性鼻內窺鏡手術

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/sinus-surgery-robot

M-Health: A Novel Wireless Therapeutic Endoscopic Capsule for Treating Gastrointestinal Bleeding
移動保健：治療胃腸道出血的新型無線治療性內窺鏡膠囊

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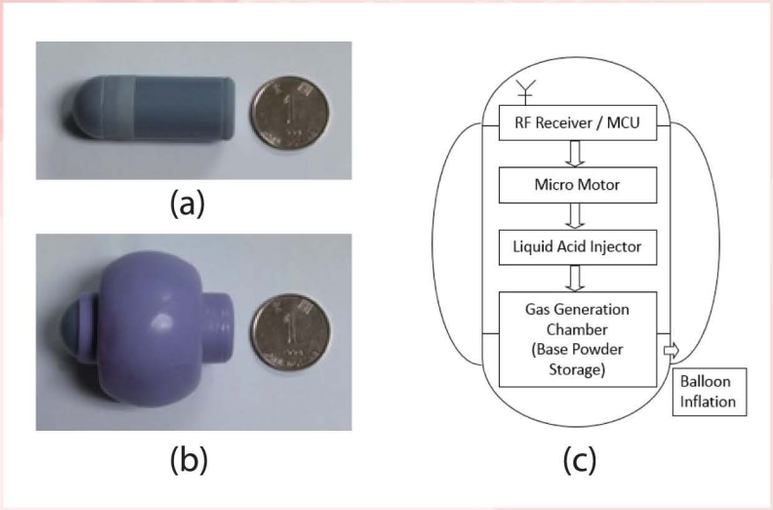
Funded by Innovation and Technology Commission
由創新科技署資助

Award: IFMBE/IAMBE Early Career Award for the Asia-Pacific Region
獎項: 國際醫學與生物工程學聯合會/國際醫學與生物工程院傑出青年學者亞太區得獎者



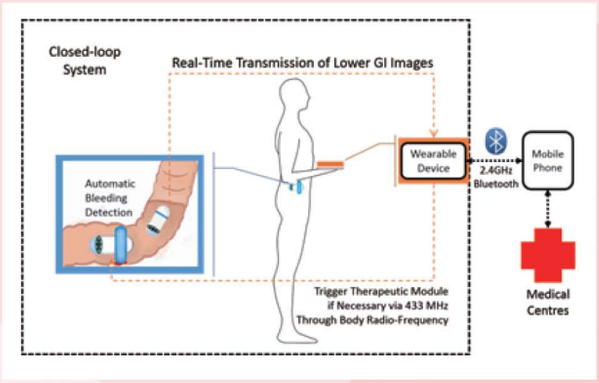
Our proposed WCE system:
(a) inactive capsule endoscope
(b) activated capsule endoscope with the balloon inflated
(c) schematic diagram of the capsule
我們提出的無線膠囊內窺鏡系統:
(a) 未激活的無線膠囊內窺鏡
(b) 激活了的無線膠囊內窺鏡(汽球已充氣)
(c) 膠囊結構圖解

Wireless capsule endoscope is a revolutionary approach for diagnosis of small bowel pathologies. It enables non-invasive examination of the gastrointestinal (GI) tracts, preventing the risks and discomfort during conventional endoscopy diagnosis. Nevertheless, currently available wireless capsule endoscopes are mostly passive devices with only a single function of image capturing. If a disease is identified, the patient has to be readmitted to hospital and undergo conventional endoscopy operation for treatment.

In this project, a novel therapeutic module for implementing with the wireless capsule is proposed for treating haemostasis in GI tracts. The proposed therapeutic module enables the development of a closed-loop solution based on a body sensor network for possible early diagnosis and early treatment of GI bleeding by a mobile-health approach. The proposed closed-loop system aims to enable treating GI bleeding in an out-of-hospital environment and at the point-of-care in order to reduce hospital admission resulted from the disease.

Uniqueness and Competitive Advantages:
- A novel Wireless Capsule Endoscope (WCE) designed with therapeutic function

Applications:
- In case of obscure bleeding, patients can be diagnosed and treated by our proposed WCE at the point-of-care, reducing hospital admission resulted from the disease.



Overview of the closed-loop system based on a real-time therapeutic wireless capsule and a body sensor network for treating gastrointestinal haemorrhage in the small bowel.
建基於實時治療性無線膠囊及軀感網以治療小腸出血的閉環系統

無線膠囊內窺鏡是一種用於診斷小腸病理的革命性方法。這造就了非侵入性的胃腸道檢查，免卻了傳統內窺鏡檢查給患者帶來的風險和不適。但現行的無線膠囊內窺鏡大多是被動性設備，僅擁有捕捉影像的單一功能。一旦確診，患者必須再次入院接受傳統的內窺鏡手術治療。

本項目提出了一種新型的無線膠囊治療技術，用以治療胃腸道出血。這種無線膠囊治療技術使基於軀感網的閉環方案得以發展，令我們可以通過「移動保健」的方式實現對胃腸道出血的早期診斷及早期治療。我們目標透過此閉環系統，令胃腸道出血可以在醫院以外的護理點得到治療，從而減少因該疾病而入院的需求。

特點及優勢：
- 具實時診斷以及治療功能的無線膠囊內窺鏡

應用：
- 在腸道少量出血的情況下，我們研發的膠囊內窺鏡能夠在醫院以外的護理點完成診斷以及治療，從而減少因該疾病而入院的需求。

Noninvasive Prenatal Diagnostic Service for Chromosomal Aneuploidies in Hong Kong
在香港發展染色體非整倍體的無創性產前診斷服務

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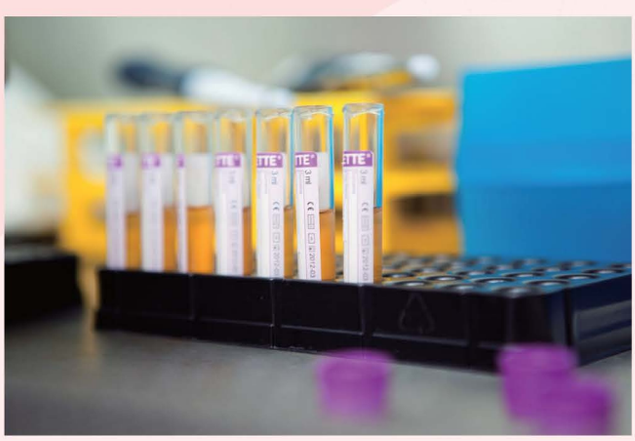
Funded by Innovation and Technology Commission
由創新科技署資助



Diagnostic tests are often performed in early pregnancy to diagnose fetal defects. However, many of the conventional diagnostic methods are invasive, posing risk to the health of the fetus and the mother.

In 1997, our group was the first to discover that during pregnancy the unborn child (fetus) releases small amounts of its DNA into the blood of its mother. After a decade of research, we successfully developed a test for the non-invasive prenatal diagnosis of fetal Down syndrome based on the analysis of plasma samples from pregnant women.

Uniqueness and Competitive Advantages:
- Our non-invasive prenatal diagnostic approach reduces the risk of fetal miscarriage caused by invasive prenatal diagnosis, such as amniocentesis.
- Our test has an accuracy of 99%.
- Since 2011, clinical laboratories offering the test have been set up around the world.
- Our test has been rapidly accepted into clinical practice and led to a paradigm shift in the practice of prenatal diagnosis.
- Our project widens the local accessibility of a test that is born and bred in Hong Kong.

Applications:
- To transfer the technology developed by The Chinese University of Hong Kong to setup clinical service locally, so as to provide safe and non-invasive prenatal diagnostic service for fetal chromosomal aneuploidies in Hong Kong.

孕婦一般會於懷孕初期進行檢查以診斷胎兒的健康狀況。不過，很多現行的產前檢查方法都具損傷性，對胎兒和母親造成一定的風險。

我們的研究團隊在1997年率先發現，少量的胎兒DNA會在懷孕期間被釋放到母體的血漿裡。經過多年研究，我們成功發明了一種無創傷性的產前診斷技術，能夠透過分析孕婦血漿樣本，檢測胎兒有否罹患唐氏綜合症。

特點及優勢：
- 我們的無創產前診斷技術，減少了因傳統具損傷性產前檢查（如羊水穿刺術）所引致的胎兒流產風險。
- 此技術的準確性達99%。
- 2011年至今，已有多個國家的臨床實驗室提供我們的無創產前診斷技術。
- 這套技術被迅速採納作臨床診斷，為產前診斷領域帶來了革命性的改變。
- 此項目讓這套香港研發的技術得以在本地發展。

應用：
- 透過技術轉移，採用由香港中文大學研發的這套技術開設本地臨床服務，以提供安全和無創傷性的唐氏症產前診斷服務。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/prenatal-diagnosis

Automatic Retinal Image Analyzer (ARIA): A Glimpse of Our Health
全自動視網膜圖像分析(ARIA): 健康掠影

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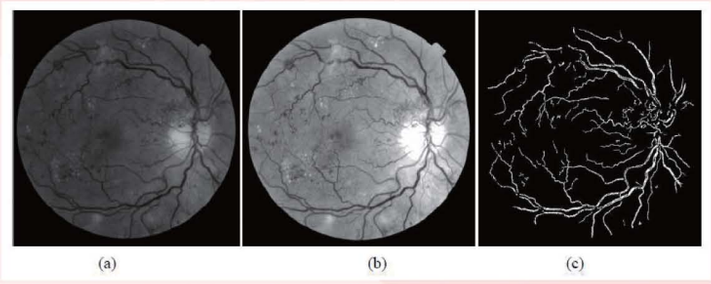
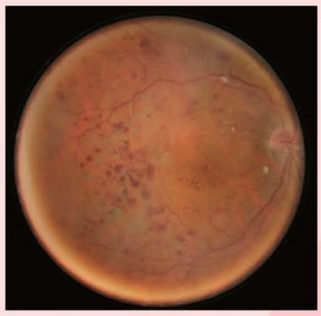
Collaboration with Health View Bioanalytic Limited
合作夥伴為康訊生物分析有限公司



Retinal image after preprocessing: (a) original green channel image; (b) enhanced/preprocessed image; (c) vessels extracted image
經前期處理的視網膜圖像：(a)綠通道原圖 (b)經優化/前期處理的圖像 (c)提取血管影像

Normal retinal image
正常視網膜圖像



Abnormal retinal image
異常視網膜圖像

Retinal vessels are the only visible vessels accessible by simple fundus photography. Retinal vessels have the same embryo origin and histological structure with cerebral vessels. It provides us a convenient way to assess the cardiovascular condition and reflects pathological change caused by diabetes and hypertension.

ARIA, developed by CUHK, is an algorithm built on the cloud internet platform. Standard retinal images can be transmitted through internet to server installed with the computer algorithm, which uses advanced biostatistics method to read pixel-by-pixel the retinal images and analyze these pixels to come up with measurements on exudates, hemorrhages, new vessels etc.. Finally, an overall rating will be given on several different diseases, which include: Diabetic Retinopathy (DR), Age-related Macular Degeneration (AMD) and cardiovascular diseases such as stroke.

Uniqueness and Competitive Advantages:
- Fully automatic
- No specialist needed
- Non-invasive
- No radiation
- No side effects
- Fast
- Accurate
- Can be done as frequently as one likes
- Convenient

Applications:
- Risk assessment for Diabetic Retinopathy (DR), Age-related Macular Degeneration (AMD) and cardiovascular diseases such as stroke

視網膜血管是唯一可使用視網膜成像技術（如眼底照相機）直接觀察到的身體血管。視網膜血管和腦部血管有相同的源頭，我們可透過眼底的血管，分析心血管的健康狀況以及因糖尿病和高血壓引起的組織結構和病理變化。

中大開發的全自動視網膜圖像分析系統(ARIA)，是一個建立在雲計算網絡平台上的電腦程式。標準的視網模圖像會透過互聯網傳輸到載有ARIA程式的伺服器上，ARIA會讀取並自動分析圖像上的每個像素，然後配以嶄新計算程式和先進的生物統計學，量度出分泌物、視網膜出血量和新生血管等數據，最後計算出患以下疾病的風險：糖尿病視網膜病變、年齡相關性黃斑變性、心血管病如中風。

特點及優勢：
- 全自動
- 無需專業人員操作
- 非侵入性
- 無輻射
- 無副作用
- 快速
- 準確
- 無次數限制
- 方便

應用：
- 作為糖尿病視網膜病變、年齡相關性黃斑變性、心血管病如中風的風險評估

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/aria

Computerised Cognitive Screening Assessment (CoCoSc)
電子化認知篩查系統

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Housing Society Elderly Resources Centre
合作夥伴為香港理工大學方靖行博士及
房協長者安居資源中心

An elderly is conducting the assessment using a tablet
一位長者正使用平版電腦進行評估

With the collaboration of the expertise in cognitive research and IT domains at The Chinese University of Hong Kong and The Hong Kong Polytechnic University, Hong Kong's first Computerised Cognitive Screening (CoCoSc) assessment has been developed. With CoCoSc, elderly and brain-injured patients can receive self-service assessment on their cognitive functions through an interactive touch-based computer/tablet.

The system provides screening assessment on six cognitive domains of the subjects, including prospective memory, conflicting response inhibition, orientation, visual digit span, delayed memory, and visuoconstruction. The test takes about 20 minutes. A final assessment score will be given by the system which indicates the level of cognitive functions of the subjects. A threshold is set by a validation trial to determine people with cognitive impairment. In additional to the assessment score, the system can record detailed response of the subjects during the assessment tasks, such as reaction time and position, duration and track of touch points. The system is also capable of uploading assessment data anonymously to cloud server for providing big data for potential academic research and healthcare policy decision making in cognitive domain.

Uniqueness and Competitive Advantages:

- During the assessment, the system guides the subjects to respond to every section. No professional clinicians or well-trained assessors are required.
- Though the system is not designed to replace current standard assessment tools (such as MoCA and MMSE), it provides a quick examination and helps determine whether the participant should consult a professional doctor for follow-up. Thus, the demand for both professional manpower and assessment venue in public hospital system would be reduced.
- Persons with low mobility can benefit from the system to receive self-assessment in any elderly centres or even at their home under supervision.

Applications:

- All service providers for elderly, including NGOs, rehabilitation centres, clinics, elderly centres, and elderly housing, can adopt the CoCoSc system as front line cognitive screening assessment.

Award: Special Mention, Hong Kong ICT Awards 2015 Best Innovation Award

Assessment interface of CoCoSc
自助認知篩查系統的評估介面

在香港中文大學和香港理工大學認知領域專家的共同努力下，全香港首個自助認知篩查系統（CoCoSc）的研究獲得了階段性的成果。長者和腦部創傷者可透過接觸式平板電腦，自助地進行認知能力評估。

系統提供包括六個認知領域的評估：專注力、記憶力、視覺及空間認知能力、執行能力及語言能力。評估需時約二十分鐘，系統最後會輸出一個考核得分，反映測試者的認知功能水平，而我們亦透過驗證性測試設定出一個參考數值。除了評分，系統亦會記錄測試者在評估測試中的詳細反應：例如反應時間、位置、接觸點的持續時間和軌跡等。該系統還能夠上載匿名評估數據到雲服務器中，以提供大數據支持有關認知範疇的學術研究以及醫療政策制訂。

特點及優勢：

- CoCoSc是一個全獨立和自動化的評估系統，在評估過程中，軟件可以引導用戶全自動地完成整個認知測試，而無需任何醫護人士或專業評估人士協助。
- 雖然系統並不會全面取代現有的標準篩查工具(例如MoCA和MMSE)，卻為有需要人士提供了一種快速容易的評估方法，幫助他們考慮是否需要進一步向醫生求助。系統因而大大減輕了公共醫療系統的人力資源和地方需求。
- 行動不便的人士更為受益，系統讓他們可以在家中或長者中心裡完成自我評估，令這一群體不會被忽略。

應用：

- 所有長者服務機構包括非政府組織（NGOs）、康復中心、診所、長者中心、長者住宅等，均可採用CoCoSc作為前線認知評估系統。

獎項: 香港資訊及通訊科技獎2015 最佳創新 (科技創新) 獎特別嘉許證書

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/cocosc

Interactive Exoskeleton Ankle Robot for Walking
智能機械腳托

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

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項目其他研究小組成員:
楊凌鋒、OCKENFELD Corinna Ursula、
何思傑及彭民傑

Stroke patient walks outdoor with the ankle robot
中風患者在戶外使用
機械腳托步行

Stroke patient walks upstairs and downstairs with the ankle robot
中風患者使用機械腳托上落樓梯

Drop-foot is a gait abnormality that is common among stroke survivors. Patients show muscle weakness at the ankle dorsiflexors and hence experience difficulty in lifting up the forefoot, resulting in foot dragging on the ground during walking. Steppage gait and outward leg swinging are two compensation mechanisms of drop foot gait, which would increase chance of fall and ankle sprain.

Conventional gait rehabilitation consists of high intensity and repetitive walking exercises, which is physically demanding even for the physiotherapists. Stroke patients with drop foot could wear an AFO to passively support the drop foot during swing phase. However, AFO has limited therapeutic effect and imposes undesirable restriction to the ankle's range of motion.

In view of the above issues, The Chinese University of Hong Kong collaborates with The Hong Kong Polytechnic University to develop an interactive exoskeleton ankle robot which can assist stroke patients in gait rehabilitation.

Uniqueness and Competitive Advantages:

- Our system provides power assistance for ankle joint movement with proper feedback to enhance the quality and speed of walking pattern. It aids users to walk outdoor, upstairs and downstairs, and is suitable for users with different walking pace.
- The system design is portable and light-weight. User can wear it on his shank as an exoskeleton to control his leg again.
- This exoskeleton ankle robot can sense the gait pattern of the user using embedded motion sensors and force sensors. Our research team has developed a smart control algorithm that can classify the walking intention of the user based on their kinetic and kinematic gait parameters. The robot can then actuate the ankle joint to provide powered assistance during walking.
- This robot can provide highly intensive, repetitive and programmable walking exercises.

Applications:

- The device provides walking assistance for gait training and daily walking to post-stroke survivors who suffer from drop foot problem, and people with muscle weakness or joint problem in the ankle.

足下垂是一種神經肌肉問題，在中風患者中尤其常見。患者的小腿前方肌肉無力，以致踝關節無法提起足部，走路時腳掌會在地面拖行或內反，出現高跨步或腿往外劃弧的不自然步態。這種步態不但會增加失平衡的風險，更會引致踝關節扭傷。為改善步姿，患者一般會接受步行復康療程，進行一系列高強度的重複步行訓練，這種傳統訓練對患者以至物理治療師的體力要求都很高。患者可配戴踝足矯形器（AFO）去幫助改善足下垂問題，但AFO只能被動地支撐著下垂的足部以固定其位置，對復康的療效有限，而且會限制了關節的活動。針對以上問題，香港中文大學和香港理工大學合作研發出智能機械腳托，以幫助中風患者進行步行訓練。

特點及優勢：

- 機械腳托能夠主動提供推動力，輔助踝關節的活動，並且提供適當反饋，以改善步行的質素及速度，幫助患者戶外走路和上落樓梯，適合不同步速的人士使用。
- 設計輕巧而且方便携帶，只需套在小腿上，即變成體外骨胳，幫助控制腳部動作。
- 機械腳托利用運動傳感器及力度傳感器，感測使用者的步態模式。我們研發的智能控制算法，會基於動力學和運動學參數，分析出使用者的步行意向，然後以馬達驅動機械腳托，輔助踝關節完成動作。
- 機械腳托能夠提供高強度的重複步行訓練，並可透過程式控制及編改。

應用：

- 讓患足下垂的中風患者、踝關節肌肉無力患者及其他關節問題患者，能夠更安全有效地進行步行訓練及日常走動。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/exo-skeleton-ankle-robot

An Intelligent Software for 3D Printed Custom-made Orthopedic Casts
個人化三維打印復康支架的智能設計軟件

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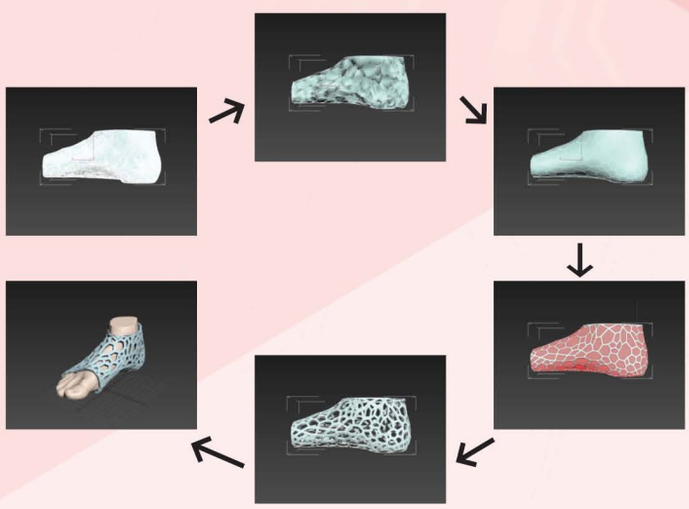
Funded by Innovation and Technology Commission
由創新科技署資助

Orthopaedic casts
復康支架



Development procedure
製作流程

Bone fracture is a common medical condition. Conventionally, splints or plaster casts are used to immobilize the broken bone and provide extra support, thereby allow self-healing. Although it is an effective measure, the bulkiness and heavy weight of the casts restrict the motion of patients, greatly affecting their daily life. The casts may also lead to unpleasant conditions such as itchiness and dry skin. In view of this, we propose an orthopedic cast designing software which helps to fabricate custom-made light-weight orthopaedic casts.

The software will be embedded with an automatic geometric design algorithm for the basic structure of the casts. It will also be integrated with an optimization function based on stress analysis, which allows manual input by professional clinical staff for different fracture conditions. The designed casts will then be 3D printed using materials that are light, breathable and environmental friendly. The printed casts will fit well with the patients and provide strong support to the fractured limbs. Our design software can fabricate custom-made casts for individual patients in a short time, allowing practitioners to focus on diagnosis and treatment planning.

Uniqueness and Competitive Advantages:
- Patient-specific geometry
- Custom-made orthopaedic cast
- Light structure with good air-permeability
- Intelligent manufacture

Applications:
- Bone fracture healing or bone deformity correction

骨折是一種常見的臨床症狀。醫生一般會使用夾板或石膏固定骨折位置及提供額外支撐，從而讓骨頭自癒。雖然打石膏是一個有效的復康處理，但笨重的石膏限制了患者的活動，大大影響他們的日常生活。因此，我們提出一個設計軟件，以製造個人化而且輕巧的復康支架。

軟件嵌入了基於肢體形狀的自動設計功能，我們置入了基於壓力分析的優化算法，可因應臨床專家手動輸入的骨折情況調校支架形狀的設計。設計完成後，系統會使用輕便、透氣且環保的材料透過三維打印技術製造出復康支架。生產出來的支架可以緊貼患者，支撐傷肢。我們的智能設計軟件可以在短時間內為不同病人度身訂造復康支架，讓醫療人員可專注於診斷和治療規劃。

特點及優勢：
- 針對病人個別的幾何特徵
- 度身訂造的康復支架
- 輕便且透氣的結構
- 智慧型製造

應用：
- 骨折的康復治療或骨骼矯形

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/Orthopaedic-cast-design-software

Technology-assisted Assessment & Rehabilitation of Language & Communication Disorders
語言及溝通障礙的評估和康復輔助技術

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Collaboration with
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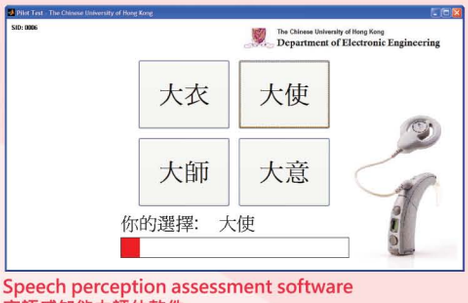
Advanced Bionics Asia Pacific Limited,
Widefly Limited and Sengital Limited
合作夥伴包括香港中文大學深圳研究院、
Advanced Bionics Asia Pacific Limited、
Widefly Limited 及 Sengital Limited

Computerized assessment of Chinese grammar
電腦化中文語法評估工具

Assessment of communication ability for children
兒童溝通能力評估



Speech perception assessment software
言語感知能力評估軟件

Communication via speech and language is one of the most important parts of our everyday life. Impairments on speech, hearing and language abilities not only deteriorate the quality of life but also hinder social interaction and whole-life development. Assessment is a key component of speech and language rehabilitation. However, the conventional manually operated and administrated assessment process depends greatly on the clinicians' experience. A more efficient and reliable method is deemed necessary. With inter-disciplinary close collaboration, we develop a series of computerized assessment tools for the Chinese-speaking population (including Putonghua and Cantonese) for determining the type and degree of speech and language disorders, with the aim to improve the efficacy and effectiveness of speech and language therapy.

Uniqueness and Competitive Advantages:

- The expertise from professional speech therapists, linguistics, speech scientists and software engineers are successfully integrated to contribute to the reliability, accuracy and effectiveness of the developed assessment tools.
- Computer-guided assessment is repeatable, and provides effective controls over the process, improving the validity and reliability of the assessment.
- The improvement in accessibility enables early diagnosis.
- Computerized tools facilitate to spread and popularize the best and latest clinical practice and hence elevate the quality of rehabilitation service.

Applications:

- Immediately applicable in various work settings of speech and language therapy in Hong Kong, Macau and Mainland.
- Facilitate evidence-based evaluation on the effectiveness of hearing aids and cochlear implants, and advance the development of hearing assistive technology.

利用言語及語言進行溝通，是日常生活中的重要部分。言語、聽力和語言能力的缺失，不但影響病人的基本生活，亦阻礙其社交生活以至人生發展。評估對言語及語言復康十分重要，但現行的評估過程十分依賴治療師的經驗和主觀判斷，因此我們有需要設計出一種更高效率及可靠的評估方式。有見及此，我們透過跨學科的合作，開發出一系列針對中文語言環境（包括普通話和廣東話）的電腦輔助評估工具，用以判別溝通障礙的類型以及程度，從而改善言語及語言治療的成效。

特點及優勢：

- 這個項目是跨學科合作的成果，團隊成員包括專業言語治療師，語言學家，語音學家及計算機軟件工程師，他們憑藉在基礎研究和臨床治療上的豐富經驗，研發出各種可靠、準確及有效的評估工具。
- 電腦輔助工具不但能提升評估的可重複性，而且能有效控制評估過程，改善評估的真確性和可靠性。
- 使評估變得方便容易，有助及早診斷。
- 電腦化工具有助普及最新最好的臨床實踐經驗，從而提高復康服務的質素。

應用：

- 評估工具可立即在聽覺言語障礙的臨床治療康復場合發揮作用，適用於香港，澳門和中國大陸。
- 為助聽器和人工耳蝸產品提供有效可信的評估，促進相關技術的發展。

Wearable Exoskeleton Suit for Paralyzed Individuals
適用於癱瘓病人的穿戴式外骨骼套裝

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Funded by Innovation and Technology Commission
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Collaboration with Prince of Wales Hospital and Tai Po Hospital
合作夥伴為威爾斯親王醫院及大埔醫院

Prototype of exoskeleton suit
外骨骼套裝的原型

Patients suffering from lower extremity paralysis, which can be caused by stroke, spinal cord injury or other diseases, have to rely on wheelchairs for locomotion. In long term, it will increase the risk for several secondary medical consequences of paralysis, including osteoporosis, muscle atrophy, obesity, diabetes, and pressure ulcers. To improve the health and the quality of life of paralyzed patients, researchers worldwide are developing devices that can assist paralyzed patients to stand up and walk again.

An exoskeleton suit has been developed in this project. It is a wearable robotic device designed to aid paralyzed patients to stand and walk. The overall exoskeleton design includes ergonomics and body mechanics, actuators, embedded control, multi-sensor, and user interface. Powerful actuators are equipped at the suit's hip and knee joints to provide propulsion in place of the wearer's lower limbs' strength. In addition, gait analysis and motion control algorithms have been developed so that the system can recognize the wearer's motion intention based on his or her body posture and center of gravity and provide the desired thrust accordingly. With this innovative exoskeleton suit, paralyzed patients can gain significant benefits in both physiological and psychological levels.

Uniqueness and Competitive Advantages:

- 3D printing technology is used to fabricate the parts for better customizability and overall weight reduction.
- Novel multifunctional magneto-rheological actuators are designed for active joints for better bionic functions and energy efficiency.
- Ergonomic design is adopted for better wearing comfort.
- A pair of smart crutches is developed. Through their multi-sensor system, we can better predict the user's motion intention.
- Applications on smart phone or tablet are designed as the interfaces for different user groups like patients, family members, and physical therapists.

不少病人因中風、脊髓損傷等疾病而下身癱瘓，需要使用輪椅代步。但長期使用輪椅會誘發其他疾病，例如骨質疏鬆症、肌肉萎縮、肥胖、糖尿病、褥瘡等。為了改善癱瘓病人的健康和生活質量，世界各地的科研人員正積極研發步行輔助裝置，讓病人能夠再次站立和行走。

本項目研發出一個外骨骼套裝，即一種能夠幫助癱瘓病人站立和行走的穿戴式機械人裝置，當中包括了人體工學機械、驅動器、嵌入式控制、多傳感器系統以及使用介面的設計。我們於外骨骼套裝的下肢關節設置了高性能驅動器，能夠提供充足動力替代失去了的下肢力量。另外我們編寫出一種步態分析和運動控制算法，能夠基於人體姿態和重心變化而識別使用者的運動意向，繼而控制驅動器提供相應的推動力。這項創新技術，將大大改善下身癱瘓病人的生理和心理健康。

特點及優勢：

- 起用3D打印技術製造組件，方便度身製造，同時減輕整體重量。
- 外骨骼主動關節採用了多功能磁流變驅動器設計，可提供更好的仿生功能，同時更加節能。
- 切合人體工學，穿戴更舒適。
- 我們同時設計了一對智能拐杖，能透過拐杖上的傳感器更有效地偵測使用者的步行意向。
- 配備智能手機及平版電腦應用程式，分別向病人、家屬及物理治療師等群組提供不同的使用輔助功能。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/Exoskeleton-suit-for-paralyzed-individuals

Herbal Agents for Skin Care
中草藥護膚產品

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Funded by Innovation and Technology Commission
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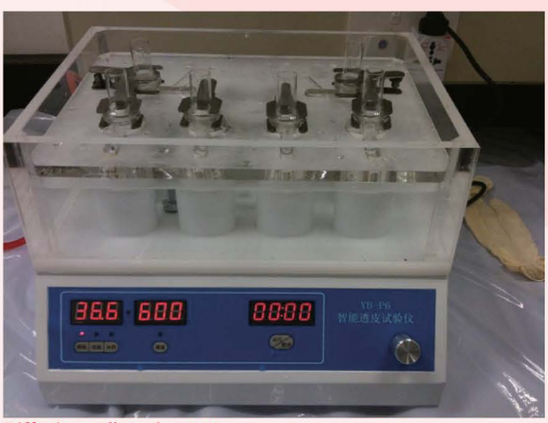
Collaboration with 5100 Cosmetic Co. Ltd.
合作夥伴為5100化妝品有限公司

Cell culture hood
細胞培養超淨台



Diffusion cell equipment
皮膚滲透擴散儀

Fermentation tank
專用發酵罐

Topical Agents for skin care have broad areas of utilization: from day to day cosmetic uses to special applications e.g. eczema and acne. The need for research and development is always in high demand. In ancient China, ladies used various special herbs to maintain healthy skin. One popular formula among the upper class was called Qi Bai San (七白散), which remained in the market after the Qing Dynasty. Nevertheless, its efficacy lacks scientific evidence.

Our research team at CUHK will focus on this well-known and popular herbal formula from the Chinese Medicinal classics for in-depth research; The research results will lead to the production of a novel topical agent for skin care and facilitate a product which carries the special attraction of herbal contents.

Uniqueness and Competitive Advantages:
- We provide scientific evidences for the popular formula of Qi Bai San in maintaining healthy skin.
- The herbs will be chemically authenticated and biologically tested for skin vitality and depigmentation effects. Skin penetration studies will be performed on the herbal formula.

Applications:
- Production of a novel topical agent for skin care which helps to improve skin vitality and reduce skin pigmentation.

護膚品用途廣泛，日常美容以至特殊皮膚護理（如皮疹、暗瘡治理等）方面的研究及開發需求都很大。於中國古代，女士們使用特殊的草藥去護理皮膚。七白散是古代上流社會非常流行的草藥配方，而且一直留存至今，惟其成效缺乏科學驗證。

中大研究團隊針對研究七白散這種於傳統中草藥典籍記載的古代婦女護膚良方，研究結果將應用於生產一種全新的護膚品，並為研發含中草藥成份的護膚產品提供極具創意的空間和前景。

特點及優勢:
- 為古代婦女護膚良方七白散的成效提供科學依據。
- 為草藥進行化學和活性性能鑑定，以測試草藥在活膚及減少黑色素方面的效果。

應用:
- 製造能改善肌膚彈性、活力，並預防黑色素形成的全新草藥外用護膚產品。

Herbal Tonic to Improve Dementia
使用中藥改善智能衰退

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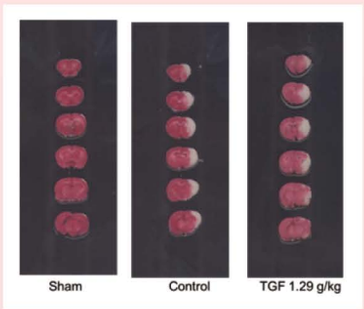
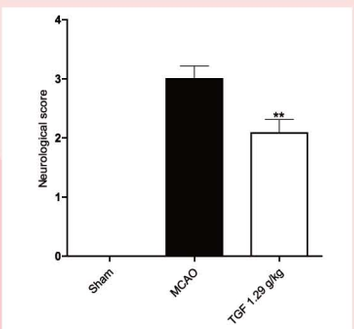
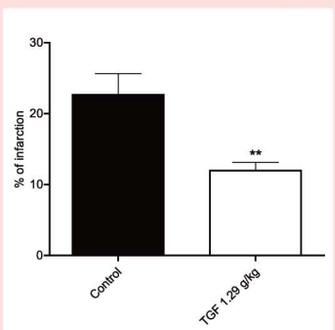
Collaboratrion with Creation Chance Limited
合作夥伴為天凱有限公司



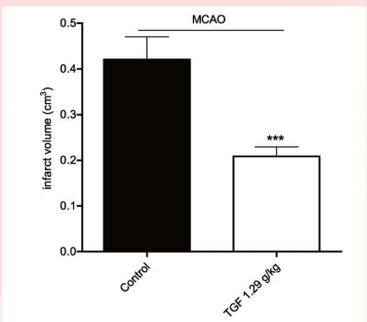
A) Representative photos of brain sections (6 coronal sections) in each group
各組的腦區域圖像 (6個冠狀區域)



B) TGF significantly decreased neurological score in the behavior tests after TGF treatments
TGF治療顯著減低行為測試中的神經缺損



C) TGF significantly reduced MCAO- induced infarct as detected by staining
染色顯示TGF 顯著減低因動脈閉塞引起的腦梗死



D) TGF significantly attenuated MCAO-induced infarct volume.
TGF 顯著減小因動脈閉塞引起的腦梗死體積

With ageing population, dementia has become a global problem. The two major causes of dementia are Alzheimer's disease and cerebrovascular disease. Despite intensive research, the drug treatment for dementia has limited efficacy. A number of Chinese herbs and herbal formulae have been used for dementia symptoms such as loss of memory, cognitive impairment, seizures and tremors. These herbs are protective of vascular health as well.

The aim of this project is to compile and evaluate a herbal formula which has protective effects against neurodegeneration and atherosclerosis at the same time. As dementia in old age is usually caused by the combination of neurodegeneration and atherosclerosis, our proposed herbal formula may be more efficacious than the current drugs for dementia.

Uniqueness and Competitive Advantages:
- State of the art bench experiments will be performed to identify the mechanism of action of the selected herbs in support of neuro-regeneration, using in vitro and in vivo research platforms.
- Our preliminary results indicate that our formula TGF (Tian-ma Gou-Teng Formula) being developed can attenuate vascular dementia in cell models in vitro and in middle cerebral artery occlusion rats in vivo. The beneficial effect and the underlying mechanisms of this formula for Alzheimer's disease will be investigated both in cells and mouse model.

Applications:
- Our formula will serve as supportive treatment for declining cognitive power among old people.
- The deliverable product of this research is a quality production with clinical and biological evidence.

人口老化帶來不少生理機能衰退的醫學問題，包括腦退化症。阿爾茨海默症和腦血管疾病是引起腦退化症的兩個主要原因。近年，相關治療雖有進步，但總體療效還是極不理想。坊間使用一些傳統中草藥及其複方來治療智能衰退相關症狀，對記憶和智力消退、暈眩、顫肌、驚風等具有治療和預防的作用。此外，這些中草藥對血管健康亦有保護作用。

老年人的腦退化症通常是由神經衰退和動脈粥樣硬化同時誘發。本項目研究目的在於開發以中草藥為主的複方，希望該複方能同時緩解神經衰退和動脈粥樣硬化，從而提供優於現有西藥的腦退化症治療。

特點及優勢：
- 使用最新有關中草藥研究的實驗平台，給選定的中草藥實行科學鑑定、機理探查，及安全評估。
- 研究初步表明，本項目所研發的複方TGF(由天麻、鉤藤等組成)在細胞和動物測試中，對血管性疾病引起的腦退化症狀有一定的緩解作用。我們將進一步研究此複方對阿爾茨海默症引起的腦退化症的預防治療作用及其分子藥理學機制。

應用:
- 作為老人智能衰退的支援療法
- 研製具有現代科學研究論證及以中草藥為主的之複方製劑

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/herbal-tonic-for-dementia

環境和綠色科技
Environmental & Green Technologies

A Novel, Fine Prediction System of Storm Surge Inundation for Hong Kong Coastal Area
新型、高精度香港沿岸風暴潮海水漫灘預測系統

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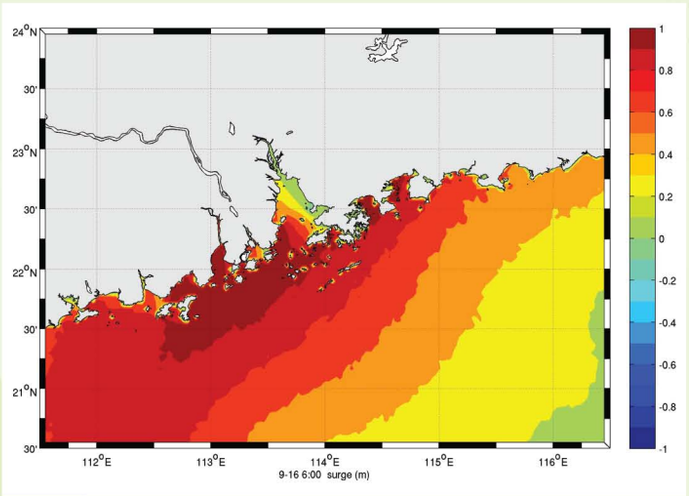
Collaboration with Hong Kong Observatory, Marine Department and Laurel Technologies Company Limited
合作夥伴包括香港天文台、香港特區政府海事署及香港勞雷工業有限公司



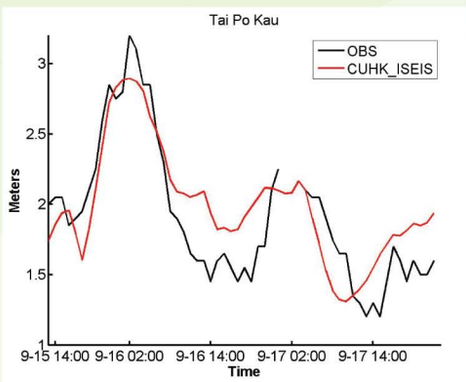
Sea level rise in Hong Kong coastal water on 16 September 2014
2014年9月16日香港海域海平面上升高度

The typhoon related storm surges can induce disastrous inundations in the Hong Kong coastal area, resulting in serious casualty and property loss. Thus, rapid and precise prediction of the storm surge-induced inundations is of great importance to mitigation of inundation disasters in the coastal area of Hong Kong. This project aims at developing a precise and fine prediction system for storm surge inundation in the Hong Kong coastal area with the satellite remote sensing technology on the platform of open source Geographic Information System (GIS), incorporating the enhanced Hong Kong coastal Digital Elevation Model (DEM) database to provide an operational inundation forecast system for relevant users.

The prediction of typhoon-induced inundations is one of the most difficult topics in oceanographic studies. In the Hong Kong coastal area including the near-shore water, complicacies in bottom topography, land elevation, and coastline cause strong nonlinearity in the storm surge current and increase uncertainty in the inundation prediction. Typhoon may induce strong coastal waves and nonlinear interaction between wave and current. The precise simulation of this nonlinear interaction is also a key issue in the storm surge and inundation prediction.

With satellite remote sensing technology combining with current DEM dataset, this project is to develop an improved DEM with higher resolution for the Hong Kong coastal area for the inundation prediction. The nonlinearity of the strong current caused by complex coastline will be modeled to increase the accuracy of the storm surge prediction. The interaction between wave and current will be solved to account for the effect of typhoon-induced huge waves.

The developed system can provide precise predictions on storm surge and inundation and help assessment of potential damages caused by upcoming typhoons for preparing protection measures. The system may also help to develop necessary safety measures for seaway transportation and harbors to increase the protection capability under the storm surge disaster condition. The project may as well provide safety assessment for coastal land utilization, thus increase the efficiency in coastal land development.



Sea level height at Tai Po Kau tidal gauge station on 16 September 2014
2014年9月16日大埔滘海平面高度

風暴潮可為香港沿岸近海地區帶來洪水，沖毀房屋，導致嚴重的生命和財產損失。因此快速精確地預測風暴潮洪水對減低颱風災害十分重要。本項目借助開源地理資訊系統（GIS）平臺上的衛星遙感技術，以及優化了的香港近岸DEM模型，開發一套高精度、精細化的香港近岸風暴潮洪水預測系統。

預測因颱風引致的洪水是海洋科學中其中一個最難的項目，香港的海洋近岸地形、高程、海岸形態較為復雜，因而海流有著很強的非線性特徵，增加了洪水預測的難度。而颱風亦會引致強烈的近岸海浪，以及海浪和海流之間的非線性相互作用。準確模擬以上的非線性相互作用是預測風暴潮洪水的關鍵。

本項目基於衛星遙感技術和現有的DEM數據，開發出更高空間解析度的香港近海陸地DEM模型以作洪水預測。我們會模擬由複雜海岸線產生的非線性海洋強流，以提高預測風暴的準確度，我們亦將解釋波浪與海流之間的相互作用，以說明強風暴海浪的效應。

本系統可提供準確的風暴潮和洪水預測，幫助評估颱風帶來的破壞，從而計劃相應的保護措施。系統有助設計航海運輸工具及碼頭的安全措施，以增強其在風暴潮下的防護力。系統亦有助評估沿岸土地使用的安全性，以提高沿岸土地發展的效率。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/storm-surge-inundation-prediction

Plasmonic Solar Cell
等離子體激元太陽能薄膜電池

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Funded by Innovation and Technology Commission
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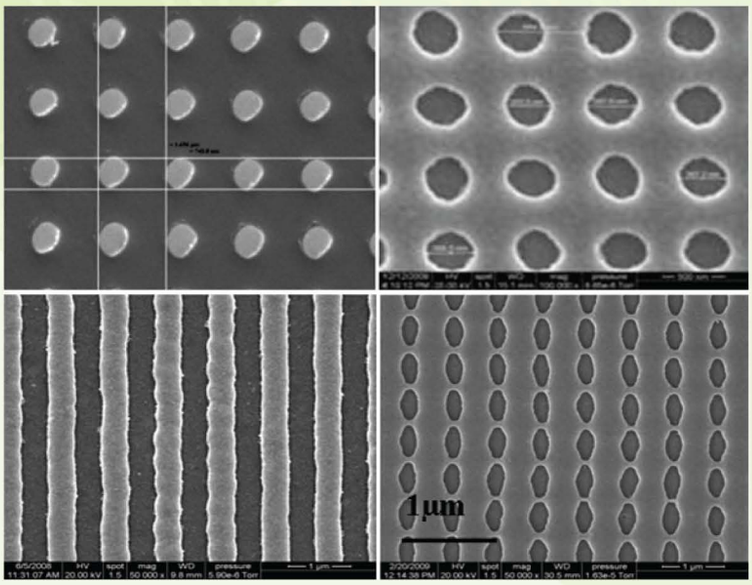
Collaboration with Hong Kong Polytechnic University
合作夥伴為香港理工大學



Different nanometer scaled plasmonic structures under scanning electron microscope
掃描電子顯微鏡下不同納米尺寸的電漿結構

The development of highly efficient and low-cost renewable energy sources is of great importance. Particularly in Hong Kong and the nearby Pearl River Delta where large-scale wind and hydro power stations may not be feasible, solar energy has become an attractive alternative. However, present marketplace is still relying heavily on the bulky wafer-based devices. To allow complete absorption of light, silicon-based solar cells usually require a thickness of 180-300 micrometers. The material, preparation and handling expenses are high. As a result, the cost of photovoltaics is still about 5-7 times higher than that of coal-related technologies and thus is not economically feasible for large-scale implementation. Recent attention has been shifted towards thin film structures. Although the material and production costs of thin film-based solar cells are much lower, the penalty of reducing the material thickness is the reduction of light absorption, resulting in lower power conversion efficiency.

Plasmonics is a new area which exploits the optical resonances at the interface between metal and dielectrics. New phenomena arising from it can be explored for different applications. In this project, we apply plasmonic structures to increase the light trapping and power conversion efficiency of thin-film solar cells, so as to develop low-cost high-throughput solar cells.

Uniqueness and Competitive Advantages:

- Theory is developed to quickly maximize light trapping and absorption for any given plasmonic structures, creating desirable plasmonic structures with strong omnidirectional, polarization-independent, and broadband absorption and intense electric field for increasing conversion efficiency.
- 2 times of power conversion efficiency enhancement is expected for ultrathin solar cells when compared with control samples.
- This approach results in a cost-effective and high throughput method for making high efficiency solar cells.

開發高效率和低成本的可再生能源是非常重要的研究方向。在香港和珠江三角洲，建造大型風電和水電發電站並不可行，故開發太陽能是尤其吸引的方案。然而目前市場仍非常依賴於笨重的晶片太陽能裝置。使用晶片基片的主要缺點是製造成本。要把光完全吸收，矽系太陽能電池通常需要180-300微米的厚度，故此材料、準備、處理費用十分高。光電的成本因此仍比煤相關技術高約5-7倍，要大規模實施實在難以符合經濟效益。最近研發的方向轉向薄膜結構。雖然基於薄膜的太陽能電池的材料和生產成本要低得多，但降低了材料厚度則導致光吸收的減少，從而降低了功率轉換效率。

等離子體激元是一個新的研究領域，利用金屬和電介質之間的光學共振所帶來之新現象，研發不同的應用。在這個項目中，我們運用等離子體激元結構，提高薄膜太陽能電池的光捕獲和功率轉換效率，從而開發成本低但高吞吐量的太陽能電池。

特點及優勢：

- 我們研究出能於任何電漿結構迅速將光捕捉和光吸收提升至最高的理論，創建強全向、偏振無關的寬帶吸收和強電場，以提高轉換效率。
- 與對照樣品相比，我們研發的超薄太陽能電池的能量轉換效率預計可提升2倍。
- 我們的提案提供高成本效益和高通量的方法去製造高效率的太陽能電池。

信息和通訊科技
Information & Communication Technologies

Open-source Cloud-based SDK Framework for Location-based Services
基於位置服務的開源雲計算軟件開發工具包框架

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Funded by Innovation and Technology Commission
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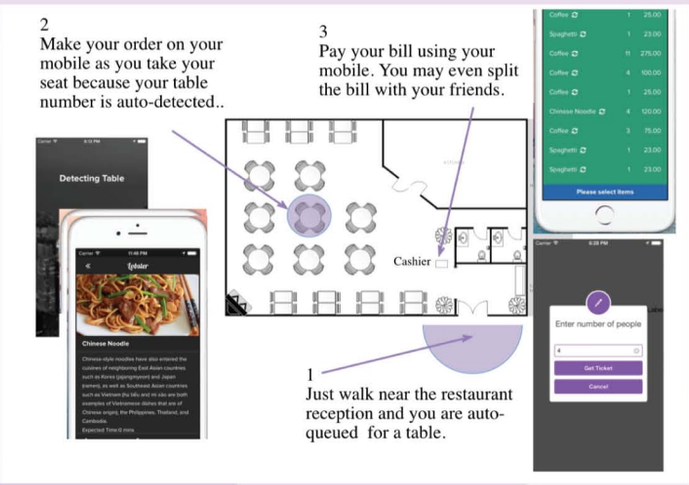
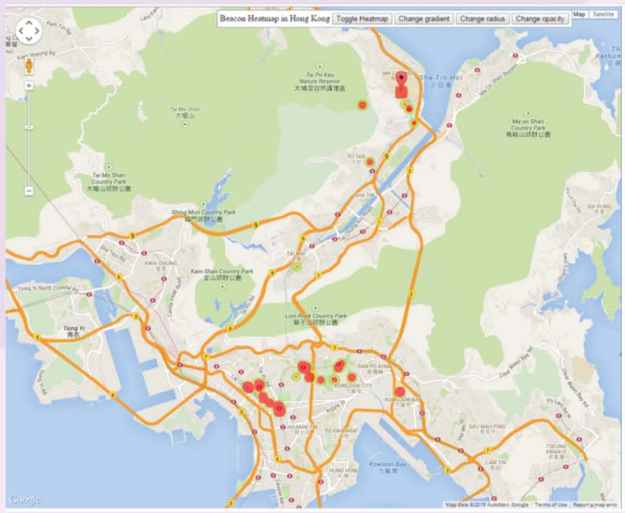


Location-based services for restaurant mobile app
基於位置服務的餐廳流動應用程式



The "HeatMap" shows the density of Beacons around Hong Kong
Beacon information is obtained by OpenLobster Scanner App (Android)
上圖顯示了Beacon在香港的密度
Beacon資料透過OpenLobster Scanner App(Android)獲得

With the advancement of Internet and positioning systems such as GPS, Wi-Fi, and iBeacon, etc., accurately pinpointing users' locations, in particular indoor locations, becomes possible. This brings many new business opportunities via providing location-based services to support the fast development of mobile apps such as recommender systems, proximity information pushing, parking guidance, tourism/trajectory suggestion, and emergent evacuation.

In view of this, CUHK developed a set of Software Development Kits (SDKs) and Application Programming Interfaces (APIs) for developers to create new location-based services. The open-source cloud-based SDKs will provide an easily developed and deployed location-based services framework. In addition, it will bring about numerous location-based services, which will increase both convenience and value for the Hong Kong society.

Uniqueness and Competitive Advantages:
- Novel algorithms for users' accurate position identification and calibration
- Cloud-based big data analytics techniques

互聯網和定位系統如GPS, Wi-Fi及iBeacon等技術的迅速發展，讓我們能夠準確仔細地追蹤用戶的位置（尤其是室內位置）。此技術給基於位置的服務帶來了許多新的商業機會，支援迅速開發流動應用程式，例如：推薦系統、信息推送、停車位引導、旅遊/軌跡推薦、緊急疏散等服務。

有見及此，中大創建了一套軟件開發工具包以及應用程式編程介面，讓開發人員開發基於位置的新應用程式。我們所提供之雲端開源軟件開發工具包，將提供一個易於開發和部署的框架予基於位置的服務。本項目將引申開發許多基於位置的服務，為香港社會帶來更多方便和效益。

特點及優勢:
- 準確識別和校準用戶位置的新演算法
- 基於雲端平台的大數據分析技術

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/location-based-services

3-D Model Based Head Tracking using RGB-Depth Camera
基於三維模型並使用色彩加深度傳感器的頭部跟踪方法

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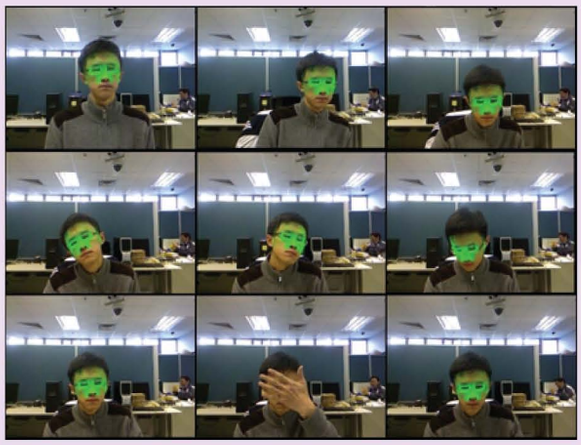
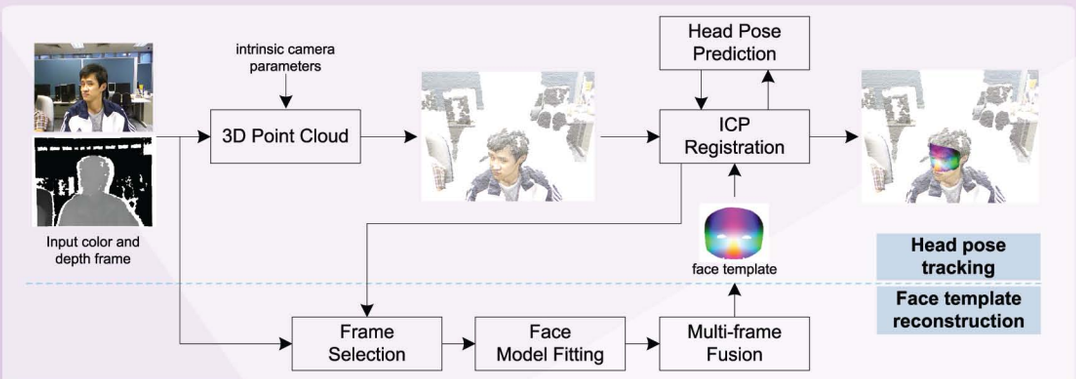


The green object is the user-specific 3D face temple used to register the Kinect input.
綠色部分是用戶的特定3D人臉模板，用來識別透過Kinect讀入的數據。



The head pose tracing process uses a user-specific 3D face template that is reconstructed during the head pose tracking in a background thread using multiple frames which are automatically selected from the input video.
系統於讀入的視訊中自動選取數個靜態影像，在後台線程重建出用戶的特定3D人臉模板，並使用這個模板作頭部跟踪。

Head tracking is a popular research topic in recent years with its function to directly link computer vision to human-computer interaction. A number of different techniques have been developed, yet accurate and robust tracking remains a challenging task.

The objective of this project is to develop a 3-D model based head tracking system using a RGB-Depth camera, such as Microsoft Kinect, so as to tackle two challenging computer vision topics: (1) fitting a 3-D morphable face model to an arbitrary user quickly, and (2) using this user-specific face model to track head movement in the 3-D space.

Uniqueness and Competitive Advantages:
Rather than requiring a pre-processing step to reconstruct the face template offline, the reconstruction can be sequentially accomplished during the head pose tracking using up to nine frames which are automatically selected from the input video. The absence of an offline pre-processing step greatly enhances the user experience.

Applications:
- Gaming or free-viewpoint video to estimate a user's viewpoint
- To control cursor with head motion, which will facilitate people with disabled arms
- To serve as a preprocessing step for free-head-movements gaze estimation etc.

頭部跟踪技術可以作為電腦視覺和人機交互的連接，是近年炙手可熱的研究題目。現今已有多種不同的頭部跟踪技術，但要達到準確而穩定的要求，仍存在一定的困難。

本項目旨在使用色彩加深度傳感器，如微軟開發的Kinect，開發一套基於三維模型的頭部跟踪系統，以實現兩個具有挑戰性的計算機視覺算法：（1） 為任意一個使用者快速建立一個三維人臉模板；（2）利用這個模板跟踪頭部在三維空間的運動。

特點及優勢：
有別於一般需要線下人臉模板重建的技術，本系統的人臉重建是在人臉跟踪的過程中完成的，系統會從輸入的視訊中自動選擇最多9個靜態影像以進行人臉重建。省卻了線下重建，可以令用戶體驗變得更流暢完善。

應用：
- 在遊戲或自由視角視訊中獲取用戶視角
- 用作控制鼠標的運動，幫助患有手部殘疾的用戶與電腦交互
- 作為目光方向預測的前處理步驟，讓頭部在目光方向預測的過程中可以自由移動等等

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/RGB-depth-head-tracking

An Emulation Platform for Fault Injection Attack
針對注錯攻擊的仿真驗證平台

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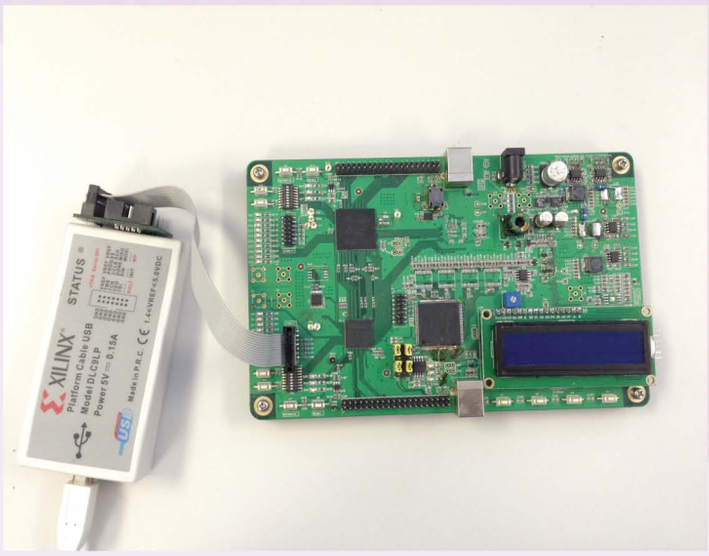

Hardware debugger of FIASim
FIASim 除錯器硬件

Prototype of FIASim emulation platform
FIASim 驗證工具介面原型

Fault-injection attack (FIA) is a technique to leak secret information of cryptographic chip through the injection of deliberate faults and the analysis of the corresponding erroneous outputs. It has been demonstrated to be highly effective. In order to guarantee the safety of security-sensitive products, manufactures are required to obtain specific certificates before putting the products onto the market. For example, in Mainland China, there are three main certificate authorities, i.e., State Cryptography Administration Office, National Information Security Engineering Technology Center and National Financial IC Card Security Test Center. Cryptographic devices such as the RFID (Radio-Frequency Identification) chips used in smart cards must pass the security test conducted by these authorities before they can be used in China. It is, however, a challenging task to pass security tests with the attack methods (e.g., FIA) advancing all the time.

This project aims to develop an efficient and effective emulation tool that verifies security under FIA at design stage. Our tool, named FIASim, features high efficiency, high accuracy and high compatibility. For high efficiency, FIASim adopts FPGA (Field-Programmable Gate Array) to accelerate the verification procedure under FIA; for high accuracy, it contains plentiful fault models corresponding to various fault injection techniques and takes physical information into consideration; for high compatibility, it emulates faults directly on top of customer systems and requires minimum development.

注錯攻擊(FIA)是指透過故意注入錯誤繼而分析錯誤輸出，從而洩露密碼芯片的機密資訊，此攻擊技術的高效性已得到廣泛的證實。不少電子產品須有嚴格的安全要求，而為了保證這類產品的安全性，生產商在推出產品前必須取得特定的安全認證。中國有三個主要的認證機構，包括國家密碼管理局、國家資訊安全工程技術中心及國家金融IC卡安全監測中心。智慧卡RFID芯片等這類產品，都必須通過以上三個機構的安全認證。然而，要通過針對FIA的安全認證，是一項極具挑戰的任務。

這個項目旨在開發一個在設計階段針對測試產品抵抗FIA能力的高效仿真驗證工具。我們的工具叫FIASim，它具有高效性、高精度性及高相容性。高效在於該平台利用FPGA來加速驗證過程；高精度在於該平台包含多種錯誤模型且每個錯誤模型均考慮了注錯方法和設計的物理資訊；高相容性在於該平台基於用戶的模擬驗證平台，且僅需要少量的修改。

Knowledge & Education Exchange Platform (KEEP)
知識與教育雲端平台 (KEEP)

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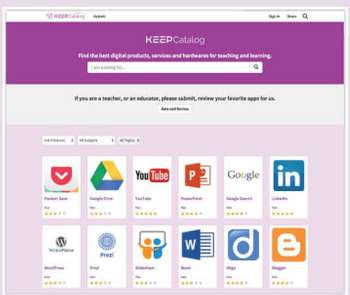
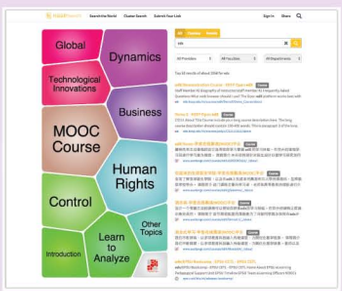
Collaboration with The Hong Kong Institute of Education, The Hong Kong Polytechnic University, Hong Kong University of Science and Technology, City University of Hong Kong, Hong Kong Baptist University and Lingnan University
合作夥伴包括香港教育學院、香港理工大學、香港科技大學、香港城市大學、香港浸會大學及嶺南大學





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 teachers in the higher education sector. 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. The vision is to build a one-stop education cloud, such that all education resources, particularly those developed by local educators can be easily showcased, shared, searched, and made accessible to target users through KEEP.

Uniqueness and Competitive Advantages:

- KEEP uses cutting-edge technology to support the development of an innovative teaching and learning cloud-based platform. Recommendations on learning resources could be provided along student's learning path with the help of big data analytics.
- KEEP is a personalized educational portal for users to easily search, subscribe and access contents. KEEP aspires to promote innovative paradigms in teaching and learning, cultivate community of practices for educators, help learners establish virtual communities of learning, mine and analyze learning data to strengthen research-teaching nexus and promote scholarship of teaching and learning.

Applications:

Four major key features of KEEP:

- KEEPCatalog: A showcase collection of the best-in-class software, hardware, and services for teaching and learning.
- KEEPCourse: LMS/MOOC hosting service for course sharing and collaboration in experimental and blended learning environments.
- KEEPoll: A real-time web and mobile polling service to increase student's engagement and improve teaching quality.
- KEEPSearch: An in-depth directory and search engine with dedicated and exclusive educational resources.

在高等教育界，整合資訊科技和學習領域的需求一直不斷增長。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。

為有效地運用以上資源，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，特別是由本地教育工作者所建立的資源，方便用戶展示、分享與檢索。

特點及優勢：

- KEEP利用先進的技術，提供創新的教學雲端平台，並借助大數據分析，就不同學生的學程推介內容相關的學習資源。KEEP整合林林總總的教育系統和資源，用戶可在此一站式的平台便捷地取得所需的教育資源，提升教與學的效率及互動性。
- KEEP是一個個性化的教育門戶網站，為用戶輕鬆搜索，訂閱和閱覽內容。KEEP亦希望帶動創新的教與學模式，透過建立教學分享社區、創建虛擬學習社群、蒐集和分析線上數據等，幫助老師了解學生的學習情況及進度，以改善課程設計。

應用：

KEEP現時主要有四大功能，包括：

- KEEPCatalog：集合各類教育軟件，學生可在此找尋做功課和簡報用的合適軟件，教學的電腦程式。
- KEEPCourse：教師亦可以簡便地使用線上課程工具去創建課程，以翻轉課堂模式，提升學習效率。
- KEEPoll：一個結合網上和手機短訊的實時投票系統，增加師生互動，提升學生的學習興趣和改善教學質素。
- KEEPSearch：一個匯集及整合了和教育相關的詳細指南和搜尋器。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/KEEP

EduVenture® - Integrated GPS-supported Outdoor Mobile Learning System
EduVenture® - 全球定位綜合戶外移動學習系統

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課程與教學學系及資訊科技教育促進中心

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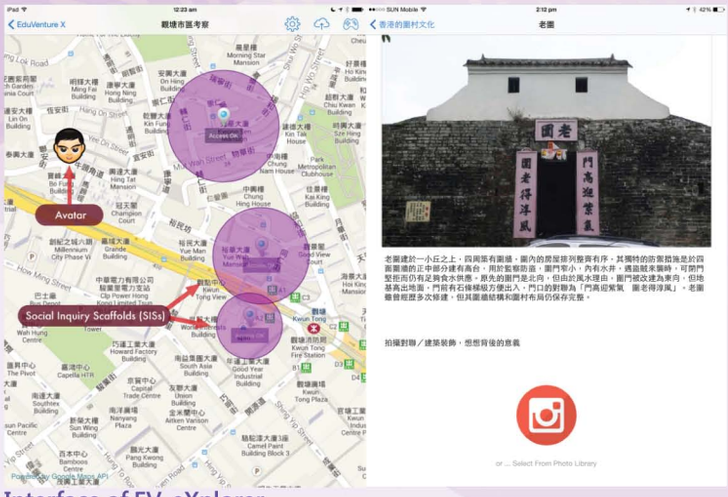

Interface of EV-eXplorer
EV-eXplorer的介面

Primary students are using EduVenture in a Taiwan fieldtrip.
小學生於一個台灣考察活動使用EduVenture

EduVenture® is an integrated GPS-supported outdoor mobile learning system by which teachers can facilitate students to conduct inquiry-based fieldtrips outside the classroom. The system consists of EV-Composer; EV-eXplorer, and EV-Retriever.

The EV-Composer is a cloud-based platform for teachers to design before the fieldtrip an outdoor inquiry learning electronic resource, namely, LOCALE (Location-Oriented Context-aware Learning Environment). The EV-eXplorer is a mobile app by which students can access the LOCALE via GPS-enabled mobile tablets. Embedded scaffolds will pop up and guide the students to probe into the exploratory spots when they physically step in the corresponding geo-locations. The EV-Retriever is a cloud-based platform for retrieving the students' fieldtrip proceedings logged on the cloud during the fieldtrip. It provides a reference for students to conduct post-fieldtrip reflection and reporting and for teachers to understand the students' learning process so as to prepare for post-fieldtrip debriefing and meta-discussion.

EduVenture® solves the following pedagogical problems which usually happen in the traditional form of outdoor fieldtrips:
- Learning takes place in a teacher-centred manner.
- Students' learning motivation cannot be sustained.
- Scaffolds are not effective enough.
- Collaboration among students is weak.

Uniqueness and Competitive Advantages:
- Provide teachers with a complete approach (before, during, and after the fieldtrip)
- Promote students' motivation in inquiry learning
- Facilitate students to sharpen their higher-order thinking skills
- Align with the key mobile learning initiative in the Education Bureau's 4th IT in Education strategy

EduVenture®是一套支持全球定位功能的綜合戶外移動學習系統，教師可利用系統為學生設計探索式戶外考察教材。系統由EV-Composer、EV-eXplorer及EV-Retriever組成。

EV-Composer是一個讓教師於戶外考察前創建電子戶外探索式學習教材的雲端平台，設計出基於地點情境的學習環境(稱為LOCALE)。EV-eXplorer是一個移動設備應用程式，讓學生可以利用具全球定位功能的移動設備存取LOCALE。當學生在進行戶外考察時到達指定的地點，鷹架裡的內容就會彈出，引領學生探索相應考察位置。EV-Retriever 則是一個用來檢索學生戶外考察記錄的雲端平台。這個平台可以作為學生做考察報告時的參考資料，亦幫助教師了解學生的學習過程，進而帶領學生作考察後的總結及討論。

EduVenture®解決了傳統的戶外考察所帶來的教學問題:
- 學習過程以老師為中心。
- 未能維持學生的學習動力。
- 鷹架效果不夠完善。
- 學生之間缺乏合作。

特點及優勢：
- 為教師提供全面的方針(包括考察前、後及進行期間)
- 提高學生對探索學習的積極性
- 促進學生提升他們的高層次思維能力
- 與教育局推行的第四個資訊科技教育策略裡的移動學習提案方向一致

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/EduVenture

Video Analytics for Resource Management
應用於資源管理的視頻分析技術

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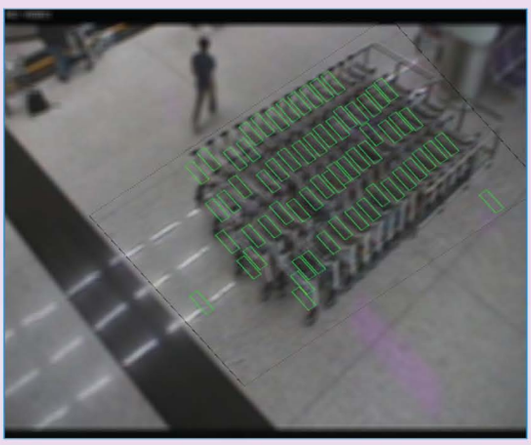
Funded by Innovation and Technology Commission and
Hong Kong R&D Centre for Logistics and
Supply Chain Management Enabling Technologies
由創新科技署及香港物流及供應鏈管理應用技術研發中心資助

Collaboration with Hong Kong International Airport
合作夥伴為香港國際機場



Detecting no. of available trolleys using a CCTV image
利用閉路電視影像偵測手推車數目

There are a vast amount of movable resources at large transit facilities such as the airport. For example, a large number of trolleys are provided at the airport for passengers to transport their luggage, and they are constantly being moved to different indoor and outdoor locations within the airport perimeter. For effective allocation, it is vital to track and monitor these movable resources. Queueing conditions may also affect and be affected by the allocation of these movable resources, and hence should be taken into consideration to ensure smooth transition. Large CCTV (Closed-Circuit Television) visual coverage is usually readily available at these transit facilities, therefore it is logical and economical to leverage existing CCTV infrastructure to help monitor and manage movable resources and customer flow.

This project aims at using video content analytic techniques to help detect specific resources in order to achieve appropriate level of resource allocation throughout transit facilities and enable efficient integrated monitoring and management. A series of pilot studies are being carried out at the Hong Kong International Airport to measure the detection and counting capabilities of our developed system.

Uniqueness and Competitive Advantages:

- Leveraging on existing CCTV infrastructure allows continuous monitoring and management at low installation and maintenance cost.
- Tracking of homogeneous items can be achieved without physically tagging them with other identification technologies.
- The bottlenecks in detection and prediction capability in existing video content analytic techniques are enhanced to ensure smooth flow throughout large, multi-stage transit centers.
- Multimodal monitoring capability is provided for managing multi-dimensional dynamics in transit centers.
- Various monitoring mechanisms are established for providing flexibility in collecting current statuses at different spots.
- Prediction of chain of reaction due to inefficiency cumulating at one or multiple spots will be provided.

Applications:

- Applicable vertically to airports around the world, or horizontally to other CCTV-ready facilities like shopping malls and exhibition centers

A summary of trolley availability over each hour
每小時的手推車數量之總結報告

在機場等大型中轉設施裡，流動著很多的可移動資源。例如，機場提供給乘客運載行李的手推車，會被不斷地移動到機場室內及室外的不同地點。要達致有效分配，我們必須追踪及監察這些可移動資源。由於人流與資源分配有著相互的影響，因此我們亦必須同時監察排隊情況以確保運轉的流暢。這類大型設施一般已擁有高覆蓋率的閉路電視系統，利用現有的閉路電視設備去監察和管理設施內可移動資源和人流，是一個合理且符合經濟效益的方案。

本項目旨在利用視頻內容分析技術來檢測指定的資源，以幫助合適地調配中轉設施裡的資源，達至高效的一體化監測及管理。我們正與香港國際機場合作，開展一系列試點研究來測試本系統的檢測和數算能力。

特點及優勢：

- 利用現有的閉路電視設備提供低安裝及保養成本的全天候監察和管理。
- 追踪指定物件而毋須在物件上加貼任何實體追踪標籤。
- 改善檢測和預測技術的瓶頸問題，以確保大型分段式中轉設施裡的運轉過程流暢。
- 提供多種監測模式以管理中轉設施裡多方面的流動。
- 建立多種監測機制以靈活地收集不同地點的狀態資訊。
- 推測於一個或多個地點發生擠塞所帶來的連鎖反應。

應用：

- 可直接應用在世界各地的機場，或延伸在其他設有閉路電視的設施裡使用，例如倉庫、分發中心、商場及展覽中心等。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/Video-analytics-for-resource-management

Recognition of Partially Occluded Traffic Sign
局部遮擋或損毀路標的識別

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Funded by Research Grants Council of Hong Kong
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The system can successfully recognize the traffic signs even under the partial occlusion attack and other harsh conditions.
系統在有局部遮擋或其他惡劣的情況下仍能成功識別出路標。

Traffic signs provide instruction and information about the traffic condition/regulation to drivers. However, drivers could be busy in controlling the vehicle in reaction to the current traffic condition and fail to catch the traffic signs. There exists intelligent vehicle applications to assist drivers. These applications capture and analyze image/video via the mounted camera. However, in many real world scenarios, traffic signs can be partially occluded by trees, buildings and other objects or even partially damaged, which leads to difficulty in recognition, posing dangers to drivers and other road users.

In this project, we make the first attempt to tackle the partial occlusion problem in traffic sign recognition. We use local shape information to compare two traffic signs. For that, we propose a shape descriptor, Local Arclength Descriptor (LAD), to represent the local shape. With the locality of LAD, our method can successfully recognize traffic signs even if there is partial occlusion.

Uniqueness and Competitive Advantages:
- Although the existing methods achieve high accuracy in traffic sign recognition, none of them try to tackle partial occlusion. They fail to recognize the correct traffic sign when partial occlusion appears. In contrast, our method can recognize traffic signs even there exists partial occlusion.
- To ensure the robustness against partial occlusion, our method measures the partial shape similarity between two traffic signs such that as long as there remains any characteristic feature, we can still recognize the correct traffic sign.

Applications:
- Traffic sign recognition in intelligent vehicle applications

交通路標能讓駕駛者清楚瞭解當前路面情況以及道路規則，但駕駛者往往因為忙於控制汽車以應對複雜的路面情況，而未能注意到路標。現時的智能汽車提供應用設備協助駕駛者瞭解路況，這些應用軟件通過車上的攝像器獲取道路的圖像或視頻並進行分析，因應路標為駕駛者提供相關資訊。然而，在現實情況中，路標往往會被汽車、樹木或其他障礙物遮擋，甚或有部分的損毀，令路標識別變得十分困難，對司機及道路使用者構成危險。

本項目提出識別被部分遮擋的路標之解決方案。我們利用局部形狀信息進行路標之間的對比。為此，我們提出一種形狀描述子，命名為局部弧長描述子（LAD）。該描述子可以通過描述局部形狀信息克服局部遮擋所帶來的問題。憑藉LAD的局部性，我們的方法可以成功識別被遮擋的路標，提供一種穩健可靠的路標識別方法。

特點及優勢：
- 儘管現有的路標識別方法能夠得到很高的準確率，但是他們仍然沒有解決局部遮擋問題。當局部遮擋出現時，現有方法便不能識別出正確的路標。相反地，我們的方法在即使有局部遮擋的情況下仍然能夠識別出正確的路標。
- 我們的方法通過量度兩個路標的局部形狀之間的相似度來應付局部遮擋問題，只要路標的主要特徵未被遮擋，我們就可以識別出正確的路標。

應用：
- 智能汽車路標識別

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/Traffic-sign-recognition

Real-time Environment Monitoring and Item Tracking Sensing Network System
實時環境監測和物件追蹤的傳感網絡系統

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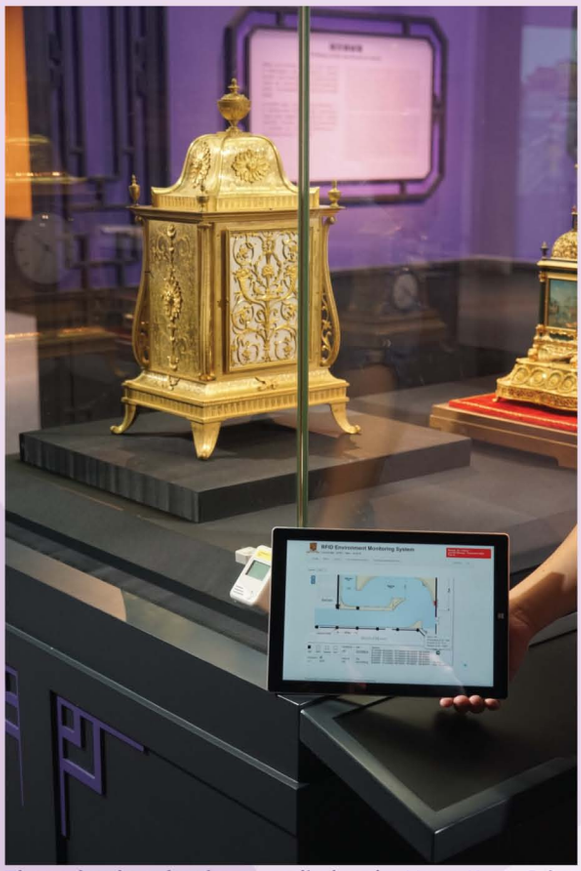
Funded by Innovation and Technology Commission and Hong Kong R&D Centre for Logistics and Supply Chain Management Enabling Technologies
由創新科技署及香港物流及供應鏈管理應用技術研發中心資助

Collaboration with Air Mail Centre, Hongkong Post and Central Conservation Section, Hong Kong Museum of History & Hong Kong Film Archive, Leisure and Cultural Services Department
合作夥伴包括香港郵政空郵中心及康樂及文化事務署文物修復組、香港歷史博物館及香港電影資料館



The technology has been applied at the Hong Kong Science Museum.
此技術已應用於香港科學館裡。

The technology has been applied at Air Mail Centre.
此技術已應用於香港郵政空郵中心。

Facilities like exhibition halls, warehouses and distribution centers often involve storage of invaluable items such as historic artifacts, wine and tea. To preserve the quality of the goods, environmental conditions such as temperature, humidity, illumination and vibrations must be effectively controlled at optimal level. In view of this, we propose a "Real-time Environment Monitoring and Item Tracking Sensing Network System" which helps improve the efficiency and accuracy in managing a vast quantity of flowing goods at large facilities.

Uniqueness and Competitive Advantages:

- We make use of a hybrid indoor communication system that can leverage on power line and wireless communications for facilitating a low energy data communications.
- The universal sensor interface allows plug-in of up to eight external sensors and utility modules to an active tag.
- The data communication protocols developed by CUHK will be further enhanced to connect thousands of wireless tags.
- The software components designed for the system can provide monitoring and alerting functions as well as analytics of collected sensor data for reporting and predictive purposes.

Applications:

- The technology has been recently applied in the Hong Kong Science Museum and Air Mail Centre to provide continuous monitoring of the environmental conditions.
- The technology can also be horizontally applied to other large facilities such as cold chain logistics, warehouse, distribution center etc.

展覽館、儲存庫和分發中心等這些儲存大量貨物的地方，不時涉及貴重物品的處理，例如歷史文物、葡萄酒、茶葉等。要妥善保存物品，必須有效控制溫度、濕度、照明、震動等環境條件。有見及此，我們設計了「實時環境監測和物件追蹤的傳感網絡系統」，以提升大型設施處理大量高流量物品的效率及準確性。

特點及優勢:

- 我們開發的是一個混合有線和無線通訊的室內通訊系統，能以低電量收集封閉地方裡的環境數據及調控其環境條件。
- 通用的傳感器接口令有源標籤可連接最多八個傳感器和功能模塊。
- 由中大開發的數據通信協議將會進一步改良，以連接數千個無線標籤。
- 配合系統而設計的軟件組件可以提供監測和警報的功能，並能夠分析收集到的環境數據以作報告和預報。

應用:

- 香港科學館及香港郵政空郵中心應用了本項技術去二十四小時實時監控設施的環境條件。
- 這項技術亦可應用到其他大型設施，例如冷藏食品物流、倉庫、分發中心等。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/EnvironmentMonitoringSensingNetwork

機械人及自動化技術
Robotics & Automation

Flexure-based Multi-axis Nanopositioners for Ultra Precision Applications
超精密柔性機構多軸納米平台

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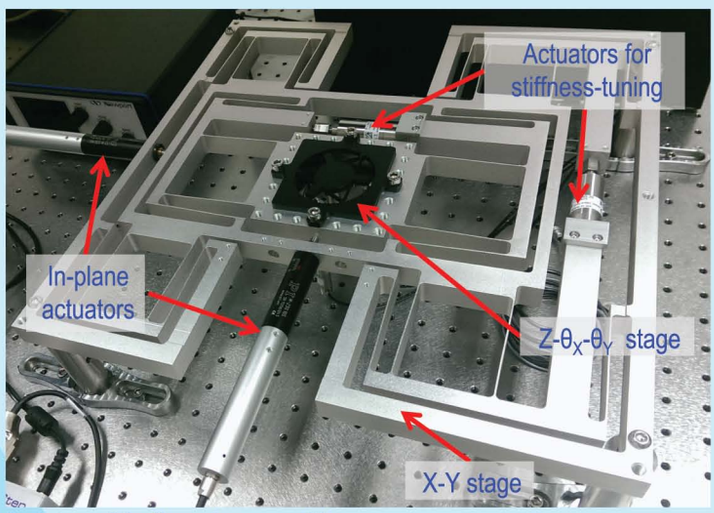
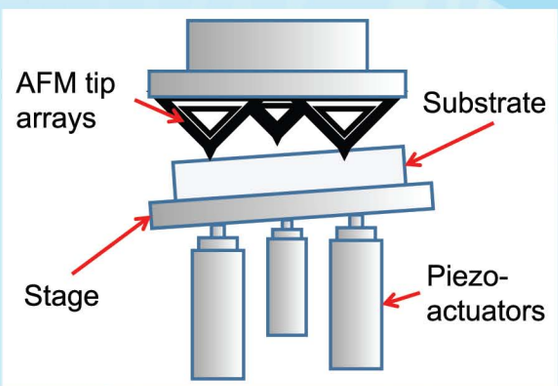
Funded by Innovation and Technology Commission
由創新科技署資助



Prototype of the five-axis nanopositioner
五軸納米定位平台的原型



Structure of nanopositioner
納米定位平台的結構

Nanopositioning is the precise motion control of objects on a very small scale - within 1nm over a range of microns. Nanopositioners are widely applied in microscopy, optics, nanolithography, and semiconductor manufacturing. However, nanopositioners in the market have some limitations, such as large stroke to footprint ratio, limited bandwidth, and lack of advanced control implementation.

To solve the problems, CUHK developed a low-cost flexure-based five-axis nanopositioner which is for tip-based parallel nanomanufacturing, and allows tradeoffs between its speed (natural frequency) and range (stroke) according to different requirements. It can also provide real-time position feedback and dynamic-tuning during nanomanufacturing. Furthermore, our novel nanopositioner is capable of producing high-throughput large-area (2×2 cm^2) parallel 2D nanofabrications.

A monolithic compliant mechanism was used to generate the repeatable guided motion. A parametric model that provides a deterministic link between the design parameters and system performance was developed for optimization. The new dynamic-tuning concept was inspired by compliant actuators used in humanoid robots, and achieved by exploiting the “stress-stiffening effect”, i.e. the stiffness of a beam increases when it experiences tensile loads in the axial direction.

To demonstrate the practicality, the nanopositioner was used to perform a parallel nano-scratching process, where arrays of Atomic Force Microscope (AFM) tips were positioned in parallel to a work surface and remove materials at nano-resolution. The nanopositioner is readily for various industrial and research applications after simple modifications. Examples include ultra-precise machining process, multi-axis wire-EDM, on-chip nano-manipulation, nano-lithography or equipment for characterizing irregular nano-surfaces etc.

納米平台是用來精密地控制物體之微細運動定位工具，比如在微米級範圍內移動1納米（nm）或以下的距離，這類納米平台可廣泛應用於顯微鏡、光學儀器、納米光刻和半導體製造等。然而，市場上的納米平台都存在一些限制，例如速度受納米加工的範圍所限、有限的帶寬以及缺乏先進的控制方式。

有見及此，中大研發低成本、基於柔性機構的五軸納米定位平台，適用於基於探針的並行納米製造，可根據不同的需求，調整加工速度（固有頻率）以及加工範圍，更可在納米製造過程中，作出實時的位置反饋及動態性能調整。此外，這嶄新的納米平台還能作高產量、大面積（2×2 cm^2）的並行平面納米加工。

本項目採用了一整體式柔性機構來產生重複性極高的導引運動，並在設計過程中提出一種參數化模型進行優化，該模型提供了設計參數和系統性能之間的確定性關係。全新的動態性能調整理念啟發自人形機械人上的柔性驅動器，可利用應力鋼化效應，調整柔性機構的內應力來實現各項調整。

我們在此納米定位平台上實施並行納米劃刻加工來驗證其實用性。在這過程中，探針陣列先被定位至平行於工作平面，然後探針陣列會以納米級的精度從此工作平面上移除材料。本納米定位平台經過簡單的調整後，可方便地應用在各式各樣的工業生產和實驗室研究中，如超精密加工、多軸電火花線切割、片上納米操作、納米光刻以及不規則納米表面特徵識別等。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/nanopositioner

Vacuum Nanoimprinting System for Low-cost Parallel Nanomanufacturing
應用於低成本並行納米製造的真空納米壓印系統

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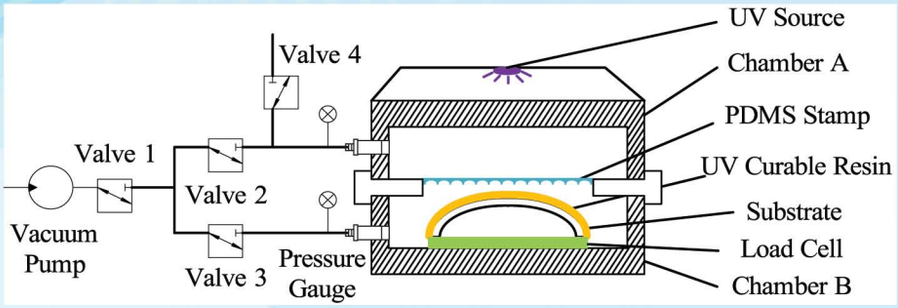
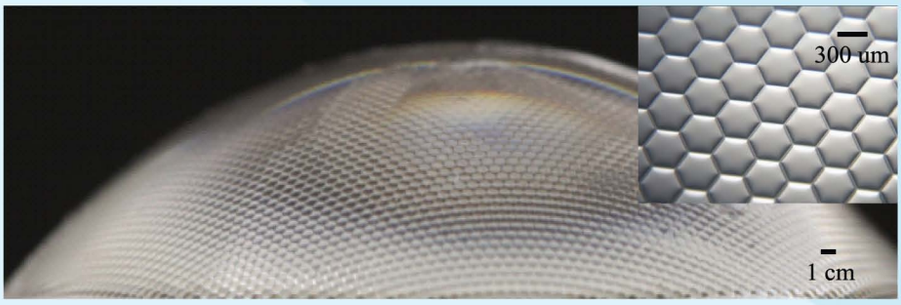


Design of vacuum nanoimprinting system
真空納米壓印系統之設計



Artificial compound eyes fabricated by UV imprint process
以紫外微鑄模成型技術製造的人工複眼

Although nano-imprinting technology is rapidly developing to be widely adopted in precision electronic products, such as micro optical devices, large-area nano-scale fabrication on curved substrates still remains expensive and difficult. CUHK developed an automated low-cost multi-modality vacuum-based nano-imprinting system that will enable large scale application (e.g. 4" substrates) in a non-cleanroom environment, of a wide variety of novel contact printing techniques, including (1) microcontact printing, (2) UV micro-molding, and (3) nanoscale hot embossing.

Our vacuum nanoimprinter can pattern 2D and 3D micro-structures on both planar and nonplanar substrates with the ingenious utilization of an elastomer stamp/mold. In addition, the aforementioned three techniques together provide wide material options, e.g. metals and polymers. Presently, there is no practical way to fabricate patterns on nonplanar substrates other than the costly laser lithographic technique that directly writes onto a nonplanar substrate, fixed on a six-axis positioner. The vacuum nanoimprinter will generate significant impact in the manufacturing industry by presenting this new nanomanufacturing platform for fabricating 2D/3D structures on nonplanar substrates in a parallel and cost effective way.

We have fabricated samples of different materials on 4" substrates of various curvatures. In addition, a vacuum-imprinted micro-lens array was used to construct a multi-channel compound eye imaging system for surveillance and ultra-wide angle imaging applications. This vacuum nanoimprinting system will be readily for various industrial and research applications after simple modifications.

納米壓印技術能廣泛應用於精密電子產品，例如微光電器件。其發展雖然一日千里，但要在曲面作大範圍的納米級加工，以現行的技術，仍十分昂貴及困難。中大研發低成本的多功能自動化真空納米壓印系統，不僅能於非無塵室的環境進行壓印，還能滿足大面積（4英寸）高精度的製造需求，而且適用於多種納米接觸式壓印技術，包括（1）微接觸壓印技術、（2）紫外微鑄模成型技術、及（3）納米尺度熱壓成型技術。

我們是首個能把彈性印章（或彈性模具）應用到真空納米壓印系統中的研究團隊，能夠在平面基底甚至曲面基底上壓印二維與三維的微納結構。此外，上述三種壓印技術的結合使得本系統可應用於多種不同的壓印材料（如金屬、聚合物）。迄今，在非平面基底上製造微納結構的唯一方法是把基底固定在六軸精密平台上，並使用昂貴的雷射直寫技術刻蝕圖案。而中大開發的真空納米壓印系統能夠提供一個全新的納米製造平台，採用低成本高效率的並行製造工藝，在非平面基底上製造複雜的微納結構，這將會對微納製造行業產生深遠的影響。

我們曾在不同曲率的4英寸基底上製造不同材料的樣品。此外，我們使用本技術製造的微透鏡陣列開發出多通道複眼成像系統，並將其應用於監測技術和超廣視角成像系統中。通過簡單的改裝，真空納米壓印技術將可以廣泛應用於不同的工業或科學研究中。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/nanoimprinting

Vision-based Intelligent Forklift Automatic Guided Vehicle (AGV)
視覺感測叉車式智能搬運機械人

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This intelligent forklift AGV (Automatic Guided Vehicle) is built on an advanced robotic and automation technology for improving the quality and productivity of manufacturing and service industries as the next generation industrial transporting robot. It can replace manually operated forklift trucks to perform various transporting tasks in factories, warehouses, etc. without changing current settings of the working environments. It provides an innovative and cost-effective solution to automation in manufacturing and service industries.

This AGV uses vision as primary sensor and fuses visual information with measurement of other sensors for navigation, positioning and motion control in natural industrial environment, which is Patent Cooperation Treaty (PCT) protected.

Uniqueness and Competitive Advantages:

- Valuable Core Technology: "New Vision-based Navigation Technology for Intelligent Vehicles / Mobile Robots" is adopted for navigation, positioning and motion control in natural environments
- Effective Solutions: Besides full set AGV, an environmental-friendly solution for upgrading/retrofitting existing factory forklift to intelligent AGV is available.
- Easy to adopt: No need to alter the current settings of factories and warehouses. No tracks or laser guidance are required. As a result, switching cost is low.
- Flexibility: Our AGV can move automatically, yet we also keep the manual control option.

我們以先進的機械人與自動化技術，開發出叉車式智能搬運機械人（AGV），以提升製造業和服務業的生產品質和效率，是下一代工業搬運機械人的先鋒。我們的AGV能夠在無需改動工場環境建設的情況下，取代人手操作的叉車在工廠和倉庫等地方完成搬運工作，為製造業和服務業提供一個高成本效益的嶄新自動化方案。

本AGV利用視覺作為主要的感測器，並融合其他感測器所獲取的視覺數據，在現有的工業環境裡實現導航、定位以及運動控制的功能。此技術已獲得PCT知識產權保護。

特點及優勢:

- 重要核心技術：以「全新的基於視覺的智能車/移動機械人技術」，於現有的工業環境裡實現導航、定位以及運動控制；
- 高效方案：除了提供整套的叉車式智能搬運機械人，我們亦可以將現有的搬運叉車改裝升級為叉車式智能搬運機械人，提供一個環保的方案。
- 容易採用：無需改動工廠和倉庫的現存建設，亦無需鋪設軌道或鐳射反射板，轉換成本因此十分低。
- 彈性選擇：除了可全自動工作，我們的AGV亦保留了人手操作的選擇。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/forklift-agv

An IMU-based Wearable Real-time Body Motion Control System for Tele-operated Robots
用於遠程控制機械人的基於IMU感測器的穿戴式動作控制系統

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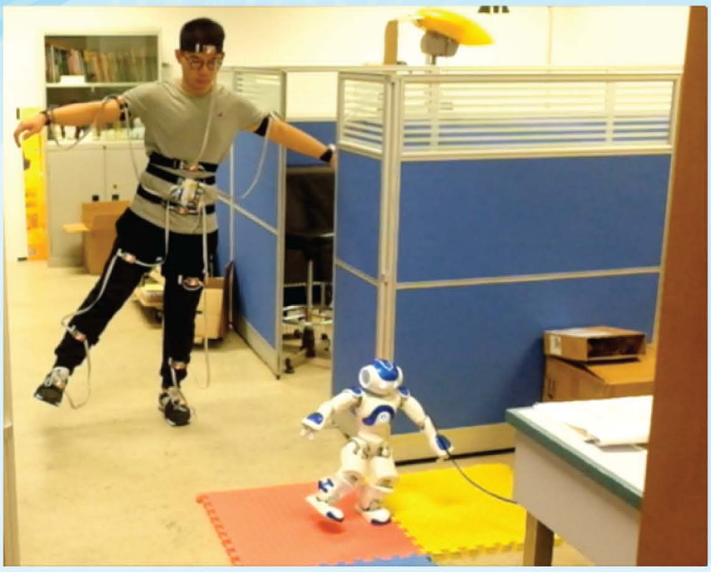

Teleoperated robot imitates one-leg supported human motion in real time while keeping perfect balance.
遠程機械人實時模仿人類的單腳動作同時保持平衡。

Nowadays, teleoperated robots are playing an increasingly important role in tasks with high risks (e.g., bomb-disposal, nuclear accident processing). Although the techniques of teleoperation have been well-developed, the interface for portable teleoperation is still very primitive (e.g., based on joysticks or touch-screens). A more natural interface is demanded for controlling teleoperated robots using body movements.

This project aims at developing an IMU-based wearable system, which can capture the full-body motion of users in real-time so as to provide the function of controlling a teleoperated robot at indoor and outdoor environment.

Uniqueness and Competitive Advantages:

- Our system is able to control the robot to imitate one-leg supported human motion in real time while keeping perfect balance, realizing high-level real-time whole-body motion imitation.
- Our system can achieve real-time sophisticated operations while it is of a significantly lower cost than the currently available systems which can perform tasks at the same level.
- The interface of our proposed system is notably lighter than the market available systems. It allows users to operate the robot with comforts even for lengthy tasks such as bomb disposal.
- Our system is robust at outdoor environment even against visual obstacles or under imperfect lighting.

現今，遠程式控制機械人在高危的行動中（例如：炸彈拆除、核電站事故處理等）扮演著愈來愈重要的角色。雖然遠程式控制機械人的技術已經發展得很成熟，但用於控制遠程機械人的操作介面仍然十分簡單，大多數仍是使用控制杆或觸踫式螢幕等。業界需要一種能夠更自然操作的控制介面，例如透過偵測操作員的身體動作來直接控制遠程機械人。

本項目旨在開發一個基於慣性測量組合的可穿戴式控制系統，以於戶內及戶外環境實時捕捉操作員的全身動作，從而控制遠程機械人的運動。

特點及優勢:

- 我們的系統能夠控制機械人實時模仿人類的單腳動作同時保持平衡，實現了高質量的全身動作實時模仿。
- 我們的系統可以實時完成精密的動作，而與現有的擁有相同功能的系統相比，成本則大大降低。
- 我們的操作介面比市場上的系統明顯輕巧得多，讓使用者即使要進行長時間的任務如拆除炸彈時，仍能夠舒適地穿戴。
- 我們的系統即使在戶外環境面對著視覺障礙物以及不理想的照明條件等變數，仍擁有很高的穩定性。

http://exhibition.cintec.cuhk.edu.hk/exhibition/project-item/IMU-body-motion-control-for-teleoperated-robot

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項目資料已上載於以下網頁
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