Innovation for Better Life 2014 - 2015
Being a forward-looking comprehensive research university, the Chinese University of Hong Kong (CUHK) conducts extensive innovative research projects. In this booklet, we compiled some of the latest CUHK research results, which are the contributions of various faculties, namely Faculty of Education, Faculty of Engineering, Faculty of Medicine, Faculty of Science, Faculty of Social Science as well as research units, such as Centre for Soybean Research of the State Key Laboratory of Agrobiotechnology, Centre for Learning Enhancement and Research, Institute of Chinese Medicine, Institute of Network Coding, Institute of Space and Earth Information Science, etc.

Centre for Innovation and Technology (CINTEC) is pleased to share these excellent research results with you. As a technology transfer arm of CUHK under the Faculty of Engineering, 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 promoting innovation through technology transfer to the society.

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Thank you for your interest in the innovations of CUHK.

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

作為一所具前瞻性的研究型綜合大學，香港中文大學（中大）進行大量創新科學研究。我們編修部份中大最新的科研成果於本刊物內，這些研究來自中大多個不同學院及研究單位，包括教育學院、工程學院、醫學院、理學院、社會科學學院，以及農業生物技術國家重點實驗室大豆研究中心、學能提升研究中心、中醫中藥研究所、網絡編碼研究所、太空與地球資訊科學研究所等。

創新科技中心樂意與您分享這些卓越的科研成果。作為隸屬於中大工程學院的技術轉移部門，創新科技中心是連繫大學與業界的橋樑，以促進中大研究團隊與業界的交流與合作為己任，同時亦透過向社會和業界的技術轉移，推動創新。

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謹此感謝您對中大創新發明的興趣。

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生物醫藥科學

穀片實驗室 (LOAD) - 醫療診斷設備的選擇
Lab-on-a-disc (LOAD) - A Possible Choice for Health Diagnostic Device Platforms

低成本高通量流動大腸桿菌立體成像系統
High-throughput Low-cost 3D Imaging System for Flowing Escherichia Coli

內鏡手術機械人
Endoscopic Surgical Robotic System

應用於助聽器植入手術的電腦輔助系統
A Computer-assisted Platform for Hearing Aid Implantation Surgery

綠茶提取物及其前藥作為血管增生抑制劑以治療子宮內膜異位症
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循證研發的止痛消腫外用中藥
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智能化太陽能技術 – 採集、儲存和應用
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Biomedical Sciences
生物醫藥科學
Bioassays are scientific experiments conducted to provide assessment of the effects of a substance on a living organism. They are commonly used in medical diagnostics, pharmaceutical analysis, environment and food safety tests. A conventional bioassay involves many procedures undertaken by trained personnel. They tend to be tedious and labour-intensive, hence time-consuming and costly. In this work, we have developed an integrated biomedical testing platform called Lab-On-A-Disc (LOAD). The LOAD system executes all steps of a bioassay within a single automated disc device, therefore offering true sample-to-answer operation.

The concept is based on the use centrifugal force, which occurs naturally in a spinning disc, to actuate movement of aqueous samples and reagents within a spinning microfluidic device under highly controlled manner. Reactions are programmed to take place in designated chambers in a desired sequence. Another unique yet simple feature is the introduction of electricity coupling capability to the rotating disc, which has enabled a multitude of bio-detection functionalities that were previously not possible. LOAD offers an open platform, users can design their customized discs according to their bioassay requirements. Power-enabled LOAD platform acts as an all-in-one system where all bioassay steps including sample actuation, heating and cooling, signal excitation and capture are performed with full automation. By eliminating tedious manual operations, LOAD significantly reduces time and costs.

LOAD can be used in point-of-care healthcare detection instrument and high-throughput screening of biomolecules. We have successfully used a LOAD system for DNA amplification through polymerase chain reaction (PCR) and loop-mediated amplification (LAMP) protocols.

**Demonstrated Applications**

- **Cell-based Allergy Test**
  - 以細胞為基礎的過敏測試
  - Non-invasive And Low Cost
  - 非侵入性及低成本

- **Real-Time DNA Amplification by PCR**
  - 實時DNA擴增 - 整合酶反應用
  - Fast and Simple
  - 快速簡單

- **Whole Blood DNA Screening**
  - 全血DNA篩檢
  - Fully Automated One-step Operation
  - 全自動化一步操作

生物檢測是指以科學測試去檢測某種物質對生物的影響。傳統生物檢測方法，需要由受訓人員進行多個實驗程序，既繁複又涉及大量人手。在本項目中，我們研發了一款稱為「碟片實驗室」(LOAD)的綜合生物醫學測試平台，將生物檢測的步驟整合在一個單一自動化設備上，真正從樣本直接得出檢測結果。

我們利用碟片旋轉時自然形成的離心力，精確地控制帶入樣本和試劑在碟片表面的移動。碟片的設計令實驗反應該在固定的次序在指定的反應室發生。此外，我們將電橋結合到旋轉碟片上，此簡單而獨特的設計令許多過去不可能做到的生物檢測能夠實現。LOAD提供開放式的平台，使用者可根據需要自訂碟片設計。引人電能的LOAD平台是一個一體化的設備，能夠自動進行生物檢測的全部步驟，包括樣本移動、加熱和冷卻，以及信號激發和收集等。LOAD免除了繁複的手動程序，大大減少了生物檢測所需的时间及成本。

技術可應用在床邊醫療篩檢設備，高效篩選生物分子等領域。此外，我們已成功利用LOAD透過整合酶反應用及及反應實現DNA擴增，
The objective of this project is to develop a low-cost, high-throughput hologram-based 3D imaging system for the detection of Escherichia coli (E. coli). This focusing-free system will capture image of food samples flowing in a transparent micro-channel under illumination of RGB lasers, and yield their 3D chromatic structures in real-time using hologram-based reconstruction algorithms.

Two key technical problems have been solved to realize the system:

1. Modification on a high-speed (200fps) imaging system for capturing full-frame holograms of the flowing cells;
2. Reconstruction of 3D chromatic structure of E. coli by characterizing the holograms under low-cost incoherent light sources.

The proposed system is over 1,000 times faster than existing methods. It can serve to safeguard food safety in our society against the virulent and ever-evolving serogroups of E. coli and fecal contamination. The technology also fulfills the demand of food industry and point-of-care testing (POCT) for rapid and low-cost E. coli detection. Additionally, the system can be adapted to other applications such as detection of circulating tumor cells in blood.
Endoscopic Surgical Robotic System

The therapeutic management of early gastrointestinal cancer and many other digestive diseases has changed in recent years by minimally invasive surgeries (MIS). Flexible endoscopy is an emerging technique to inspect and treat gastrointestinal (GI) tract disorders. Surgical procedures can be performed by introducing flexible tools through the working channel of an endoscope to reach the site of interest without the need for creating an opening in the patients' body, greatly reducing the pain and speeding up recovery. However, the lack of maneuverability of endoscopic platforms and tools makes complex surgical procedures, such as dissection and suturing, technically challenging to perform.

In view of this problem, CUHK is developing a high maneuverability two-arm endoscopic surgical robotic system for digestive diseases, which will enable surgeons to perform sophisticated surgical procedures with high accuracy and thus increase surgical safety and success rate.

CUHK research team has already developed a robotic system consisting of two arms with a total of 9 degree-of-freedom (DOF), which is able to complete simpler surgical procedures such as tissue retraction. Yet, the limited size of the working channel of conventional endoscope, which is of 3mm diameter, is a bottleneck for further increasing the DOF of the robotic arms.

To overcome the above inadequacy, we proposed in this project to develop smart and flexible technologies in three technical areas: 1) smart sensors and actuators for flexible robots; 2) intelligent robotic control systems; and 3) bio-inspired suturing protocols. Making use of a hollow overtube, which provides a larger channel for surgical tools to pass through, the developed robotic arms will couple with the latest ultrathin endoscope to set out the basic working platform for endoscopic surgeries. The freed space allows improvements in the DOF and sensing functions of the robotic arms. Together with our control system with high maneuverability, the accuracy of surgeries will be further enhanced.
Implantable active bone conduction hearing aid (Fig. 1) is designed to help patients suffering from conductive hearing loss, mixed hearing loss or unilateral hearing loss, as they cannot benefit from traditional hearing aids. However, implantation of hearing aids to patients’ skulls leads to high risk and surgery complexity. Effective and reliable surgical assistance is therefore essential. In view of this problem, CUHK developed a pioneer computer-assisted platform for the planning and navigation of implantation surgery. The system helps to reduce surgical risk, shorten operation time, avoid secondary surgery and minimize the cost.

Using patient-specific pre-operative CT data (Fig. 2), the skull in 3D view (Fig. 3) is constructed by core algorithms consisting of efficient 3D skull segmentation and modeling operations. The skull thickness is calculated and color-coded, and then mapped to the outer skull surface in order to assist the operator to select the optimal position to accommodate the implant. To ensure operation safety, alerting signals will be given if the operation is detected inappropriate. The 3D planning result will then be converted to DICOM images and sent to the intra-operative navigation system (Fig. 4).

With the user-friendly interface and the smooth and efficient 3D surface manipulation function, surgeons can easily operate the system. In addition, the system can be conveniently modified to apply to implantation surgeries of other skull implants.
Green Tea Extracts and Pro-EGCG as a Novel Anti-angiogenesis Agent for Endometriosis Treatment

One of the substances found in green tea, epigallocatechin-3-gallate (EGCG), is a potent antioxidant that has therapeutic applications. While there are many health products derived from green tea available on the market, we are the very first research team to study the use of EGCG in endometriosis treatment.

Endometriosis is a common chronic disorder characterized by implantation of endometrium outside the uterine cavity. The condition leads to chronic pelvic pain, infertility and menstrual problems in women during reproductive age and millions of women in the world are suffering from it. Current hormonal treatment will lead to undesired endocrine side effects while the chances for disease recurrence after surgical treatments are high. Thus, there is an urgent need in seeking better therapeutic approaches.

Anti-angiogenesis therapy offers a new opportunity for endometriosis treatment. Studies show that small anti-angiogenic molecules derived from natural products have great potential and advantages over synthetic inhibitors. EGCG is one natural anti-angiogenic agent. However, it suffers from instability and poor bioavailability. In this project, a prodrug of EGCG (Pro-EGCG) is utilized to enhance the stability and bioavailability. Laboratory test results show that EGCG and Pro-EGCG have potent antioxidant-independent inhibitory effects on the endothelial proliferation, migration, invasion and tube formation in vitro; and also significantly inhibit the growth of endometrial implants. Pro-EGCG has even greater potential than EGCG, with better anti-oxidation and anti-angiogenesis capacities.

Furthermore, Pro-EGCG also has promising potentials for treatments of other angiogenesis-dependent disorders such as diabetic retinopathy and cancers.
Musculo-skeletal pain and swellings are very common illnesses resulting from injuries, chronic mechanical stress or aging. Hospital and rehabilitation facilities may not be able to meet the high demand. Chinese Medicine offers various alternative treatments to these patients. One of which is topical herbal application, which provides an economical and safe remedy with minimal adverse effects.

There are many topical products available in today’s market for the treatment of acute and chronic injuries. However, most of these products are repetitions of traditional recipes and there is a lack of scientific evidence supporting the efficacy. Since 2003, a research team at CUHK has been exploring the scientific and clinical value of a simplified herbal formula derived from ancient texts for the treatment of injuries. It has been proven, on scientific platforms of cells and animals in the laboratory, that the herbal bath and paste are effective in treating local pain and swelling, as well as promoting blood vessel growth. A clinical trial has been completed for the herbal bath with positive results, while other trials are being analysed.
Environmental & Green Technologies
環境和綠色科技
The purpose of this project is to reconstruct Synthetic Aperture Radar (SAR) tomography of targets and fill the gap of this technology in current commercial software. The product will establish a foundation for the applications of more accurate deformation monitoring, biomass estimation, detection of hidden targets, change of global glacier, etc.

This project will be completed by the integrated development of VC++ and Matlab. Layover problems can be resolved through compressed sensing based superresolution tomography using multi-source and multi-temporal SAR observations. The reflectivity at different heights can be deduced. Finally, 3-D SAR models can be constructed.

The tomographic resolution achieved, i.e. separation capability, can be close to the highest theoretical bound. The outcome can be directly applied to ameliorate the precision of deformation monitoring of 3-D Hong Kong infrastructures by introducing Differential SAR Interferometry (DInSAR) technique.
With fossil fuels being hazardous to global climate change and nuclear power inevitably posing threats to human life, there is an urgent need to develop clean and renewable energy. Harvesting energy directly from sunlight provides a promising solution to this problem.

Professor WONG Ching-ping, Dean of Faculty of Engineering, The Chinese University of Hong Kong (CUHK) is leading an inter-disciplinary, multi-institutional research team consisting of more than 30 academic experts to carry out a holistic research project, which covers the development of thin film photovoltaic (PV) devices and modules to enhance the performance of solar energy harvesting; the design of smart electricity storage; and the establishment of distributed grid systems to increase the penetration of solar energy utilization. The research project aims to strengthen the competitive edge of Hong Kong in solar energy technologies and their market penetration by combining the newly developed PV modules with the intelligent system integration.

In the final stage, field demonstration of microgrids will be carried out at a student hostel at CUHK by incorporating the PV modules, the smart storage and the advanced management system developed in this scheme. This will be the first R&D project of its kind focusing on rooftop solar panel and building-integrated PV (BIPV) powered urban level microgrid systems at the very end of power grid (lowest voltage level). Uniquely, a full-scale system solution of urban microgrids from specific devices to system operation and management level will be provided, offering a significant reference for PV development in modern metropolitans like Hong Kong. 

最後，本計劃將會應用由本項目研發的太陽能電池板。電力儲能儲能系統及系統管理方案。在中大學生宿舍進行微電網的實際應用示範。本計劃將主力研發屋頂發電板及與建築物一體化的光伏設施，為城市級的微電網，提供末端用戶使用（即最低電壓）的電力。是同類科研項目中的先鋒，本計劃將從定點設備到系統運作及管理水平、獨有地為城市微電網提供整套的系統解決方案，為香港這類現代大都會在發展光伏太陽能發電方面，起重要的示範作用，
Salt Tolerance Gene in Wild Soybean

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Collaboration with BGI-Shenzhen,
Institute of Crop Sciences,
The Chinese Academy of Agricultural Sciences,
Kazusa DNA Research Institute, Japan and
Department of Computer Science,
The University of Hong Kong

Salinization of land worldwide has posed severe threat to agricultural productivity. There are over 900 million hectares of salt-affected land globally where one tenth are located in China. A total of 6.7 million hectares of arable land in China have undergone salinization.

Soybean is the third most important cash crop in international trade. Besides dietary consumption, soybean can also be used to produce biodiesel and cultivation of soybean can replenish soil nutrients. After over 10 years of research and field work, CUHK research team has successfully identified and cloned a major salt tolerance gene from wild soybean. This breakthrough will not only facilitate crop improvement related to saline land cultivation, but will also contribute to relief the global food crisis.

Due to human selection during domestication, many crops have lost genes/alleles that are important for adaptation to different environments. Wild soybeans are valuable genetic resources as they grow in a wide range of environments without artificial selection and have no breeding barrier with domesticated soybeans.

The research team in CUHK has started to work with soybean breeders in China to produce soybeans that can be grown on saline lands via non-GM methods. Meanwhile, they have continued their experiments in semi-arid and arid lands in Northwest China, with a goal of identifying drought tolerant genes from wild soybeans. The ultimate objective is to produce 'super-soybean' that is tolerant to both salt and drought.
Tree Guard Monitoring System (TGMS) is an automatic and continuous monitoring system developed to fight against possible tree thefts at places ranging from public country parks, institution managed properties, to private gardens. It is especially vital for the protection of endangered species such as Incense Tree and Buddhist Pine, which are often cut down for black market sales. TGMS will provide functions including tree theft prevention, protection and monitoring, to aid tree management teams to devise proactive and reactive measures for safeguarding invaluable trees.

Multiple sensors, such as sonic, temperature, humidity and tilt sensors, will be integrated into a hardware device with wireless communication capabilities, for monitoring the status of trees continuously. Sensing devices are tested on trees and data analysis algorithms are used to identify the external stimuli exerted on the trees. Alerts will be sent when abnormal activities, such as sawing and hammering, are identified.

TGMS will utilize various wireless technologies to form a scalable wireless mesh network for transmitting sensor data to a monitoring center. The wireless communication network can be scaled up for a wider coverage in two dimensions. The first is the expansion within a tree group, which uses a low-bandwidth, low-energy wireless communication. The second dimension is forming multiple tree groups to extend the coverage using Wi-Fi network communication. The Wi-Fi expansion may leverage on existing Wi-Fi network infrastructure readily available in private premises and Hong Kong government facilities.
Information & Communication Technologies
信息和通讯科技
Animation is a worldwide popular entertainment. With the increasing popularity of 3D cinemas and household 3D TVs, there has been a growing demand for 3D animations. The common way to create stereoscopic animation is through 3D modeling and toon-shading. To convert existing 2D animations into stereoscopic ones, a possible way is to first reconstruct the 3D models and then perform toon-shading. However, the manual work is costly and labor-intensive. And often the original 2D cartoon style cannot be preserved.

In this project, we designed the very first fully automatic system to "stereocropize" (introduce stereoscopic effect to) traditional 2D animations. The proposed system eliminates the costly 3D geometry reconstruction process. Instead, it infers the pseudo-depth and thereby computes the disparity of every object in each frame. With the computed depth, the system can then synthesize a stereo pair for each frame by rendering from novel viewpoints.

This technology saves the animation industry from costly labor-intensive manual work. It fits naturally into the existing production flow of the 2D cel animation and is able to fully preserve the original cartoon style.
Batched Sparse Code (BATS Code)

In recent years, there has been great advancement in wireless communication technologies. However, data loss during wireless transmission is still inevitable. In view of this problem, CUHK research team has developed Batched Sparse Code (BATS Code) to improve the network transmission rate of wireless networks with packet loss.

BATS code is one of the most mature network coding techniques in the world. All existing techniques based on retransmission suffer from significant performance loss due to unavailability of feedback in wireless networks with more than one hop. BATS code overcomes this problem and pushes the wireless multi-hop network transmission rate to close to theoretical limit. Its impact is particularly evident in scenario where feedbacks are not allowed or long delay occurs.

Compared with random linear network coding, BATS code offers a low encoding and decoding complexity, which is of the same order as that of fountain code. BATS code requires a much smaller buffer size at the network intermediate nodes. Yet, while compared with fountain code, BATS code provides higher speed and achieves an end-to-end capacity as good as that of a lossy hop.

A wireless mesh network (WMN) protocol has been built using BATS code. It enables efficient communications through tens of wireless hops. A more sophisticated protocol for large networks with dynamic link loss patterns is being developed. Besides, we completed a proof-of-concept demonstration of using BATS code to maintain high throughput for an end-to-end path consisting of five lossy links. A video streaming demonstration using BATS code has also been carried out successfully.
物理層網絡編碼
Physical-layer Network Coding

The number of transmission time slots required
箭頭上的數字表示傳輸所需的時隙

The number of wireless communication users is continuously increasing. Spectrum, however, is a limited resource. Enhancing the efficiency of wireless communication is therefore an important research goal. To realize it, one of the key challenges is to tackle the wave interference problem.

At the physical-layer of wireless networks, all data are transmitted through electro-magnetic (EM) waves. EM wave interference has long been conceived as something we should avoid in wireless communication. Physical-layer Network Coding (PNC), which is developed by CUHK research team, is able to shift the paradigm from this traditional view to embrace interference. PNC allows multiple devices to transmit their messages simultaneously, and its essence is to harness multi-user interference. PNC systems treat the interference as the linear encoding of multiple user signals and compute a linear function of the source messages. The computed functions are then forwarded to the destinations. Upon collecting sufficient linear functions, each destination recovers its desired messages by solving these linear functions.

This mechanism efficiently addresses the interference bottleneck problem, leading to a dramatically improved system performance. To illustrate the performance of PNC comparing with conventional schemes, we take the communication in a linear three-node multi-hop network as an example (refer to graph). It is shown that only two time slots are required in PNC for the two end-nodes to exchange two frames, one in each direction via the middle relay node. In contrast, three time slots are needed in straightforward network coding, while four time slots are needed if network coding is not used at all.

PNC has emerged as a promising technique that can significantly improve the capacity and energy efficiency of future wireless networks. PNC is not merely a theoretical concept, but a workable solution in real wireless networks. Recently, our team has built a prototype that can allow two terminals to exchange image files using the PNC mechanism in real-time.
CodFS: 具備高效率更新及快速修復功能的總統碼分佈式儲存系統

CodFS: An Erasure-Coded Clustered File System with Efficient Updates and Fast Recovery

Big data analytics provides government and enterprises with useful information which aids their decision making. However, effective storage of such enormous amount of data has been a great challenge. Applying Erasure Coding (EC) is one of the data protection methods in which, instead of replicating a whole file as backup copies, portions of a file are replicated and stored across a set of different locations (nodes) and, upon data corruption, the original file is recovered by retrieving these data fragments. EC guarantees data availability and security while lowers data redundancy.

In this project, research team of CUHK proposes an advanced erasure-coded clustered storage system named CodFS, which makes use of our newly developed scheme called "parity logging with reserved space". CodFS enables efficient updates and fast recovery of big data at low cost.

To achieve high efficiency in updating files, log-based storage is often adopted to append new data rather than overwrite existing data (in-place update). However, reassembling these updates from data and parity chunks stored at different nodes during recovery introduces significant I/O overhead. Our proposed scheme "parity logging with reserved space" takes a hybrid of in-place data updates and log-based parity updates by keeping parity updates in a reserved space next to the parity chunk. Disk seeks can therefore be mitigated to achieve efficient recovery. It is proved that CodFS achieves 66% speedup over conventional in-place data update while preserves the recovery performance. Additionally, to ensure efficient use of storage space, a workload-aware scheme is proposed to dynamically predict and adjust the reserved space size.
RevDedup: Efficient Hybrid Inline and Out-of-line Deduplication for Backup Storage

Deduplication has been commonly deployed in storage systems to reduce disk space by eliminating redundancy. Inline deduplication and out-of-line reverse deduplication are two conventional deduplication methods. Each, however, has its own shortcomings. CUHK proposes RevDedup which is a hybrid between the two. It provides high backup and restore throughput of recent backup versions, and at the same time facilitates fast deletion of expired versions.

Inline deduplication (Fig. 1) removes duplicates from new data on the write path, inducing fragmentation in the latest backup and thus reducing the restore performance. Sharing of chunks also complicates the deletion process of expired backups. While out-of-line reverse deduplication (Fig. 2), redundancy is removed from old backups after new data has been stored. It introduces additional I/Os in writing and removing duplicate chunks.

RevDedup efficiently combines the two methods by adopting a two-phase approach: (1) Inline deduplication is first applied at coarse-grained level (large segments of several MBs). It reduces fragmentation of the latest backup versions and thus maintains the restore throughput; (2) Out-of-line reverse deduplication is then employed at fine-grained level (small blocks of several KBs). It shifts fragmentation to old versions and prepares data for fast deletion, while limits the I/O overhead at the same time.

We implemented RevDedup on a real-life virtual machine. Results show that RevDedup achieves high deduplication efficiency with around 97% of space saving, high write throughput at 4-7GB/s, and high read throughput for the latest backup at 1.2-1.7GB/s.
Different parts of radio spectrum are allocated for different uses in telecommunications, such as radio broadcast, TV broadcast and mobile data communication. There is a rapid growth in mobile data usage worldwide over recent years. In Hong Kong alone, the local mobile data usage in Dec 2013 reached up to 12.1 million Gigabytes, which is 19 times of that in the same period in 2009. With the limited number of frequencies available, it interests researchers around the world to investigate the efficient use of spectrum. There is a noticeable amount of licensed but underutilized TV spectrum in the TV bands. These unoccupied portions, namely TV White Space, offer the first and promising opportunity to provide additional spectrum for mobile data communication.

It is found that 70% of the traffic demand comes from indoor environment. However, most prior works have focused on exploring outdoor white spaces. We are the first group in the world focusing on indoor TV white space identification and network design. Our system WISER (White-space Indoor Spectrum Enhancer) can effectively identify and track indoor white spaces, without requiring user devices to sense the spectrum. Based on our previous large-scale measurement across 30+ diverse locations in Hong Kong, more than 50% and 70% of the TV spectrum are white spaces in outdoor and indoor scenarios, respectively. WISER can fully utilize up to 70% of the underutilized indoor TV spectrum without interfering currently used spectrum to help improve the indoor wireless network congestion.

These techniques are not limited to TV white spaces and can be broadly used for dynamic spectrum access in other parts of the spectrum. WISER thus has huge potential in wireless communications worldwide.
用於 4G 無線 TD-LTE 的超高速模擬前端芯片的關鍵技術研發和產業化
Research and Development on High-speed Analog Front-end for 4G TD-LTE

Long-Term Evolution (LTE) 是一個發達技術，應用於無線通信的領域。現有的模擬數字轉換器 (ADC)，應用於無線通信，需要高靈敏度的放大器。然而，CMOS 技術的不斷進步，使得在設計中，即使在低功率消耗的情況下，也可以達到好的性能。

在此項目中，CUHK 與 Evoc 智能科技有限公司及 Shenzhen Amplify Electronics Co. Ltd 合作，研究開發了超高速模擬前端芯片技術。此技術可以解決上述的瓶頸問題，能夠實現高速運動範圍同時降低電源設計。

移動端類比數位轉換器的性能:
- 在 20MHz 時，功耗低於 6mW 或以下；
- 在 4.1MHz 時，功耗低於 20mW；
- 運動範圍可達 60dB 或以上；

超高速採樣保持器的性能:
- 20 GSp/s 采樣率
- 8-bit 準確度

Layout of an amplifier-less pipelined ADC in 0.18um CMOS
0.18微米 CMOS 無放大器管線式類比數位轉換器
With the advancement of social media, creation and spreading of messages, including rumors, are becoming increasingly easy and rapid, posing enormous impact on society. There are growing interests in the research on rumor detection and credibility ranking. However, existing methods simply based on popularities of topics are ineffective in discovering and identifying suspected emergent rumors. In this project, we propose an opinion-based framework for suspected rumor detection and credibility ranking by calculating the following features:

User Credibility:
Generally, if a user often posts opinionated posts while his/her opinions are supported by other users, it reflects that he/she has a relatively high credibility. Using “Learning to Rank” algorithm, the user credibility will be calculated based on the volume of opinionated posts, the acceptance of opinions and the changes of acceptance of opinions over time.

Uncertainty:
A topic is more likely to be a rumor if more users present uncertain opinions towards it. We will collect a database of uncertain expressions and study the features of the use of vocabularies, grammars and sentence structures. We will then design a binary classifier to identify opinions with uncertainty and thereby calculate the overall degree of uncertainty.

Controversy:
Whether opinions on a certain topic are supporting or opposing each other is another significant feature for determining the credibility of the message. We will design an opinion mining system to analyze the polarity of opinions and thereby calculate the overall degree of controversy.
實時環境監測及風險管理傳感網絡系統
Real-time Environmental Monitoring and Risk Management Sensing Network System

At facilities like exhibition halls, warehouses and distribution centers, storage of invaluable items such as historic artifacts, wine and tea is often involved. 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, CUHK proposes a "Real-time Environmental Monitoring and Risk Management Sensing Network System", which helps to improve the efficiency and accuracy in managing a vast quantity of flowing goods at large facilities.

We developed a hybrid indoor communication system to leverage on power line and wireless communication for facilitating low energy data communications which support sensor data collection and the control of environment conditions at closed environments. A pluggable hardware platform is designed to house external sensors and utility modules based on monitoring needs. 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. We will also optimize the communication propagation algorithm and mechanism to reduce network traffic in a vast hybrid network. 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.
Terahertz light is part of the electromagnetic spectrum between microwave and infrared. It can penetrate clothes, wood and plastics, but it is strongly absorbed by water. With its non-destructive characteristic, terahertz technology is an emerging field for applications ranging from medical imaging, industrial quality control, to hidden weapon detection.

In this project, we aim to design and demonstrate a liquid crystal based spatial light modulator which can operate at terahertz frequencies. Combined with compressed sensing theories, the modulator could ultimately be used to form a single pixel high speed terahertz camera.

Liquid crystal based spatial light modulators are widely used at visible light frequencies but it is a challenge at terahertz frequencies because of the longer switching times (due to the thicker layer of liquid crystal needed for terahertz). To overcome this problem, we have built a groundbreaking electrode design which improves the switching time and transmission efficiency in liquid crystal devices.

In addition, we will design and evaluate liquid crystal cells suitable for terahertz wave modulation and incorporate the abovementioned electrode design into these cells. As liquid crystal devices offer superior electronic control, the optimized cell design can be used to build a switchable array to form the terahertz spatial light modulator.
LATIA: Mobile Information Wallet Development Library

A large number of exhibitions are held at international cities like Hong Kong every year. Mobile communication devices have become an important tool in exhibitions to effectively deliver information to audience so as to maximize promotion outcomes. We developed an Android application design middleware namely LATIA, which enables exhibition organizers and exhibitors to easily design a "mobile information wallet" to fit their promotion strategy.

The "mobile information wallet" app designed with LATIA allows visitors to load different exhibition information to their mobile device through Near Field Communication (NFC) technology. After downloading the app, they can record the exhibitors/exhibits they have visited, download related information, and even automatically add an event to their e-calendars by simply putting their smart phones or tablets close to the NFC tags on promotion posters, brochures, or other promotion materials. The app will be activated once the mobile device detects the NFC tag. It saves visitors from manually launching the app, making it even more convenient.

The interface of LATIA is user-friendly, enabling users to easily design their tailor-made "mobile information wallet" by adding texts, photos, URLs, calendars or even polls/votes the way as they prefer.

LATIA designed the "mobile information wallet" application, which allows users to easily access information about exhibitions and events. The app can be activated by simply touching a NFC tag on a poster or brochure. This makes it convenient for visitors to keep track of the information they are interested in.

Users can design their own Mobile Information Wallet by adding different elements.

# LATIA NFC Tag
LATIA NFC 標籤

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Users can design their own Mobile Information Wallet by adding different elements.
uReply: 互動移動學習
uReply: Interactive Mobile Learning

Prof. LAM Lai Chuen Paul
Centre for Learning Enhancement and Research
學能提升研究中心
藍慧銓教授

Funded by Teaching Development Grants
由教學發展基金資助

The aim of the Mobile Learning project at CUHK is to pursue the possibilities in enhancing the teaching and learning environment through the use of various mobile technologies.

To enrich interactions in classrooms, we designed a web-based student response system namely uReply. The system allows all students in a class to answer a question simultaneously through using mobile devices. Instead of installing costly equipment in a classroom, we adopt the “Bring Your Own Device” (BYOD) strategy. That is, students can access to the platform simply using their own smart phones, tablets or laptop computers.

uReply provides an easy-to-use interface that no prior trainings will have to be given to teachers or students. Teachers can set up a question during class or select a pre-set question which they have prepared in advance. Answers will be sent to the teacher’s interface in real time and can be instantly analyzed. In addition, records of the class activities are retrievable by teachers at any later time for further analysis.

香港中文大學移動學習項目的目標，是透過利用各種移動科技，提供更優質的教學環境。

為加強課堂裡的互動，我們設計了一個名為uReply的學生應答網絡系統，系統讓課堂裡的學生能夠一起利用流動設備同時回答教師的問題。本項目的其中一個優點是無須在課室裡添置昂貴的儀器，相反，我們善用「自帶設備」的方針，讓學生透過使用自己的智能電話、平板電腦或手提電腦去使用應答平台。

uReply提供簡單易用的用戶介面，教師和學生均無須事先學習如何使用。教師可在課堂即時設定或點選已預先設定的問題，學生的答案會即時傳送到教師介面，更可作即時分析。此外，教師更可隨時存取課堂活動的數據，日後作更詳細的分析。

The system supports multiple-choice questions and short questions. Students can input answers via their own mobile devices such as smart phones, tablets or laptop computers.

系統支援選擇題及文字題，學生可透過他們的流動設備，例如智能手機、平板電腦和手提電腦等去輸入答案。
Teacher Professional Development through MOOC

In this project, the very first in-service teacher professional development massive open online course (MOOC), funded by Education Bureau (EDB), has been developed to aid primary and secondary school teachers to implement WebQuest.

WebQuest is a learner-centric project-based learning approach for facilitating K-12 students to pursue collaborative inquiry learning on the Internet, and is becoming an integral part of education. For effective integration of WebQuest into school education, trainings should be provided to teachers to equip them with the pedagogical knowledge and skills required. Yet, most in-service teachers cannot afford time to participate in conventional face-to-face professional development training. MOOC provides a promising solution to the problem.

This MOOC is composed of video-based lecture modules, formative assessment quizzes (each articulated to the end of a module), virtual forums for teacher community building (each facilitated by an online tutor), and summative assessment tasks. In the course, participants can select their own learning track by taking different lecture modules in accordance with their own grade of teaching (primary or secondary) and their own subject of teaching (four key learning areas: English Language, Chinese Language, Mathematics, or Humanities). After passing all formative assessment quizzes and completing all community-building and summative assessment tasks, participants will be each awarded an eCertificate, and six hours of continuing professional development (CPD) by EDB.

In addition, inter-school subject-specific teacher communities are built for users to share good teaching practices.
Robotics & Automation
機械人及自動化技術
Mobile Microvortex Tweezers: Noninvasive, Low-cost Tools for Cell Manipulation and Nanomedicine

To assist high precision manipulation of cellular-scale objects such as cells and microorganisms, we are developing a micro-robotic system namely Mobile Microvortex Tweezers (MMT). The technology enables us to control magnetic microrobots containing drug or cells to travel in body fluids, such as blood, urine, or cerebrospinal fluid, to a target position. MMT thereby has high potential for nanomedicine such as in vivo targeted drug/cell delivery for the minimally invasive medical treatment.

MMT is composed of mainly a PC controller, a vision system, electromagnetic coils and a magnetic microrobot. The PC controller manipulates the generation of electromagnetic field by electromagnetic coils, which in turn remotely actuate and control the motion of the magnetic microrobot. Microvortices are generated by the rotation of the microrobot and are used to trap and transport microscale objects, including living cells and microorganisms. MMT could maneuver extremely small fluid volumes down to femto-liters (10^-15 L). It provides a noncontact and controlled manipulation means for cells and other biological samples with minimal change to their physiological condition.

MMT enables manipulation of individual microscale objects in 2D or 3D with a high spatial and temporal resolution. Compared to other advanced cell-manipulation tools, e.g. optical tweezers and magnetic tweezers, MMT provides a low-cost and noninvasive manipulation solution, and have no restrictions on the material properties of the sample.
Dampers are an energy dissipation device installed in vehicle suspension system for reducing vibration of vehicle body and improving ride comfort. Upon accelerating, cornering, braking and passing road irregularities, a large amount of energy is wasted due to the energy dissipation by dampers. CUHK research team proposes regenerative Magnetorheological (MR) dampers with self-contained power regeneration ability. Kinetic energy generated in vibration will be converted into useful electrical energy to sustain the dampers. Moreover, extra batteries and dynamic sensors that are required in current MR damper systems can be eliminated.

The proposed dampers will promote both renewable energy and vehicle performances. Overall energy efficiency of the vehicle will be improved, while fuel consumption and emission will be reduced. With other advantages including reduction in size and weight, higher reliability and less maintenance required, performance of vehicle suspensions is improved.

In addition, our technology will also benefit electric and hybrid electric vehicles, as it can be used to charge the vehicle batteries and thus increase the battery running time. The technology is especially beneficial to densely populated cities, such as Hong Kong and Beijing.
If you are interested in the projects listed, please contact

Centre for Innovation and Technology
The Chinese University of Hong Kong

項目資料已上載於以下網頁
Project information is also available at
www.cintec.cuhk.edu.hk/exhibition

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