大學教育資助委員會
University Grants Committee

香港城市大學
City University of Hong Kong

TRS 主題研究計劃 Symposium 研討會 2020

Research Grants Council
Theme-based Research Scheme
Public Symposium 2020

研究資助局
主題研究計劃
研討會

13 December 2020 (Sunday)
9:00 am – 5:15 pm
Zoom Webinar

2020年12月13日 (星期日)
上午9時至下午5時15分
網絡研討會

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Delivering 21st Century Healthcare in Hong Kong - Building a Quality-and-Efficiency Driven System
為香港提供21世紀的醫療服務 —— 構造一個品質與效率驅動的服務體系

Safety, Reliability, and Disruption Management of High Speed Rail and Metro Systems
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Message from Chairman of Research Grants Council

On behalf of the Research Grants Council, I welcome you to the Theme-based Research Scheme Public Symposium 2020.

The Theme-based Research Scheme (TRS) aims to focus academic research efforts of the University Grants Committee-funded universities on themes of strategic importance to the long-term development of Hong Kong. Since the launch of the Scheme in 2011, ten rounds of exercise have been conducted. 12 projects funded in the third, fourth and fifth rounds of exercise will share the achievements of their frontier research in the Symposium. In addition to the interactive presentations at the Symposium, the project teams have produced videos to demonstrate their novel discoveries and research impact. These videos are available for viewing on the RGC website.

Taking this opportunity, I would like to express my sincere gratitude to members of the 12 project teams and their universities for their contributions in making this symposium a success. I would also like to thank the Research Grants and Contracts Office of City University of Hong Kong in coordinating this event.

We look forward to seeing the impact and benefits brought by these TRS projects to the social and economic development of Hong Kong. I hope you would enjoy the Symposium.

Professor Joseph Hun-wei Lee
Chairman
Research Grants Council

研究資助局主席的話

我謹代表研究資助局，歡迎您參加主題研究計劃研討會2020。

主題研究計劃的目的是集中大學教育資助委員會資助大學的學術研究力量，對香港長遠發展具策略重要性的主題進行研究。自2011年計劃推出以來，至今已舉行了十輪計劃。在第三、第四及第五輪獲得撥款的十二個項目團隊將於是次活動中分享他們的前沿研究成果。項目團隊將在是次研討會上介紹項目成果，並與參加者交流。另外，項目團隊亦已製作短片分享項目的嶄新發現及研究影響。有關短片已上載至研資局網頁讓公眾收看。

藉此機會，我衷心感謝12個項目的團隊成員和他們所屬的大學對是次研討會的支持，使研討會得以成功舉行。我亦感謝香港城市大學的研究資助處協助籌辦是次研討會。

我們期望這些主題研究計劃項目為香港的社會和經濟發展帶來影響及裨益。希望您熱烈參與是次研討會。

研究資助局主席
李行偉教授

About the Theme-based Research Scheme

Theme-based Research Scheme (TRS) aims to focus academic research efforts of University Grants Committee UGC-funded universities on themes of strategic importance to the long-term development of Hong Kong.

There are four designated research themes under the TRS. Under the four research themes, there are 19 grand challenge topics. The themes and grand challenge topics are as follows:

a. **Promoting Good Health**
   1. Infectious Diseases
   2. Understanding Disease Mechanisms to Improving Health
   3. Stem Cells and Regenerative Medicine
   4. Wellness Enhancement

b. **Developing a Sustainable Environment**
   1. Water Pollution and Water Treatment
   2. Sustainable Built Environment
   3. Energy Conservation, Conversion and Harvesting
   4. Air Quality
   5. Food Production and Food Security

c. **Enhancing Hong Kong's Strategic Position as a Regional and International Business Centre**
   1. Hong Kong's Future as an International Financial Centre
   2. Promoting Hong Kong's Business through Networking Capability
   3. Promoting Hong Kong as a Centre of Excellence for Business Services
   4. Innovation Ecology and Business Creation
   5. Financial Technologies (FinTech) and Regulatory Technologies (RegTech)

d. **Advancing Emerging Research and Innovations Important to Hong Kong**
   1. Big Data
   2. Imaging, Robotics and Smart Manufacturing
   3. Urban Infrastructure and Smart City
   4. E-learning and Digital Citizenship
   5. Artificial Intelligence

The maximum duration of a project is five years. The ceiling of direct project cost per project to be awarded by the RGC is $75 million.

主題研究計劃概要

主題研究計劃的目的是集中大學教育資助委員會（教資會）資助大學的學術研究力量，對香港長遠發展具策略重要性的主題進行研究。

主題研究計劃設有四個研究主題，四個主題下共設有19個具挑戰性的題目：

1. 促進健康
   1. 傳染病
   2. 剖析發病機制以保障健康
   3. 幹細胞與再生醫學
   4. 提升健康

2. 建設可持續發展的環境
   1. 水污染及水處理
   2. 可持續建築環境
   3. 節約、轉化及採集能源
   4. 空氣質素
   5. 食物生產及食物安全

3. 加強香港作為地區及國際商業中心的策略地位
   1. 香港作為國際金融中心的未來發展
   2. 透過網絡能力推動香港商業發展
   3. 推廣香港成為卓越的商業中心
   4. 創新生態與商業創意
   5. 金融科技及監管科技

4. 促進對香港起重要作用的新興研究及創新項目
   1. 大數據
   2. 造像、機械人技術及智能製造
   3. 城市基礎建設及智慧城市
   4. 網上學習及數碼公民身分
   5. 人工智能

每個項目的年期最長為五年，研資局資助金額上限為7千5百萬元（按直接項目成本計算）。

Programme

	TIME	PROGRAMME
	9:00–9:15	**Opening Speech by Chairman of the RGC** *Prof Joseph Hun-wei LEE*
	9:15–9:45	**Plenary Session by Chairman of the Major Projects Steering Committee – Funding Mechanism of the TRS** *Prof Edward Sze-shing YEUNG*
Business Theme	9:45–10:15	Delivering 21st Century Healthcare in Hong Kong – Building a Quality-and-Efficiency Driven System *Speaker: Prof Frank Youhua CHEN (CityU)*
Business Theme	10:15–10:45	Safety, Reliability, and Disruption Management of High Speed Rail and Metro Systems *Speaker: Prof Kwok-leung TSUI (CityU)*
	10:45–11:00	**Break**
Environment Theme	11:00–11:30	Smart Solar Energy Harvesting, Storage, and Utilization *Speaker: Prof Jianbin XU (CUHK)*
Environment Theme	11:30–12:00	Sustainable Power Delivery Structures for High Renewables *Speaker: Prof Ron Shu-yuen HUI (HKU)*
Environment Theme	12:00–12:30	Smart Urban Water Supply Systems (Smart UWSS) *Speaker: Prof Mohamed S GHIDAOUI (HKUST)*
Environment Theme	12:30–13:00	Understanding Debris Flow Mechanisms and Mitigating Risks for a Sustainable Hong Kong *Speaker: Prof Charles Wang Wai NG (HKUST)*
	13:00–14:00	**Lunch Break**
Health Theme – Part 1	14:00–14:30	Viral, Host and Environmental Determinants of Influenza Virus Transmission and Pathogenesis *Speaker: Prof Joseph Sriyal Malik PEIRIS (HKU)*
Health Theme – Part 1	14:30–15:00	Molecular Basis for Interspecies Transmission and Pathogenesis of Middle East Respiratory Syndrome Coronavirus *Speaker: Prof Dong-yan JIN (HKU)*
Health Theme – Part 1	15:00–15:30	Systematic Development of Molecular Targets for Nasopharyngeal Carcinoma *Speaker: Prof Kwok-wai LO (CUHK)*
	15:30–15:45	**Break**
Health Theme – Part 2	15:45–16:15	An Integrated Trans-omics Approach to Diabetic Cardio-renal Complications: From Novel Discoveries to Personalized Medicine *Speaker: Prof Ronald Ching-wan MA (CUHK)*
Health Theme – Part 2	16:15–16:45	Genetics and Functional Genomics of Neural Crest Stem Cells and Associated Disease: Hirschsprung Disease *Speaker: Prof Paul Kwong-hang TAM (HKU)*
Health Theme – Part 2	16:45–17:15	Centre for Research into Circulating Fetal Nucleic Acids *Speaker: Prof Dennis Yuk-ming LO (CUHK)*

THE END

研討會活動

	時間	活動
	9:00–9:15	**開幕致詞：研究資助局主席** 李行偉教授
	9:15–9:45	**主題研究計劃撥款機制簡介：大型研究項目督導委員會主席** 楊仕成教授
商業主題研究項目	9:45–10:15	**為香港提供21世紀的醫療服務 —— 構造一個品質與效率驅動的服務體系** 講者：陳友華教授（香港城市大學）
	10:15–10:45	**高速鐵路和鐵道系統的安全性、可靠性和應急管理研究** 講者：徐國良教授（香港城市大學）
	10:45–11:00	**小休**
環境主題研究項目	11:00–11:30	**智能化太陽能技術：採集、存儲和應用** 講者：許建斌教授（香港中文大學）
	11:30–12:00	**可容納大量可再生能源的可持續電力輸送結構** 講者：許樹源教授（香港大學）
	12:00–12:30	**智慧型城市供水系統** 講者：招捷達教授（香港科技大學）
	12:30–13:00	**香港泥石流流動機理及風險控制** 講者：吳宏偉教授（香港科技大學）
	13:00–14:00	**午膳**
健康主題研究項目 — 第一部份	14:00–14:30	**探討流感病毒、宿主和環境各種因素對流感傳播和病理的影響** 講者：裴偉士教授（香港大學）
	14:30–15:00	**中東呼吸綜合症冠狀病毒跨種傳播和致病機制的分子基礎** 講者：金冬雁教授（香港大學）
	15:00–15:30	**系統性開發鼻咽癌的分子靶標** 講者：羅國煒教授（香港中文大學）
	15:30–15:45	**小休**
健康主題研究項目 — 第二部份	15:45–16:15	**對糖尿病心血管及腎臟併發症的跨組學基因研究 —— 從創新發現至個性化治療** 講者：馬青雲教授（香港中文大學）
	16:15–16:45	**神經脊幹細胞及相關疾病的遺傳學和功能基因組學：先天性巨結腸症** 講者：譚廣亨教授（香港大學）
	16:45–17:15	**母體血漿胎兒核酸研究中心** 講者：盧煜明教授（香港中文大學）
		活動完結

Kwok-wai Lo (PC); Anthony Tak-cheung Chan (Co-PI); Ka-fai To (Co-PI); Edwin Pun Hui (Co-I)

羅國煒 (PC); 陳德章 (Co-PI); 杜家輝 (Co-PI); 許斌 (Co-I)

Systematic Development of Molecular Targets for Nasopharyngeal Carcinoma

系統性開發鼻咽癌的分子靶標

T12-401/13-R

Project Coordinator

Professor Kwok-wai LO

The Chinese University of Hong Kong

Participating Institutions

The University of Hong Kong

Beijing Genomics Institute (Shenzhen)

項目統籌人

羅國煒教授

香港中文大學

參與院校

香港大學

深圳華大基因組研究所

Short Biography of Project Coordinator 項目統籌人簡介

Professor Lo, Kwok Wai received his PhD from the Chinese University of Hong Kong (CUHK) in 1997. Currently, he is the Professor of Department of Anatomical & Cellular Pathology at CUHK. His long term research interest is to unveil the molecular basis of nasopharyngeal carcinoma (NPC). His research group has focused on identification and functional characterization of the NPC-associated tumor suppressor genes and oncogenes. He has successfully delineated the early events in NPC tumorigenesis and determined multiple recurrent genetic and epigenetic abnormalities in this EBV-associated cancer. Recently, he has systematically characterized the NPC genome by next-generation sequencing approaches. He is also working on establishing new tumor models, elucidating the mechanisms for immune evasion, and developing novel therapeutic strategies of NPC.

羅國煒教授於一九九七年獲得香港中文大學博士學位，現任中大病理解剖及細胞系教授。他的研究興趣主要是揭示鼻咽癌發病變的分子基理，集中鑑定與鼻咽癌相關的腫瘤抑制基因和致癌基因和分析其功能表徵。他成功展示了鼻咽癌早期腫瘤發生過程，並確定了這種與EBV相關的癌症中多種遺傳和表觀遺傳學變異。他最近利用大規模基因組測序系統地分析鼻咽癌基因組。現在，他正在建立新的鼻咽癌模型，研究其免疫逃避的機制和開發新型治療策略。

Project Summary 項目概要

- To catalogue the whole spectrum of genomic changes in NPC by genome sequencing;
- To define driver mutations, molecular and druggable targets and recurrent somatic alterations of NPC through integrative informatic analysis;
- To elucidate the functional roles of driver mutations and develop new targeted therapies in preclinical NPC models.

- 利用大規模基因組測序建立鼻咽癌基因組改變完整目錄；
- 以生物信息分析方法系統地鑒定驅動突變和關鍵的分子標靶；
- 分析驅動突變的功能作用，並利用臨床前鼻咽癌模型開發新型靶向治療。

Abstract of the Project 項目簡介

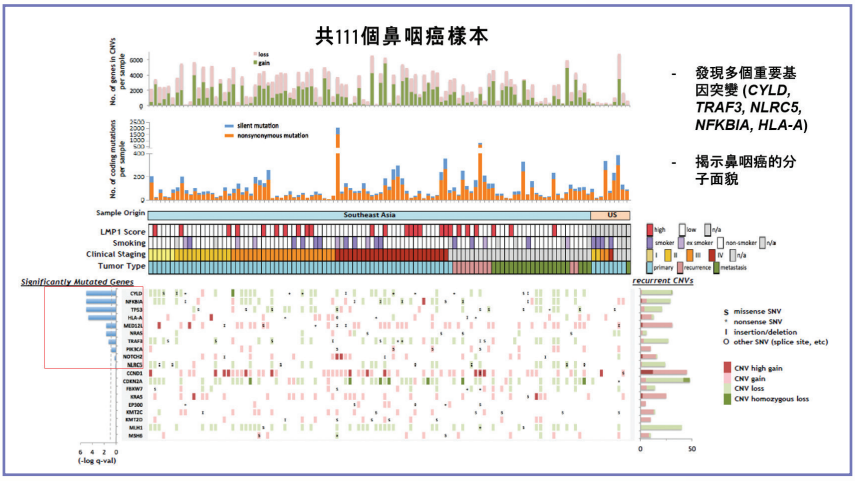
As the most prevalent cancer in our middle-aged workforce population, NPC is a major health-care problem in Hong Kong. More than 60% of newly diagnosed NPC patients are presented with advanced stage disease and show poor clinical outcome. The key problems of these patients are distant failure and lack of efficient treatment for recurrent diseases. New clinical interventions to treat the disease, prolong disease-free survival and improve quality of life of patients are therefore of strategic importance. A comprehensive understanding of genetic changes involved in NPC tumorigenesis is expected to offer the basis for research to develop promising disease control strategies for this cancer. Systematic discovering driver genetic lesions and apprehending how they contribute to transformation and progression of NPC are essential information to underpin reliable biomarkers and novel molecular targets for therapy; the cornerstone of developing patient-specific personalized medicine. In this project, we have decoded the DNA sequence of entire NPC genome and thereby catalogue the whole spectrum of genomic changes involved in NPC tumorigenesis by massive parallel genome sequencing. Our team has systematically defined the driver mutations and identified key "molecular targets" through large-scale genome and transcriptome sequencing, bioinformatic analysis and extensive validation in primary NPC samples. Functional studies have confirmed the oncogenic activities and biological significances of candidate driver mutations. To translate the genomic findings to specific NPC biomarkers, statistical analysis has been conducted to determine the clinical correlation between somatic variants and patients' clinical outcome. Importantly, candidate molecular targets and relevant tumour dependency can be elucidated for their therapeutic potentials in our unique panel of in vitro and in vivo NPC models. Our findings provide important novel biomarkers and therapeutic targets for developing personalized cancer treatment strategies. This TRS project makes strategic breakthrough in molecular genetics of NPC and contributes significant impact to the control of this common cancer.

鼻咽癌是中國南方常見的致命惡性腫瘤，亦是香港的主要醫療健康問題。其中關鍵問題是超過60%的患者在初次診斷時已是晚期，治療對癌症擴散和復發效果較差。因此發展嶄新臨床治療方案以延長患者存期和提高生活質量對控制鼻咽癌非常重要。系統分析鼻咽癌致癌機理有關的基因改變是發展可靠的生物標誌和分子靶向治療的依據及個體化治療的基礎，可以幫助發展有效控制癌症的策略。在本研究中，我們使用大規模基因組測序方法對鼻咽癌的全基因組DNA序列進行解碼，由此建立鼻咽癌基因組改變完整目錄。我們對鼻咽癌腫瘤組織進行大規模全基因組和轉錄組序列，生物信息分析及廣泛驗證，並系統地鑒定驅動突變和關鍵的分子標靶。我們亦進行功能研究以確定驅動突變的致癌活性和生物學意義。為了把基因組的發現轉化成鼻咽癌的分子標誌，我們使用統計分析方法確定基因變異與病人臨床預後的聯繫。在我們建立的獨特的鼻咽癌體外和活體模型中研究腫瘤對候選分子標靶的依賴，更可以闡明它們的治療潛力。這些發現將為發展鼻咽癌個體化治療策略提供重要的新分子標誌和治療標靶。我們預期該項研究計劃將促使鼻咽癌分子遺傳學研究的突破和對控制此常見腫瘤產生顯著深遠的影響。

Research Impact
研究影響

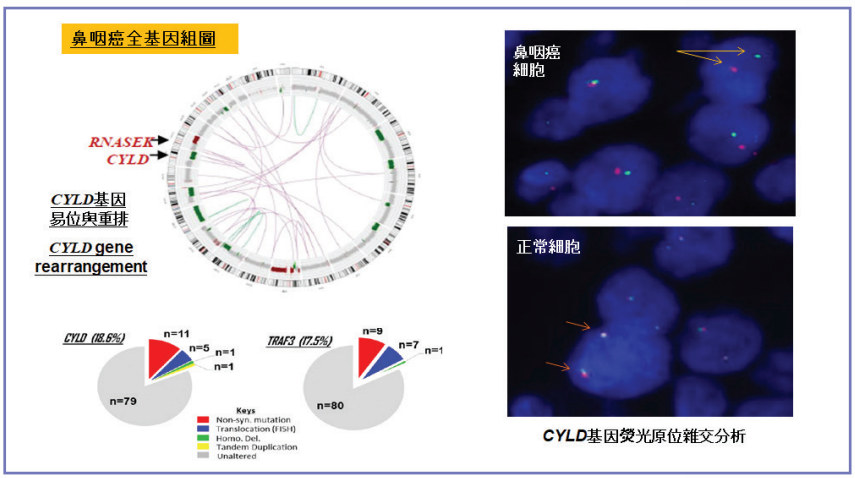
With the support of TRS, we have reported the first NPC whole genome sequencing study and a whole-genome sequencing dataset of 70 tumors will be available for the community. In addition, we have deposited the largest whole-exome sequencing datasets of 111 tumors to public database. Through integrated informatics analysis, a comprehensive catalog of somatic alterations of NPC has been established. Our findings have revealed majority of NPC displayed activation of the NF-κB inflammation pathways as a result of either somatic mutations in the NF-κB regulatory proteins or expression of viral oncoprotein. The novel genome discoveries greatly enhance our understanding on the molecular basis of NPC and inform the development of new therapies to target these aberrant signaling pathways. The identification of multiple novel biomarkers including total mutation rate and mutated MHC genes will help to select the optimal treatment to the NPC patients. The TRS project will significantly advance the current clinical management and facilitate the development of personalized medicine for NPC patients.

在主題研究計劃支持下，我們發表了第一個鼻咽癌全基因組測序研究報告。除了111個鼻咽癌全外顯子序列數據集已經存儲到公共數據庫，大型全基因組測序數據亦將可供使用。通過綜合信息學分析，我們建立了全面的鼻咽癌基因改變目錄。研究結果發現大部分鼻咽癌的NF-κB炎症通路的激活是由於其調節蛋白基因失活突變或病毒癌蛋白的表達導致的。這些全新基因組發現增強了我們對鼻咽癌分子基理的理解，並指導了開發針對這些異常信號通路的新療法。我們發現和鑑定包括總突變率和人類白細胞抗原基因突變等多種新生物標誌物有助鼻咽癌患者選擇最佳治療方法。此主題研究計劃項目有助改進目前臨床管理和發展鼻咽癌患者個人化醫學。



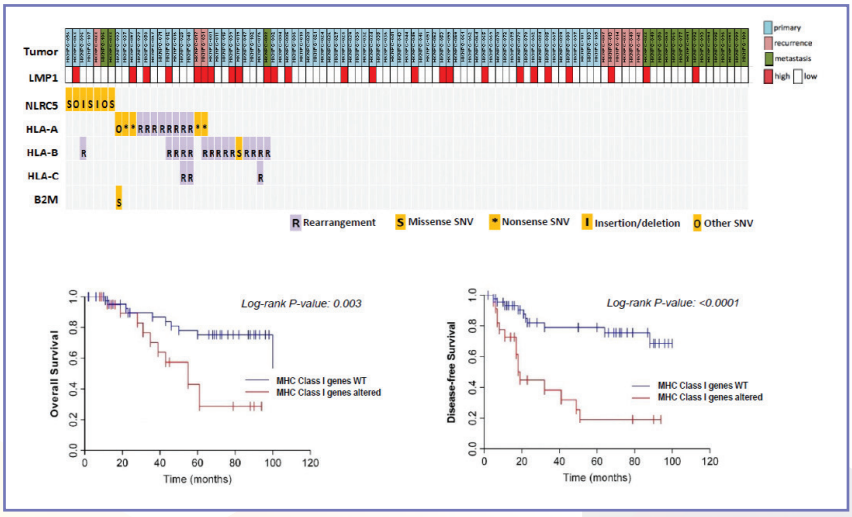
Genomic landscape of nasopharyngeal carcinoma – the largest whole-exome sequencing study of nasopharyngeal carcinoma

鼻咽癌基因組圖譜——全球最大規模鼻咽癌全外顯子組測序研究



Genome sequencing identified multiple somatic alterations of negative regulators in NF-κB signaling pathways

基因組序列發現鼻咽癌中多個NF-κB信號通路負調節物基因變異



Genome sequencing revealed somatic changes of MHC class I genes in 30% nasopharyngeal carcinoma cases that is associated with poor outcome of the patients

基因組序列發現30%鼻咽癌具有人類白細胞抗原基因變異，這些患者的存活率相對較差

From left to right: (front row) Professors Brian Tomlinson (Co-PI), Si Lok (Co-PI), Wing Yee So, Ronald Ma (Project Co-ordinator), Juliana Chan (Co-PI, deputy co-ordinator), Weichuan Yu (Co-PI), Hui-yao Lan (Co-PI), Yu Huang (Co-PI), Xiaodan Fan; (back row) Professors Kevin Yip, Ting Fung Chan, Cheuk Chun Szeto, Nelson Tang, Stephen Tsui (Co-PI)
前排：教授 湯寧信、駱樹恩、蘇詠儀、馬青雲、陳重娥、余維川、藍輝耀、黃聿、樊曉丹
後排：教授 葉旭立、陳廷峰、司徒卓俊、鄧亮生、徐國榮

An Integrated Trans-omics Approach to Diabetic Cardio-renal Complications: From Novel Discoveries to Personalized Medicine

對糖尿病心血管及腎臟併發症的跨組學基因研究 —— 從創新發現至個性化治療

T12-402/13-N

Project Coordinator
Professor Ronald Ching-wan MA
The Chinese University of Hong Kong

Participating Institution
The Hong Kong University of Science and Technology

項目統籌人
馬青雲教授
香港中文大學

參與院校
香港科技大學

Short Biography of Project Coordinator 項目統籌人簡介

Professor Ronald Ma is Professor at the Department of Medicine and Therapeutics, The Chinese University of Hong Kong and Honorary Consultant Physician, specialist in Endocrinology, Metabolism and Diabetes, Prince of Wales Hospital. As a clinician-scientist, Professor Ma's research focuses on the epidemiology and genetics of diabetes and its complications, gestational diabetes, and the developmental origins of diabetes. His group has a special interest in biomarker discovery and translational studies in diabetes. He is currently leading a multi-disciplinary project team to leverage on the large Hong Kong Diabetes Registry and accompanying biobank to identify novel molecular markers for diabetic complications, and is the principal investigator of the newly established Hong Kong Diabetes Biobank, which was initiated in 2014.

馬青雲是香港中文大學藥物及治療學系教授，亦是威爾斯親王醫院糖尿病和內分泌專科醫生。作為一位臨床醫生及科研家，他的研究重點為糖尿病及其併發症流行病學及遺傳學，及妊娠糖尿病。他的研究團隊特別專攻發掘糖尿病相關的生物標誌，並將研究轉化於臨床應用。他目前正在領導一個多學科項目團隊，發掘及驗證糖尿病新生物標記。他亦於2014年啟動了“香港糖尿病生物樣本庫”，對所發現的新生物標記進行大規模的驗證。

Project Summary 項目概要

- Diabetes affects >10% of the population
- Heart and kidney complications are main causes of death for patients with diabetes. There are currently few treatments to prevent these complications, and it is difficult to identify people at risk of complications
- Our project aims to develop new tests to identify high risk individuals before they develop the complications, and develop better treatments

- 糖尿病影響超過百份之十的人口
- 糖尿病所帶來的醫療負擔，主要來自治療糖尿病導致的併發症，特別是心血管和腎臟併發症。
- 這個項目研究新發現與糖尿病併發症相關的基因和生物標誌，應用於識別高風險糖尿病人士，並旨在開發更好的治療方法。

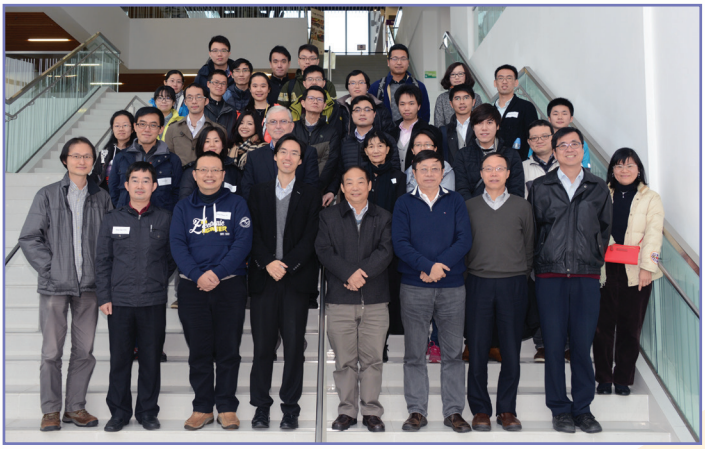


Photo of Project team taken at the Project Team Research Retreat in January 2016
2016年1月項目團隊研究論壇後拍照留念

Professor Ronald C.W. Ma
馬青雲教授

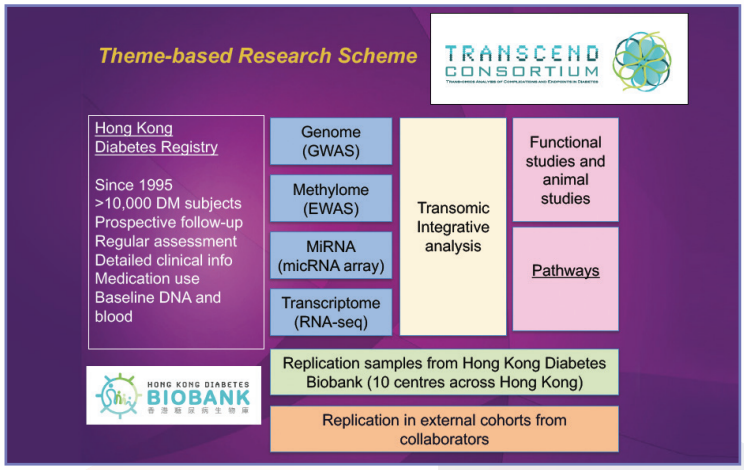
Abstract of the Project
項目簡介

Diabetes is a major health problem worldwide, including in Hong Kong. Most of the healthcare burden from diabetes is associated with the management of diabetic complications, in particular, cardiovascular and renal complications. Diabetes is the major cause of end-stage renal disease (ESRD), and increases the risk of cardiovascular disease (CVD) by 3-4 fold. Asian patients with type 2 diabetes (T2D) are particularly prone to renal complications when compared to patients of European origin. Only few genetic markers have so far been identified to predict diabetic cardiovascular-renal complications. Discovery of novel genetic or other biomarkers for diabetic complications can help identify at risk subjects for intensive risk factors management, advance our understanding of disease pathogenesis, revolutionize care and provide novel targets for drug development. In this Grand Challenge, we have utilized the unique resource from the Hong Kong Diabetes Registry, with more than 10,000 patients with T2D with detailed biochemical assessment of risk factors and documentation of medication history, who have been prospectively followed up for a mean duration of 8 years, with an accrual of 4,000 events of cardiovascular and renal complications. We applied a multi-omics approach and used new-generation sequencing (NGS) and other technologies to conduct a comprehensive evaluation of the genome, epigenome and transcriptome of diabetic patients with complications and diabetic patients free of complications despite long duration of disease. We have utilized advanced bioinformatics analysis to integrate findings from these different approaches. Insights from this multi-faceted investigation will be compared to findings from animal models of diabetic complications. We are using bioinformatics, in vitro experiments and animal models to characterize the functional significance and regulatory pathways of novel genes identified from the genomic studies. In addition to novel biological discoveries, we aim to translate our findings and examine the clinical significance of these novel biomarkers, as well as their interactions with different treatments on disease outcomes. Finally, we have leveraged on the existing healthcare infrastructure and detailed clinical information available to establish an expanded diabetes registry and biobank with contribution from major diabetes centres across Hong Kong for large-scale replication of any novel biomarkers discovered. This resource is a first-of-its-kind. In sum, the translation of our genomic discoveries to clinical care will consolidate Hong Kong as a centre for innovative biomedical research and chronic care excellence.

糖尿病已成為香港以及全球的主要疾病之一。糖尿病所帶來的醫療負擔，主要是由於對其併發症的治療，尤其是心血管和腎臟的併發症。探索和發現新的糖尿病併發症相關的遺傳或其它生物標記，將有助於識別高危人士而對其進行風險因素的強化控制；將進一步提高我們對發病機制的認識及促進治療水平的提升；還將為藥物研發提供新的靶向。面對這個巨大的挑戰，我們利用“香港糖尿病登記”，進行相關的研究和探索。“香港糖尿病登記”收錄了多個2型糖尿病病人的資料，包括糖尿病及其併發症相關風險因素的生化指標評估。這些病人的平均隨訪時間超過8年，累計了4000個心血管及腎臟相關的臨床終點事件。我們採用多組學的方法、新一代測序及其它先進分子生物學技術，研究和比較基因組、表觀基因組及轉錄組的變化和特徵。我們利用生物信息學、體外實驗和動物模型方法，分析和驗證所鑑定的新基因的功能和調節途徑。此外，我們還旨在將這些研究結果轉化為臨床應用，檢驗和分析這些新遺傳標記的臨床應用價值。最終，我們聯合香港多個糖尿病中心建立“香港糖尿病生物樣本庫”，對所發現的新生物標記進行大規模的驗證。研究的成果，將進一步鞏固香港作為創新生物醫學研究和卓越醫療中心的地位。

Research Impact
研究影響

Healthcare costs associated with diabetes in China was 200 billion RMB in 2007, and is forecasted to exceed 360 billion RMB by 2030. In Hong Kong, diabetes accounts for annual healthcare costs of approximately 5 billion HKD, mostly due to burden from heart and kidney complications. Early identification of high-risk individuals with diabetes and multifactorial interventions can substantially reduce the burden of diabetic complications. Through work in the project, the project team has identified a panel of genetic and other molecular markers that can identify patients at higher risk of future diabetes complications. Ongoing work is focused on large-scale replication of these findings in different populations, application to patients in real-life clinical setting, and studies to understand how these genes affect development of diabetes-related complications. Findings from the project is helping to transform the way we treat patients with diabetes, whereby each patient can receive tailored treatment regimens that are most suitable and effective for them. Discoveries arising from the project are also providing us with new insights and leads for developing new drugs to treat diabetes and prevent its associated complications.



Overall design of Study to identify new markers and pathways for diabetic complications

整體研究項目的概述——旨在研究與糖尿病併發症相關的基因和生物標誌

2007年中國與糖尿病相關的醫療保健費用為2000億元人民幣，預計到2030年將超過3600億元人民幣。在香港，糖尿病每年的醫療費用約為五十億港元，主要是由於心臟和腎臟並發症的負擔。早期鑑定高危糖尿病患者可減輕糖尿病並發症的負擔。通過本研究項目的工作，項目組已經確定了一組基因和其他分子標記，可以識別未來糖尿病並發症風險較高的患者。正在進行的工作包括在不同人群中大規模確認這些標記，並對現實臨床環境中的患者的應用，並且研究了解這些基因如何影響糖尿病相關並發症的發展。本項目的結果將改變我們對糖尿病患者的治療方式，從而提供糖尿病患者可以獲得最適合和有效的治療方案。本項目的研究突破和發現也為我們提供了新的見解，為治療糖尿病並預防其相關並發症開發新藥提供新的方向。

Viral, Host and Environmental Determinants of Influenza Virus Transmission and Pathogenesis

探討流感病毒、宿主和環境各種因素對流感傳播和病理的影響

T11-705/14-N

Project Coordinator

Professor Joseph Sriyal Malik PEIRIS
The University of Hong Kong

Participating Institutions

The Chinese University of Hong Kong
The Hong Kong University of Science and Technology

項目統籌人

裴偉士教授
香港大學

參與院校

香港中文大學
香港科技大學

Short Biography of Project Coordinator
項目統籌人簡介

Professor Malik Peiris is currently a Professor and Chair in Virology at the School of Public Health, The University of Hong Kong. His research is on the virology, pathogenesis and epidemiology of influenza, coronaviruses and other emerging respiratory viral infections. In 2003, he played a key role in the discovery that a novel coronavirus was the cause of SARS, to understanding its pathogenesis and control.

In collaboration with his colleagues at the School of Public Health, his research has elucidated the emergence, transmission and pathogenesis of avian influenza viruses H5N1, H9N2, H7N9 and the pandemic H1N1 virus of 2009 and more recently, of the MERS coronavirus. He was elected a Fellow of the Royal Society of London in 2006, awarded the Silver Bauhinia Star of the HKSAR in 2008, and as a Foreign Member of the US National Academy of Science in 2017.

裴偉士教授現任香港大學公共衛生學院病毒學講座教授。他的研究涵蓋了流感病毒、冠狀病毒及其他呼吸道病毒的病毒學以及其發病機制及流行病學。2003年，在發現引致沙士(SARS)的新型冠狀病毒，瞭解其發病機制及如何控制疫情的過程中，裴教授擔任了重要的角色。其後，他和公共衛生學院的研究團隊合作，闡明了H5N1、H9N2及H7N9禽流感病毒、2009年甲型H1N1流感病毒以及較近期的中東呼吸綜合症冠狀病毒的出現、傳播及發病機制。裴教授於2006年獲選為倫敦皇家學會院士，2008年獲頒香港特區銀紫荊星章(SBS)以及2017年獲選為美國國家科學院外籍院士。

Project Summary
項目概要

Influenza is a major threat to global public health. This theme-based research project has addressed the following research questions:

- Transmission of influenza from animals-to-humans and from human-to-humans
  - provided options to minimize emergence and spread of both pandemic and seasonal influenza
- The mechanisms of acute lung injury associated with severe influenza disease
  - provided novel therapeutic options for severe influenza
- Enhance development of new-generation influenza vaccines
  - provided novel treatment options

流感嚴重威脅全球公共衛生。此主題研究計劃探討了以下課題並提供解決方案：

- 流感從動物到人及人與人的傳播
  - 盡量減少季節性流感及流感大流行的出現及散播
- 嚴重流感引致急性肺損傷的發病機制
  - 提供治療嚴重流感的新方案
- 促進研發新型流感疫苗
  - 提供嶄新的治療方案

Plaque Unveiling Ceremony of WHO Collaborating Centre for Infectious Disease Epidemiology and Control
香港大學李嘉誠醫學院公共衛生學院世衛「傳染病流行病學及控制」合作中心之揭幕儀式

TRS Knowledge Exchange Program – Little Dr Flu
主題研究知識交流活動——港大流感小博士

Abstract of the Project
項目簡介

Influenza is a major threat to global public health. Hong Kong is situated at an epicenter of pandemic emergence. Pandemic influenza arises from animals at unpredictable intervals and can spread worldwide within weeks. Seasonal influenza is a predictable yearly occurrence that is associated with significant morbidity and mortality.

We established a multi-disciplinary influenza research program which has contributed to public health responses locally and globally. We have investigated the viral, host and environmental factors that allow animal viruses to adapt to humans. We have helped improve risk-assessment of animal viruses for pandemic or zoonotic threat, contributed to enhancing global pandemic preparedness and provided evidence-based interventions to contain emerging threats. We have worked with local Government Departments to reduce the threats of avian influenza outbreaks in Hong Kong. We investigated the factors that pre-dispose to transmission of seasonal influenza viruses in humans by studies of influenza transmission within families and within hospital settings. These studies have helped provide understanding of the mechanisms of influenza transmission and allowed evidence based interventions that can reduce influenza virus transmission within the community and within hospitals.

Through studies of influenza in the community and by vaccine trials we have provided a better understanding of the immune mechanisms that protect against influenza and investigated new approaches to influenza vaccine development for both seasonal influenza epidemics and pandemics. We have investigated how influenza viruses cause severe pneumonia and acute lung injury and are pursuing novel therapeutic approaches for treating patients with severe influenza disease.

This program is an inter-disciplinary collaborative project involving The University of Hong Kong, the Chinese University of Hong Kong and the Hong Kong University of Science and Technology. It enhances global public health, provides high quality research, intellectual property, real-time data to inform local, national and global health policy, trains the next generation of scientists and helps maintain and enhance Hong Kong's world-leading status in influenza research.

流感嚴重威脅全球公共衛生，而香港正處於流感大流行的高發地區。流感大流行源於動物病毒，難以預測，而且可於數星期內散播全球。而每年出現的季節性流感雖然較易預測，但發病率及死亡率顯著。

我們建立的跨學科流感研究計劃，對本地和全球公共衛生均有貢獻。我們集中研究病毒、宿主和環境因素如何使動物流感病毒傳染給人類，提高對動物病毒引致流感大流行或人畜共患病的風險評估能力，加強全球對流感大流行的應變能力及建立以實據為基礎的防控措施。我們亦與港府合作，減低禽流感在本港爆發的威脅。我們對流感於家庭及醫院中的傳播因素的研究，則有助瞭解病毒傳播機制及建立基於實據的措施，減低病毒在社區及醫院內的傳播。

透過研究流感病毒的社區傳播及疫苗測試，我們對抵抗流感的免疫機制有更深入的瞭解，有助開發新型流感疫苗。此外，對流感病毒引致嚴重肺炎及急性肺損傷的瞭解，亦有助研發嚴重流感的新療法。

此跨學科研究項目由香港大學、香港中文大學及香港科技大學組成，旨在加強全球公共衛生，同時提供高質素的研究及知識產權。此外，此計劃向本地和國際組織提供實時數據作全球衛生政策研究，並培養下一代科研人才，以維持及提升香港在流感研究上的領先地位。

Research Impact
研究影響

TRS members and the team have / are:

- Provided real-time data on emerging viral pathogens such as avian influenza H7N9 and H5N6 viruses to WHO, FAO and other international agencies for risk assessment and pandemic vaccine response.
- Members of the WHO steering group developing risk assessment algorithms and methods assessing animal viruses for pandemic threat.
- Provided submissions to the Legislative Council of Hong Kong on the subject of the "Study of the Way Forward for the live poultry trade in Hong Kong."
- Organised three pivotal international conferences and workshops on the themes of Respiratory virus transmission and Emerging Virus Infections (including the Keystone Symposium "Framing the Response to Emerging Virus Infections" in Hong Kong) and in scientific advisory board to organise Control of Influenza X to be held in Singapore.
- Advised Hong Kong Food and Environmental Hygiene Department on modifications implemented in live poultry markets in Hong Kong so as to further reduce zoonotic risk.
- Published 150 refereed research papers, including in Science, Nature Genetics, Nature Microbiology and Lancet Infectious Diseases.

主題研究計劃的團隊成員：

- 向世衛、聯合國農糧組織及其他國際組織提供H7N9及H5N6禽流感病毒等新發病毒的實時數據，用作風險評估及準備應對疫苗
- 出任世衛督導委員會成員，制定風險評估演算法及動物病毒的大流行威脅評估方法
- 向立法會提交關於《香港活家禽業的未來路向研究》的意見
- 籌辦了三個以呼吸道病毒傳播及新發病毒感染為主題的國際會議及研討會，當中包括於本港舉行的Keystone Symposium "Framing the Response to Emerging Virus Infections"，以及在新加坡舉行的會議(Control of Influenza X)中擔任科學咨詢委員會成員
- 向食物環境衛生署就本港活家禽市場實施的修改提供建議，進一步減低人畜共患病風險
- 發表了150篇學術論文，刊登於包括《科學》、《自然——遺傳學》、《自然——微生物學》及《刺針傳染病》等期刊

Professor Malik Peiris, School of Public Health, HKU (Left on the first row) and Professor Zhong Nan-shan (Right on the first row), Director of State Key Laboratory of Respiratory Disease signed a Memorandum of Understanding to facilitate research collaboration between the two institutions

香港大學公共衛生學院裴偉士教授與呼吸疾病國家重點實驗室主任鍾南山教授簽訂雙方科研合作協議典禮

Group Photo of Project Team with Scientific Advisory Board Members
研究團隊及科學顧問委員會合照

Genetics and Functional Genomics of Neural Crest Stem Cells and Associated Disease: Hirschsprung Disease

神經脊幹細胞及相關疾病的遺傳學和功能基因組學：先天性巨結腸症

T12C-714/14-R

Project Coordinator
Professor Paul Kwong-hang TAM
The University of Hong Kong

Participating Institutions
The Chinese University of Hong Kong
University of Toronto
The Francis Crick Institute

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香港中文大學
多倫多大學
弗朗西斯．克里克研究所

Short Biography of Project Coordinator
項目統籌人簡介

Professor Paul Kwong-hang Tam is a surgeon, scientist, educator and university leader. Professor Tam graduated from The University of Hong Kong in 1976, and has been Chair of Paediatric Surgery at The University of Hong Kong since 1996 and Li Shu-Pui Professor in Surgery since 2013. He was the Vice-President for Research (2003–2015), Acting President and Vice-Chancellor (February – July 2018) and Provost and Deputy Vice-Chancellor (2015-2019) of the University of Hong Kong. He is currently the Director of Dr. Li Dak-Sum Research Centre, The University of Hong Kong – Karolinska Institutet Collaboration in Regenerative Medicine.

Professor Tam has special interests in minimal invasive surgery, genetics and regenerative medicine of birth defects such as Hirschsprung disease. He has published 428 articles in internationally refereed journals with 21267 citations and h-index = 48, is ranked amongst the top 1% of most-cited scientists (ESI) and has been awarded grants totalling $200m.

He has given invited lectures at BAPS, EUPSA, AAPS, Nature Forum and Days of Molecular Medicine. He has received numerous awards including the BAPS Prize, Lifetime Achievement Award (AAPS) and Honorary Fellowship of the American Surgical Association. He was awarded the 2017 Denis Browne Gold Medal, the highest award of the British Association of Paediatric Surgeons. In February 2019, Professor Tam has been named the recipient of the Rehbein Medal for 2020 by the European Paediatric Surgeons' Association in recognition of his outstanding contribution to the advancement of paediatric surgery. Professor Tam is the first surgeon in Asia to be presented with this prestigious award.

譚廣亨教授為一名著名的外科醫生、科學家及大學高級行政人員。譚教授1976年畢業於香港大學後，分別由1996年及2013年起擔任香港大學小兒外科講座教授及李樹培基金教授（外科），並於2003年至2015年擔任該校副校長（研究），2015至2019年擔任首席副校長，並於2018年2月至7月在任其間擔任署理校長。目前，香港大學李達三博士再生醫學研究中心主任。

譚教授研究興趣為微創手術及先天性巨大結腸症等先天缺陷的基因及再生治療。他是全球最廣獲徵引的首1%科學家，曾於國際性學術期刊發表超過427篇研究論文，其研究共獲得21,267次引用，H指數高達48，過往獲得的研究資助金額逾二億元。

譚教授歷年獲多個國際會議邀請講學，更獲頒英國小兒外科學會大獎、美國藥劑科學家學會終身成就獎及美國外科協會榮譽院士等多項殊榮。他在2017年獲頒英國小兒外科醫師協會的最高榮譽獎項：Denis Browne金獎。他於2019年2月獲歐洲小兒外科醫師協會頒授2020年度Rehbein Medal卓越成就獎，以表揚其在國際小兒外科領域的終生傑出貢獻，而他更是亞洲首位獲此殊榮的小兒外科教授。

Project Summary
項目概要

- Hirschsprung disease (HSCR) is a rare congenital disorder due to defects in the enteric neural crest stem cells and the disease is particularly prevalent in Asia
- The aims of the project are:
  - To identify new genetic risk factors for HSCR through genome study
  - To understand the functional impact of HSCR genetic risk factors by studying patient-derived induced pluripotent stem cells (iPSC)
  - To obtain mechanistic insights into enteric nervous system development and the molecular pathogenesis of HSCR using animal models

- 先天性巨結腸症(HSCR)是一種由腸神經脊幹細胞缺陷所引起的罕見先天性疾病，在亞洲尤其普遍。
- 本項目的目標是：
  - 通過基因組研究尋找與HSCR相關的新遺傳風險因素
  - 通過研究源自患者的誘導多能幹細胞(iPSC)了解HSCR遺傳風險因素對腸功能的損害
  - 利用動物模型提升對腸神經系統發育的認知及了解HSCR分子致病機理

Abstract of the Project
項目簡介

Hirschsprung (HSCR) disease (congenital megacolon) is a birth defect affecting the motility of the bowel. It is one of the most common causes of neonatal intestinal obstruction and is particularly prevalent in China, where the disease has one of the highest incidences worldwide (2.8/10,000 live-births). It is also characterized to have a male preponderance. HSCR is attributed to the failure in formation of nerve cells in the colon, due to dysregulation of migration and differentiation of the enteric neural crest cells, a multipotent stem cell-like population capable of differentiating into

先天性巨結腸病(HSCR)是一種影響腸道蠕動的遺傳病，它是初生嬰兒腸梗阻的最常見原因之一。在中國更是全球發病率最高的國家之一，每三千多名嬰兒中約有1人患病。巨結腸病患者大多為男性。病因是在腸神經系統(ENS)的發育過程中，腸道神經脊細胞的遷移和分化失調，導致腸道先天缺乏神經細胞，令初生嬰兒出現嚴重便秘或腸梗阻。

neurons and glia, during the development of the enteric nervous system (ENS) essential for gut motility.

HSCR is a complex disorder in which genetic factors play the primary role in clinical expression, phenotypic heterogeneity and disease severity. Thus far, only a few genetic factors have been found and the detailed underlying molecular mechanisms remain largely unexplored. The challenges are to discover the full spectrum of unidentified disease-associated genetic factors, to elucidate their molecular mechanisms in regulating ENS development, and to integrate the knowledge gained to model and understand the disease. As an internationally recognized multidisciplinary team of world leading clinicians and scientists, we aim to address these grand challenges by integrating the state-of-art techniques in genome sequencing, single-cell transcriptomic profiling, as well as genome editing and disease modelling using patient-specific stem cell models.

In this project, we performed whole genome sequencing (WGS) to the world largest disease cohort of over 440 Chinese HSCR patients to identify novel disease-causal variants. We also compiled a list of regulatory and protein-coding variants that can conform with the risk stratification of HSCR patients. The team has also established an induced pluripotent stem cell-based model of HSCR for functional characterization of novel disease-associated variants. By utilizing the cutting-edge genome editing in the established stem cell models, we revealed novel molecular pathways critical in ENS development and shed light into novel disease mechanisms. Seamless integration of information from these human model systems and their animal counterparts provided clues to decipher the sex bias underlying HSCR. From these researches, we gained new insights into the biology of HSCR, which can be potentially translated into new approaches for more accurate diagnosis and risk stratification of patients with HSCR to improve prognosis and enhance clinical outcome after surgery.

巨結腸病的成因十分複雜，其病徵的表達及臨床症狀，以至疾病的嚴重程度大多取決於遺傳因素。迄今為止，只發現少量與巨結腸病相關的遺傳風險因素，潛在的分子致病機理仍有很多的未知領域需要深入研究。要克服巨結腸病的挑戰首要在於鑑定尚未發現的相關遺傳因素，並闡明其在調節腸道神經系統發展中的分子機理，從而將獲得的知識整合到模型和理解疾病。作為世界領先的臨床醫生和科學家的跨學科團隊，我們將整合最先進的技術，如基因組測序、單細胞轉錄組學分析、基因組編輯及建立個人化的幹細胞模型來去拆解巨結腸病的成因。

在這項世界最大規模的巨結腸病基因研究中，我們一共為 440 多名患者進行全基因組測序 (WGS) 以尋找尚未發現的致病基因變異，並為巨結腸病患者的基因風險評估奠定基礎。團隊同時亦建立了一個誘導多能幹細胞的巨結腸病模型，以釐清新發現的遺傳變異對腸功能表徵的影響。通過尖端基因組編輯的幹細胞模型，我們揭示了腸神經系統發展中關鍵的新分子途徑，開展對疾病機理的嶄新認識。另外，透過人類疾病模型及其動物模型，團隊揭示了巨結腸病男女患者比例失衡的根本原因。是項研究令我們獲得對巨結腸病成因的新見解，有助轉化為新式診斷方法及開展巨結腸病患者的基因風險評估，從而提升手術療效及手術後的臨床結果。

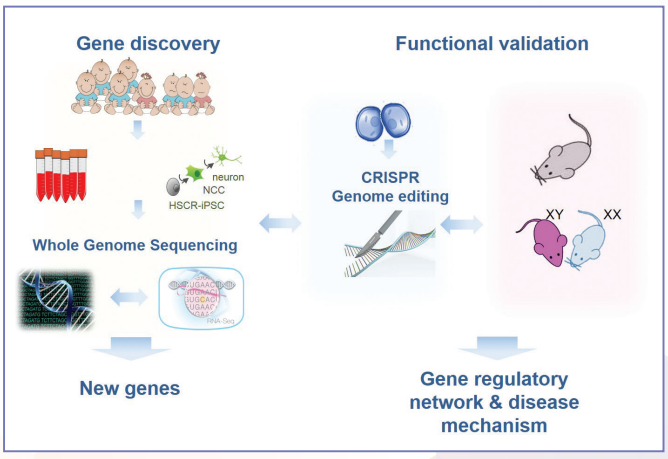
Research Impact
研究影響

Babies born with HSCR will die unless the affected portion of the bowel with no nerve cells is surgically removed. Nevertheless, the functional outcome of surgery is variable and a significant number of patients still suffer from life-long complications, ranging from intractable constipation, incontinence, enterocolitis to devastating short bowel syndrome, leading to not only tremendous psychosocial impact on the patients and their families, but also a heavy financial burden to the health care system.

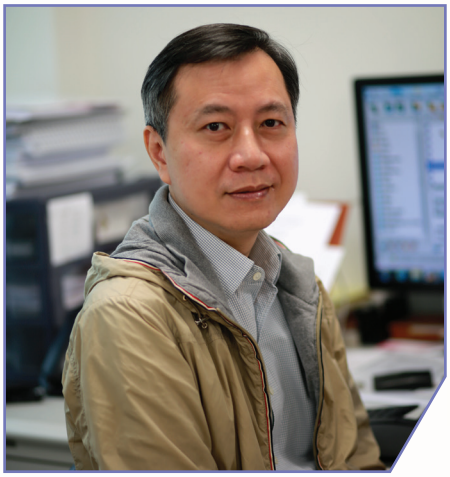
Through the first ever WGS on HSCR coupled with the established human pluripotent stem cell-based disease model, we have decoded the complex genetic basis of the disease and have interconnected the disease-causal variants with novel pathological pathways. The newly developed stem cell-based disease model provides a powerful platform for studying the heterogeneous phenotypes of the diseases and represents an important step toward personalised treatment. The project has also established a new paradigm for identification of homogeneous sub-populations of patients, paving a way to develop precise and subtype-matched treatment strategies that target shared pathological mechanisms and clinical impact. Our long-term goal is to instigate a paradigm shift in the clinical diagnosis of HSCR, permitting stratified patient care and laying the foundation for novel reconstructive treatment. This will ultimately improve the quality of life of children with these congenital malformations and of the families at risk of having an affected child.

罹患先天性巨結腸病的嬰兒必須通過外科手術切除沒有神經細胞的病變腸道才能存活。然而，手術療效不一，令不少病人終生仍要面對 HSCR 併發症帶來的威脅，包括頑固性便秘、大小便失禁、結腸炎，甚至更嚴重的短腸綜合症等。故此，這病症不僅對患者和其家庭造成嚴重生心理創傷，亦對香港醫療系統帶來長遠的沉重負擔。

透過全球首次針對巨結腸病患者全基因組測序分析並結合人類多能幹細胞疾病模型，我們解構了巨結腸病的複雜遺傳機理，並把致病基因變異與病理途徑相互連繫。新開發的人類多能幹細胞疾病模型為研究巨結腸病多變的臨床症狀提供了先進紮實的基礎，是邁向個人化治療的重要根基。研究團隊已建立一種嶄新的範例，根據病理機制和臨床特性把患者分類，有助制定精確和針對性的治療策略。我們的長遠目標是促進臨床診斷模式的轉變，使患者的個人化護理普及並為新的治療方案奠定基礎，最終改善患有先天性巨結腸病的兒童和其家庭的生活質量。



Programme Overview
研究項目概覽



Molecular Basis for Interspecies Transmission and Pathogenesis of Middle East Respiratory Syndrome Coronavirus

中東呼吸綜合症冠狀病毒跨種傳播和致病機制的分子基礎

T11-707/15-R

Project Coordinator

Professor Patrick Chiu-yat WOO
The University of Hong Kong

Participating Institutions

The Chinese University of Hong Kong
City University of Hong Kong
Hong Kong Baptist University

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香港中文大學
香港城市大學
香港浸會大學

Short Biography of Project Coordinator 項目統籌人簡介

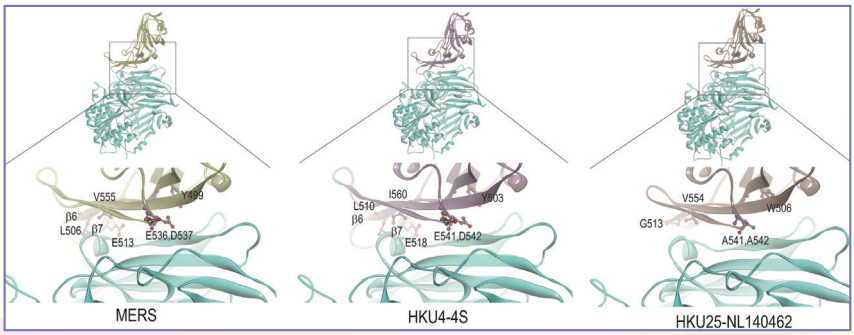
Professor Patrick Chiu-yat Woo was Head of the Department of Microbiology, Director of Research Centre of Infection and Immunology and Convener of Strategic Research Theme in Infection and Immunology in HKU. He has a wide research interest in basic and applied microbiology and infectious diseases. He was awarded the Croucher Senior Medical Research Fellowship in 2015/16. His work has been published in New England Journal of Medicine, Lancet, Nature Microbiology, Nature Communications, PNAS, Cell Host & Microbe, PLoS Genetics, PLoS Biology, PLoS Pathogens, British Medical Journal etc., the leading journals in the field. He has led the discovery of >30 novel human and animal coronaviruses. He is among the top 1% researchers. He was invited to be a member of the Coronavirus Taxonomy Study Group and Picornavirus Taxonomy Study Group of the International Committee on Taxonomy of Viruses. He has obtained >HK$70,000,000 as principal investigator, from various sources, with wide experience in leading large research projects.

胡釗逸教授曾任香港大學微生物學系主任，香港大學感染及免疫學研究中心主任及感染與免疫學策略研究專題召集人。胡釗逸教授在基礎及應用微生物學和感染性疾病中有夯實的研究基礎和豐富的研究經驗，在2015/16榮獲Croucher資深醫學研究院士，其研究成果在國際高水平學術期刊New England Journal of Medicine, Lancet, Nature Microbiology, Nature Communications, PNAS, Cell Host & Microbe, PLoS Genetics, PLoS Biology, PLoS Pathogens, British Medical Journal等上發表。他帶領發現了多達30種新型的人及動物源中東呼吸綜合症冠狀病毒。為全球Top 1%學者，並被受邀為國際病毒分類委員會冠狀病毒分類學研究組和微小核糖核酸病毒分類學研究組的專家。作為主要項目主持人胡釗逸教授曾獲各方項目資助超過7000萬港幣，具有多年主持大型科研項目的經驗。

Project Summary 項目概要

- The emergence of MERS-CoV in 2012 has alerted the public and WHO, who considered MERS-CoV "a threat to the entire world". The virus is still causing outbreaks in the Middle East and cases outside the Middle East in 2019. The total number of fatalities due to MERS is indeed more than SARS!
- Here, we will address three important issues on MERS-CoV:
  - To identify the evolutionary paths leading to emergence of MERS and mechanisms of interspecies transmission
  - To delineate molecular mechanisms by which MERS-CoV evades innate immunity
  - To characterize pulmonary and extrapulmonary replication and pathogenesis of MERS-CoV
- By identifying new intermediate viruses and hosts and new disease mechanisms, our studies will offer insights to prevention, diagnosis and treatment of MERS and future emerging CoVs.

- 2012年MERS-CoV的出現提醒它是"對整個世界的威脅"，2019年MERS-CoV仍在中東及以外地區爆發，引起的死亡數超過SARS。
- 我們將討論MERS-CoV的三個重要問題：
  - 確定MERS的進化路徑和種間傳播機制
  - 闡明MERS-CoV免疫逃避機制
  - 探討MERS-CoV肺和肺外複製及發病機制
- 我們的研究將為MERS的預防、診斷和治療以及新型CoVs提供見解。



Structural modeling of the receptor-binding domain of the spike protein of MERS-CoV, Ty-BatCoV HKU4-4S, and Hp-BatCoV HKU25-NL140462 are shown with hDPP4 structure in ribbon diagram

MERS-CoV，Ty-BatCoV HKU4-4S及Hp-BatCoV HKU25-NL140462纖突蛋白與hDPP4受體結合域的結構模式

Abstract of the Project
項目簡介

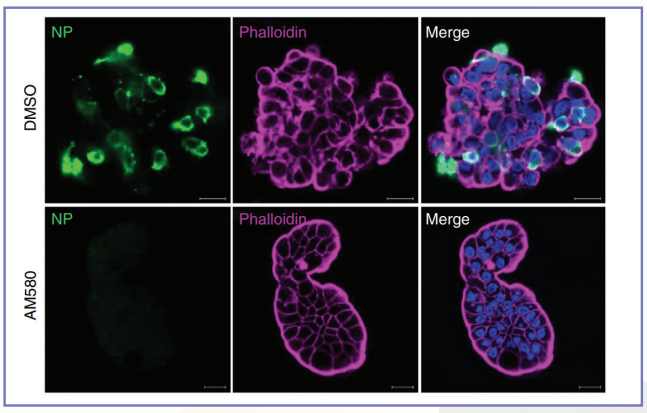
Global health threats due to emerging infectious agents are exemplified by HIV, influenza virus, SARS coronavirus (CoV) and Ebola virus. Compared to other viruses, CoVs are grossly understudied. The recent emergence of MERS-CoV has alerted the public and WHO, who considered MERS-CoV "a threat to the entire world". Unlike SARS which rapidly died off after the intermediate amplification animal hosts were identified and segregated from humans by closure of wild animal markets in Southern China, the MERS epidemic has persisted for at least seven years with a scary fatality rate of >30%. In the past 14 years, our group has been taking a lead internationally in discovering and characterizing novel CoVs in animals and human. We identified the largest number of CoVs globally, including SARS-CoV, human CoV HKU1, SARS-CoV-like bat CoVs and most importantly, Tylonycteris bat CoV HKU4 and Pipistrellus bat CoV HKU5 (BatCoV HKU4/5), which are closely related to MERS-CoV and have formed the foundation for identifying the animal origin of MERS-CoV. Our contributions have revolutionized CoV research and provided the ground for in-depth mechanistic studies on CoVs. Built on the previous findings and unique resources, we will address the above three important issues on MERS-CoV. Currently, we have successfully developed a DPP4-transgenic mouse model which was shown to be useful for susceptibility and pathogenesis studies for MERS-CoV. We have identified a novel MERS-CoV-related betacoronavirus, Hp-BatCoV HKU25, from Chinese pipistrelle bats, which further supports a possible bat origin of MERS-CoV. We have developed a novel MERS-CoV vaccine candidate which is being tested using our transgenic mouse model. We have also identified lopinavir-ritonavir and betaferon as potential drugs to protect against MERS-CoV infection. These drugs are a valuable resource and can be developed commercially into an antiviral option against MERS-CoV infection for local and international markets. By further identifying new intermediate viruses and hosts and new disease mechanisms, our studies will offer insights to prevention, diagnosis and treatment of MERS and future emerging CoVs.

艾滋病毒、流感病毒、SARS 冠狀病毒 (CoV) 和埃博拉病毒等引起的新型傳染病對全球健康構成威脅。與其他病毒相比，CoVs 的研究還遠遠不足。最近出現的 MERS-CoV 提醒公眾和世衛組織 MERS-CoV是“對整個世界的威脅”。與SARS中間宿主在中國南方野生動物市場被發現並與人類隔離後SARS迅速消失不同，MERS疫情至少持續了7年，死亡率高達30%，令人恐慌。在過去14年，我們團隊在發現和描述動物和人類新型 CoV 方面國際領先。我們在全球範圍內具有最多數量的 CoV 的發現，包括 SARS-CoV、人 CoV HKU1、和 SARS-CoV 樣蝙蝠 CoV，最重要的是 Tylonycteris 蝙蝠 CoV HKU4 和 Pipistrellus 蝙蝠 CoV HKU5 (BatCoV HKU4/5) 與 MERS-CoV 關係密切，為確定 MERS-CoV 的動物起源奠定了基礎。我們的貢獻徹底改變了 CoV 的研究，為深入研究 CoV 的機制奠定了基礎。基於以往的研究成果和獨特的資源，我們將解決上述三個關於 MERS-CoV 的重要問題。目前，我們已經成功建立了一種 DPP4 轉基因小鼠模型，該模型對研究 MERS-CoV 的易感性和發病機制具有重要意義。我們還在中國的 Pipistrelle 蝙蝠中發現了一種新的與 MERS-CoV 相關的 β 冠狀病毒 Hp-BatCoV HKU25，這進一步支持了 MERS-CoV 可能起源於蝙蝠。我們開發了一種新的 MERS-CoV 疫苗候選體，正在我們的轉基因小鼠模型上進行測試。我們還確定了洛吡那韋—利托那韋和倍他氟隆可作為潛在的藥物保護 MERS-CoV 感染。這些藥物是一種寶貴的資源，可以在當地和國際市場上開發成對抗 MERS-CoV 感染的抗病毒藥物。最後通過進一步識別新的中間病毒和宿主以及新的疾病機制，我們的研究將為 MERS 的預防、診斷和治療以及應對未來新出現的 CoVs 提供見解。

Research Impact
研究影響

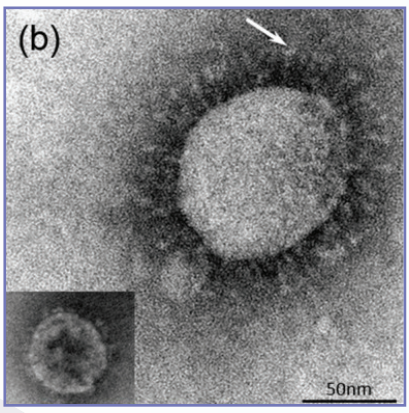
Research on CoVs was rather neglected after a short period of enthusiasm with absence of new human SARS cases after 2004. The emergence of MERS-CoV has shown again that this grossly understudied family of virus' capability in causing globally important highly lethal infections. With such leading clinical-basic coronavirologists/immunologists in HK, we should not miss the chance to study and tackle this family of virus. The present TBR program will not only improve our understanding on the mechanisms of interspecies jumping, immune modulation and pathogenesis of MERS-CoV, but also reveal potential targets for diagnosis, antiviral and vaccine development, which are crucial in the control of MERS-CoV. For example, the identification of Hp-BatCoV HKU25 from Chinese pipistrelle bats supports a possible bat origin of MERS-CoV and suggests that continuous surveillance of bats in the Middle East, Africa, and other regions may reveal the immediate animal origin of MERS-CoV. The novel MERS-CoV vaccine candidate can be further evaluated for its application in animals, such as camels, and in humans. The identification of potential drugs, lopinavir-ritonavir and betaferon, can also be further developed commercially into an antiviral option against MERS-CoV infection for local and international markets.

由於 2004 年以後沒有出現新的 SARS 病例，CoVs 的研究在短暫的熱情後被忽視。MERS-CoV 的出現再次表明，這個尚未得到充分研究的病毒家族具有引起全球重要的高致命性感染的能力。香港擁有頂尖的臨床基礎冠狀病毒/免疫學家，我們不應錯過研究和處理這類病毒的機會。目前的 TBR 項目不僅將提高我們對 MERS-CoV 種間轉換、免疫調節和發病機制的認識，還將為診斷、抗病毒和疫苗開發提供潛在的靶點，這對控制 MERS-CoV 至關重要。例如，從中國 pipistrelle 蝙蝠中鑒定出的 Hp-BatCoV HKU25 支持了 MERS-CoV 可能是來源於蝙蝠的假設，這表明對中東、非洲和其他地區蝙蝠的持續監測可能揭示MERS-CoV的直接動物來源。新 MERS-CoV 候選疫苗的應用可在動物（如駱駝）和人類中進一步進行評估。鑒定的洛吡那韋—利托那韋和倍他氟隆等潛在藥物，也可以進一步通過商業化發展成為本地和國際市場上的抗 MERS-CoV 的抗病毒藥。



Broad-spectrum antiviral target AM580 showed anti-MERS-CoV activity in human intestinal organoid

廣譜抗病毒藥AM580在人腸道器官中表現出抗MERS-CoV的活性



Negative contrast electron microscopy of dromedary camel CoV UAE-HKU23

單峰駱駝CoV UAE-HKU23的負差電子顯微鏡成像圖

Centre for Research into Circulating Fetal Nucleic Acids
母體血漿胎兒核酸研究中心

T12-403/15-N

Project Coordinator
Professor Dennis Yuk-ming LO
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Participating Institution
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香港大學

Professor Dennis Lo and his research team
盧煜明教授及其研究團隊

Short Biography of Project Coordinator
項目統籌人簡介

Professor Dennis Lo is the Director of the Li Ka Shing Institute of Health Sciences, the Chairman of Department of Chemical Pathology, the Li Ka Shing Professor of Medicine and Professor of Chemical Pathology of The Chinese University of Hong Kong (CUHK). He is also the Associate Dean (Research) of the Faculty of Medicine of CUHK. Professor Dennis Lo received his Bachelor of Arts degree from the University of Cambridge and the Doctor of Medicine and Doctor of Philosophy degrees from the University of Oxford.

Professor Dennis Lo discovered the presence of cell-free fetal DNA in maternal plasma in 1997, and has since then remained at the forefront of the field of non-invasive prenatal testing (NIPT). NIPT is now available in over 90 countries, benefiting millions of pregnant women every year. Professor Dennis Lo sees the parallels between circulating fetal DNA and circulating tumour DNA and has made pioneering contributions to the liquid biopsies for cancer, especially for the early detection and monitoring of nasopharyngeal carcinoma.

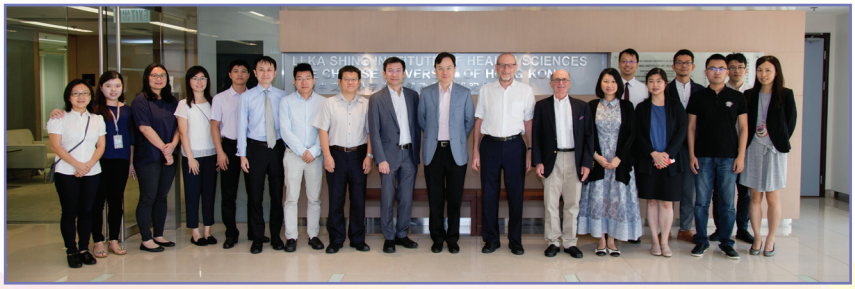
盧煜明教授現任香港中文大學醫學院李嘉誠健康科學研究所所長、化學病理學系系主任、李嘉誠醫學講座教授及化學病理學講座教授，他同時兼任醫學院副院長（研究）。盧教授於英國劍橋大學取得文學士學位，其後再於牛津大學取得哲學博士及醫學博士學位。

於1997年，盧教授成為第一位科學家發表有關於孕婦血漿內發現胎兒游離DNA之研究，自此他一直處於這個嶄新研究領域的最前線。盧教授及其團隊藉此研發了唐氏綜合症的無創檢測方法，並迅速被超過90個國家所採用，每年讓數百萬孕婦受惠。盧教授亦發現了胎兒游離DNA與癌症腫瘤游離DNA之間的相似之處，並為癌症的液體活檢做出了開創性的貢獻，特別是對於鼻咽癌的早期發現和監察有重大裨益。

Project Summary
項目概要

- Professor Dennis Lo, Project Coordinator, was the first in the world to report the presence of cell-free fetal DNA in the circulation of pregnant women in 1997. This finding has opened up a new field of non-invasive prenatal diagnosis based on the analysis of cell-free DNA in maternal plasma.
- This team successfully developed a test for the non-invasive assessment of fetal Down syndrome based on maternal blood analysis. The test was launched for clinical use in 2011.

- 這項目的統籌人，香港中文大學的盧煜明教授，於1997年全球首次發現孕婦的血漿內存有胎兒的DNA。這突破開創了無創性產前診斷的新領域。
- 這研究團隊成功發展出準確及無創產前診斷唐氏綜合症的方法。這技術並於2011年開始在臨床應用。



Scientific Advisory Board meeting in 2017
2017年科學諮詢委員會會議

Abstract of the Project
項目簡介

Prenatal diagnosis is an integral part of obstetrics. Non-invasive prenatal testing based on circulating fetal DNA analysis has resulted in a paradigm shift in antenatal care. In 1997, the project coordinator first discovered the presence of cell-free fetal DNA in the circulation of pregnant women. In 2008, this research group was awarded funding for an Areas of Excellence (AoE) project (AoE/M-04/06). The funding enabled the team to make non-invasive DNA-based prenatal testing a clinical reality by developing a Down syndrome test that has subsequently been adopted in many countries. In the present project, we brought together the same multi-disciplinary team of pathologists, laboratory scientists, obstetricians, bioinformaticians and public health specialists, to solve the key unmet diagnostic needs in prenatal medicine. Specifically, we have been developing the next generation tools for the analysis of cell-free nucleic acids and to study the biology and pathological characteristics of cell-free fetal nucleic acids that have not been unravelled to date. The novel tools and new biological insights will be directed towards the overall goal of developing approaches for the assessment of pregnancy-associated pathologies, such as single gene diseases, fetal demise and preeclampsia. The implications and benefits of non-invasive prenatal testing will be explored by an ethical, legal and social arm of our team. Knowledge and know-how have been disseminated through training of postgraduate students and research personnel, as well as through educational workshops for the obstetrics and laboratory medicine professions.

產前診斷是產科服務必不可缺的重要部分。基於母體血漿循環胎兒脫氧核糖核酸(DNA)分析的無創性檢測突破了傳統模式，已帶來了產前診斷的革新和巨變。1997年，項目統籌負責人，盧煜明教授，率先在孕婦的外周血漿中發現了游離胎兒DNA的存在。2008年，該研究團隊獲得了大學教育資助委員會卓越學科領域計劃(AoE)的資助(AoE/M-04/06)，研發了唐氏綜合症的無創檢驗方法，並成功應用於臨床診斷，逐步被多個國家所採用。這實現了基於DNA分析的無創性產前診斷技術從科學研究到臨床檢測的重大飛躍。

在此研究項目中，我們組建由病理學家、實驗科學家、產科專家、生物信息學家以及公共衛生專家等多學科研究團隊，共同解決產前領域的關鍵問題，以滿足臨床診斷的需要。尤其是研發用於分析游離核酸的新一代技術，探索目前了解甚微的游離胎兒核酸的生物學以及病理學特性。利用此項嶄新技術與生物學見解，致力於達成妊娠相關疾病（如單基因遺傳疾病、胎兒死亡、妊娠毒血症等）的無創診斷目標。無創性產前檢測的意義及益處也將從倫理、法律以及社會學等多角度探索分析。通過培養研究生與研究人員，予產科專家和醫學檢驗從業人員的教育工作坊，我們的研究成果帶來的知識信息與檢驗技術也進一步廣泛傳播，令更多人士受惠。

Research Impact
研究影響

In terms of research, the team has continued to push the envelope of the field. The team has achieved the non-invasive decoding of the fetal genome at much higher resolution which resulted in substantial improvement in one's ability to non-invasively detect fetal *de novo* mutations. The team has successfully developed several approaches for the non-invasive detection of fetal single gene diseases, thus expanding the clinical applications of non-invasive prenatal testing beyond the assessment of fetal chromosomal aneuploidies. The team has uncovered interesting biological phenomenon about circulating DNA that was not appreciated previously. The team found that there are specific genomic locations that serve as preferential fragmentation sites of cell-free DNA. These preferred sites on the ends of cell-free DNA fragments aid with the identification of which organ released the DNA molecules. The team has transferred the non-invasive prenatal test for fetal chromosomal aneuploidy screening to the Hospital Authority, with service delivered at the Hong Kong Children's Hospital. Two companies, Xcelom and DRA, have been founded by Professors Dennis Lo, Rossa Chiu and Allen Chan, to offer non-invasive prenatal testing services to pregnant women in Hong Kong and in Mainland China, respectively.

盧煜明教授團隊一直敢於創新，挑戰游離核酸研究領域的極限，成功以無創方式為胎兒基因解碼並繪製出高解像度胎兒基因圖譜，大大提高以往胎兒新生突變檢測的精準度。團隊亦研發出各種胎兒單基因遺傳病的檢測方案，令無創產檢的臨床應用並不局限於檢測胎兒染色體異常。團隊的研究也揭示了一些有趣又鮮為人知的游離DNA生物現象，研究發現基因組上有些特定位置是游離DNA的偏好斷點，處於游離DNA盡頭的偏好斷點位置正好反映出該DNA從何器官而來，有助辨識游離DNA的來源。另外，團隊將胎兒染色體異常的無創篩檢技術轉移至醫院管理局，香港兒童醫院為有需要的市民提供該項服務，惠及社群。除此以外，盧教授夥拍趙慧君教授及陳君賜教授成立了兩間公司Xcelom及DRA，分別為香港及中國內地孕婦提供無創產檢服務。

Professor Dennis Lo receiving the inaugural Future Science Prize in Life Sciences in Beijing in 2016

盧煜明教授在北京獲頒2016年未來科學大獎－生命科學獎

The DRA management team

明君賜有限公司管理團隊

Smart Solar Energy Harvesting, Storage, and Utilization
智能化太陽能技術：採集、存儲和應用

T23-407/13-N

Project Coordinator
Professor Jianbin XU
The Chinese University of Hong Kong

Participating Institutions
The Hong Kong Polytechnic University
The Hong Kong University of Science and Technology
The University of Hong Kong

項目統籌人
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香港科技大學
香港大學

Short Biography of Project Coordinator 項目統籌人簡介

Professor Jianbin Xu received the B.Sc. and M.Sc. degrees in physics and information physics from Nanjing University, Nanjing, China, in 1983 and 1986, respectively, and the Doctor of Natural Science (Dr. rer. nat) in mid-1993 from the University of Konstanz, Germany, where he studied under the supervision of Professor Klaus Dransfeld. His doctoral dissertation was focused on the near-field sensing and nanoscopic energy transfer and heat transport associated with electronic processes. Afterward, he joined the Department of Electronic Engineering, The Chinese University of Hong Kong, where he has been a Professor in the Department of Electronic Engineering since mid-2002. Meanwhile, he is a Distinguished Research Fellow at Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences. His research interests contain advanced electro- and photo-active materials and devices as well as nanotechnology.

Professor Xu is a Fellow of IEEE and The Hong Kong Institution of Engineers; Chang Jiang Scholar Chair Professor; a Recipient of Research Excellence Award, CUHK; a Member of several other professional societies. Also, he is an Associate Editor of *Science Bulletin*. Recently, he is named as a Highly Cited Researcher 2020 by Clarivate Analytics.

許建斌是香港中文大學電子工程學系教授，工程傑出學人，教育部長江學者講座教授，卓越研究獎獲得者，並兼任該校材料科學與技術研究中心主任。他先後於1983年和1986年在南京大學獲得理學學士及碩士學位。1988年初赴德國康斯坦茨大學深造。1993年夏獲得德國自然科學博士學位。其後任職於香港中文大學電子工程學系，自2002年至今擔任該系教授。

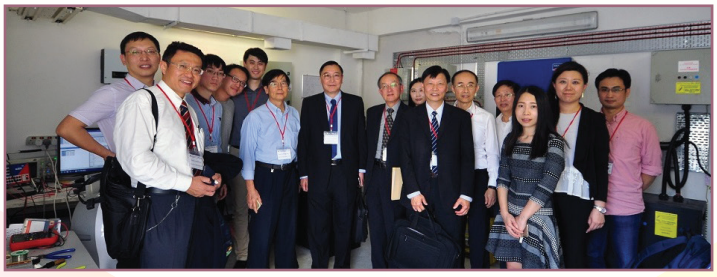
他已發表了450餘篇學術論文。同時，他是IEEE和香港工程師學會(HKIE) Fellow，香港材料研究學會副會長，中國真空學會理事，美國物理學會會員等。他被科睿唯安選錄為2020年全球高被引學者。自2007年起，他擔任材料科學與技術研究中心主任。

許建斌教授目前主要從事包括二維層狀材料和器件；混合鈣鈦礦材料和光電器件；有機半導體；高導熱材料等在內的相關研究工作。

Project Summary 項目概要

- Commercialization of Flexible CIGS Thin Film Solar Panels.
- Fabrication and Stability Improvement of High Performance Perovskite Photovoltaics.
- Design, Synthesis of New OPV Materials and Commercially Producible Thereafter.
- Plasmonic and Upconversion Nanomaterials.
- An Elemental Phosphorus Photocatalyst with a Record High Hydrogen Evolution Efficiency.
- Record-High Energy-Density for Aqueous Redox-Flow Batteries (ARFBs).
- Development of Nanostructured Electrode Materials for High Energy Density Supercapacitors.
- Online Energy Generation Scheduling for Microgrids.
- Laboratory Microgrids Demonstration.

- 銅銦鎵硒柔性薄膜太陽能電池板的商業化。
- 高性能混合鈣鈦礦太陽能電池的製備及穩定性的改進。
- 新型有機機光伏材料的設計、合成和商業化探索。
- 表面等離子光學及能量上轉換材料在太陽能方面的應用。
- 創紀錄高析氫效率的磷系元素光催化劑。
- 創紀錄能量密度的水氧化還原液流電池(ARFBs)。
- 基於納米結構電極材料的高能量密度超級電容器。
- 微電網的在線能源生成調度。
- 實驗室微電網示範。



Abstract of the Project
項目簡介

The research scheme is aimed at the project's strategic objectives through exploring various approaches in solar energy harvesting, storage, and utilization, to increase solar penetration up to 10% in a selected campus building microgrid system under grid interconnected operation, and more importantly explore the feasibility of enhancing local security and independency of electricity supply of the microgrid through solar enabled islanded operation by end of 2017. The merit of this scheme lies in the fact that solar energy harvesting, storage, and utilization are holistically considered and thereafter they will be meticulously investigated. Accordingly the research topics covered by this scheme include:

- The development of high-performance vacuum deposited thin-film PV devices and modules with new materials and processing techniques, particularly based on earth-abundant materials;
- The establishment of an interdisciplinary research platform for fundamental research in solution-processed thin-film PV devices and modules based on inorganic and organic active materials, as well as the development of novel light-trapping schemes for efficiency enhancement;
- The exploration of novel metal-oxides and organic dyes for chemical fuels production via artificial photosynthesis and photocatalysis;
- The development of new materials and processing approaches for high energy-density batteries and supercapacitors, so as to realize a hybrid storage system;
- The development of advanced strategies to integrate, manage, and control various subsystems based on information and communication technology (ICT) infrastructure and protocols, so as to enhance the performance and security of solar-enabled microgrids under various operating modes;
- The practical demonstration of microgrid (MG) operations based on intelligent control and integration of PV modules, smart storages and loads and other technologies in a laboratory and selected campus building systems under interconnected and islanded modes.

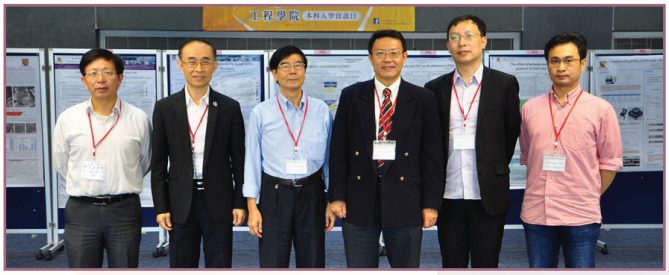
我們所提出的研究計劃緊密圍繞香港特區政府的可持續發展綱要，亦即開發多種途徑以實現太陽能的有效轉換，可靠存儲和使用。總體而言，我們研究了在微電網互聯運行模式下實現校園選定建築物最高達10%的電力供給的可能性。進一步，我們在2017年底前探索了微電網孤島運行模式下太陽能供電的區域安全性和獨立性。我們提出的微電網運行模式，其優勢在於全方位地考慮太陽能的轉化，存儲和利用。本計劃研究如下課題：

- 開發高性能的真空沉積的薄膜太陽能電池結構和組件技術，著重於新材料（尤其基於自然界中富含元素的光吸收材料）和新的工藝技術；
- 建立跨學科研究平台，開展無機和有機光伏活性材料，溶液工藝製作的太陽能電池和組件的基礎研究；同時開發新型的光採集形式以提高電池的光電轉換效率；
- 開發新型的金屬氧化物和有機染料分子，從而在化學燃料的合成中實現高效的人工光合作用和光催化；
- 開發新材料和新工藝技術以實現高能量密度的蓄電池和超電容，及由此構建的混和存儲系統；
- 開發基於先進資訊和通訊技術基礎設施和傳輸協議的控制策略以實現集成，管理，和控制各種子系統，從而增強太陽能技術和微電網系統在各種運行模式下的性能和安全性；
- 在實驗室和校園選定的建築物內進行基於智慧控制，一體化的太陽能組件，智慧存儲和電力使用，以及與其他技術相結合的微電網運行以及實際應用示範。在此，我們將試驗互聯和孤島兩種模式的微電網運行調配。

Research Impact
研究影響

Harvesting energy directly from sunlight by utilizing photovoltaics (PV), photocatalysis, artificial photosynthesis, and other enabling technologies is an effective way to develop renewable energy resources. In this project we have developed the vacuum-deposited CIGS thin-film PV panels and CZTS thin-film PV cells as well as solution-processed hybrid perovskite thin-film PV cells which offer the promising processing advantages to enable low-cost, high-throughput, and large-area PV production. Meanwhile, we have developed several effective ways for efficient and smart energy storage devices in order to ensure reliable energy supply and to increase the penetration of solar energy utilization. To further facilitate the utilization, we have developed the intelligent power distribution grids for solar energy utilization with enhanced security of supply through advanced scheduling and flexible transition between the operating modes. Record-high efficient OPV cells and batteries have been developed with certification by NREL and publications in top journals. Mechanistic understandings of OPV cells and perovskite PV cells as well as other alternative solar energy harvesting methods have been achieved. So far there are 35 highly-cited papers with a citation number c.a. 10,000 since the end of 2014. Several patents have been granted. More than 50 postgraduate students have been trained. Commercialization of flexible CIGS thin-film PV panels is in progress.

利用光伏、光催化、人工光合作用等技術直接從太陽光中獲取能量是開發可再生能源的有效途徑。在本項目中，我們開發了真空沉積銅銦鎵硒薄膜光伏電池板和銅鋅錫硫薄膜光伏電池以及溶液製備的混合鈣鈦礦薄膜光伏電池。它們具有良好的加工優勢，從而能夠實現低成本，高通量和大面積光伏電池板生產。同時，我們為實現高效智能儲能器件，開發了多種有效儲能方式，以確保可靠的能源供應，並提高太陽能利用率。為了進一步促進利用太陽能，我們開發了智能配電電網，通過先進的調度和靈活過渡的運行方式，增强了供電安全性。開發出創紀錄的高效有機太陽能電池，並獲得了美國國家再生能源研究所的技術認證和頂級期刊的出版。實現了對有機太陽能電池和鈣鈦礦光伏電池以及其他替代型太陽能收集方法機理的深入理解。到目前為止，本項目產出了35篇高被引用論文，總引用數自2014年底以來已達到10,000多次。已授予多項專利。超過50名研究生通過本項目接受了培訓。而柔性銅銦鎵硒薄膜光伏板的商業化正在進行中。



Sustainable Power Delivery Structures for High Renewables

可容納大量可再生能源的可持續電力輸送結構

T23-701/14-N

Project Coordinator

Professor David John HILL

The University of Hong Kong

Participating Institutions

The Hong Kong University of Science and Technology

The Hong Kong Polytechnic University

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山大衛教授

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參與院校

香港科技大學

香港理工大學

Short Biography of Project Coordinator 項目統籌人簡介

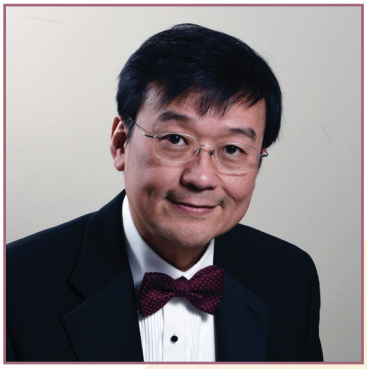
Professor David J. Hill holds the Chair of Electrical Engineering and is Director of the Centre for Electrical Energy Systems in the Department of Electrical and Electronic Engineering at the University of Hong Kong. He is also Emeritus Professor and Founding Director of the Centre for Future Energy Networks at the University of Sydney, Australia. He held the Chair of Electrical Engineering in The University of Sydney from 1994–2002 and again during 2010–2013. He has also held academic and substantial visiting positions at many universities including Berkeley (USA), Newcastle (Australia), Lund (Sweden), Australian National University and City University of Hong Kong. Professor Hill is a Life Fellow of the IEEE, USA. He is a Fellow of the SIAM, USA, the Australian Academy of Science, the Australian Academy of Technological Sciences and Engineering and the Hong Kong Academy of Engineering Sciences. He is also a Foreign Member of the Royal Swedish Academy of Engineering Sciences.

山大衛教授現任香港大學電機與電子工程學系電氣工程學科講席教授，並兼任香港大學電力能源系統中心主任。他創立了澳大利亞悉尼大學未來能源網絡中心，並長期擔任該中心主任，目前為該中心的榮休教授。在1994—2002年及2010–2013年期間，他在悉尼大學擔任電氣工程學科講席教授。山教授曾在多所大學擔任重要的學術和訪問學者職位，包括美國加州大學伯克利分校，澳大利亞紐卡斯爾大學，瑞典隆德大學，澳大利亞國立大學和香港城市大學。山教授是美國IEEE終身會士，美國SIAM會士，澳大利亞科學院院士，澳大利亞技術科學與工程學院院士、香港工程科學院院士及瑞典皇家工程科學院外籍院士。

Project Summary 項目概要

- Develop an integrated approach based on all four key technical areas, including a novel 'demand response' balancing paradigm
- Develop power electronic based electric springs into universal type smart load controllers, which locally achieve contributions to basic balancing and stability
- Integrate decision and control and information and communication strategies to study distributed control algorithms that can achieve the 'smart grid'
- Integrate the outcomes of the above steps to incorporate further requirements on improving the energy efficiency and reliability of power system operation
- Further enabling increased consumer participation in power system operation with various financial considerations
- Establish a regional research and educational hub in energy harvesting and sustainable grid technology for university, industry and governments.

- 基於四個關鍵技術領域系統性地構建了可持續電能傳輸的新架構和方法，包括“需求響應”平衡模式；
- 基於電力彈簧理念開發了可滿足局部功率平衡和穩定控制需求的通用型智能負載控制器；
- 融合信息和通信技術及先進的決策控制方法，研究使電網更趨智能化的分佈式控制算法；
- 在進一步考慮提高電網運行能效性和可靠性等需求的基礎上，全面整合上述理論方法和研究成果；
- 綜合考慮各種經濟因素，進一步提高用戶對電力系統調度和運行的參與度；
- 為大學、工業界和政府共同建立能源高效利用和可持續電網技術的區域性研究樞紐和教育中心。



Abstract of the Project
項目簡介

This project addresses the sustainability of future electrical power delivery systems. It is now clear that energy sustainability refers to the complete network (or grid), which delivers the power as much as the sources of energy. This package of energy supply and grid can make a major contribution to solving the urgent and potentially devastating problems of pollution and climate change. Much higher use of renewable power, including offshore wind-power (and demand management), is under serious consideration already. The proper operation of an electricity grid involves an intricate set of balancing processes for energy, power, ramping all while achieving the regulation of system variables, e.g. voltages, frequency, line powers, and keeping the system protected and secure following disturbances. This is achieved with layers of system control (and market) processes. These processes all need to be redesigned for high levels of renewable power due to the weather driven variability of the power supply. Our research is aimed to determine the structure of the delivery systems, which can overcome any such limitations and be sustainable in the long-term, including the appropriate system wide information and control systems.

The basic requirement is instantaneous balance of power generation and load demand in order to maintain a stable frequency. The traditional paradigm of generation following demand, where millions of diverse customer actions are balanced with the controlled output of a small number of major generation plants, cannot handle the distributed and variable nature of solar and wind energy sources. We have studied a new paradigm, which is adaptive in the sense of demand following generation. The load devices contribute to overall balancing and welfare of the system in processes of demand response and load control.

The key areas for the project are power systems, power electronics, computer networking and control technology. By integrating these areas in a balanced way, the aim is to build a unique research capability which can support the future industry in the Pearl River Region and beyond. The project builds on its own highly innovative ideas that have shown promise for the proposed research, namely (i) electric springs, and (ii) granular modelling and control integrated with communication, control and security.

本項目旨在研究未來電網的可持續性問題，即如何利用電能傳輸網絡最大限度地消納其他能源。能源供給與電力網絡的結合，可在應對環境污染、氣候變化等嚴峻問題中發揮重要作用。為此，如何高效利用可再生能源發電、需求側管理等技術，正備受業界關注。電網運行中常涉及一系列複雜的能量、功率平衡過程，在系統控制、電力市場等調控措施下，既要維持正常的電壓、頻率、線路功率，又要保證系統受擾後的安全性。然而，隨著波動性強的可再生能源高比例滲入，傳統電能傳輸架構不再適用。因此，本項目將基於先進信息和控制技術，研究電網長期可持續運行的新架構。

電網中頻率穩定的基本前提是發電和用電的實時平衡。傳統調控模式為發電跟隨負荷，通過調節少數大型發電廠來滿足大量分散負荷需求，但該模式無法適應可再生能源的分散性和波動性。本項目提出新的調控模式，即負荷自適應跟隨發電，通過需求側響應和負荷控制來高效維持電能供需平衡。

本項目涵蓋電力系統、電力電子、計算機網絡與控制等領域。項目組將整合自身跨領域優勢，建立一支一流的科研團隊，為珠三角及大灣區的行業發展提供技術支撐。本項目包含一系列獨特的原創性方法和技術，如電力彈簧，融合先進信息和通信技術的精細建模與控制等。

Research Impact
研究影響

- The establishment of HK as a world leader in innovative power system technologies to be compared with a few places in the USA and Europe
- That HKU will become a 'research window' for Mainland China to interact with other research institutes and universities internationally; this specific role is being discussed currently with Guangdong Power
- Accordingly, in this and other roles, we believe we can play a major long-term role in helping China overcome its heavy pollution problems not to mention make a contribution to the global effort to reduce climate change
- Specific technologies, such as electric springs, power flow routers and distributed control, show promise for commercial development; follow-up projects with Chinese collaboration and with Chinese power utilities are pending
- The microgrid facility can be a resource for HK to further develop its advanced education in the important area of renewable energy
- The Centre for Electrical Energy Systems at HKU has further enhanced its status as a world-renowned group for modern power and energy engineering as evidenced by numerous invitations for keynote speeches and the like

- 將香港打造成為可與美國和歐洲等地區匹敵的世界一流電力系統技術研發地；
- 將香港大學提升為中國大陸與國際其他研究機構和大學合作的互動“研究窗口”，目前正與廣東電網商討具體合作事宜；
- 在上述區位角色的基礎上，有望在幫助中國解決環境污染等重要問題方面發揮長期的重要作用，並為減緩全球氣候變暖做出重要貢獻；
- 本項目的電力彈簧、電能路由器和分佈式控制器等技術具有廣闊的商業應用前景，目前正與中國大陸的合作夥伴和電力公司商討後續的合作研究和產品研發；
- 本項目的微電網設施可作為先進的示範性資源，為香港可再生能源相關的教育提供重要支撐；
- 通過受邀主題報告等宣傳方式，進一步將香港大學電力能源系統中心提升為世界知名的現代電力和能源工程研究團隊。

Smart Urban Water Supply Systems (Smart UWSS)
智慧型城市供水系統

T21-602/15-R

Project Coordinator

Professor Mohamed Salah GHIDAOUI

The Hong Kong University of Science and Technology

Participating Institutions

The Chinese University of Hong Kong
The Hong Kong Polytechnic University
University of Canterbury
University of Toronto
University of Perugia
Zhejiang University
Massachusetts Institute of Technology
Lehigh University

項目統籌人

招捷達教授

香港科技大學

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香港中文大學
香港理工大學
坎特伯雷大學
多倫多大學
佩魯賈大學
浙江大學
麻省理工學院
理海大學

Short Biography of Project Coordinator
項目統籌人簡介

Professor M.S. Ghidaoui is the Chinese Estates Professor of Engineering and Chair Professor in the Department of Civil and Environmental Engineering at the Hong Kong University of Science & Technology (HKUST). His research interests lie in the fields of hydraulics, water resources and environmental fluid mechanics. Currently, he is leading a large-scale theme-based project on smart urban water supply systems (http://suwss-dev.ust.hk/). He is the editor of the Journal of Hydraulic Research, IAHR and served as its associate editor for 15 years. He is also the associate editor of the Journal of Hydraulic Engineering, ASCE; and the Journal of Hydro-environment Research, IAHR-APD. He is an editorial board member of the Theoretical & Applied Mechanics Letters (TAML), Chinese Academy of Sciences and the Chinese Society of Theoretical and Applied Mechanics and served on the advisory board of the Journal of Hydroinformatics for 12 years. He served as the chair of IAHR's Fluid Mechanics Committee. He has received the Arthur Thomas Ippen Award, IAHR; the Albert Berry Memorial Award, American Water Works Association; and the Hilgard Award for best paper (runner-up), Journal of Hydraulic Engineering, ASCE. He was given the Outstanding Faculty Award, HKUST in 2017. In addition, Professor Ghidaoui has received two teaching excellence awards from the School of Engineering at HKUST.

招捷達教授是香港科技大學華人置業工程學教授兼土木及環境工程學系講座教授。招教授主要從事水力學、水資源及環境流體力學的研究。他現在主持着一個大型的主題研究計劃「智慧型城市供水系統 (Smart UWSS http://suwss-dev.ust.hk/)」。招教授目前擔任國際期刊《Journal of Hydraulic Research, IAHR》的主編，亦在過去十五年間擔任該期刊的副主編。同時，他亦是國際期刊《Journal of Hydraulic Engineering, ACSE》和《Journal of Hydro-environment Research, IAHR-APD》的副主編，《Theoretical & Applied Mechanics Letters (TAML)》、《Chinese Academy of Sciences》及《The Chinese Academy of Theoretical and Applied Mechanics》的編輯委員會成員。他曾擔任《Journal of Hydroinformatics》的顧問委員會成員達十二年。另外，他曾擔任國際水利與環境工程學會流體力學分部的主席。他曾榮獲國際水利與環境工程學會頒發的 Arthur Ippen Award，美國水工程協會頒發的 Albert Berry Memorial Award 和美國土木工程師學會頒發的Hilgard Award for Best Paper (runner-up)。招教授於 2017 年獲得香港科技大學頒發的傑出教學獎。另外，他亦曾兩次獲得香港科技大學工學院教學卓越獎。

Project Summary
項目概要

- To develop the next generation of UWSS—Smart UWSS—that are better designed, instrumented, operated and managed, and where leaks and potential system failures can be reliably diagnosed.
- To achieve our mission, we propose to:
  - conduct frontier research to establish the scientific and engineering fundamentals of wave transmission in UWSS;
  - develop innovative and reliable diagnostic techniques; and
  - develop advanced experimental methodologies and techniques to test and validate the new technology and its applications.

- 本研究計劃之目的是建立新一代的智慧型城市供水系統。智慧型城市供水系統可以快速高效地檢測系統內的故障，從而改善供水系統的運作和管理。
- 為了實現我們的願景，我們提出：
  - 進行前沿研究以深入了解壓力波在供水系統中的傳播機理。
  - 開發創新和可靠的故障診斷技術。
  - 利用先進的實驗方法和技術以測試和驗證這項新技術。

Abstract of the Project
項目簡介

Urban water supply systems (UWSS) are the lifeline of 3 billion people globally. However, these vital systems are aging and fraught with deficiencies and inefficiencies. The World Bank estimates the monetary value of lost water worldwide to be about US$15 billion/year. Pipe failures can paralyze businesses and cause devastating urban floods. Worldwide, UWSS are challenged by urban growth and climate change. Yet current methods to diagnose leakages and defects in complex underground UWSS are highly inadequate.

Water infrastructure has been highlighted as a critical issue nationally in the 2011 "No. 1 document" issued by the Chinese Central Government; in the 2011 "Green Quality Living in Greater Pearl River Delta" study; and in the 2008 "Total Water Management" and 2015 "Water Intelligent Network (WIN)" policies of the HK government. Indeed, HK has

城市供水系統是全球30多億人的生命線。然而因系統老化、運行低效和功能不足等問題，世界銀行估計全球每年因管網滲漏、爆裂而造成的經濟損失為150億美元。嚴重的水管爆裂亦導致市區水浸、商業活動癱瘓。面對城市化和氣候變化帶來的挑戰，很多國家都急需改善它們的供水系統。

水利基建是全國性的重要議題，其在2011年發表的《中央一號文件》、2011年關於「綠色大珠三角地區優質生活圈」的研究工作，以及香港政府2008年的「全面水資源管理」和2015年的「智管網」政策中均是重點。事實上，香港政府已投資約二百三十億港元，進行更換及復修水管計劃。

committed HK$23 billion to the rehabilitation and replacement of its water supply infrastructure. Many other countries are long overdue for massive UWSS upgrades.

The design and management of UWSS is currently limited by the range and resolution of data that can be collected in the relatively inaccessible buried pipelines. Current methods fail to provide the diagnostic resolution needed for many practical problems. We propose a comprehensive theme-based research program involving theoretical, laboratory and field studies to develop a new diagnostic paradigm for water supply network monitoring and fault detection. We will study the sensing of actively generated waves that travel at high speeds (~1 km/s) in the fluid in the pipe and to electronically capture wave echoes. The resulting data will be processed with advanced transient-based inverse methods and algorithms to pinpoint and characterize leaks, blockages and weak pipes. The theories will be evaluated in a field test bed in HK. A pilot-scale demonstration experimental test bed will be developed for testing hydraulic transient behavior in UWSS.

We have assembled an internationally-recognized, cross-disciplinary research team to conduct the proposed research in close collaboration with the Water Supplies Department (WSD) of HK. The findings will enable timely detection of UWSS defects and formulation of proactive mitigation measures and will crucially contribute to the sustainable development of HK through water conservation.

城市供水管網一般敷設於地面以下，難以直接接觸，系統的設計和維修都受到探測方法的限制。目前的探測和數據收集方法難以準確判斷滲漏的範圍和位置。因此，我們提出了一個主題研究計劃：開發一套創新性的城市供水管網故障識別與檢測系統。本項目將包括理論研究、模型試驗與現場測試。其研究成果可用於實時診斷與檢測城市供水管網中的缺陷，並提供積極的解決方案。

本主題研究提出在待測管道中產生高速傳播的（速度約為1公里每秒）水壓力波，然後利用高靈敏傳感器採集水壓力波的反射信息。收集到的數據將會透過先進的水動力學反演法分析，從而確定水管中滲漏、阻塞和管壁變弱等缺陷的位置和特徵。這些理論與方法將會首先在香港的一個現場試驗系統中進行測試與驗證。另外，我們將會建立一個多用途的、中試規模的實驗系統來示範城市管道系統中水流及水壓的瞬變現象與過程。

我們組織了一個國際性的跨學科精英研究團隊來開發智慧型城市供水系統，並與香港水務署緊密合作。本研究符合香港政府的「智管網」政策，其成果將為香港的可持續發展，特別在水資源節約與保護方面，作出重大的貢獻。

Research Impact
研究影響

Over 30% of the water and energy lost worldwide—enough to supply 150 cities like Hong Kong—are lost through water supply systems. The amount of water lost annually is worth about US$15 billion. In Asia, over 29 billion cubic meters, valued at US$9 billion, are lost every year. The problem lies in the lack of technology to identify faults in aging water supply systems.

We have made fundamental breakthroughs in the forward and inverse problems of low (LFW) and high frequency waves (HFW) in water supply systems. Both elastic (e.g. steel) and viscoelastic (e.g. plastic) pipe materials have been tested. Novel and proven techniques have been developed to diagnose pipe systems. Examples include matched field processing and time reversal methods, both of which are robust even in noisy environments. Patents will be filed for the two as well as other techniques.

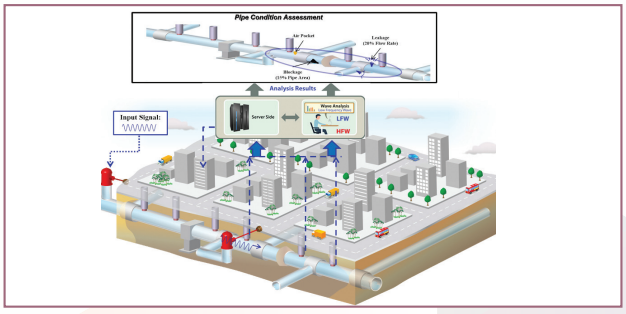
We have developed two unique test beds and one live field test program at a local water supply system in collaboration with the WSD. We are currently planning to develop a live pilot facility at HKUST which will provide a unique environment where academia, industry and government can work together to showcase and demonstrate the home-grown technology. We have built strong collaborations with outstanding researchers from HK, mainland China, USA, Canada, New Zealand and Italy. Our project paves the foundation to create the technologies for water, energy and monetary savings.

供水系統的爆裂和滲漏浪費了全球超過百分之三十的食水，這些流失的食水和能源足以供應一百五十個與香港相似的發達城市使用。每年因食水浪費而導致的經濟損失高達一百五十億美元。亞洲的供水系統每年滲漏的食水量超過二千九百萬立方米，造成了九十億美元的經濟損失。問題的癥結在於缺乏一種快速高效地檢測城市供水管網缺陷的方法。

我們在低頻和高頻水壓力波的分析和反演分析領域實現了重大的基礎性突破，並將其應用於不同管材的水管，例如剛性管和塑料管。本研究提出了多種創新性的管道故障探測方法，其中兩種方法為匹配場法（Matched Field Processing）和時間反轉法（Time Reversal），它們可以在充滿雜訊的環境中探測水管的滲漏。我們正為這兩種方法以及本項目的其他技術申請專利。

我們建造了兩套實驗系統，亦與香港水務署合作，在一個本地供水管網內進行實驗測試。同時，團隊正計劃在香港科技大學校園內的供水系統中建立一套實地試驗系統，該系統將為學術界、產業界和政府締造一個獨一無二的合作環境，團隊期望藉此展示香港本土的研發技術。本研究項目匯集了來自世界各地的頂尖研究人員，包括香港、中國大陸、美國、加拿大、新西蘭和意大利，希望能為研發節省食水、開支和能源的供水技術奠定基礎。

Advisory Board Meeting on Dec 11, 2017.
諮詢委員會會議留影（攝於2017年12月11日）



The bottom plate depicts a small section of a pipe system situated under roads and buildings. Its state and condition are unknown. The sensors in the pipes generate, transmit and receive pressure wave signals, and the data is communicated using acoustic waves to SCADA base-stations in real-time. This wave data is then relayed to remote servers using (an often existing) wireless communication platform. The data is then transformed into sharp images of system state. The top portion is a depiction of the type of defects to be identified.
該圖繪製了位於城市道路和建築物下方的局部供水管網系統。其管道及運行狀況均未知。由造波器產生的水壓力波在管網中高速傳播，並在缺陷處產生反射波，該反射波由監控及數據採集系統實時收集。隨後，利用現有的無線通訊平台，將採集到的數據發送到遠程服務器。最後，這些數據將用來構造高精度的系統狀態圖像，例如圖上方管道展示了不同類型的潛在缺陷。

Professor Charles W. W. Ng (Project Coordinator)
吳宏偉講座教授（項目統籌人）

Understanding Debris Flow Mechanisms and Mitigating Risks for a Sustainable Hong Kong
香港泥石流流動機理及風險控制

T22-603/15-N

Project Coordinator
Professor Charles Wang-wai NG
The Hong Kong University of Science and Technology

Participating Institutions
City University of Hong Kong
The University of Hong Kong

項目統籌人
吳宏偉教授
香港科技大學

參與院校
香港城市大學
香港大學

Short Biography of Project Coordinator
項目統籌人簡介

Professor Charles W. W. Ng is currently the Dean of HKUST Fok Ying Tung Graduate School, CLP Holdings Professor of Sustainability and Chair Professor in the Department of Civil and Environmental Engineering at The Hong Kong University of Science and Technology (HKUST). He is the President of International Society for Soil Mechanics and Geotechnical Engineering (2017-2021).

Professor Ng was elected an Overseas Fellow by Churchill College, the University of Cambridge, a Fellow of the Royal Academy of Engineering, a Fellow of the Hong Kong Academy of Engineering Sciences, and a Changjiang Scholar (Chair Professorship in Geotechnical Engineering).

Professor Ng has supervised more than 55 PhD and 60 MPhil students to graduation, published some 350 SCI journal articles and 250 conference papers, and delivered more than 80 keynotes and state-of-the-art reports across the six continents. He is the lead author of three reference books: (i) *A Short Course in Soil-structure Engineering of Deep Foundations, Excavations and Tunnels* by Thomas Telford in 2004, (ii) *Advanced Unsaturated Soil Mechanics and Engineering* and (iii) *Plant-Soil Slope Interaction* by CRC: Taylor & Francis in 2007 and 2019, respectively.

吳宏偉教授現任香港科技大學霍英東研究生院院長，中電控股可持續發展冠名教授，以及土木及環境工程系講座教授。吳教授亦擔任國際土力學及岩土工程學會主席（2017–2021）。

吳教授當選為英國劍橋大學丘吉爾學院海外院士，英國皇家工程院院士，香港工程科學院院士以及國家教育部長江學者獎勵計劃講座教授。

吳教授共指導了超過了55名博士研究生（PhD）和60餘名研究型碩士研究生（MPhil）畢業，並在國際學術刊物上發表SCI論文350餘篇，發表學術會議論文250餘篇。吳教授在六大洲的重要國際學術會議上作特邀和主題報告80餘次。吳教授作為第一作者撰寫了3本英文學術專著，包括2004年由Thomas Telford出版的《A Short Course in Soil-structure Engineering of Deep Foundations, Excavations and Tunnels》、分別於2007年和 2019 年由Taylor & Francis出版的《Advanced Unsaturated Soil Mechanics and Engineering》和《Plant-Soil Slope Interaction》。

Project Summary
項目概要

- Novel approach for the analysis of debris flows using particulate mechanics;
- Innovative monitoring techniques including three-dimensional (3D) reconstruction and smart soil particles;
- Understanding of debris flow dynamics and their interaction with multiple flexible barriers using a 28-m long flume;
- New multi-scale and multi-physics computational platform for simulating debris flows;
- New generation of reliability-based vulnerability models and framework for assessing debris flow hazards;
- World-leading design guidelines for multiple flexible barriers against debris flows;
- Educational material on debris flows for emergency responders and the general public.

- 嶄新的顆粒力學方法以分析泥石流運動過程；
- 創新的監測技術，包括三維重建以及智能泥土顆粒；
- 通過28米長水槽實驗加深對泥石流運動過程以及其與多重柔性防護網相互作用機理的認識；
- 新型多尺度，多重物理性的泥石流模擬計算平台；
- 新一代基於可靠性分析的泥石流災害危險性模型和框架；
- 領先世界的整治泥石流的多重柔性防護網設計指引；
- 為公眾和災害應變人員提供有關泥石流的教育材料。

Panel discussion during the 1st international advisory committee meeting
第一次國際諮詢委員會上的小組討論

Group photograph of project members next to the 28-m long flume
項目成員於28米長水槽旁合影

Newly developed Kevlar flexible barrier equipped with novel brake elements during a debris impact experiment in the 28-m long flume
新開發的裝有新型消能元件的凱夫拉柔性防護網於28米長水槽中進行測試

Abstract of the Project
項目簡介

The risk of natural terrain landslides in Hong Kong is increasing due to urban encroachment on steep natural hillsides and more frequent extreme weather events. To reduce debris flow risks and to provide a safe and sustainable environment for economic growth in Hong Kong, a university-led, industrial collaborative and inter-disciplinary project is being conducted by a team of engineers, a computer scientist, an environmental scientist, an ecologist, and representatives from the Hong Kong Institution of Engineers. The key inter-related components of this project include characterizing debris flow material from the micro- to the macro-scale, developing innovative monitoring techniques, investigating debris flow mechanisms, and developing risk mitigation measures.

In this project, a novel 3D imaging system mounted on an unmanned aerial vehicle has been developed and used to capture high-resolution aerial images. These images were used to create digital 3D terrain models to enhance the assessment of debris flow mobility. A state-of-the-art geotechnical centrifuge and a newly constructed 28-m large-scale flume using advanced instrumentation (Patent nos.: US20180274618; CN108700152; CN201810614916) have been developed in conjunction with a novel multi-scale and multi-physics numerical model, which considers fluid-solid and solid-solid interactions, for the simulation of debris flows.

The project team in conjunction with The Geotechnical Engineering Office (GEO), the de facto geotechnical authority in Hong Kong, have used the findings from this project to support the development of a set of design guidelines for practitioners to design barriers against debris flows. Also, findings for multiple barrier systems were published in a landmark forum at the World Landslide Forum organised by the International Consortium of Landslides, The United Nations Educational, Scientific and Cultural Organization (UNESCO).

The outcomes have an impact on both local and international practice and provide a sustainable and cost-effective solution against debris flow hazards in Hong Kong and countries such as Canada, USA, Brazil, Italy, Norway, Japan, and Malaysia.

As a result of this project, a total of 98 postgraduate research students from over 15 countries have been trained, 140 top journal papers have been published, and 56 keynote lectures have been delivered.

香港山多平地少，人口稠密，城市不斷向陡峭的天然山坡發展，加上極端天氣日益頻繁，由此導致香港的山地滑坡和泥石流風險與日俱增。與其他地區不同的是，香港的泥石流防治受到各種條件的挑戰，包括超過2000毫米的高密度年降雨量、陡峭的山坡、密集的人口以及昂貴的地價。因此，世界上其他國家採用的僅依靠過往經驗得來的傳統泥石流防護措施並不適用於香港。當務之急是研究開發新型可適用於香港並且安全經濟的解決方案。

為防治泥石流災害，並且為香港的經濟發展提供一個安全而可持續的環境，本研究項目以大學為主導，並與業界緊密合作，組成了一個包括工程學、計算機科學、環境科學、生態學以及香港工程師學會代表的跨界跨學科研究團隊。本研究項目包括以下四個緊密相連的重要課題：

- 泥石流物料的宏微觀特性試驗
- 新式泥石流現場監測技術
- 研究泥石流運動機理
- 發展預防風險措施

在本研究中，一個利用無人駕駛飛機的三維拍攝系統已經完成開發，並用作拍攝高解析度的航拍相片。拍攝得來的相片被用作創建數碼三維山坡模型以研究泥石流的流動性。另外，本項目開發並建造了一個用於泥石流研究的新型土工離心機模型，及一條28米長並且配置了先進監測儀器的大型泥石流實驗水槽。相關的監測儀器獲得了一項美國專利（專利編號：US20180274618）以及兩項中國專利（專利編號：CN108700152; CN201810614916）。同時，本項目創新地開發了一個考慮泥土顆粒與水之間及泥土顆粒之間相互作用的嶄新多尺度、多重物理性數值模型以用來模擬泥石流的動力過程。

研究團隊通過與香港土木工程拓展署土力工程處合作，已將本項目的研究成果用來支持開發一系列的設計指引，讓業界用作設計防治泥石流的攔擋壩。同時，本項目關於多重防護結構的研究成果已發表在由聯合國教科文組織國際滑坡聯合會舉辦的極具影響力的世界滑坡論壇中。

本項目的研究成果將對本地以及國際的工程實踐產生直接影響，為本地以及國外比如加拿大、美國、巴西、意大利、挪威、日本以及馬來西亞等國的泥石流防護技術提供具有可持續性以及造價經濟的方案。

本項目共培養了來自超過15個國家的98名研究生，發表頂級期刊論文140篇，並作主題報告56次。

Research Impact
研究影響

The current design of barriers against debris flows is empirical. Thus, it is not possible to discern whether a design is unsafe, adequate or over-designed. Barriers will not only require robust designs, but they will also need to blend in with the natural environment and be cost-effective. The scientific and theoretical advancement and discoveries obtained from this project provide the solid foundations for the development of new design guidelines. The newly developed design guidelines for multiple flexible and rigid barriers will have an immediate effect on local engineering practice and will lead to sustainable countermeasures against debris flow hazards locally and globally. Furthermore, the new guidelines can be adopted to protect highways and railways along the Belt and Road countries and beyond. For instance, the Sichuan-Tibet railway will pass through the southeast Qinghai-Tibet Plateau, which is the most geologically active and high risk mountainous region in China. Mitigation of debris flow hazards in this region will be crucial to sustainable development along the Belt and Road, especially in fuelling Tibet's economic growth and enhancing national trade with India and Nepal.

目前針對泥石流的攔擋壩設計通常是經驗性的。因此，不太可能辨別設計是不安全的，適當的，還是過度保守的。攔擋壩除了要求有堅固的設計，而且還要造價經濟並與自然環境融為一體。本項目的科學及理論進展與發現為開發新的設計指引提供了堅實的基礎。新編寫的多重柔性防護網設計指引將會對本地工程實踐帶來即時的影響，並對香港以及世界各地發展可持續的泥石流防治措施提供了核心技術支持。此外，新的設計指引可以用於保護“一帶一路”沿線國家及其他國家的公路和鐵路。例如，川藏鐵路將穿過青藏高原的東南部，該地區是中國地質災害頻發的高風險山區。因此，減輕該地區泥石流的危害對於“一帶一路”沿線的可持續發展至關重要，特別是對於推動西藏的經濟增長和加強與印度以及尼泊爾的國際貿易具有重要意義。

Photo of PC and core members
研究團隊主要成員合照

Delivering 21st Century Healthcare in Hong Kong – Building a Quality-and-Efficiency Driven System

為香港提供21世紀的醫療服務——構造一個品質與效率驅動的服務體系

T32-102/14-N

Project Coordinator
Professor Frank Youhua CHEN
City University of Hong Kong

Participating Institutions
The Chinese University of Hong Kong
The Hong Kong University of Science and Technology
The Hong Kong Polytechnic University
The University of Hong Kong
Lingnan University
Hang Seng University of Hong Kong
Columbia University
University of Waterloo
Curtin University
St. Luke's International University

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香港大學
嶺南大學
香港恒生大學
哥倫比亞大學
滑鐵盧大學
科廷大學
聖路加看護大学

Short Biography of Project Coordinator
項目統籌人簡介

Professor Frank Youhua Chen is Chair Professor of Management Science and Dean of the College of Business, City University of Hong Kong. His current research projects span healthcare and service systems, logistics/supply chains, and machine learning applications in operations and healthcare. Professor Chen is also in charge of "HomAge: Home-based Aging for Transformative Community Care," a project supported by a large HK bank (Secretariat: The Hong Kong Council of Social Service), at an amount of about $24M. It extends the strategic collaboration with the Jockey Club School of Public Health and Primary Care, Chinese University of Hong Kong, and a number of other social service organisations and medical service providers. Applying the data analytics tools developed in the TRS project, the HomAge project aims to transform the ecology of institutional elderly care and centre-based health management to an actualisation of aging-in-place with sufficient quality homecare support. Professor Chen holds a bachelor's degree in Engineering, master's degree in Economics, and doctoral degree in Management from Tsinghua University, the University of Waterloo, and the University of Toronto, respectively. Prior to joining CityU in 2012, he taught at CUHK (2001-2012) and National University of Sigapore (1997-2001).

陳友華教授現任香港城市大學商學院院長及管理科學講座教授。他目前的研究項目涵蓋醫療保健和服務系統，物流/供應鏈管理，以及運營和醫療保健中的機器學習應用。陳教授亦正領導一項大型計劃“頤年在家：家居護理新模式”，該計劃獲得本港一間大型銀行資助約2400萬元（項目秘書處：香港社會服務聯會）；透過此項計劃，陳教授的團隊將繼續與香港中文大學賽馬會公共衛生和基層醫護學院維持策略性合作，以及維繫其他社會和醫療服務團體。通過應用TRS項目研發的數據分析工具，“頤年在家”項目旨在落實及實踐社區安老，透過革新優質的家居照顧，取代現時以院舍照顧為本的長者護理模式，讓長者能在熟悉的社區及自己家中安享晚年。陳教授獲得清華大學工程本科，加拿大滑鐵盧大學經濟學碩士及多倫多大學管理學博士。曾任教於新加坡國立大學 (1997–2001) 與香港中文大學 (2001–2012)。

Project Summary
項目概要

The research plan calls for in-depth studies on problems in 3 topical areas:
1. hospital resource planning,
2. coordinated elderly care,
3. healthcare data analytics.

The project is centering around the theme "better care at affordable cost."

本專案的研究計劃建議對以下三個備受關注的方面進行深入研究：
- 醫院資源的規劃，
- 協調整合的長者醫護服務，
- 醫療服務數據的分析。

這三方面的研究都圍繞著共同的主題：“運用可承受的資源，提供更優質的醫療服務”。

Professor Frank Chen was being invited to deliver his talk "Integrated elderly care: challenges and opportunities", in the President's Lecture Series: Excellence in Academia held on 5 March 2018, photo taken with the President and guests after the talk
陳友華教授2018年3月5日主持最新一期「校長講座系列：學術薈萃」，題為「綜合安老服務：挑戰與機遇」，講座完成後與校長及一眾嘉賓合照

Abstract of the Project
項目簡介

Healthcare delivery worldwide has been fraught with high cost, low efficiency and poor quality of patient care service. Hong Kong is no exception, and the quality of service provided to patients has been far from exemplary. The objective of this project is to help Hong Kong develop a quality-and-efficiency driven healthcare delivery system that is built upon data analytics and compatible to the Internet age. Novel features of the project include: addressing healthcare delivery in Hong Kong in the context of business services innovation, the focus on quality-and-efficiency driven strategies and systems-oriented solutions, and the emphasis on networked resources and human-centric characteristics in healthcare delivery.

在全球各國醫療服務提供的過程廣泛地出現高成本，低效率和低品質的問題。這些問題在香港也不例外，為病人提供醫療服務的品質遠未能達到理想的程度。本專案的目的是幫助香港建立一個以品質和效率驅動的醫療服務傳遞系統，該系統以數據資料分析為基礎，與互聯網時代相融合。本計劃的創新之處包括：在創新商業服務的框架下，專注由品質和效率驅動的策略，以系統為本的解決方案，解決醫療服務供應過程中出現的問題，並強調資源網絡、以及提供病人為本的醫療服務。

Research Impact
研究影響

Overall scholarly contributions include 1) Coordinating community services with medical services in elderly care; 2) Community elderly health risk studies (e.g. fall risk and cognitive impairment); 3) Emergency Department patient flow prediction; 4) Planning and scheduling of key resources in a hospital, and 5) Probabilistic data linkage for integrated care coordination.

Practical contributions include 1) A patient-centric healthcare delivery framework that is based on data and emphasizes resource planning/optimization and patient-centric service innovation. 2) Estimated that a dollar invested in the integrated home care service could save 8 dollars in hospitalization cost; 3) Machine learning approach to the individualized prediction of hospital readmissions for the elderly with chronic diseases; 4) our algorithm for data-driven discharge planning at admission, etc.

整體學術貢獻包括：

1. 醫療機構及社會服務機構對長者醫護的協作及整合
2. 社區長者的健康風險研究(包括跌倒風險及認知障礙等)
3. 急症室病人的流量估算
4. 協助醫院規劃及調度有關的重要資源方法
5. 為推動醫社協作的概率化數據整合

實務貢獻包括：

1. 提供以患者為中心的醫療服務的框架，該框架基於數據並強調資源規劃/優化和以患者為中心的服務創新。
2. 估算每一元投放在綜合家居照顧服務，可以為入住醫院的開支節省約8元
3. 透過機器學習模式，根據每位長者慢性疾病及健康的情況，能個別地演算及預計該長者短期內再次入院的風險
4. 以數據導向為離院計劃建立一套演算法.

On 30 November 2018, Our Hong Kong Foundation launched a report on Hong Kong's health system, titled "Fit for Purpose: A Health System for the 21st Century", during which Mrs. Carrie Lam, Chief Executive of the Hong Kong Special Administrative Region delivered an opening remark. This report was led by Professor E.K. Yeoh (Co-PI), Director of the Jockey Club School of Public Health and Primary Care at the Chinese University of Hong Kong.

在2018年11月30日，團結香港基金發表題為《以人為本　縱橫整合》的香港醫療體系研究報告。是項研究由中文大學賽馬會公共衛生及基層醫療學院醫療體系及政策研究所總監楊永強教授帶領，並邀得時任行政長官林鄭月娥於發布會上致辭。

Professor E.K. Yeoh, joined with international experts shared his views in Leveraging Health Financing Levers to Propel Primary Care Development in Hong Kong's Segmented Health System, at Our Hong Kong Foundation Health Financing Roundtable, 07/17/2020.

楊永強教授及國際專家於團結香港基金主辦的「二十一世紀醫療融資：策略性採購中的公私營協作」圓桌會議中，分享如何藉醫療融資協作推動基層醫療發展（2020年7月17日）

Interdisciplinary project team
跨學科項目團隊

Safety, Reliability, and Disruption Management of High Speed Rail and Metro Systems

高速鐵路和地鐵系統的安全性、可靠性和應急管理

T32-101/15-R

Project Coordinator
Professor Min XIE
City University of Hong Kong

Participating Institutions
The University of Hong Kong
The Chinese University of Hong Kong
The Hong Kong Polytechnic University

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Short Biography of Project Coordinator
項目統籌人簡介

Professor Min Xie is a Chair Professor of Industrial Engineering at City University of Hong Kong. He completed his undergraduate study at Royal Institute of Technology and later completed his PhD at Linkoping University, Sweden in 1987. Professor Xie was with National University of Singapore 1991-2011. Professor Xie has been active in research in reliability engineering, quality control and industrial statistics. He has published numerous papers and 8 books, including "Software Reliability Modelling" by World Scientific, "Weibull Models" by John Wiley, "Stochastic Aging and Dependence for Reliability" by Springer. Professor Xie was elected fellow of IEEE in 2005.

Professor Min Xie has taken the role of project coordinator since August 2020. Former project coordinator Professor Kwok L. Tsui stays in project team and continues contributing to the project.

Professor Kwok L. Tsui is adjunct professor in the School of Data Science at City University of Hong Kong and the founder of Center for Systems Informatics Engineering. Professor Tsui's current research interests include data mining, surveillance in healthcare and public health, personalized health monitoring, prognostics and systems health management, and robust design and Taguchi methods. Professor Tsui is Fellow of the American Statistical Association, American Society for Quality, The Hong Kong Institution of Engineers, and Elected Council Member of the International Statistical Institute.

謝旻教授現任香港城市大學系統工程及工程管理系講座教授。 謝教授多年來一直從事可靠性與品質控制及工業統計方面的研究工作，發表 SCI 論文 300 餘篇，出版了8本專著。謝教授培養了 50 多名可靠性及品質管理的博士生，在多種相關國際雜誌擔任編輯或編委，並多次擔任國際會議主席或受邀做大會主題報告。 謝教授曾於1978年以全國第一名的成績考入中國科學技術大學少年班，入校第二年被選派到瑞典留學，1984年於瑞典皇家工學院畢業，1987年獲得林雪平大學博士學位，1991–2011年在新加坡國立大學任教 20 年。2005年入選 IEEE Fellow。

謝旻教授自2020年8月起擔任項目統籌人。前項目統籌人徐國良教授留在項目團隊中，繼續為項目作出貢獻。

徐國良教授現任香港城市大學數據科學學院客座教授，系統信息學工程研究中心創始人。徐教授目前的研究興趣包括數據挖掘、醫療保健和公共衛生監測、個體化健康監測、預測和系統健康管理、穩健設計和 Taguchi 方法。徐教授是美國統計協會 (ASA) Fellow，美國質量學會 (ASQ) Fellow，香港工程師學會 (HKIE) Fellow，及國際統計學會 (ISI) 的 Elected Member。

Project Summary
項目概要

The aims of the project are to:

- guarantee safety by implementing self-cognizant fault detection and monitoring systems;
- enable dependable train operation, performance, and service through advanced design of rail system operations;
- help administrators develop credible and sustainable transport strategies and enhance the image of HSR and metro safety and

本項目的研究目標為：

- 通過實施智能感知故障監測和監控系統來保障運輸安全；
- 通過對鐵路系統運營的先進設計，實現可靠的列車運行、性能以及服務；
- 幫助管理者制定可靠和可持續的運輸策略，提升高鐵、地鐵在安全與可靠性方面的管理

Annual Workshop on Railway Operation for Safety and Reliability
鐵路安全可靠性年度研討會

reliability management. This project will serve as a prototype that can be migrated to other networking and transport systems such as shipping, air traffic, electric power grid management, health care systems, and supply chain management.

形象。該項目作為一個技術原型，可被遷移到其他網絡和運輸系統，如航空、空中運輸、電網管理、醫療保健系統和供應鏈管理。

Abstract of the Project
項目簡介

Large network systems for electricity transmission, passenger transport, supply chain management, internet connectivity, finance and other applications may be increasing in complexity rapidly such that it is difficult to ensure their safety, reliability, and efficient operation. Monitoring technologies have developed just as rapidly, yielding large quantities of data. Massive challenges loom, however, in the synthesis of monitoring techniques with effective ways to mine the resulting data for information that can be acted on quickly and effectively.

Hong Kong has a reputation for innovation, dependability, efficiency and accountability in business services. Our project seeks to extend Hong Kong's advantages by establishing it as a center of expertise in safety, reliability, and efficient management of complex network systems. We will focus specifically on high-speed rail (HSR) and urban (metro) train systems. It is anticipated that the project results will be extendable to other complex network systems.

Our world-class team has expertise in the rapidly developing interconnected fields of remote sensing and monitoring, real-time probabilistic and statistical analysis of large, high-velocity data streams, and decision-theoretic techniques for economical operation of safe, reliable engineering systems. The proposed research focuses in two areas: ensuring safety and reliability of HSR and metro engineering systems; and ensuring safe and efficient management of passenger capacity, demand, scheduling and pricing. We will also prescribe decision processes for disaster management and rescheduling in the event of disruptions.

大型網絡系統被廣泛應用於電力傳輸、客運、供應鏈管理、互聯網聯通、金融等領域，其快速增長的複雜度對網絡的安全、可靠和高效運行提出了挑戰。與此同時，迅猛發展的監測技術為我們提供了大量的數據。因此，為了能夠及時、有效地對監測結果做出反應，需要將監測技術與數據挖掘方法相結合。然而在此過程中，目前仍存在諸多問題亟待解決。

香港在商業服務方面以創新、可靠、效率和負責任著稱。我們希望將香港建設成複雜網絡系統安全性、可靠性以及有效管理領域的研究中心，從而擴大香港的優勢。在本課題中，我們將重點關注高速鐵路和城市（地鐵）鐵路系統。研究結果將為其他複雜網絡系統的發展提供參考和借鑒。

在遙感與監測、大型高速數據流實時概率和統計分析、以及安全可靠工程系統經濟運行的決策理論技術等快速發展的交叉領域，我們有著世界一流的研究團隊及豐富的研究經驗。本課題的研究內容包括兩個方面：1.保障高鐵和地鐵工程系統的安全性和可靠性；2.建立安全高效的客運量、需求、調度和價格管理機制。此外，我們還將為災害管理和突發事件應急調度的決策程序提供建議。

Research Impact
研究影響

This project capitalizes our team's unique expertise to address issues in the safety, reliability, and efficiency of metro and HSR. We are a team of experts combining knowledge in the extremely rapidly developing interconnected fields of remote sensing and monitoring, real-time probabilistic and statistical analysis of large, high-velocity data streams, and decision-theoretic techniques for economical operation of safe and reliable engineering systems.

Our project team had strong links with industry and external organizations. We had collaborated with rail operators, regulatory authority, and peer research groups. Our global collaborations ensure that results will be communicated internationally, particularly to Asia Pacific. Results would be disseminated through well-established international conferences and consortium on Safety and Reliability Management in HSR Systems. To generate economic and social impacts, we would share research results and technologies with a broad array of potential stakeholders. Major research results and technologies would be first documented through patents, copyrights, or publications before dissemination. Over 80 papers were published in refereed journals in various disciplines.

依托團隊特有的專業知識，在本課題中，我們力圖解決影響地鐵和高鐵運行安全、可靠和效率的問題。在遙感與監測、大型高速數據流實時概率和統計分析、以及安全可靠工程系統經濟運行的決策理論技術等快速發展的交叉領域，我們的專家團隊經驗豐富。

我們的項目團隊與業界和外部組織建立了緊密的聯繫，與多個國家的鐵路運營商、監管機構和同行研究機構保持著良好的合作關係。我們的全球合作促進了研究成果在國際上，特別是在亞太地區的傳播交流。最新的研究進展會通過公認的國際會議，以及高鐵系統安全和可靠性管理聯盟進行公布。為了使科研成果轉化為經濟和社會效益，我們將與眾多潛在利益相關者分享研究成果和技術。在成果發布之前，我們會申請相關的專利、版權或編寫出版物。目前，我們團隊在不同學科的同行評審期刊上已發表論文80餘篇。

Collaboration with CRRC Corporation and State Key Laboratory of Traction Power, Southwest Jiaotong University

與中國中車股份有限公司及西南交通大學牽引動力國家重點實驗室合作交流

Collaboration with State Key Laboratory of Rail Traffic Control and Safety, Beijing Jiaotong University

與北京交通大學軌道交通控制與安全國家重點實驗室合作交流

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