THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

PolyU Academy for Interdisciplinary Research
香港理工大學高等研究院

RIAIoT

人工智能物聯網研究院

Research Institute for Artificial Intelligence of Things

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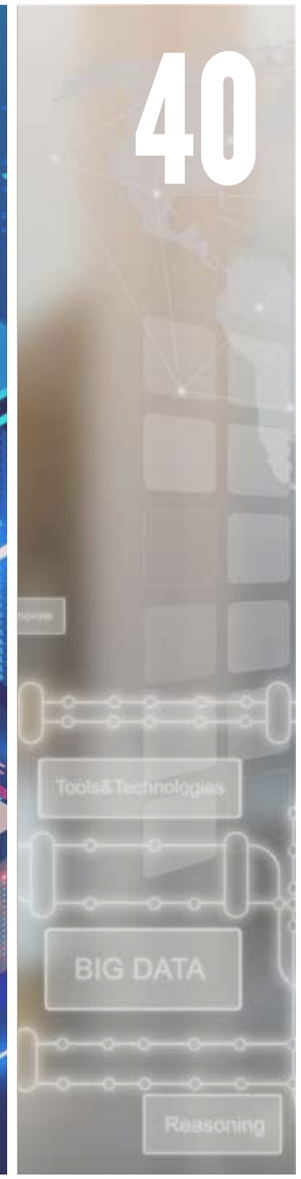


International Advisory Committee

Vision & Mission

Vision

Be a world-leading institute in providing the next-generation AI-empowered IoT solutions, enabling smartly connected societies with ground-breaking innovation, and contributing to the sustainable urban development with energy, cost, and operational efficiencies for improved quality of life.

Mission

To foster synergies within the university community by conducting interdisciplinary research in solving challenging problems and excelling in their aspirations with world-class outputs.

To pursue transformational and translational research by converging the power of AI and IoT in building a smartly connected society benefiting Hong Kong, Mainland China, and the rest of the world.

To nurture technology innovators and problem solvers in the next-generation IoT through collaborative research and innovation.

To establish and become a focal point of an international network striding on the next-generation smart IoT for partnership and alliances with academia, industry, and government bodies all over the world.

Director's Message

It is my pleasure to welcome you to the Research Institute for Artificial Intelligence of Things (RIAIoT) of The Hong Kong Polytechnic University (PolyU).

"Artificial Intelligence of Things" (AIoT) is to make the Internet of Things perform intelligent tasks through the integration of AI. The IoT-driven digital transformation is continuing around the world, integrating devices in the physical world with the virtual world, enabling seamless connectivity and the process of identifying, sensing, computing, and controlling physical systems. AIoT empowers IoT with intelligence, making almost everything smarter, including digital devices, machines, vehicles, and robots. With the big data generated by IoT sensors, networks, and applications, AIoT can capture complex and intricate patterns and reveal hidden knowledge in order to make predictive decisions. AIoT has become one of the main focuses of technology development in Hong Kong, and the government is committed to keeping pace with advancements in AIoT in order to build a smarter and more connected society.

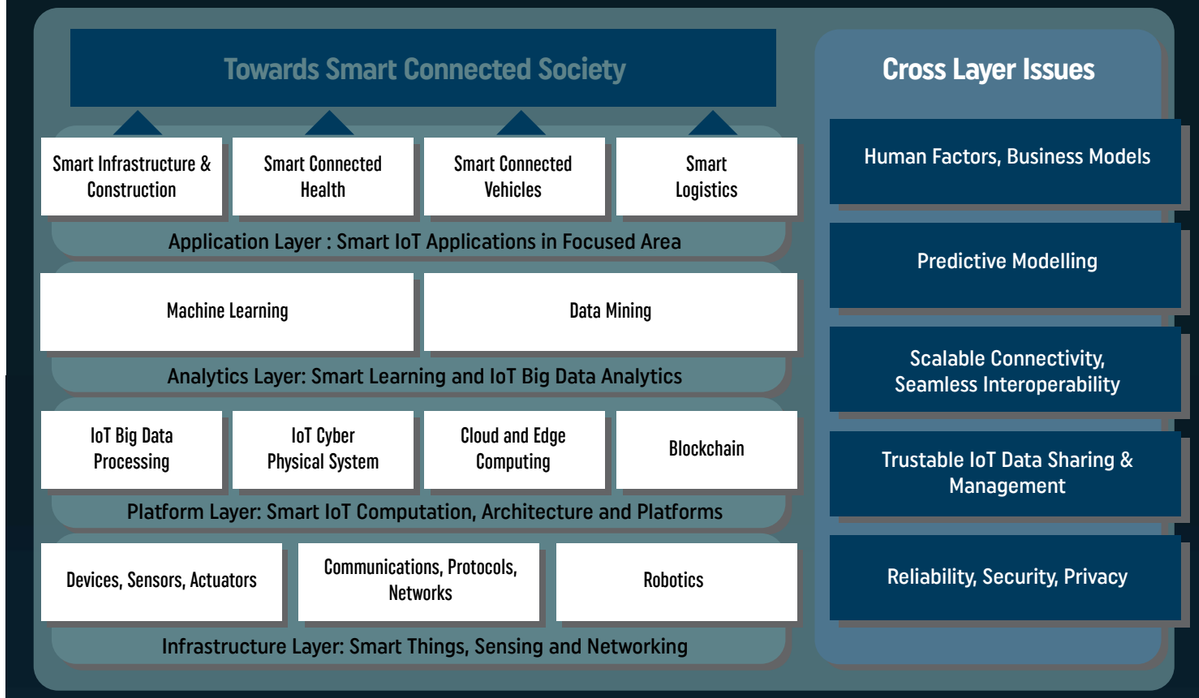
In this regard, PolyU established RIAIoT in May 2021, one of the constituent research units of the PolyU Academy for Interdisciplinary Research (PAIR). RIAIoT is a cross-disciplinary research platform developing next-generation smart IoT empowered by AI. Currently, RIAIoT consists of 41 members from 18 departments of 7 faculties and schools, and is affiliated with 6 labs and research facilities. Being the first research institute in the field run by a local university, we are committed to becoming a world-leading research institute that advances and transfers knowledge through research, public education, and professional service to address the challenges in AIoT, for the benefit of humankind.

RIAIoT is young, dynamic, and distinctive. We are living in a world where technology is evolving rapidly, and grand challenges facing humans today need solutions beyond individual disciplines. As the director of RIAIoT, I encourage you to join us in breaking traditional academic boundaries and broadening our reach through partnerships within the community, industry, and academia in Hong Kong and beyond.

Jiannong Cao, PhD; MAE, FIEEE, FCCF, DMACM
Director, Research Institute for Artificial Intelligence of Things
Dean, Graduate School
Otto Poon Charitable Foundation Professor in Data Science
Chair Professor of Distributed and Mobile Computing
Director, Internet and Mobile Computing Lab
Associate Director, University Research Facility in Big Data Analytics
The Hong Kong Polytechnic University

Research Areas & Strengths

We adopt a problem-driven approach, which begins with the identification of challenging problems in our focused application fields and with a sense that the solution is amiss with existing knowledge and technology and requires exploration. We will develop advanced solutions to address the challenges in our focused application fields using cutting-edge technologies, including machine learning, big data analytics, cloud and edge computing, blockchain, and robotics.



Multi-layer Research Framework

Infrastructure Layer: Smart Things, Sensing, and Networking.

In the infrastructure layer, we will design new hardware and fundamental protocols to support the AIoT applications. More specifically, new sensors with communication protocols will be designed to collect the environmental and personal data that cannot be collected before (e.g., precision gas detection), new robots will be developed to perform critical tasks that are dangerous and even infeasible for human beings (e.g., monitoring construction sites), and new actuators will be deployed to facilitate real-time controlling of the cyber-physical systems. Besides, we will proactively negotiate with the corresponding organizations, communities, and governments to setup the new standards for the AIoT applications.

Platform Layer: Smart IoT Computation, Architecture, and Platforms.

In between the intelligent algorithms and AIoT hardware, a platform is needed to secure the vulnerable devices, transfer the data in real time, and host the intensive computation. We will leverage the cutting-edge technologies of blockchain, edge computing, and data center to develop an integrated platform for AIoT data transmission, storage, and processing with high efficiency, security, and authenticity. Meanwhile, we will develop new algorithms and mechanisms to accommodate the AIoT hardware and computation that are with numerous data origins, variant data speeds, and heterogeneous data formats.

Analytics Layer: Smart Learning and IoT Big Data Analytics.

A large volume of data generated from smart IoT applications need to be handled to support smart decisions. The data can hardly be handled by existing machine learning and big data analytics models for the following reasons. On the one hand, the data are domain-specific and are rarely considered in the corresponding domains, e.g., construction sites, tall buildings, clinical organizations, smart vehicles, and supply chains. Second, the data are streaming IoT data, in which each piece is small but the full data are extremely large in volume and keep expanding. We will develop advanced and intelligent models, algorithms, and approaches to process the AIoT data to support the up-stream applications.

Application Layer: Smart IoT Applications in Focused Areas.

We have identified four focused application fields with the potential for contributing to the needs of Hong Kong and the world, namely smart infrastructure and construction, smart connected health, smart connected vehicles, and smart logistics. They are facing great challenges and urgently need solutions leveraging AIoT.

Smart construction: the intelligent design, construction, operation and maintenance of construction assets to improve safety and productivity, reduce costs, and maximize user benefits;

Smart infrastructure: efficient and intelligent monitoring, management and utilization of infrastructure resources, including land, water, sky, electricity, and buildings with applications such as environmental protection, advanced connected streets, smart parking, smart lighting, and smart transportation.

Smart connected health: the acceleration of the development and integration of IoT and AI to support the transformation of health and rehabilitation.

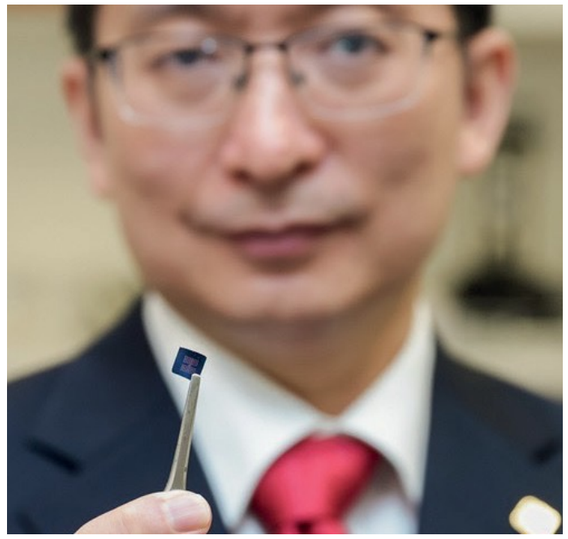
Smart connected vehicles: the vehicles that use various networking technologies to communicate with the driver, other cars on the road, roadside infrastructure, cloud, pedestrians, and finally everything.

Smart logistics: the combination of traffic management structuring and navigating traffic for optimal use of traffic system and logistics management by effective usage of data.

Research Areas & Strengths

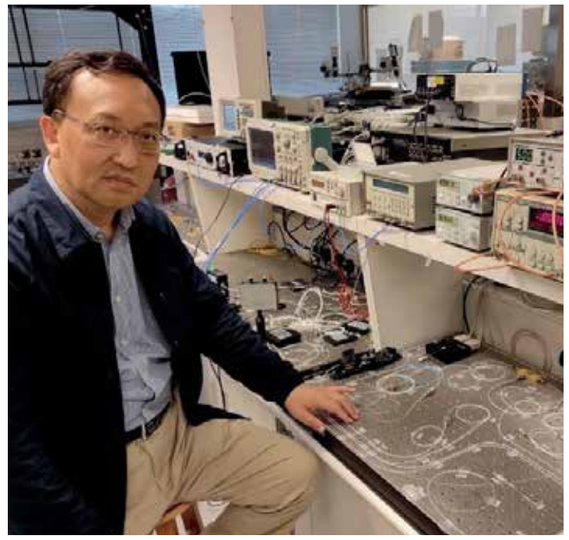
Multi-layer Research Framework

Infrastructure Layer : Smart Things, Smart Sensing & Networking



Near-sensor and in-sensor computing. Conventional digital image sensor generates large redundant data and occupy huge storage space with high power consumption. By adopting an optoelectronic memory synaptic device, Dr. Yang Chai and his team have developed a novel neuromorphic vision sensor that has the potential to help solve this problem through direct image pre- processing at the sensing devices. This technology incorporates directly image storage and pre- processing functions into image sensors, achieving a breakthrough in hardware-based artificial vision. In addition, it can be beneficial for the future development of edge computing and largely reduce the image processing load at the cloud.

Micro and nano-structured optical fibers for precision gas detection. Prof. Wei Jin's group developed an advanced gas sensing technique - Mode-phase-difference Photothermal Spectroscopy (MPD- PTS), and achieved PPT (parts-per-trillion) detection limit with 8 orders of magnitude dynamic range. This is another 2 orders of magnitude improvement over the state-of-the-art. This impressive work in optical fiber gas sensor has been reported in the journal Nature Communications on 12 February 2020. The reviewer of the journal commented that MPD-PTS is a landmark technique in fiber-optic gas sensing.



Future Edge Computing

Prof. Jiannong Cao and Prof. Song Guo envision that the future networking infrastructure will be the collaborative edge computing with intelligence.
Their teams have studied and proposed scheduling solutions for different resource management problems in edge computing, including task partitioning, computation offloading, and data dissemination. We are also working on developing EdgeOS service to support collaborative scheduling for jointly managing resources in the distributed edge computing environments. On top of EdgeOS, we develop solutions for distributed training and inference at the resource-constraint edge devices.

We are also developing a real-world prototype to test the efficacy of our proposed solutions for applications like collaborative real-time video surveillance.

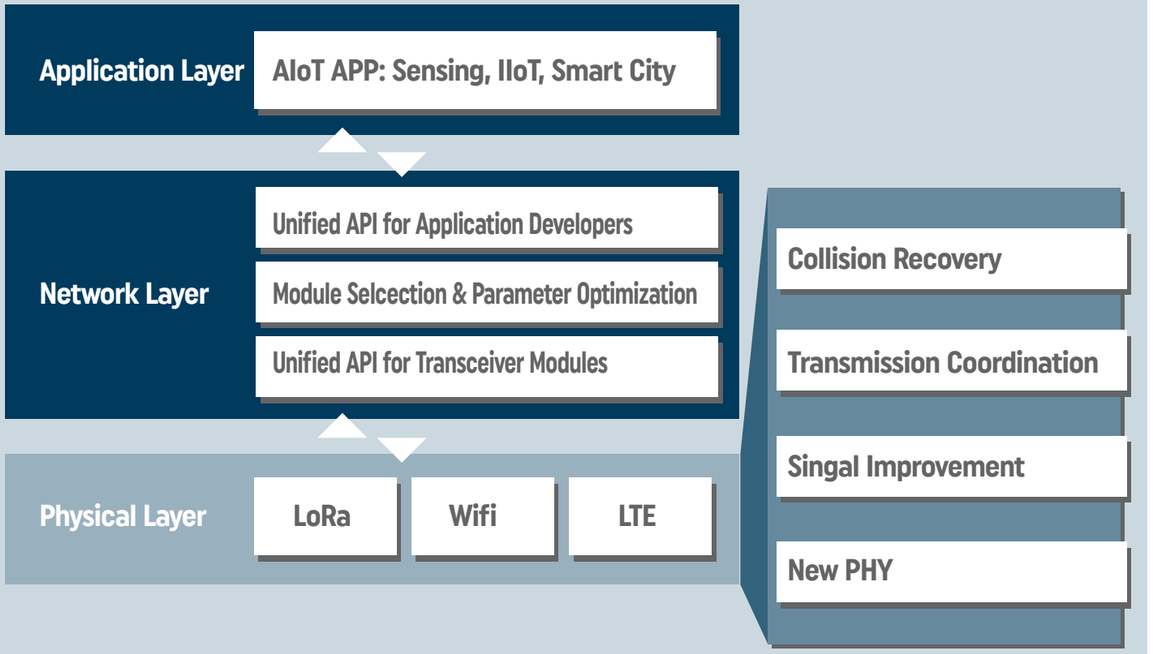
Research Areas & Strengths

Multi-layer Research Framework

Platform Layer : Smart IoT Computation, Architecture & Platforms

Future AIoT Network Connections Network Connectivity as a Service for Heterogeneous AIoT Infrastructure

Dr. Yuanqing Zheng propose to develop an easy-to-use APIs for AIoT application developers to send and receive data over heterogeneous AIoT networks, so that they can focus on application logic rather than underlying network infrastructure. The project will leverage machine learning algorithms to automatically select and configure transceiver modules to meet application requirements.

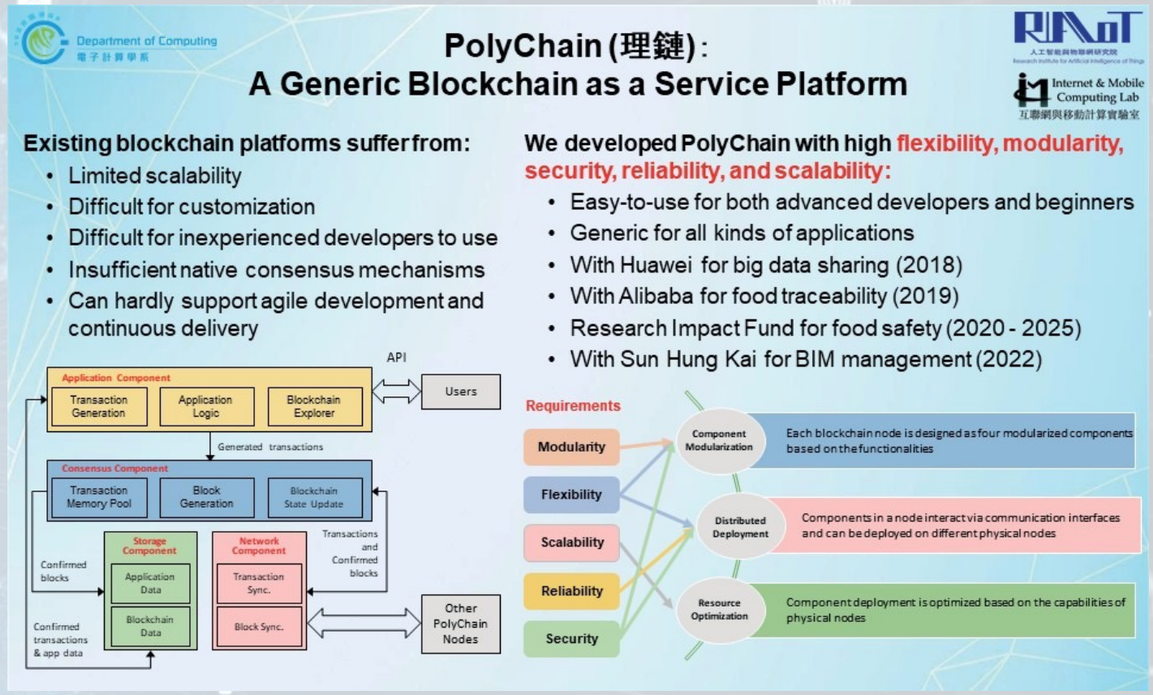


AIoT vulnerability discovery

Dr. Daniel Luo and his team have been in the area of software security for years with the topics in discovering vulnerabilities of IoT systems, context-aware intrusion detection system for vehicles, dissecting sophisticated mobile malware, security assessment of blockchain smart contracts.

PolyChain : A Generic Blockchain as a Service Platform

Prof. Jiannong Cao, Dr. Shan Jiang, and their teams proposed and developed PolyChain, the first service-oriented blockchain solutions for various applications with high modularity, flexibility, scalability, reliability, and security. The solutions result from close collaborations with Huawei for big data sharing, Alibaba for food traceability, PolyU CSFO for sustainability ecosystem, SHKP for decentralized management of building information models, etc.



Privacy Awareness in AIoT-related User Experience Design.

To protect the data privacy, users need to notice the data collection, understand the usage and sharing, alongside the potential risks. Additionally, IoT devices may have indirect interactions with each other by manipulating the physical factors. In such a sophisticated context, conventional privacy designfor single device faces great challenges.

Prof. Stephen Wang proposes to focus on the data transparency design in the AIoT environment to enhance the users' privacy awareness. A profile for the AIoT device will be designed with the help of program analysis and natural language processing to facilitate the user understand device's privacy practice. Then, according to the generated AIoT profiles, the data entanglements among the devices could be extracted to form a dependency network of the devices. Based on the visualization and interaction medium design, the dependency graph could help the users perceive and understand the data entanglements among the devices, as well as the consequences.

Research Areas & Strengths

Multi-layer Research Framework

Analytics Layer : Smart Learning & Big Data Analytics

Infrastructure Layer : Smart Things, Smart Sensing & Networking

AI-empowered Health Monitoring of Large-scale Structures

Increasingly developed large-scale and complex civil infrastructures, such as long-span bridges and high-rise buildings, need huge investment and are critical to economy in highly urbanized regions such as Hong Kong, the Greater Bay Area, and beyond. Civil infrastructures inevitably suffer from environmental corrosion, long term fatigue, and natural or man-made hazards during their service life. It is therefore imperative to understand the structural condition in real time, alert the owners as early as possible for potential damage, and provide cost-effective maintenance and management suggestions to prevent catastrophic collapse, extend the service life, and reduce the life-cycle maintenance cost.

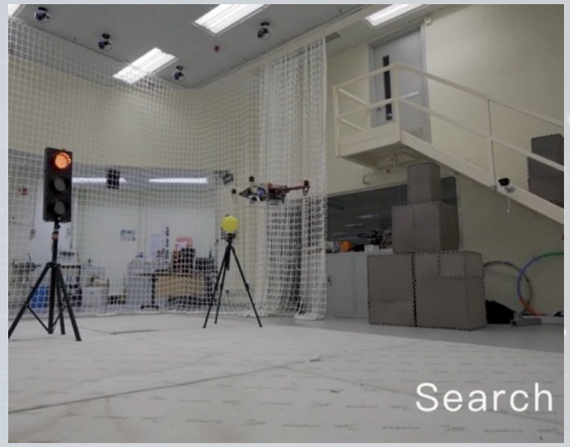
The recently developed real-time structural health monitoring (SHM) technology is a cutting-edge technology of civil infrastructures by collecting the load data, environmental factors, and responses of the structure from a sensor network; assessing the structural safety condition; and guiding the maintenance and inspection. Existing SHM systems are far from mature due to several challenges. First, algorithms for automatically processing and analyzing the massive multimodality data received from SHM systems are lacking. Second, assessing the safety condition and detecting possible damage of large-scale structures are difficult, given a large number of structural components, the limited number of sensors and the complicated uncertain environment.

Our research aims to overcome these challenges by developing an AI-empowered SHM strategy through four closely-linked tasks, regarding data analytics, numerical models, condition assessment, and maintenance strategy. We will apply relevant research outputs to large-scale infrastructures, such as Hong Kong-Zhuhai-Macao bridge and Canton Tower, etc.

Infrastructure Layer : Smart Things, Smart Sensing & Networking

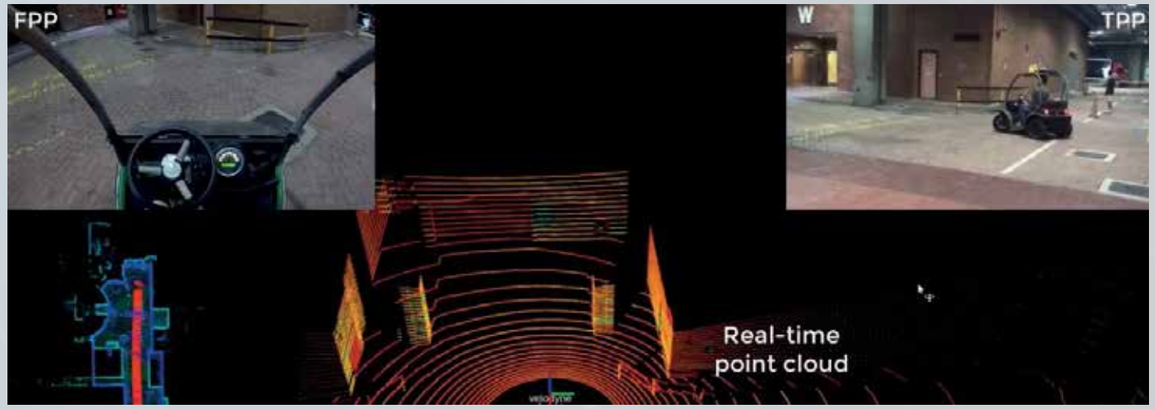
Deep Learning-based UA

Deep learning is a subfield of machine learning based on a set of algorithms that attempt to understand data like human being. Prof. Chih-Yung Wen, Dr. Li- ta Hsu, and their team applied deep learning to solve different UAV problems, such as end-to-end perception, navigation, and control. Prof. Chih-Yung Wen and his team have developed a UAV system for autonomously performing electrical and mechanical device inspection. The proposed system relies on learning-based detection for perception, multi-sensor fusion for localization, and path planning for fully autonomous inspection. The perception method utilizes semantic and spatial information generated by a 2-D object detector. The information is then fused with depth measurements for object state estimation. No prior knowledge about the location and category of the target device is needed.



Autonomous Driving inside PolyU Campus

Prof. Chih-Yung Wen, Dr. Li-ta Hsu, and their team have proposed methods for (1) simultaneous localization and mapping (SLAM) using 32 Channel LiDAR scanner and (2) smooth PID control of the vehicle. The test is conducted by the PNT lab in Hong Kong Polytechnic University.

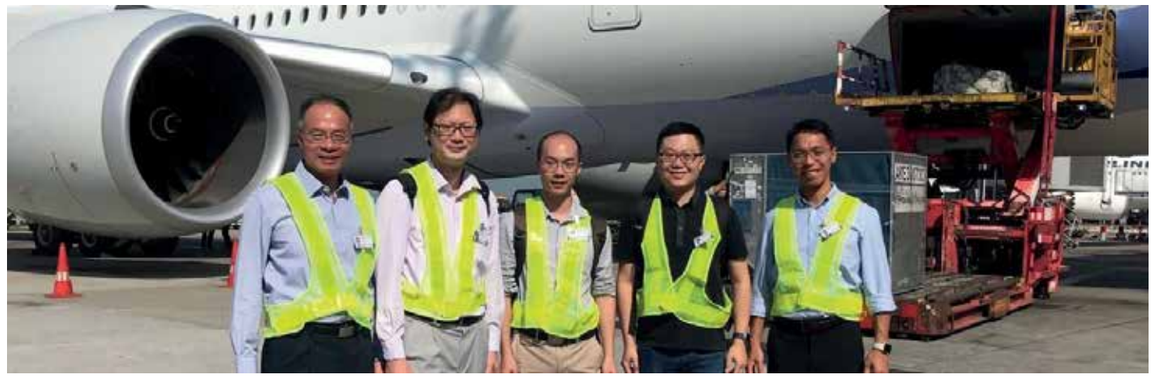


Research Areas & Strengths

Multi-layer Research Framework

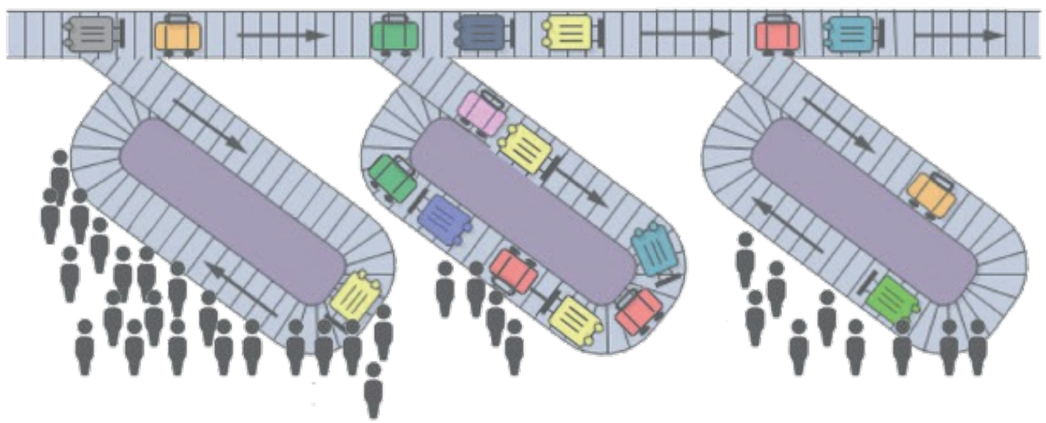
Analytics Layer : Smart Learning and IoT Big Data Analytics

Big Data - Driven Airport Resource Management



Intelligent resource scheduling for complex systems. Due to the complexity of airport operations, it is extremely difficult for airports to well allocate available resources for meeting the huge and growing passenger throughputs. Prof. Jiannong Cao and his team have developed a big data engine, called BigARM, equipped with powerful big data analytics and AI techniques to achieve efficient and intelligent airport recourse management. BigARM collects real- time flight data, airfield operation data and various external data. With these data, an operational factor analytics module is developed for BigARM to uncover the underlying patterns in daily airport operation from different angles, e.g., passengers, airport operators and resources.

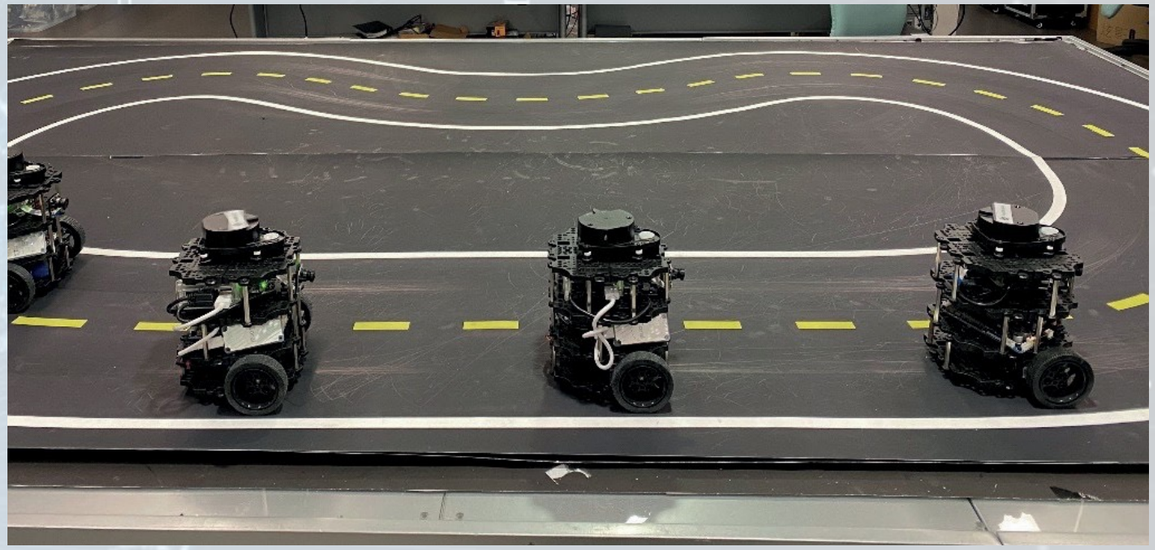
With such discovery, BigARM further develops a reinforcement learning-based method to make smart resource allocation plans and recommend real-time adjustments in a complex and dynamic environment, aiming to achieve balanced airport resource allocation. Compared to the airport's existing practice, BigARM achieves over 30% and 64% more accurate results respectively in predicting the arrival time and bag counts for upcoming flights, 12% more balanced resource utilization, and reduces the allocation plan generation time from hours to seconds.



Over-crowded belts, inefficient carousel utilization, long waiting time

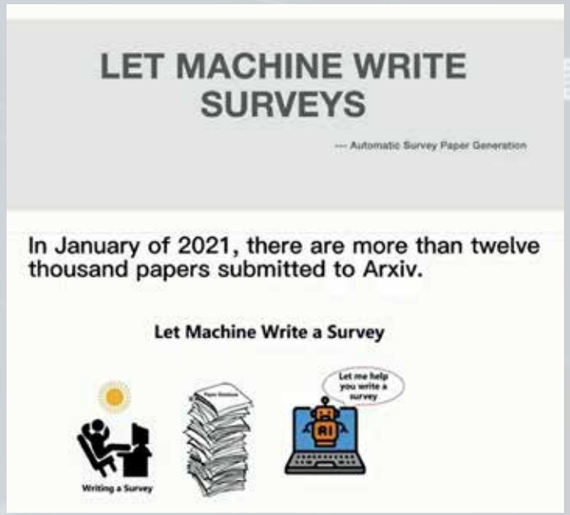
Distributed Reinforcement Learning for Autonomous Robot Cooperation

We aim to develop intelligent robots that can learn cooperative strategies from interactions with others. Specifically, we investigate the challenges of learning cooperation in a distributed way such as: partner modeling, partial observation problem and large-scale multi-robot system.



Auto Survey Generation

Survey paper generation faces great challenges from cognitive linguistics and natural language processing. Prof. Jiannong Cao and his team have investigated this problem with automatic generation only from references. In the view of Cognitive Linguistics, references taxonomy and the writing logic are non-trivial, while the difficulty in NLP lies in the document-level text generation with well- organized structure. Inspired by the writing process of human beings, we split this problem into three sub-problems: automatic references taxonomy, survey outline generation, and section content generation. We first proposed a pre-trained language model by adding pre-train tasks to extract information for sub-problems. Then for each sub-problem, we propose several possible solutions and attempt to tackle their challenging issues. Compared with existing works, the innovation parts are (1) our results preserve the hierarchical structure of survey papers, which provides clear content organization, and (2) we integrate the knowledge of writing logic in the generation process to make the result more readable.



Research Areas & Strengths

Multi-layer Research Framework

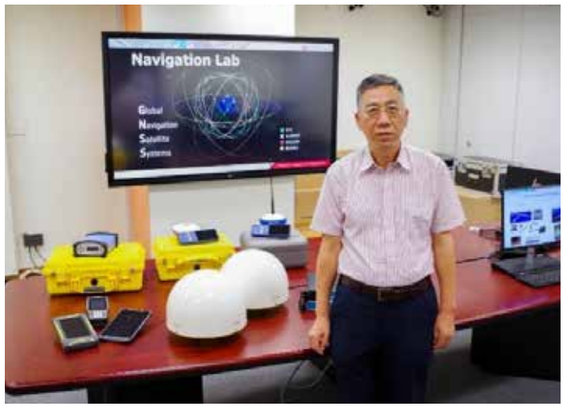
Application Layer : Smart IoT Applications in Focused Area

Smart Infrastructure and Construction

How the Research Contributes to fulfilling the Visions and Missions of RIAIoT

AI-empowered Health Monitoring of Large-scale Structures research project aims at developing the next generation of Structure Health Monitoring (SHM) framework with the aid of the powerful Artificial Intelligence (AI) and Internet of things (IoT) techniques. It focuses on developing AI-empowered data analytics for processing multimodality field monitoring data of large-scale structures automatically and accurately; establishing high material, load, and bridge models for structure safety condition assessment by integrating advanced numerical analysis and field motioning data from sparse sensors; developing a multistep transfer learning-based damage identification technique and a hybrid deep learning-based structure rating system; and optimizing structure maintenance framework by utilizing quantitative damage identification results, inspection data, and deep reinforcement learning. To achieve our goals, deep cross-disciplinary collaboration with academic researchers in relevant fields is necessary and highly encouraged. Hopefully, our research is able to benefit the society by assessing the structural condition in real-time accurately, alerting the potential structural damage promptly, and providing cost-effective maintenance and management suggestions to prevent catastrophic collapse, extend the service life, and reduce the life-cycle maintenance cost. The practical application of this new-developed technique will also promote our collaboration with the industry community and Hong Kong government, leading the development of SHM techniques in the future.

Global Navigation Satellite Systems (GNSS) have become the fundamental infrastructure to support economic development globally. However, GNSS does not work well in urban areas, as GNSS signals can be blocked or blocked by the nearby buildings. The positioning error of tens of meters can occur in the dense city regions due to the multipath effect, which restricts the applications of positioning technologies in Hong Kong. Prof. Wu Chen and his team have developed an integrated solution to solve the multipath problem in Hong Kong. It integrates multiple sensors, including Micro-electromechanical Systems sensors, WIFI, and multiple GNSS constellations (i.e. GPS, Beidou, GLONASS, and other available satellite navigation systems), together with 3D city model, to significantly reduce multipath effect by using advanced fusion algorithms and multipath modeling. This leads to seamless positioning service in both open area and dense building regions for Hong Kong. The accuracy can be within 10 m with smartphones and up to 10 cm when specialized receivers are used. A powerful cloud server ensures positioning is updated in real time, supporting various smart city functions.



Prof. Li's research mainly focused on the IoT applications in Smart Infrastructure and Construction area. The aforementioned projects focused on adopting sensing, information modelling, and visualization technologies to improve construction projects in terms of quality, safety, and productivity. These projects contribute to achieving the vision & mission of RIAIoT as follows:

1

To explore and develop new intelligent IoT-enabled techniques for applications in construction and infrastructure management. In recent years the Hong Kong construction industry has also witnessed a series of incidents related to certain high-profile mega-projects. These incidents have included unsatisfactory cost performance, commissioning delays, site safety incidents and in a more recent case, alleged issues related to the quality of construction delivery. To address these challenges and ensure a bright and prosperous future, the Hong Kong Government is taking the initiative to be a leading agent for change. This is presented in Construction 2.0 –an expression of the Industry changes required across three key pillars: Innovation, Professionalization and Revitalization. Prof. Li's projects have introduced new intelligent technologies (e.g., image processing, Building Information Modeling, and digital twins) in construction management, which significantly contributed to the Construction 2.0 in Hong Kong.

2

Pursuing transformational and translational research bringing the power of AI to Hong Kong construction industry. Prof. Li's projects contributed to transforming the construction management practice to be a population-based, intensive, and proactive process; it will improve resource productivity, reduce resource waste and progress lagging, as well as improve project performance. Additionally, these projects have the potential to improve the competitiveness of the Hong Kong construction industry. The success of this project could also promote creativity and innovation.

3

To build and be a key point of an international network on the next generation smart IoT for exchanges and collaborations with academia, industry, and government over the world. Prof. Li's projects and research have been internationally recognized and won several awards, such as 2018 Best Paper Award of Journal of Computing in Civil Engineering and 2019 Gold Medal in the 47th International Exhibition of Inventions, Geneva, Switzerland. Meanwhile, the research outcomes delivered from these projects have benefited multiple local construction companies in Hong Kong, such as Chun Wo Building Construction, Hailong Construction Technology, Harbour Group, and Openplatform Technology. The Smart Construction Laboratory (SCL) leaded by Prof. Li has 1 Chair Professor, 3 Research Assistant Professors, 2 Postdoctoral Fellows and 7 other researchers. The Lab has won 5 regional and international prizes by far. The SCL has become one of the leading groups in the research area of smart construction internationally.

Research Areas & Strengths

Multi-layer Research Framework

Application Layer : Smart IoT Applications in Focused Area

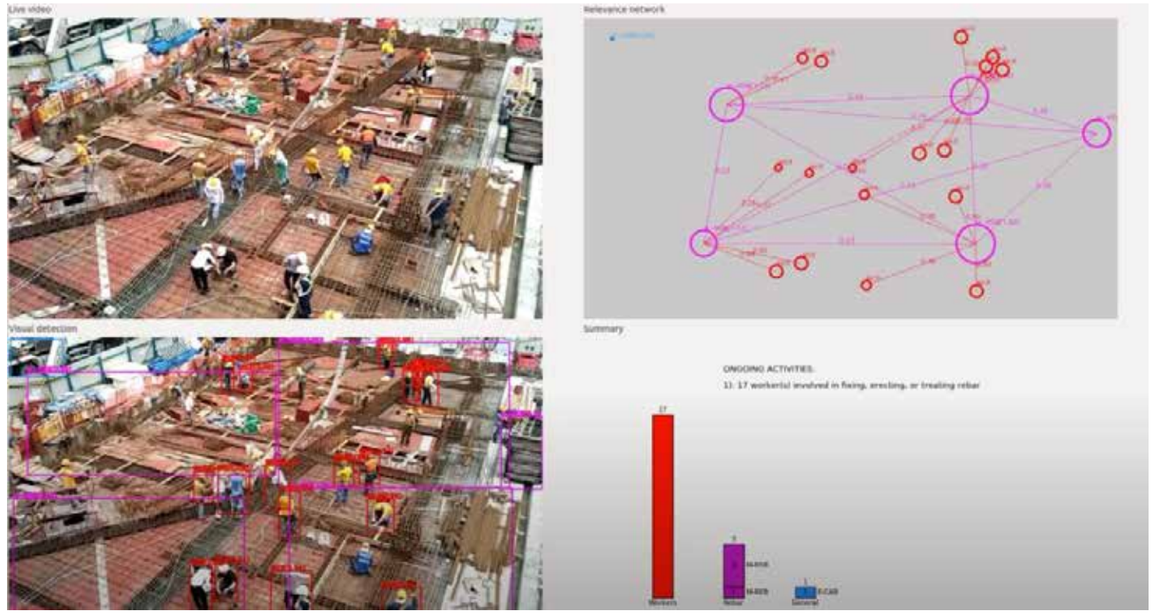
Smart Infrastructure and Construction

Enabling technologies based on computer vision and machine learning for better quality management on construction sites

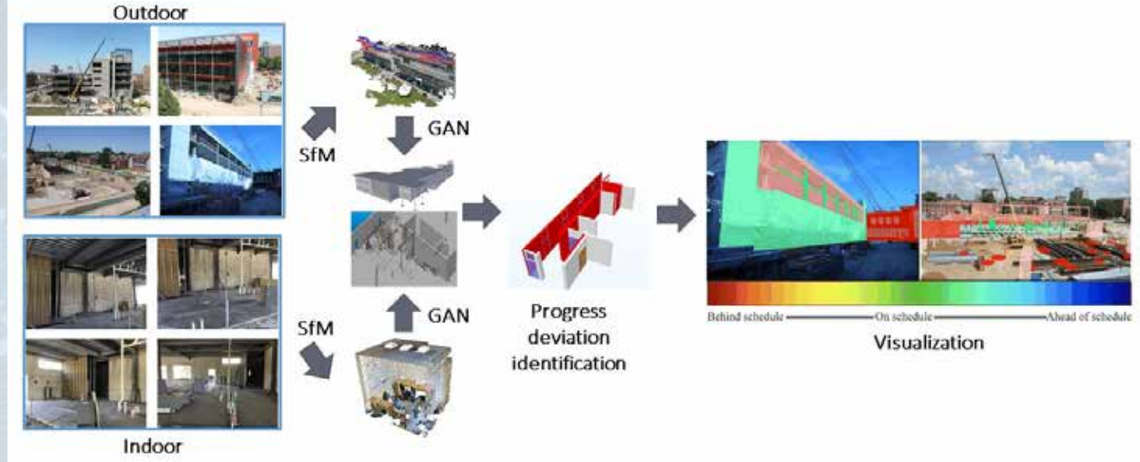
Quality deviations are common phenomena in the Hong Kong construction industry and they cannot be effectively managed by conventional methods. Quality deviations can cause significant cost overruns and project delays, and even become threats to public health and well-being. Specifically, this project aims to develop computer vision (CV) based technologies with machine learning (ML) to transform the current manual quality management practice to an automatic process. The enabling technologies will analyse site activities; real-time captured by surveillance cameras, and then utilize machine intelligence to determine if there are any quality deviations and/or defects within these site activities.

This study represents a novel development and adaption of CV and ML to liberate human inspectors from tedious site inspections and manual documentation.The developed technology can eliminate the root causes of quality deviations in construction projects. The technology is non-intrusive, and it requires little additional costs (surveillance cameras are already commonly installed in sites) in its implementation. The estimated cost of upgrading an average security surveillance camera to serve quality monitoring is around 300 HK dollars. Therefore, it possesses a great potential to be widely adopted.

Multiple organizations, including Chun Wo Building Construction, Hailong Construction Technology, Harbour Group, and Openplatform Technology, have all expressed strong interests and supports. Two trial projects are provided by the contractors. This project has been internationally recognized and won the following awards: 1) 2018 Best Paper Award of Journal of Computing in Civil Engineering; and 2) 2019 Gold Medal in the 47th International Exhibition of Inventions, Geneva, Switzerland.



A Computer Vision-enabled Digital Twin for Construction Resource and Progress Management



The construction industry has played a key role in Hong Kong and been an instrumental driver of economic growth and enabler of social development for many generations. Whilst the construction industry has a long and proud history, it has not been without its challenges, among which high costs and declining productivity have been highlighted in recent years. This has led to adverse effects on the broader Hong Kong economy and community.

The conventional construction management relies on sampling labour productivity data to form a baseline to control the overall project budget and progress. Although there are numerous diverse activities on sites, site management can only manually inspect (sample) a limited number of activities to gauge the overall cost and productivity. This error-prone process inevitably leads to mis-judgment and unnecessary resource overrun, and post-event remedies (rework). The industry is longing for a new management tool for better construction project management.

In this project, a Digital Twin technology to support construction management has been developed. Digital Twin is a concept of having a real-time digital representation of a physical object. The digital twin allows up-to-date information to be fed back to the field so as to provide automatic resource allocation monitoring and waste tracking. The technology decreases the number of errors and reworks; and allowing for a predictive and lean approach to resource management.

This project contributed to transforming the construction management practice to be a population-based, intensive, and proactive process; it improved resource productivity, reduce resource waste and progress lagging, as well as improve project performance.

Research Areas & Strengths

Multi-layer Research Framework

Application Layer : Smart IoT Applications in Focused Area

Smart Infrastructure and Construction

Global Navigation Satellite Systems (GNSS)

The urban positioning, navigation, and timing (PNT) services are crucial infrastructure for economic development. The continuous availability of the GNSS means that a wide variety of sectors and industries rely on it, such as transportation (unmanned aerial systems and intelligent transportation systems), emergency services, electric power grids, cellular communications, agriculture, finance (stock exchange systems), government and various global, regional and national infrastructures that use geodetic features. In the city level, GNSS coverage is significantly reduced, due to the fact that GNSS signals are blocked by buildings and most of human activities are in indoor environment where GNSS will not work. Moreover, GNSS signals are easy to be jammed. Therefore, there is an urgent need to develop an integrated urban PNT infrastructure to satisfy various applications, as diversified applications have different requirements.

Prof. Wu Chen proposed the PNT infrastructure development in Hong Kong. The AI technologies are used in a recent project to identify the GNSS satellites that are blocked by obstacles in dense urban areas. He developed a positioning platform based on the edge-cloud architecture for mitigating the multipath and the system errors. With the platform, a new DGNSS service is introduced for mobile users which improves the positioning accuracy from 5-10m to 2m. He also proposed to use the BLE sensors in the smart lampposts, which improves the positioning performance in urban areas. Nowadays, the GNSS signals can be jammed, and the critical infrastructures can be affected. The intelligent algorithms are also being developed to detect and locate the jammed signals.

Design and Development of an AI-based Video Analytics System: A Novel Approach

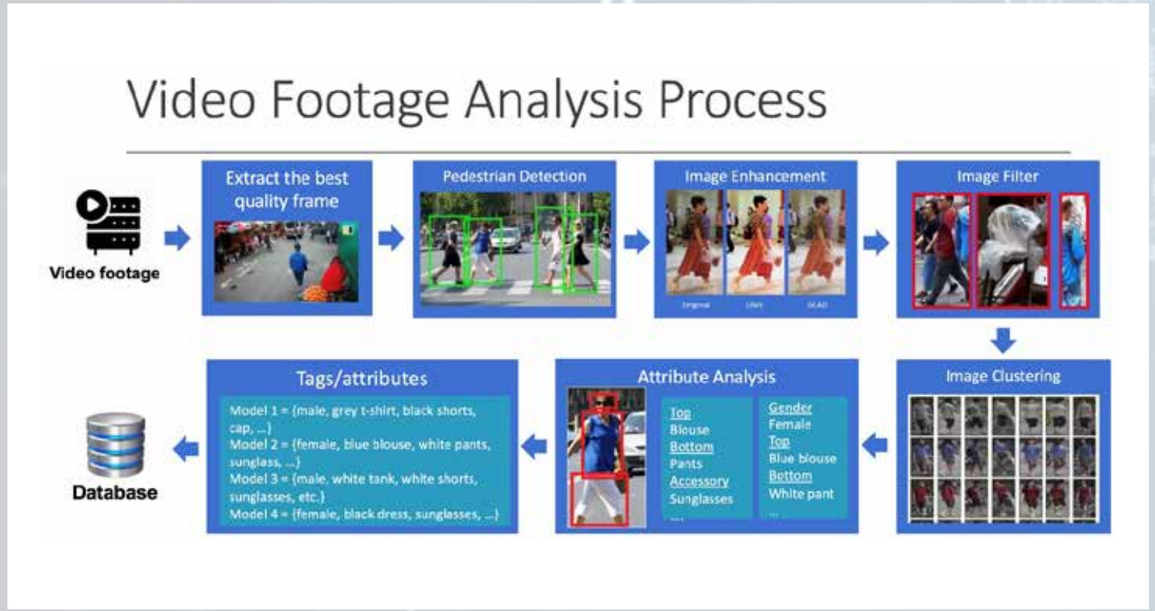
Most video analytics solutions on the market are based on face detection technology for gender and age analyses. However, in this global pandemic, where everyone wears face masks, system performance and accuracy are significantly reduced because computers no longer recognize people's faces.

The PolyU research team transferred the core technology from our self-developed clothing identification model to the video analytics system. The team developed a system that extracts full-body clothing characteristics for attribute-based analysis. This approach reduces usage restrictions and provides AI-based video analytics to support marketers and decision-making.

This one-stop video analytics is for object tracking, store traffic analysis, and visitor analytics for physical shops. The purpose is to provide a reliable and automatic approach for people detection, crowd analysis, and visitor analytics for physical shops.

Through the clothing identification model, the system can identify not only the gender and age of the target person but also a total of 68 attributes, including upper and lower body clothes, patterns, colors, accessories (bags, hats, glasses, and masks), and hairstyle, without infringing on personal privacy.

The data provided by the system can be used to facilitate various business operations, such as pedestrian flow analysis that can assist in the estimation of shop rental value and visitor analytics for shops that can help shopkeepers make strategic decisions on product display and personnel deployment.



Research Areas & Strengths

Multi-layer Research Framework

Application Layer : Smart IoT Applications in Focused Area

Smart Infrastructure & Construction

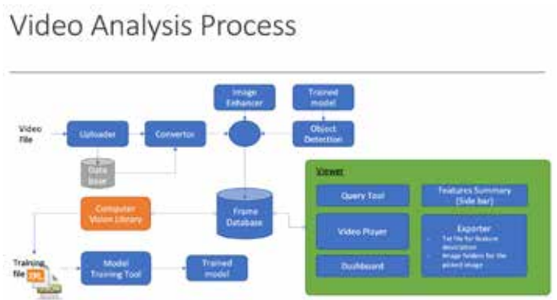
How the Research Contributes to fulfilling the Visions and Missions of RIAIoT

Motivated to address the challenges on reliability and privacy of the conventional AIoT solutions on video analytics, which are based on face detection technology, Prof. Ngai and his team developed a video analytic system based on our self-developed clothing identification model.

This innovative video analytic system integrates the power of AI into IoT by adopting a neural network to analyze the data captured by networks of video cameras installed in different venues.

Overcoming the challenge on reliability, i.e., lower performance of face detection-based video analytic systems caused by the COVID-19 pandemic with everybody wearing a mask, our system can accurately extract 68 attributes of a person captured in a video through our self-developed clothing identification model.

Overcoming the challenge on privacy, our system can extract full-body clothing characteristics for attribute-based analysis without infringing on personal privacy.



Application Layer : Smart IoT Applications in Focused Area

Smart Connected Health

AIoT-empowered Food Safety

Prof. Jiannong Cao and his team have applied AIoT-related research achievements to food safety area and tackle the critical issues including biological risks, chemical risks, and food fraud in food safety. These issues are not adequately addressed by current solutions, e.g., sampling inspection. First, although biological and chemical risks can be well detected, food status cannot be traced in a secure and authentic way to avoid food fraud.

Second, the sampling inspection is conducted by human resources, which is labor-intensive and time-consuming. Third, the sampling inspection can only detect food status while it leaves unknown which part

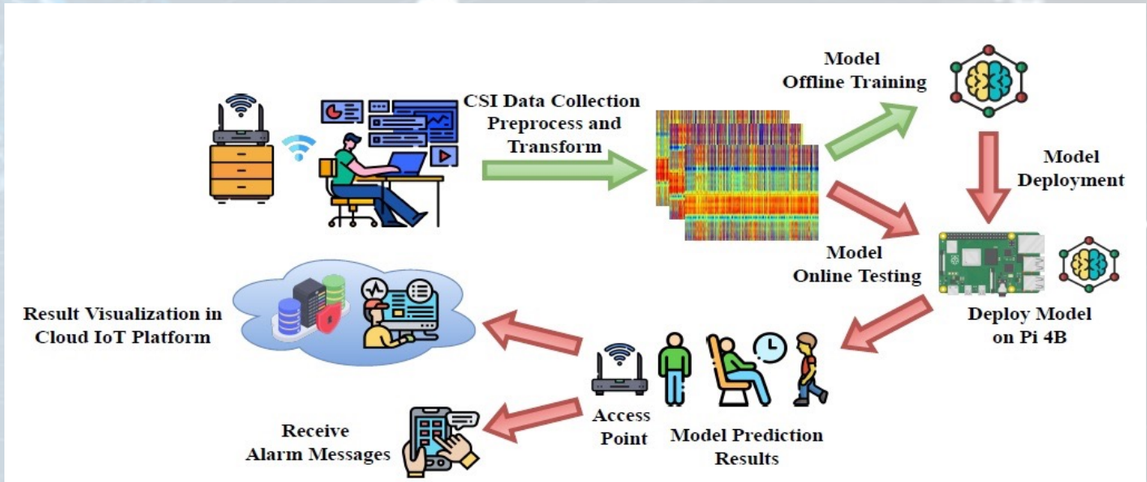
goes wrong and what the future food status will be. To tackle the above food safety issues, we develop a big data and IoT enabled system, which provides three food safety services, i.e., traceability, status detection, and risk prediction.

Application Layer : Smart IoT Applications in Focused Area

Smart Connected Vehicles

Analytics Layer : Smart Learning and IoT Big Data Analytics

Channel State Information-Learning-based Passenger Counting System on Public Transport Vehicles (Smart Traffic Fund)



There has been growing research interest in using wireless channel state information (CSI) for various wireless sensing applications, such as indoor positioning, human activity recognition, crowd counting, etc., as it can preserve user privacy and easily work with existing wireless infrastructure (e.g., Wi-Fi) at low cost. The detection performance of CSI-based wireless sensing is also prominent. For example, it was found that CSI-based indoor positioning has the potential of achieving centimeter-level accuracy even with a single anchor point only. This project aims to develop a low-cost, efficient, and robust passenger counting system via the deep learning of CSI data on public transport vehicles (e.g., buses, minibuses, etc.).

Research Areas & Strengths

Multi-layer Research Framework

Application Layer : Smart IoT Applications in Focused Area

Smart Connected Health

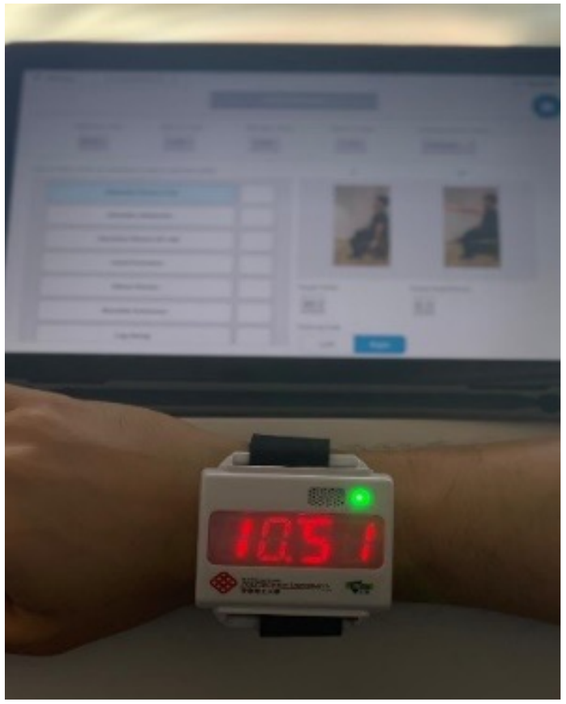
Remind-to-move (RTM)

Wearable device helping stroke patients recover arm movement. Strokes are the second highest cause of death and the third highest cause of disability worldwide. In Hong Kong, strokes are among the most common causes of hospital admissions. Stroke survivors not only account for the highest number of days spent in hospital, but 70% of them have to live with paralysis or weakness, known as hemiparesis, in their arms for the rest of their lives. To help speed up the recovery of stroke patients with hemiparetic arms, Professor Kenneth Fong, Department of Rehabilitation Sciences, has spent more than a decade developing an innovative treatment method. Professor Fong received HK$9.19 million from the Research Grants Council's Research Impact Fund (RIF) (Ref. no.: R5028-20F) in 2021 for his project "Wearable closed-loop neural control 'remind-to-move' (RTM) treatment for hemiparetic upper extremity in people with hemiplegia after stroke".

Professor Fong first developed the RTM treatment in 2009. The device uses a sensory-cueing wristwatch, which is strapped to the patient's affected arm and emits vibration signals at fixed intervals to remind the patient to do exercises as instructed by therapists. RTM was the first treatment of its kind to promote the use of a hemiparetic arm due to non-use in adult stroke patients or people with cerebral palsy. The wristwatch's built-in sensor detects and records the arm's movements for therapists to analyse. This pioneering treatment enables rehabilitation to be integrated into patients' daily lives to achieve maximum outcomes.

Eleven years later, Professor Fong developed a second-generation device which is paired up with an app that enables therapists to set time schedules for patients to exercise. Patients can then follow videos in the app to complete the exercises selected by therapists. The app also records the range of motions achieved during exercises, providing feedback for patients and therapists. The new device has been incorporated into Telerehabiliation.

Professor Fong is exploring how to enhance RTM treatment further through a third-generation device that leverages technological advances. Supported by local and Mainland industrial partners, he plans to harness kinematics, neuroscience and artificial intelligence to develop a closed-loop wearable device. It will stimulate the hemiparetic arm based on a machine learning algorithm developed by capturing the affected arm's activities and comparing them with those of the non-affected arm. The new closed-loop treatment will facilitate motor control more naturally and improve the brain's ability to adapt to the environment and adjust based on experience, enabling patients to recover better. On the scientific front, the project will enable researchers to establish the connection between patient's self-initiated movements and external assistance provided by the new device. It will also highlight the development of wearable neuroelectronic augmentation devices for patients with impaired motor functions due to neurological diseases. Alongside benefitting thousands of stroke patients, the science behind the development of this novel device will lead to further research and breakthroughs in stroke rehabilitation in the coming decades.



Application Layer : Smart IoT Applications in Focused Area

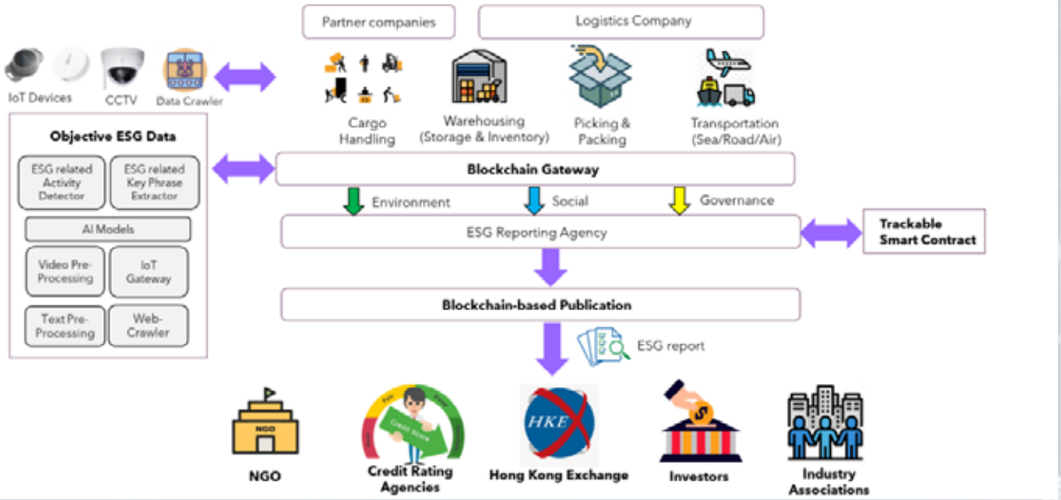
Smart Connected Health

How the Research Contributes to fulfilling the Visions and Missions of RIAIoT

Professor Fong's projects contribute to the vision and mission of the RIAIoT by developing state-of-art technology in the rehabilitation field to improve the quality of life of persons with stroke and persons with substance disorders. The paramount importance of ongoing research studies is to provide translational research involving cross-disciplinary solutions using technology and innovative healthcare. To do that, Professor Fong is building a large body of research with an extensive network in academia, industry and healthcare service by incorporating smart IoT that will benefit healthcare providers and patients.

Smart Logistics

Environmental, Social and Governance (ESG) Management – A Systems Design Approach



This study aims to investigate the ESG system architecture and propose a conceptual model of ESG management in the logistics industry. An ESG system can monitor the ESG practices and measure the ESG performance of the logistics industry, as well as evaluating both, including providing information on ESG key performance indicators. An ESG prototype system can be used to identify ESG practices and trends in the logistics industry. The proposed project intends to accomplish the following objectives: (i) analyze the complex situation of ESG management practices and performance in the logistics industry; (ii) develop a conceptual model for monitoring the ESG practices and measuring and analyzing the ESG performance of selected sectors in the logistics industry; (iii) develop a novel method for the collection and verification of ESG information through the prototype system; (iv) design and develop an AI-based ESG prototype system to investigate and analyze ESG practices and performance using the design science approach; and (v) evaluate the effectiveness of the proposed approach through experiments using real-world data and system evaluation.

Achievements & Contributions

In the first year after the establishment, RIAIoT has made significant contributions in securing external research grants, obtaining national / international awards and recognitions, and promoting knowledge transfer for adoption by industries.

External Research Grants

RIAIoT members have secured 16 projects, with the total funding amount over HK$91.6 million, from various funding bodies and donors, including Hong Kong Research Grant Council (HK RGC), Hong Kong Jockey Club, Zhong Shan HK Co. Ltd., V-Fun Co. Ltd., Innovation and Technology Commission (ITC) and HK Productivity Council (HKPC).

No.	Project Title	List of PI & Co-PIs in RIAIoT	Funding Body/Donor	Project Duration	Funding/Donation Amount (HK$)
1	Wearable closed-loop neural control 'Remind-to-move' treatment for hemiparetic upper extremity in people with hemiplegia after stroke	Prof. Kenneth Fong N.K. (PC)	HK RGC Research Impact Fund (RIF)	01/05/2021 - 30/04/2025	$13,128,572
2	Development of Next-generation Key Technologies for Smart Buildings	Prof. Shengwei Wang (PI) Prof. Jiannong Cao (Co-PI)	HK RGC Collaborative Research Fund (CRF)	01/06/2021 - 01/06/2024	$5,840,000
3	Intelligent Manufacturing-oriented Big Data Analytics across the Production Process: Methodologies and Applications	Prof. Jiannong Cao (PI)	Shenzhen-Hong Kong-Macau Technology Research Programme (Type C)	01/07/2021 - 30/06/2023	$1,100,000
4	School-based Diversity Management (DM) 2.0	Prof. Jiannong Cao (PI)	Hong Kong Jockey Club Charities Trust (Donation)	01/09/2021 - 31/08/2024	$26,690,000
5	Decentralized Model Learning with Unlabeled Streaming Data for Edge AI	Prof. Jiannong Cao (PI)	HK RGC General Research Fund (GRF)	01/01/2022 - 31/12/2024	$1,093,580
6	Donation from Zhong Shan "3D cloud point based approach to life cycle management of construction projects"	Prof. Heng Li (PI)	Zhong Shan Co. Ltd. (Donation)	01/04/2022 - 01/04/2027	$5,000,000
7	Donation from V-Fun "Benchmarking performances of prevailing e-marketing platforms"	Prof. Heng Li (PI)	V-Fun Co. Ltd. (Donation)	01/04/2022 - 01/04/2027	$5,000,000
8	Vision-based badminton Match Analysis	Prof. Heng Li (PI)	HK ITC Innovation and Technology Fund (ITF)	01/05/2022 - 31/04/2024	$7,710,000
9	User-Controlled Secure Data Sharing and Analytics with Blockchain and Trusted Computing Technologies	Prof. Jiannong Cao (Co-PI)	HK RGC Collaborative Research Fund (CRF)	01/06/2022 - 31/05/2025	$6,734,880
10	High Performance Deep Learning Clusters for Big Data Analytics	Prof. Xiaojun Chen (PC), Prof. Jiannong Cao (Co-PI)	HK RGC Collaborative Research Equipment Grant (CREG)	01/04/2022 - 01/04/2024	$3,099,659
11	Reliable Multi-Agent Collaborative Global Navigation Satellite System Positioning for Intelligent Transportation Systems	Dr. Li-ta Hsu (PI) Prof. Wu Chen (Co-PI) Prof. Jiannong Cao (Co-PI)	HK RGC Research Impact Fund (RIF)	01/06/2022 - 31/05/2025	$4,428,580
12	Intelligent Knowledge Transfer for Damage Identification of Steel Structure Using Vibration Data	Prof. Xia, Yong (PI) Dr. Wang, Xiaoyou (Co-I)	HK RGC General Research Fund (GRF)	01/01/2023 - 01/01/2025	$1,115,452
13	Smart Assessment of Bridge Deck Efficiency and Safety in Hong Kong	Prof. Tarek Zayed (PI) Prof. Xia, Yong (Co-I)	Hong Kong Productivity Council	01/10/2022 - 01/10/2024	$1,600,000
14	Channel State Information-Learning-based Passenger Counting System on Public Transport Vehicles	Dr. Ivan Ho (PI)	Smart Traffic Fund	01/01/2023 - 01/01/2025	$1,349,416
15	Cycling Track Video Intelligence	Prof. Heng Li (PI)	HKSAR Government and Hong Kong Jockey Club Charities Trust (HKJCCT)	01/08/2022 - 31/07/2025	$6,500,000
16	Prediction of Traffic Speed and Volume considering Malfunctioning Detectors using Deep Learning	Prof. Edward Chung (PI)	Smart Traffic Fund	01/01/2023 - 30/06/2024	$1,300,075

National / International Awards and Recognitions

Since the establishment of RIAIoT, the members have obtained numerous prestigious awards and recognitions, including best paper awards at major conferences and fellowship of international communities.

No.	RIAIoT Member	Name of Award / Recognition	Details
1	Prof. Jiannong Cao	Fellow of China Computer Federation (CCF)	For his outstanding contributions in distributed computing, wireless network and mobile computing, and big data analysis.
2	Prof. Jiannong Cao and Dr. Shan Jiang	Best Paper Award, International Conference on Blockchain andn Trustworthy Systems (Blocksys'2021)	For the work "PolyChain: a Generic Blockchain as a Service Platform."
3	Prof. Heng Li	The world's top 2% most-cited scientists, Stanford University Citation Ranking	World scientist ranking according to number of citations and research areas.
4	Prof. Qing Li	Fellow of Institute of Electrical and Electronics Engineers (IEEE)	For his outstanding contributions to machine learning in multimedia, data mining, and data warehousing.
5	Prof. Eric Ngai W.T.	The world's top 2% most-cited scientists, Stanford University Citation Ranking	World scientist ranking according to number of citations and research areas.
6	Prof. Yong Xia	Commendation Merit Award, The Hong Kong Intuition of Engineers (HKIE)	For the research work "Analytical solution to temperature-induced deformation of suspension bridges"
7	Prof. Yong Xia	State Technological Innovation Award, State Council, China	For his outstanding contributions in structural health monitoring, structural condition assessment and damage detection, and structural dynamics
8	Prof. Song Guo	Fellow of Asia-Pacific Artificial Intelligence Association (AAIA)	For his outstanding contributions in edge AI, big data and cloud computing, wireless networking, emergency network, mobile computing, and distributed systems.
9	Prof. Song Guo	2021 Highly Cited Researchers, Clarivate Analytics	World scientist ranking according to number of citations and research areas.
10	Prof. Song Guo	Fellow of the Canadian Academy of Engineering (CAE)	For his distinguished achievements and career-long service to the engineering profession.
11	Dr. Gong Chen	2022 Inventions Geneva - Bronze Medal	For his outstanding contributions in "Algorithmic Music Composition Software for Popularising AI Education" for non-professionals
12	Dr. Liang Liu	Best Paper Award, 2021 IEEE Signal Processing Society	For the work "Massive connectivity with massive MIMO-Part I: Device activity detection and channel estimation."
13	Dr. Xiapu Luo	ACM SIGSOFT Distinguished Paper Award, 43rd International Conference on Software Engineering (ICSE) 2021	For the work " ATVHunter: Reliable Version Detection of Third-Party Libraries for Vulnerability Identifaction in Android Applications."
14	Dr. Yuanqing Zheng	Best Paper Candidate, IEEE Coference on computer Communication (INFOCOM) 2021	For the work "RFace: Anti-Spoofing Facial Authentication Using COTS RFID."
15	Dr. Liang Liu	Best Student Paper Award, 2022 IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)	X. Fan, Y-F. Liu, and L. Liu, "Efficiently and globally solving joint beamforming and compression problem in the cooperative cellular network via Lagrangian Proc. IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), 2022.
16	Dr. Xiapu Daniel Luo	ACM SIGSOFT Distinguished Paper Award	For the paper titled "NCScope: Hardware-Assisted Analyzer for Native Code in Android Apps" at the 31st edition of ACM SIGSOFT International Symposium on Software Testing and Analysis (ISSTA). ISSTA, a CCF-A conference, is the leading research symposium on software testing and analysis.
17	Dr. Shahnawaz Anwer	Occupational Safety & Health (OSH) Best Project Award, 2021	For his PhD project titled "Evaluation of wearable sensors for noninvasive real-time assessment of physical fatigue using physiological and biomechanical parameters among construction workers" under the supervision of Prof. Heng Li.

Achievements & Contributions

Knowledge Transfer Activities

No.	RIAIoT Member(s)	Type of Knowledge Transfer	Details
1	Prof. Jiannong Cao	Prototype and adoption of research outcomes	**Distributed Edge Intelligence for AI-empowered Applications** A significant problem in real-time video surveillance is providing advanced analytical services while reducing latency. We develop a distributed edge intelligence system with multiple edge devices (i.e., Jetson Tx2, Xavier NX) sharing both data and computation resources to support collaborative real-time video surveillance. We deploy lightweight deep learning models on resource-constraint edge devices to provide pedestrian tracking and reidentification services. To reduce the latency, we designed a scheduler running independently on each edge device to enable sharing of the computation resources. The scheduler dynamically offloads the computation tasks within the cluster whenever the device is overloaded. We build a real-world prototype deployed in an indoor environment showing near-real-time performance Our system has many benefits, including low latency, low cost, higher scalability, and increased data privacy. **We are adopting the research outcomes for:** 1. application of a departmental demo funding; 2. application of an MHKJFS (Mainland-Hong Kong Joint Funding Scheme) project; 3. collaboration with PolyU CFSO for campus video surveillance; and 4. collaboration with Queen Elizabeth Hospital for hand hygiene monitoring in clinical environments.
2	Prof. Jiannong Cao	Prototype	**Autonomous Cooperative Multi-robot System: A Fully Distributed Approach** We aim to develop intelligent robots that can learn cooperative strategies from interactions with others. Specifically, we investigate the challenges of learning cooperation in a distributed way, such as: partner modeling, partial observation, and large-scale multi-robot system. **We are adopting the research outcomes for:** 1. application of a departmental demo funding project; and 2. application of an STF (smart traffic fund) project.
3	Prof. Jiannong Cao	Prototype and adoption of research outcomes	**Low-cost Hyperspectral Sensing for Food Freshness Detection supported by RGC Research Impact Fund "Tackling Grand Challenges in Food Safety: A Big Data and IoT Enabled Approach."** RGB imaging can be used to detect food quality but is not accurate as it can not capture minor and subtle details of food images. Hyperspectral imaging (HSI) systems can capture the spectrum of each pixel of a food image but are highly expensive and available only in laboratories and industries. We develop the first smartphone-based low-cost hyperspectral imaging technique without embedding any external sensor to achieve low-cost hyperspectral sensing for food freshness detection. Our system can detect food freshness with 90% - 92% accuracy.
4	Prof. Jiannong Cao	Prototype and adoption of research outcomes	**Low-cost Acoustic-based Liquid Fraud Detection supported by RGC Research Impact Fund "Tackling Grand Challenges in Food Safety: A Big Data and IoT Enabled Approach."** Acoustic techniques have been used for liquid detection but with expensive ultrasound devices. To achieve low-cost liquid fraud detection, we develop a low-cost method by measuring the acoustic absorption of the liquid using commodity acoustic devices. Our method can detect fake liquor, wine, and olive oil with an accuracy above 92%. We are adopting the research outcomes for the application of a project with The Hong Kong Sports Institute.
5	Prof. Xia Yong	Adoption of research outcomes and real-world deployment	**PolyU Footbridge Health Monitoring System.** The system consists of 88 sensors of 13 type to monitor the environmental parameters, various loads, and responses of the bridge in real-time. A touchscreen mounted at the bridge end of Block Z and an Internet website provides an education platform for students and the public.
6	Prof. Xia Yong	Others: Standards	Guangdong-Hong Kong-Macao Greater Bay Area Standards, T/GBAS 0001–2021, "Data standard system for intelligent operation and maintenance of bridge-island-tunnel crossings — Guidelines on the establishment of standards."
7	Prof. Xia Yong	Others: Standards	Guangdong-Hong Kong-Macao Greater Bay Area Standards, T/GBAS 0003–2021, "Data for intelligent operation and maintenance of bridge-islandtunnel crossings — Bridge structures." This standard specifies the data format for intelligent operation and maintenance of bridges in the GBA.

Affiliated Labs and Research Facilities

Smart Construction Lab (SC Lab)

The Smart Construction Laboratory (SCL) (previously known as Construction Virtual Prototyping Laboratory (CVPL)) leaded by Prof. Heng Li, established in 2005, has a group of experts focusing on the R&D of advanced computer-based simulation systems to support decision making processes in managing construction projects. SCL has 1 Chair Professor, 3 Research Assistant Professors, 2 Postdoctoral Fellows and 7 other researchers. The SCL has been providing industrial services covering Building Information Modeling (BIM), process simulation solutions, and professional training to the construction industry. The SCL has become one of the leading groups in the research area of smart construction internationally. In 2012, SCL won a 1st Prize for its research excellence from the Ministry of Education. The SCL has also been internationally recognized and won several research awards, such as 2018 Best Paper Award of Journal of Computing in Civil Engineering and 2019 Gold Medal in the 47th International Exhibition of Inventions, Geneva, Switzerland.

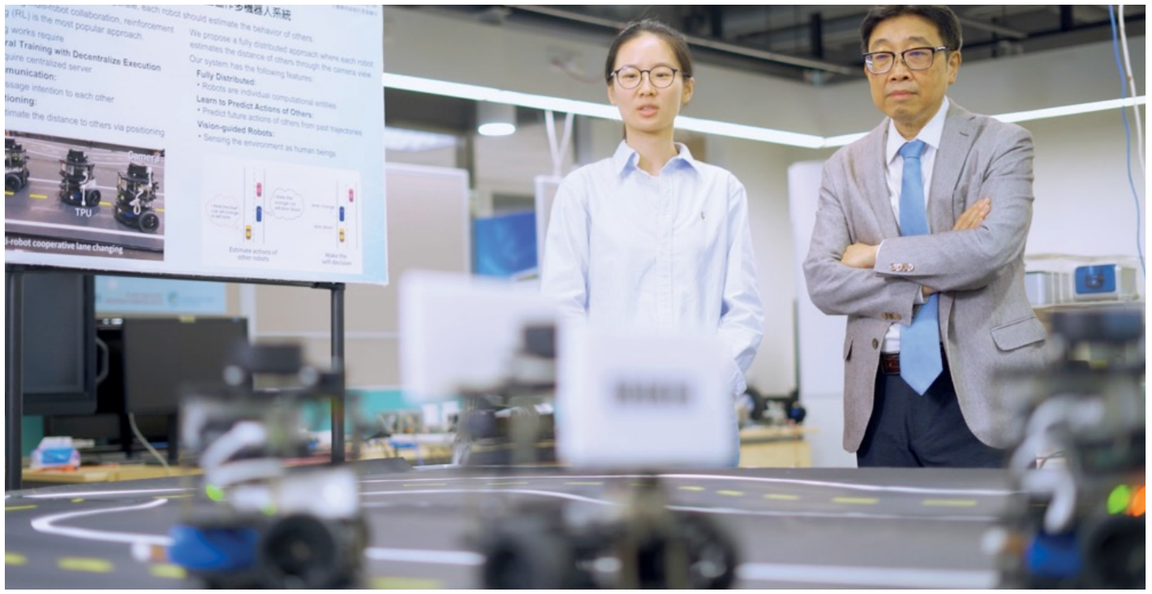
Affiliated Labs and Research Facilities

University Research Facility in Big Data Analytics (UBDA)

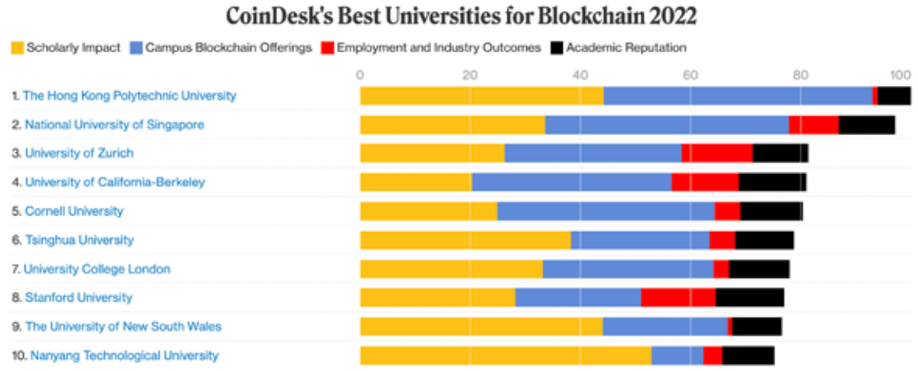
UBDA is the first university-wide research facility in Big Data analytics in Hong Kong. Equipped with Big Data expertise in PolyU and the advanced computing infrastructure and tools, UBDA supports cross-disciplinary research collaborations on Big Data analytics and applications. IoT produces huge volume of data collected by connected sensors, devices, machinery, and other "things". The facility and tools of UBDA are useful for corralling the influx of data streaming in from IoT devices, and enable us to create platforms, software and applications to manage IoT devices and the data generated.

Internet & Mobile Computing Laboratory (IMCL)

IMCL was established in 2002 at the Department of Computing, The Hong Kong Polytechnic University. Prof. Jiannong Cao, Director of IMCL, brings forth the expertise and experiences of researchers from diverse backgrounds include parallel and distributed computing, wireless networking and mobile computing, big data and machine learning, and cloud and edge computing. Besides state-of-the-art research, IMCL also aims at facilitating the transfer of technology from mainstream research into applied research.



Research Centre of Blockchain (RCB)



RCB is a newly established research center to coordinate PolyU researchers working on blockchain in different departments, foster internal collaboration and external collaboration with leading partners, and attract and nurture blockchain talents. The director of RCB is Dr. Xiapu Luo. RCB aims to develop innovative blockchain technologies and applications to benefit mankind, and generate great impact on academia, industry, society, and nurture talents in blockchain at different levels. The center organizes regular activities to facilitate internal/external research collaboration and strive for external fund to perform sustainable research and development. The RCB's vision is to become a world-leading research center in blockchain technology, tackling grand theoretical and practical challenges, boosting the development of blockchain-based applications, and cultivating blockchain-savvy talents. First, the RCB will dedicate itself to tackling fundamental problems at the different layers of blockchain systems (e.g., new consensus protocols, new smart contract languages and verification approaches, new incentive mechanisms) as well as cross-layer research issues, such as dependability, security and privacy, scalability and interoperability, data provenance and sharing. Based on the output of fundamental research on blockchain, the RCB will explore strategic application areas, including blockchain as a service, blockchain-empowered smart cities, blockchain for finance, and blockchain-enable digital government.

In September 2022, PolyU was named the best university for blockchain 2022 in the world by CoinDesk's Education Week.

Consortium for Sound and Vibration Research

This Consortium for Sound and Vibration (PolyU Niche Area) was established in 2007, upgraded from the former Research Centre for Noise and Abatement Control which was established by the Department of Mechanical Engineering in 2001. The Consortium is directed by Prof. Li Cheng and was officially recognized and supported by PolyU in a global effort to promote and consolidate research excellence in a number of strategic areas within the University. The mission of the Consortium is to carry out high-quality research and development to meet the industrial, commercial and community needs of the society.

Affiliated Labs and Research Facilities

Assistive Technology Lab (ATL)

Prof. Kenneth Fong directs ATL at the Department of Rehabilitation Sciences, The Hong Kong Polytechnic University. ATL has a total floor space of 92 square meters, with three function rooms and two functional areas. The three functional rooms dedicated to different research areas are the Neuromodulation Research Laboratory, the Driver Assessment Rehabilitation Laboratory, and the Assistive Technology Products and Technical Workshop. There is also a functional area for displaying AT products, and another area for robotic therapy and upper-limb motion studies. The Assistive Technology Lab is equipped with state-of-the-art facilities including robots (e.g. end-effectors and exoskeletons for physical rehabilitation, social robots for psychosocial rehabilitation), a brain-computer interface system, brain modulation devices such as TMS and tDCS, neurofeedback and EEG systems and a portable motion capture and analysis system.

Closed-Loop Brain-Computer Interface Training for Hemiparetic Upper Extremities in Patients with Chronic Stroke

Stroke is one of the leading causes of motor impairment in adults, in particular, the dysfunction of hemiparetic upper extremities is refractory to recovery and even persists permanently, resulting in disabilities in activities of daily living and dramatically decreased quality of life. Many hi-tech rehabilitation interventions have been developed and used to promote motor recovery over the last decade, BCI technology is one of the new training approaches to achieve motor restoration through a closed-loop system from brain activity through event-related desynchronization after motor imagery or movement attempt to peripheral feedback triggered by an external device.

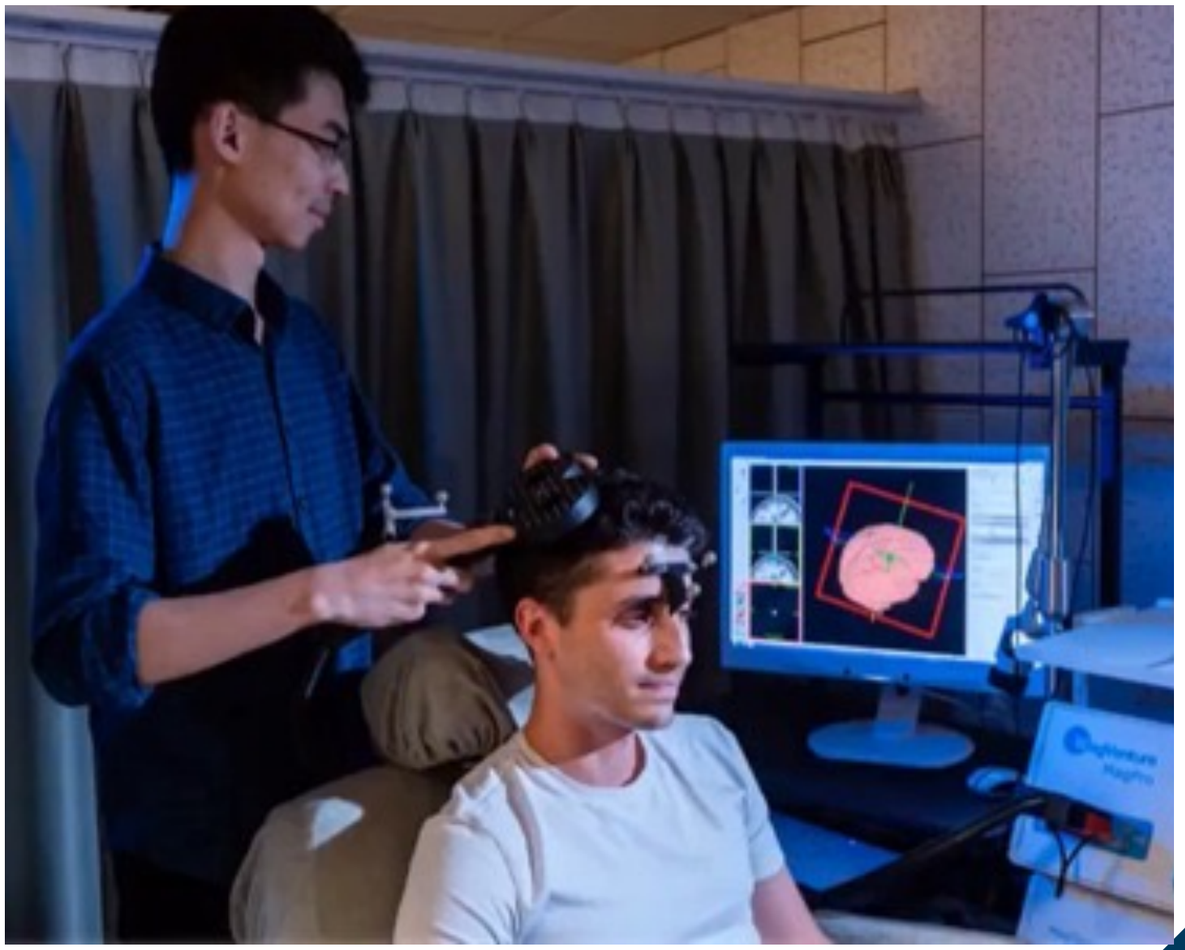
BCI captures specific features of brain activity and translates them into computerized commands to controlled external devices, such as functional electrical stimulation (FES). The patient is asked to imagine a wrist dorsiflexion movement of either hand. The BCI system will detect via EEG the brain signal associated with motor imagery performed by the patient. If well performed, the BCI system will provide FES feedback, inducing passive movement in the patient. An extra visual feedback aid is added using virtual reality. The findings of this study will verify whether a closed-loop system using BCI can enhance the recovery of the upper extremity after stroke. The ultimate goal is to translate the innovative benefits of BCI technology into clinical practice. This on-going project is funded by the Donation of Ir Tam Wing Fan Edmund to RS, PolyU in 2020 (Ref. no. ZJMC).

The Application of Repetitive Transcranial Magnetic Stimulation (rTMS) as an Adjunct Therapy in Reduction of Craving and Consumption of Illicit Drugs

Substance dependence is a chronic psychiatric disorder. Craving is an intense and uncontrollable desire to use a substance linked to substance dependence. In addition, craving has been shown to be one of the most critical contributors to relapse. The brain learns that addictive substances are rewarding and becomes conditioned by their consumption.

Transcranial magnetic stimulation (TMS) is a neurophysiological technique for noninvasive brain stimulation. Based on the principle of electromagnetic induction, TMS can be used to stimulate brain regions and modulate neural activities. TMS has been proposed as a novel therapeutic intervention for a variety of disorders, such as major depressive disorders, pain, insomnia, and motor dysfunctions after stroke. TMS is also widely used to investigate the relationship between brain functions and human behaviors.

TMS has also shown promising potential to be used as an intervention for treating the reduction of craving and consumption of drugs. Substance dependence is associated with an imbalance within the prefrontal cortex that leads to a hyperactive emotional processing and hypoactive executive functioning system (staying focused, inhibitory control, mental flexibility, planning). In this study, we are using TMS targeting the dorsolateral prefrontal cortex to help reduce craving and consumption of illicit drugs. This on-going study is funded by Beat Drugs Fund, Narcotics Division, Hong Kong SAR (Ref. no.: BDF199052) in 2019.



Affiliated Labs and Research Facilities

Centre for Humanistic Artificial Intelligence and Robotics (CHAiR)

CHAiR is a centre set up collaboratively by RIAIoT and Hanson Robotics Limited for advancing development of the state-of-the-art humanistic robots and creation of robust, adaptive, and generally-intelligent machines which contribute significantly to the well-being of human races. It functions as an interdisciplinary research and development (R&D) centre pioneering projects on topics regarding AI, IoT, neuroscience, design, computer science, mechanical engineering, materials science, health care, and hospitality for humanities. A majority of CHAiR's R&D projects focus on advancement of real-life deployable technologies in addressing practical commercial needs and challenges.

CHAiR supports innovation and entrepreneurship in Hong Kong and the Greater Bay Area by materially contributing to industrial growth of the future of humanistic robotics.

Director

Prof. Jiannong Cao
Department of Computing

Research Interests
Parallel and Distributed Computing, Wireless Networks and Mobile Computing, Big Data and Cloud Computing, Pervasive Computing

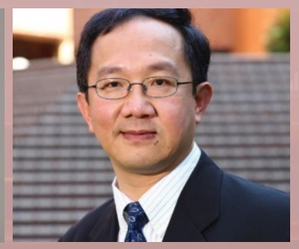
Associate Directors

Prof. Wu Chen
Department of Land Surveying and Geo-informatics **(Associate Director in Research)**

Research Interests
GNSS Applications on Transportation, Kinematic GPS, System Integration, GNSS Performance Evaluation, GPS Software Receiver, Regional GPS Network, Vehicle and Personal Navigation Systems, and Wireless Sensor Network.

Prof. Heng Li
Department of Building and Real Estate **(Associate Director in Entrepreneurship)**

Research Interests
Smart Construction



Prof. Eric Ngai W.T.
Department of Marketing and Management **(Associate Director in Collaboration)**

Research Interests
E-Commerce, Decision Support Systems, Logistics and Supply Chain Management, Knowledge Management & Innovation, IoT and AI Methods and Applications

Management Committee Members

Prof. Li Cheng
Department of Mechanical Engineering

Research Interests
Sound and vibration, structural health monitoring, smart structures and control.

Prof. Kenneth Fong N.K.
Department of Rehabilitation Science

Research Interests
Human Performance; Neuroscience; Assistive Technology

Prof. Qing Li
Department of Computing

Research Interests
Multi-modal Data Management, Data Warehousing and Mining, Social Media and Web Services, and e-Learning Technologies

Prof. Yong Xia
Department of Civil and Environmental Engineering

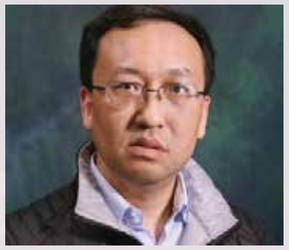
Research Interests
Structural Health Monitoring; Structural Damage Identification; Finite Element Model Updating; Nonlinear Vibration of Cables

RIAIoT People

Leading Members

Prof. Song Guo
Department of Computing

Research Interests
Edge AI, Big Data, Machine Learning, Mobile Computing, Wireless Networking, Distributed Systems



Prof. Wei Jin
Department of Electrical Engineering

Research Interests
Photonic sensors, Optical Fiber Sensors, Gas Sensors

Prof. Chea-su Kee
School of Optometry

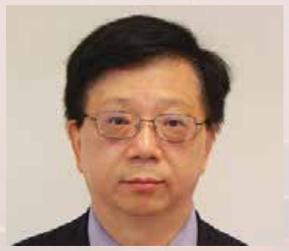
Research Interests
Myopia, Astigmatism, Emmetropization, Ophthalmic optics dispensing and management of patients with refractive errors, Novel biomedical devices

Prof. Francis Lau C.M.
Department of Electronic and Information Engineering

Research Interests
Channel coding, Cooperative networks, Wireless sensor networks, Chaos-based digital communications, Applications of complex- network

Dr. Xiapu Luo
Department of Computing

Research Interests
IoT/Vehicle Security, Mobile and System Security and Privacy, Blockchain and Smart Contracts, Software Engineering



Prof. Defeng Sun
Department of Applied Mathematics

Research Interests
Sparse Newton Methods with Low Complexities, Matrix Optimization (MatOpt): Theory, Algorithms, Software and Applications, High- Dimensional Statistical Optimization, Second Order Variational Analysis; and Risk Management and Computational Finance

Dr. Dan Wang
Department of Computing

Research Interests
IoT, Computer Networking, Smart Energy systems

Prof. Stephen Wang Jia
School of Design

Research Interests
User Experience Design, Interaction Design, Industrial Design, Product Design

Prof. Shuaian (Hans) Wang
Department of Logistics and Maritime Studies

Research Interests
Big data in shipping; Low-carbon shipping; Green shipping; Shipping operations management; Port planning and operations; Urban transport network modeling; Logistics and supply chain management

Prof. Chih-Yung Wen
Department of Aeronautical and Aviation Engineering

Research Interests
Applications of AI Technologies in Unmanned Autonomous Systems, including UAV, UGV and UUV.

Prof. Songye Zhu
Department of Civil and Environmental Engineering

Research Interests
Smart structures, structural control and health monitoring, renewable energy

Ms. Justine Tang
Project Manager

Members

Prof. Yang Chai
Department of Applied Physics

Research Interests
In-sensor/in-memory computing, bioinspired computing

Prof. Edward Chung C.S.
Department of Electrical Engineering

Research Interests
Intelligent Transportation Systems

Dr. Ivan Ho W.H
Department of Electronic and Information Engineering

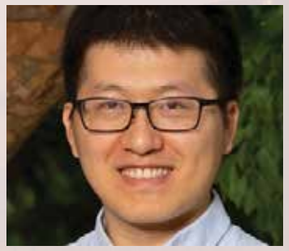
Research Interests
Vehicle-to-Everything Communications, Vehicular Networks, Intelligent Transportation Systems

Dr. Li-ta Hsu
Department of Aeronautical and Aviation Engineering

Research Interests
Positioning, Localization and Navigation. Unmanned Autonomous Systems

Dr. Haibo Hu
Department of Electronic and Information Engineering

Research Interests
Data privacy and security, mobile and spatiotemporal databases, and internet of things



Dr Hailong Huang
Department of Aeronautical and Aviation Engineering

Research Interests
Planning, navigation and control of UAVs/mobile robots; multi-agent systems

Dr. Jimmy Yong Jin
School of Accounting and Finance

Research Interests
Financial Technology

Dr. Liang Liu
Department of Electronic and Information Engineering

Research Interests
Wireless communication, Internet of Things, Integrated sensing and communication

Prof. Derek Or SW
Department of Electrical Engineering

Research Interests
Multifunctional Smart Materials, Devices & Applications; AIoT Sensing & Condition Monitoring; Energy Harvesting, Conversion, Storage & Management; Electromagnetic Absorption & Shielding;

Dr. Xin Xu
Department of Management and Marketing

Research Interests
Fields of management of IT service, Organizational implementation of IT, HCI for E-commerce, Mobile Computing, and Social Media and Business Analytics.

Dr. Bo Yang
Department of Computing

Research Interests
Computer Vision, Machine Learning, Robotics

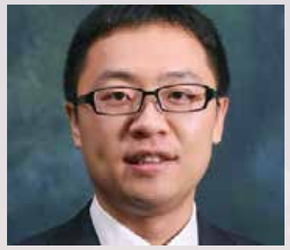
Prof. Tarek Zayed
Department of Building and Real Estate

Research Interests
Simulation and IT-Based Modeling, Integrated Reliability and Risk Assessment, Client Driven Serviceability Assessment, Sustainability of Educational Buildings

RIAIoT People

Organisational Structure

Members



Dr. Yuanqing Zheng
Department of Computing

Research Interests
Wireless Networking and Mobile Computing, Acoustic and RF Sensing, Internet of Things

Prof. Zijian Zheng
Institute of Textiles and Clothing

Research Interests
Polymer and Surface Science, Nanofabrication, Flexible and Wearable Materials and Devices, Energy Conversion and Storage

Dr. Shan Jiang
Department of Computing

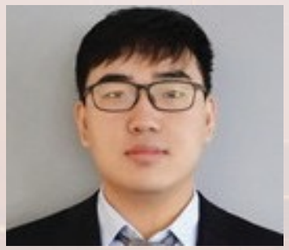
Research Interests
Blockchain, metaverse, distributed systems

Dr. Chun Fong Lei
Department of Management and Marketing

Research Interests
E-Commerce, Decision Support Systems, Knowledge Management & Innovation, IoT and AI Methods and Applications

Dr. Junqiu Wei
Department of Computing

Research Interests
Graph Databases, Spatial Databases, Random Sampling and Natural Language Processing



Dr. Bo (Eric) Xiao
Department of Building and Real Estate

Research Interests
Construction Management, Automation in Construction, Deep Learning and Image Processing

Dr. Yu Yang
Department of Computing

Research Interests
Representation learning for dynamic data, Spatiotemporal data mining, Traffic prediction, Learning analytics

Dr. Fei Wang
Department of Civil and Environmental Engineering

Research Interests
Aerodynamics, Data-driven Modelling, Fluid Dynamics

Dr. Duojie Weng
Department of Land Surveying and Geo-Informatics

Research Interests
GNSS, High-precision Positioning, Indoor Positioning, Sensor Fusion

Dr. Shah nawaz Anwer
Department of Building and Real Estate

Research Interests
Construction Ergonomics; Occupational Health and Safety; Exoskeleton Devices; Work-related Musculoskeletal Disorders; Fatigue; Wearable sensors; Rehabilitation

Dr. Xinyu Zhou
Department of Electronic and Information Engineering

Research Interests
RF/Microwave microelectronics circuits; Monolithic Microwave Integrated Circuit based on the third-generation semiconductor technology; Artificial intelligence circuits designed for the Internet of Things

Dr. Xiaoyou Wang
Deparment of Civil and Environmental Engineering

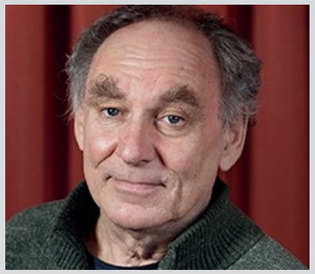
Research Interests
Structural health monitoring, Artificial intelligence, Bayesian inference, Statistical learning

RIAIoT International Advisory Committee (IAC)

Chairman

Prof. Xuemin Sherman Shen
University Professor
University of Waterloo, Canada
President of IEEE Communications Society (2022-2023)
Fellow of IEEE
Fellow of the Engineering Institute of Canada
Fellow of the Canadian Academy of Engineering
Fellow of the Royal Society of Canada

Leading Members



Prof. Jon Crowcroft
Marconi Professor of Communications Systems
University of Cambridge, UK
Fellow of the Royal Society
Fellow of ACM
Fellow of IEEE
Fellow of the British Computer Society
Fellow of the UK Institution of Engineering and Technology
Fellow of the Royal Academy of Engineering

Prof. Jack Dongarra
University Distinguished Professor
Director of Innovative Computing Laboratory
Director of Information Technology Research. University of Tennessee, US
A.M. Turing Award (2021)
Computer Pioneer Award (2020)
Fellow of SIAM Fellow of ACM Fellow of IEEE
Foreign Member of the Royal Society
Fellow of the American Association for the Advancement of Science
Member of the US National Academy of Engineering

Prof. Hong Hao
Professor
Curtin University, Australia
Fellow of the Australian Academy of Technological Science and Engineering
Fellow of Engineers Australia
Fellow of the American Society of Civil Engineers
Fellow of the International Society of Engineering Asset Management
President of the International Association of Protective Structures

Prof. Hui Li
Harbin Institute of Technology
China
Cheung Kong Scholarship Professor
Harbin Institute of Technology, China
President of Asian-Pacific Network Center of Research in Smart Structure Technology

Prof. Hong Mei
Professor
Peking University, China
Fellow of the World Academy of Sciences
Fellow of the Institution of Engineering and Technology
Member of Chinese Academy of Sciences

Prof. Washington Yotto Ochieng
Professor
Imperial College London, UK
Fellow of the Royal Academy of Engineering
Chartered Engineer of the UK Engineering Council
Fellow of the UK Institution of Civil Engineers
Fellow of the UK Chartered Institution of Civil Engineering Surveyors
Fellow of the UK Chartered Royal Institute of Navigation
Fellow of the UK Chartered Institution of Highways and Transportation

Prof. Rick So
Professor Emeritus
Associate Dean of the Paul Merage School of Business
University of California-Irvine, US
Chair Professor of the Department of Management,
The Hong Kong Polytechnic University
Member of Technical Staff, AT&T Bell Laboratories,
Princeton, New Jersey

Prof. Weimin Zheng
Professor
Tsinghua University, China
Academician of the Chinese Academy of Engineering
President of the China Computer Federation (2012-16)

RIAIoT

are developing both fundamental technologies and intelligent applications of AIoT, and therefore have many opportunities to collaborate with industry partners. We adopt a problem-driven end-to-end approach in solving impactful and prominent problems to benefit the industry and society.

Three ways to collaborate with RIAIoT:

1. Consultancy project

RIAIoT can conduct research for your company via PolyU Technology &

Consultancy Company Limited (PTeC).

Your company maintains full intellectual property rights.

2. Contract research

Research by RIAIoT with the help of PolyU Research and Innovation Office (RIO).

Intellectual property rights to be co-owned by your company and RIAIoT.

3. Innovation and Technology Fund (ITF)

RIAIoT and your company apply for ITF together. The copyright division depends on how much your company and ITF invest. Good for exploratory research.

Contact:

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Email: info.riaiot@polyu.edu.hk

Website: www.polyu.edu.hk/riaiot

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