Smart computing is emerging as an important multidisciplinary arena. It can be broadly classified into two different areas: how to design and build smart computing systems and how to use computing technology to design smart things and environments to make human life better. The advancement of cloud computing, big data analysis, pervasive computing, artificial intelligence and cognitive computing are bringing smart computing to a newer dimension with many important applications.

**3-Tier Research Framework**

The Department concentrates on high quality, interdisciplinary research which aims at creating new computing related knowledge and benefits for the entire world. We have established a three-tier framework with a common research infrastructure for achieving that goal.
**Tier 1:**
**Department-Driven Initiatives**

Tier 1 of our strategic research framework focuses our overall research efforts on the Department-Driven Initiatives, shaping our drive to provide ground-breaking innovations in truly smart computing. Current focus areas are big data analytics, human-centered computing and cyber security.

**Tier 2:**
**Research Competence**

Tier 2 of our strategic research framework provides the backbone to Tier 1, grouping the existing strengths of our faculty members and research personnel into different clearly defined areas of departmental expertise in which they produce globally recognised research achievements.

- Big Data Analytics and Information Retrieval
- Graphics, Visualisation and Multimedia
- Human-Centered Computing
- Networking and Mobile Computing
- Pattern Recognition and Machine Intelligence
- Systems and Software Engineering
- Algorithms and Formal Methods

**Tier 3:**
**Joint Labs, Cross-area Departmental Centres and Labs**

**JOINT LABORATORIES**

| PolyU-IBM Enterprise Data Analytics Laboratory | PolyU-Microsoft Smart Computing Laboratory | PolyU-Yonyou Joint Laboratory on Smart Cloud Computing |

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Research Themes and Strengths

Smart Aging

Smart Aging is using computing-driven innovative technology and services for active aging - to enhance quality of life as people age. Our strengths include:

• AI-enabled robots for elderly
• Data analytics for early diagnosis of elderly disease
• Data collection and processing platform for elderly care application development

![Diagram of Loneliness Index and Health Index]

- Spiritual/Behavioral
  - Robotics, VR/AR, Game, Elderly Social Network
- Physical
  - Robotics, VR/AR, Wheel Rehabilitation

- AI, Machine Learning, Data Analytics
  - Monitoring, Analysis and Prediction of Physical, Spiritual and Behavioral Status

- Sensing and Platform
  - Multi-modality Data Sensing, Storage and Database, Communications, Cloud Computing, Operation System

Smart IoT

Smart IoT builds intelligence into IoT, moving forward from connecting the things to facilitating their interactions and enabling them to make smart decisions with added values. Our strengths include:

• Smart sensing and edge computing
• Big data analytics
• IoT and mobile security and privacy

![Diagram of IoT Services and Marketplaces]

- Security of Things
  - Secure IoT Sensing; Cloud/IoT Threads; IoT/Data Protection
- Data of Things
  - Big Data & IoT; Data Management, Integration & Warehousing

- IoT Platforms, Connectivity and Device Management
  - Smart Sensing; Smart Networking
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Balance - we demonstrate that the seemingly contradictory requirements on the security and privacy of publish/subscribe services usually assume the underlying network is secure and that attacks are non-adaptive. However, these assumptions do not hold in reality. This project focus on the security and privacy issues in publish/subscribe services under realistic settings through the use of modern cryptographic techniques.

Special Features and Advantages
- Provide enhanced mechanisms to improve integrity of the messages from the publishers
- Improve the granularity of access control over the subscribers
- Also consider privacy of the subscribers

Achievements

Collaborators and Funding Body
- University of Wallongong
- PolU

Project 2: Accountable Privacy-Preserving Authentication / Accountable Anonymity - Towards Achieving Security and Privacy without Trusted Entities 責任匿名與隱私保護間的平衡

A credential is a piece of certification from some authority that certify some of our attributes. We use credentials every day for various purposes, ranging from entering public transportation system to logging into our personal computers. Some advanced systems respect user privacy by allowing unlikable use of credentials. However, users may misbehave under the name of privacy. This project aims to prevent such abuse by developing mechanisms that balance security, privacy and accountability.

Special Features and Advantages
- Formal analysis - system properties is guaranteed via rigorous mathematical proofs
- Balance - we demonstrate that the seemingly contradictory requirements can be achieved simultaneously in some application scenarios

Achievements
- Man Ho Au and Apu Kapadia. PERM: Practical Reputation Based Blacklisting without TTPs, ACM CCS 2012
- Runner-up for PET Award, 2009: Outstanding Research in Privacy Enhancing Technologies

Collaborators and Funding Body
- NSFC

Project 3: Research on Provable Data Storage in Cloud Computing 稽計算中可證明安全的數據儲存研究

Cloud computing has become increasingly popular throughout the business community due to its remote accessibility, lower costs, and quick re-provisioning. While users are excited about this new computing paradigm, they are equally concerned about the security risks associated with the shift to the cloud. While the benefits of cloud computing are clear, it also introduces new challenges. As client data and computations are outsourced to the cloud, security concerns arise naturally as the cloud providers are not fully trusted. The project aims to develop mechanisms for users to detect whether or not the cloud is trying to cover up data loss incidents.

Special Features and Advantages
- Formal analysis - system properties is guaranteed via rigorous mathematical proofs
- Data privacy - verifiers learns nothing about the data being audited
- Efficient - the overall computational and transmission cost does not grow linearly in the data size

Achievements
- Zuxiao Yu, Man Ho Au, Qiuilang X., Rupeng Yang and Jinguang Han. Leakage-Resilient Functional Encryption via Pair Encodings. ACISP 2016 (to appear)
- Yong Yu, Man Ho Au, Giuseppe Ateneise, Xinyi Huang, Willy Susilo, Yuanshun Dai, and Geyong Min. Identity-based Remote Data Integrity Checking with Perfect Data Privacy Preserving for Cloud Storage IEEE TIFS 2016 (to appear)
- Yong Yu, Liang Xue, Man Ho Au, Willy Susilo, Jianbing Ni, Yafang Zhang, Athanasios V. Vasilakos and Jian Shen. Data Integrity Checking with Identity-based Auditing Mechanism from RSA. Future Generation Computer Systems 2016 (to appear)
- Jinguang Han, Willy Susilo, Yi Mu, Man Ho Au and Jie Cao. ACC-OT: Accountable Oblivious Transfer with Access Control. IEEE TIFS 10(12): 2502-2514, 2015

Collaborators and Funding Body
- NSFC (in collaboration with Dr. Yong Yu of UESTC and Dr. Jinguang Han of NJFC)

Dr Man Ho Allen Au received the bachelor’s and master’s degrees from the Department of Information Engineering, The Chinese University of Hong Kong, in 2003 and 05 respectively, and the Ph.D. degree from the University of Wallongong, Australia, in 2009. Currently, he is an assistant professor at Department of Computing, The Hong Kong Polytechnic University. Dr Au's research interests include Information Security and Privacy, Applied Cryptography, Accountable Anonymity and Cloud Computing. He has published over 180 papers in those areas, in journals such as IEEE Transactions on Information Forensics and Security, IEEE Transactions on Knowledge and Data Engineering, ACM Transaction on Information and System Security and international conferences including the Network and Distributed System Security Symposium (NDSS) and the ACM Conference on Computer and Communications Security (CCS). He has served as a program committee member in over 30 international conferences/workshops. He also is a program committee co-chair of the 8th International Conference on Network and System Security and the 9th International Conference on Provability Security.
Project 1: An Automatic Cloud 一個自動雲端

On top of the OpenStack cloud, we initially automatically launch a small-sized cluster, which is deployed with Spark and Hadoop. With the combination of Ganglia and Nagios, we can monitor the resources’ utilization during the execution of tasks. Our automatic cluster-builder tool can select any number of virtual machines and bring them into a cluster. Since Spark is auto-deployed among the cluster, calculation tasks submitted to it will be executed in a very short time. To present the execution results, interactive visualization techniques are also applied.

Special Features and Advantages

• The automatic cluster builder tool is a highlight in our project. It largely simplifies the deployment of Spark and Hadoop among a cluster. With just one button click, users do not need to worry about the details of configuration and they can launch and remove clusters at any time.

• Our project is capable of dealing with scalable number of data. This is done by a separated Hadoop File System. For small-sized data, we directly submitted them to cluster file system. For large-sized data, the separated large file system is used for further processing.

• The cluster is also equipped with monitoring tools which can report the resource utilization of each machine in the cluster in real time.

• Interactive visualization part vividly demonstrates the execution results of the Spark task. Instead of boring statistic numbers, our visualization tool gives a straightforward experience to users.

Achievements


Collaborators and Funding Body

• PolyU

Project 2: Location Analytics and Indoor Floorplan Reconstruction

位置分析及室內平面圖重構

Large scale location analytics is currently the primary service in a modern urban environment. It provides timely and accurate positioning and navigation information. Location analytics facilitates the optimal planning, delivery, and distribution of materials, goods, and services. It also enables people to meet, plan, function, and make critical decisions in a timely manner. Location analytics improves movement and access within an organization and between multiple hybrid indoor/outdoor facilities.

Special Features and Advantages

• Low cost, landmark-based indoor localization for complex hybrid environments as well as crowd-sourcing geolocation data on landmark features and navigation routes between points of interest

• Hybrid system for localization based on both visual landmark features as well as WiFi and GPS signals

Achievements

• The localization problem is challenging for both people and machines. The first challenge is the relative large size of indoor facilities and interconnections devoid of any natural long-lasting landmarks. The second challenge is the increased frequency of changes in large indoor passages. The third challenge is facilitating proper emergency response plans in critical situations, such as crowding, fire, floods, damages, and security enforcement. These challenges create the need to provide an optimal dynamic indoor location-based service system based on a dynamic floorplan generation and updating service.

• We have the following achievements: (1) Basic visual feature detection for landmarks; (2) Navigation and tracking under different environmental lighting and conditions; (3) WiFi-based localization and fingerprinting.

Collaborators and Funding Body

• Dr Bin Xiao and Dr Yuanqing Zheng, Department of Computing, PolyU

Project 3: VALID: Visual Analytics and Stream Visualization

基於Web的規模流數據可視化框架

The project is focused on information visualization and visual analytics. New techniques are employed such as saliency map from image processing and computer vision and kernel density estimation from statistics are adopted to solve new big data problems.

Special Features and Advantages

• The framework we have constructed, improves the applications of data processing and geographic information systems.

• Other direct applications are in streaming databases and information retrieval, cloud computing and optimal communication network for streaming data.

• For cognitive visual analytics we are using machine learning, new paradigms in user interfaces and high performance computer graphics and rendering.

Achievements

• A prototype system for large data visualization has been implemented and tested

• Four papers have been published on the technical details of the solution to this problem

Collaborators and Funding Body

• PolyU

Project 4: iTextile: An Intelligent Searching System for Woven Fabric Database

基於紡織布料數據庫的智能搜索系統

In this project, we have developed a general texture searching system for a woven fabric database. This is a specific searching engine for fabric materials that operates in three modes: image, color and texture. The project provides a faster solution for the collecting, analyzing, indexing, searching, designing, and prototyping of woven fabrics. We have built and delivered an industrial grade scanner for textile fabrics.

Special Features and Advantages

• The system is composed of three components. The first component is the establishment of a woven fabric database platform, including detailed manufacturing specifications used in industry for the weave design (loom draft, denting plan, and draft plan). The second component is the digital scanning engine for the fabric database. It can collect and analyze the dual-side images of fabrics for the purpose of indexing each weave pattern style. The third component is the searching engine for the texture in the fabric database.

• The main advantages are easy to deploy, low cost, high resolution scanner for flexible micro-surfaces, a ranking system for textile materials and providing the first integrated image plus industrial textile specification database.

Collaborators and Funding Body

• ITT

• Collaborator: Institute for Textile and Clothing, PolyU

Prof. George Baciu received the degree in computer science and applied mathematics and the Ph.D. degree in systems design engineering from the University of Waterloo, Waterloo, Canada. Currently, Prof. Baciu is with the Department of Computing, The Hong Kong Polytechnic University, Hong Kong. He has published extensively and has served as a Chair in international conference committees, such as ACM SIGGRAPH, Pacific Graphics, Eurographics, Computer Graphics International and CAD/Graphics. His main research interests include big data visualization, image processing, and computer graphics.
Project 1: A Distributed Intelligent Multi-Robot System
分布式智能多機器人系統
This project aims at developing a multi-robot system that is completely distributed with built-in swarm intelligence. The system contains multiple mobile robots, which can perform sensing and computation autonomously, and communicate with each other via wireless channel for coordination. The project enables multiple robots to accomplish common tasks in complicated environments with applications such as cooperative exploration, industrial automation, and education.

Special Features and Advantages
- Completely Distributed: The robots can make decision by themselves independently
- Collaborative Intelligence: The robots can learn to cooperatively finish user-defined tasks according to historical experience and human demonstration
- Scalability: The number of robots in the system can be thousands or more

Achievements
- Publications on top journals and conferences including IEEE Transactions on Computers (TC 2016), ACM Computing Surveys (2016), International Conference on Computer Communication and Networks (ICCCN 2016), and IEEE International Conference on Pervasive Computing (PERCOM 2016)

Collaborators and Funding Body
- HK ANR/RGC Joint Research Scheme, “Coordination and Computation in Distributed Intelligent MEMS”, 03/2013-08/2016, HK$ 1,390,600

Project 2: Human Health Anomaly Detection and Analytics
人體健康異常檢測與分析
This project aims to detect and analyze human health anomaly from both physical and mental aspects. For physical health aspect, we monitor human’s respiration via off-the-shelf WiFi devices based on the observation that fine-grained respiration information of a person under different sleeping positions can be successfully revealed. The rhythmic patterns associated with respiration and abrupt changes due to the body movement are then identified. This approach is completely contactless, robust to low-light environments and does not raise privacy concerns. For the mental health aspect, we focus on stress detection and analysis since it is one of the most important factors that affect our mental health. The stress is detected by using pervasive sensing technologies. We propose novel sensing devices that is non-intrusive and unobtrusive to capture stress related markers. With the detected stress, the underlying relationship between stress and human performance can be uncovered, thus helping to alleviating negative stress.

Special Features and Advantages
- Non-invasive: without attaching any devices on a person to obtain his/her fine-grained information
- Robust to low light environment and no privacy concerns

Achievements

Project 3: Cross-disciplinary Big Data Analytics and Sharing
交叉領域大數據分析與共享
This project aims to develop a framework and methodology for analyzing and sharing massive interdisciplinary datasets. More specifically, for big data analytics, we focus on correlation mining of datasets from a diversity of sources. Correlation mining allows us to figure out the dependency relationship among a set of variables, and thus discovering invisible knowledge. With this framework, we have studied a series of practical problems, e.g., traffic correlation mining between different roads, order response time and demand prediction in on-demand transport services, and dead WiFi spots detection in shopping malls. Additionally, we build a federated big data sharing infrastructure which provides abundant functions for sharing data from different disciplines. The infrastructure works as an adaptor between data sources, thus making it application-independent and applicable to heterogeneous datasets in different disciplines.

Special Features and Advantages
- Valuable insights in different domains as well as their correlations can be discovered
- Existing technology in each single domain can be improved by utilizing the correlations across domains
- Various applications can be built based on the proposed framework
- Application-independent data sharing can greatly facilitate the usage of big data in different disciplines

Achievements
- Publications on top journals and conferences including ACM Transactions on Intelligent Systems and Technology (TIST), IEEE International Conference on Smart Computing (SMARTCOMP 2016), and IEEE International Conference on Parallel and Distributed Systems (ICPADS 2015)

Collaborators and Funding Body
- Collaborators include Huawei, GoGoTech, Zurich Insurance, and NextWiFi
- HK PolyU Project of Strategic Importance, “Cross-disciplinary Big Data Processing and Analytics”, 07/2015-06/2018, HK$3,000,000 (including $25,000 undergraduate allowance)
- Consultancy project with Huawei Technologies Co. Ltd, “AI3- A Layered-Federation Information Sharing Architecture”, 07/2016-02/2018, HK$ 1,920,000
Project 1: Efficient Algorithms to Fix Graphs with Mistakes
如何快速找到並修復圖中的錯誤

A large amount of data is produced daily in bioinformatics, mainly by experimental methods. The raw data we obtain are usually flawed, so an important step to make sense of these data is to find and fix these mistakes. Graphs are a common tool for modeling data, and this brings us to graph modification problems, which ask for a minimum number of modifications that transform a given graph to have a certain property (corresponding to the structures the data should have). A common fact observed in real applications is that only a small amount of modifications is of practical meaning. In view of this, this project is devoted to the design of tailored algorithms for graph modification problems with a small number of modifications.

Special Features and Advantages
• With running time proportional to the graph size, the algorithms are applicable to large-scale graphs
• Using only simple techniques, the algorithms can be easily implemented
• Deep combinatorial study behind this study has benefit in the algorithmic graph theory

Achievements
• Yixin Cao, “Unit interval editing is fixed-parameter tractable,” in Proceedings of the 42nd International Colloquium on Automata, Languages, and Programming (ICALP 2015), 306–317.
• Wenjun Li, Jianxin Wang, Jianer Chen, and Yixin Cao, “A 2k-vertex kernel for maximum internal spanning tree,” in Proceedings of 14th International Symposium on Algorithms and Data Structures (WADS 2015), 495–505.

Collaborators and Funding Body
• Collaborator: Dr. Dániel Marx, Institute for Computer Science and Control, Hungarian Academy of Sciences (MTA SZTAKI)
• GRF

Project 2: Heuristic Algorithms and Exact Algorithms: The Cross-Fertilization
啟發式演算法和精確演算法的相互促進和發展

Algorithms, the fundamentals of computation, are roughly labeled as exact, approximation, or heuristic. While exact algorithms and approximation algorithms with good performance guarantee are the ultimate sought in theory, heuristic algorithms are ubiquitous in practical computing, e.g., networking, robots, and artificial intelligence, and usually work very well. Though the solutions found by a heuristic algorithm cannot always be optimal, they may be close to optimal.

Different algorithmic approaches to the same problem should have connections. This project explores cross-fertilization of heuristic algorithms and exact algorithms. We revisit successful heuristic algorithms and investigate the use of their main insights in designing exact algorithms. We also produce new heuristic algorithms, and improve known heuristic algorithms by using ideas from exact algorithms. For this purpose, we need to have a better understanding of the heuristic algorithms, and simplify the exact algorithms. This study is a part of the big campaign aiming to bridge the theoretical and applied communities in computer science.

Special Features and Advantages
• This project would motivate researchers from both theory and application sides to reconsider our aversion to the other side: If we are working on the same problem, the observations should be useful.
• This project contributes to the ongoing campaign of bridging the gap between theory and applications in computing.

Dr Cao is a Research Assistant Professor of the Department of Computing, The Hong Kong Polytechnic University. Before joining The Hong Kong Polytechnic University in 2014, he was a research fellow in Institute for Computer Science and Control, Hungarian Academy of Sciences (MTA SZTAKI). Dr Cao’s research interests include algorithmic graph theory, combinatorial optimization, social networks, and bioinformatics.
Project 1: Adaptive Data Management for Cloud-based Wireless Mesh Networks

A wireless mesh network is formed by wireless mesh routers, which are interconnected by wireless links. The aim of this project is to develop adaptive data management mechanisms for cloud-based wireless mesh networks. To provide cloud-based services, each wireless mesh router is capable of storing, replicating, and/or moving data effectively and flexibly over a wireless mesh network, providing cloud computing-like services. The project involves designing a person-based adaptive data management mechanism and a group-based adaptive data management mechanism.

Special Features and Advantages
- Person-based adaptive data management mechanism - Data can be stored in a mesh router under each user account. For example, a user can store frequently used data files in a cloud-based wireless mesh network, as the user moves around, the wireless mesh network can keep track of the user’s location so that the data can be moved based on that user’s location (i.e., certain data can follow a user).
- Group-based adaptive data management mechanism - Data can be shared among a group of users through a cloud-based wireless mesh network. For example, in a classroom, a teacher can upload teaching materials to a cloud-based wireless mesh network such that students inside a classroom can download them directly from the wireless mesh network (i.e., rather than accessing them from a server through the wireless mesh network).

Achievements
- Best Student Paper Award at the 2015 IAENG International Conference on Communication Systems and Applications

Collaborator and Funding Body
- Supported by the Innovation and Technology Fund and P2 Mobile Telecommunications Limited

Project 2: Dynamic and Intelligent Channel Allocation Methods for Multi-Radio Wireless Mesh Networks

The aim of this project is to develop dynamic and intelligent channel allocation methods for multi-radio wireless mesh networks. Through these methods, the mesh routers of a multi-radio wireless mesh network can change their frequency channels dynamically, intelligently, and collaboratively based on environmental conditions and other factors. It is important to allocate the frequency channels effectively and efficiently because the available frequency channels are limited and because of issues with interference (e.g., due to changes in environmental conditions and to effects from other wireless networks). Furthermore, in a wireless mesh network, links may occasionally become not usable (e.g., due to interference). Therefore, channels may need to be re-allocated dynamically in order to ensure the continuous operation of the network. The project involves designing the system architecture to enable it to support the intelligent and dynamic channel allocation methods, a macro channel allocation method, and a micro channel allocation method.

Special Features and Advantages
- Macro channel allocation method - Based on the channel information, channels are assigned to maximize the overall performance of the network, while meeting interference constraints and possibly other requirements. We have studied a genetic algorithm-based technique as well as heuristic algorithms for assigning channels.
- Micro channel allocation method - After the channels are assigned by the macro channel allocation method, the channel conditions may change. The micro channel allocation method is used to re-shuffle some of the channel allocations, typically on a local basis. Furthermore, we have developed a reboot algorithm to reboot the wireless mesh routers in the correct order.

Collaborator and Funding Body
- Supported by the Innovation and Technology Fund and P2 Mobile Telecommunications Limited

Project 3: Cloud-to-Cloud Data Communications and Management

The aim of this project is to develop the system and protocols to facilitate cloud-to-cloud data communications and management through university-industry collaboration. In essence, the system allows heterogeneous clouds to communicate effectively with each other. An effective data communications protocol has been developed to facilitate data transfers and other data management functions between two heterogeneous clouds. Inspired by the web system, the protocol is similar to the HTTP protocol for effective client/server communications. The protocol also supports security functions such as authentication and data confidentiality functions. A basic intercloud gateway prototype has been developed to demonstrate the functions and protocols.

Special Features and Advantages
- Intercloud system - Inspired by the IEEE P2302 draft standard and the Internet, an intercloud system can be formed.
- Data communications protocol - Two clouds can communicate with each other using an XMR-based protocol.
- Intercloud applications - Intercloud applications (e.g., data backup) can be developed using the application programming interfaces

Collaborators and Funding Body
- Supported by the Innovation and Technology Fund and CITIC Telecom International CPC Limited (over HK$ 2 million)

Dr CHAN Chun Bun Henry

RESEARCH INTERESTS
Networking and Communications, Cloud Computing, Internet Technologies, Electronic Commerce
Project 1: Predicting Drug-Target Interactions by Machine Learning Techniques - Predicting Drug-Target Interactions for Better Drug Design

A machine learning technique, called MFDR, has been developed to make use of a deep representation scheme that can represent multi-scale features for the prediction of possible interaction relationships between a drug and a protein. The technique can be used to handle big data involving large volumes of drug molecules and protein sequence descriptors. It makes use of Auto-Encoders as building blocks for deep network to reconstruct drug and protein features for new representations with lower dimensions. Based on such representation, a SVM is used to infer potential drug-target interactions. MFDR has been tested and found to be effective.

Special Features and Advantages
• Highly accurate predictions of drug-target interactions
• New deep representation schemes based on deep learning models
• Potentially useful for drug design and development

Project 2: Community Detection in Social Networks - Customer Segmentation for Effective Marketing

Identifying people with similar needs, interests, habits and characteristics for users to participate in a community or for a company to identify targets for marketing. With the development of an evolutionary algorithm, we have designed an effective technique to help users identify a particular community that they can join to either share what they have in common with the others, or to learn from and know more about the others that are within the same community. Our technique can also be used to identify communities that share common interests, habits, political views, etc., for target marketing. Unlike other techniques for discovering communities in social networks, the evolutionary algorithm that we have developed takes into account not just network topologies, but also considers the attributes that each member in a social network shares. As a result, users in the same community are not just connected more frequently with each other, but they also share similar characteristics.

Special Features and Advantages
• Discovers more than one community to which each person can belong
• Discovers community of people that share common attributes
• The evolutionary algorithm can be implemented on parallel machines to allow community detection of a very large network to be discovered in a very short time

Project 3: Social Media Analytics for Stock Price Prediction - Discovering Patterns in Public Opinion and Sentiment in Social Media

Social media like Twitter and Facebook has significant exploded as the online forum that change the public discourse in society fast, and set trends in topics in a large range. It is well accepted that the decision making and individual behaviors can be affected by the individual sentiment. Therefore, this situation leads to researchers a question: can the sentiment of publics affect some social behaviors like the trend of stock market prices? Followed by the above motivation, in this project, we propose to find a solution for mining the online data from social media database in order to predict the real stock market prices up or down through these ambiguous information by applying the sentiment analysis and data mining algorithms.

Special Features and Advantages
• Applies text mining techniques to create emotional word lists
• Uses the fuzzy set theory to increase the accuracy for mining the hidden quantitative association rules from large set of ambiguous data
• Applies statistical measure to provide a means for uncertainty representation
• Run on Cloud and Big Data platform to provide near real-time analysis

Project 4: Behavioral Analytics for Elderly Care in Smart Homes Using AI and Machine Learning

Population aging can cause various social and economic problems and much effort have been invested into developing solutions for better elderly care. Among them, the prevention of such diseases as dementia are the most important. As dementia and similar illness can be discovered through observing and analyzing of daily behaviors and activities, we have developed a system for this purpose. The system records indoor daily routines of elderly people so that their needs and interests can be better served. It uses a Kinect v2 sensor network that covers all areas that an elderly spends his or her time every day. The recorded data are then analyzed real-time using machine learning techniques so that the system can assist the lives of elderly people with automatic reminders, alarm services related to safety, the feeding of healthy information, and even discovery of dementia related symptoms. The system can work under poorly illuminated conditions and even if the elderly do not use any wearable sensors. The system protects users’ privacy by using only the skeleton data. We believe that not only elderly people will benefit from our system, but also family members and caregivers and ultimately, an aging society in entirety.

Special Features and Advantages
• Develops a scalable Kinect v2 sensor network to monitor the whole household environment.
• Provides gesture and speech control of intelligent home Z-Wave devices.
• Detects daily routines of subjects consist of low level activities like drink, cook, sleep, walk, seat etc.
• Discovers early dementia symptoms like memory and performance decline.

Collaborators and Funding Body
• PolyU

Professor Keith C.C. Chan obtained his B.Math. (Hons.) in Computer Science and Statistics in 1984 and M.A.Sc. and Ph.D. in Systems Design Engineering in 1985 and 1989 respectively from the University of Waterloo, Waterloo, Ontario, Canada. Soon after graduation, he joined the IBM Canada Laboratory in Toronto, Ontario, Canada as a software analyst and was involved in the development of multimedia and software engineering tools. He joined the Ryerson University as an Associate Professor in 1993 and in 1994, he returned to Hong Kong to join The Hong Kong Polytechnic University where he is currently a Professor in the Department of Computing. Prof. Chan’s research interests are in Machine Learning, Artificial Intelligence, Data Analytics, Bioinformatics and Computational Biology, Evolutionary Computation, Fuzzy Systems, and Software Engineering. He has published over 250 research papers in these areas in refereed journals and conference proceedings. He has also been serving actively as organizer and Program Committee member of numerous conferences in his research areas. Prof. Chan’s research has been supported by the Research Grants Council and the Innovation and Technology Commission. He also participates active in industrial contract research and has served as consultant to large and small sized corporations and government agencies in Hong Kong, China Mainland and overseas.
The FPS simulator built for the project’s experiments uses many mechanisms that are implemented in the same way as FPS games commonly do. The FPS simulator supports different implementations of lag compensation, known as “shot around a corner.” We have investigated the issues of lag compensation, one of which is widely experienced by users. To our best knowledge, no previous studies have considered the crosshair at best. The problem persists into many of today’s FPS and third-person games. Lag compensation is implemented in most, if not all, of modern first-person shooter games, including popular titles like Battlefield 4. This makes the gameplay experience more realistic for players who are used to playing in hotspots on the internet. The measurement is more accurate than other similar platforms. The measurement consumes very little bandwidth. The measurement device has a small footprint.

Special Features and Advantages
- The measurement device has a small footprint.
- The measurement consumes very little bandwidth.
- The measurement obtains multiple path-quality metrics and supports both HTTP and HTTPS.
- The measurement can be configured to diagnose performance problems.
- The measurement is more accurate than other similar platforms.

Achievements
- We have already deployed some probes in residence homes and will deploy more in the coming months. For the WiFi network monitoring, we are collaborating with the ITS to install probes to monitor the WiFi performance in hot spots in the campus.

Collaborators and Funding Body
- Two ITF tier-3 projects and one ITF tier-2 project

Project 2: Lag Compensation in First-Person Shooter Games

Lag compensation is implemented in most, if not all, of modern first-person shooter (FPS) games. Without lag compensation, players may have to aim high at the targets in order to actually hit them. This makes the gameplay experience more realistic. Lag compensation is implemented in many mechanisms that are applied in the same way as FPS games commonly do.

Special Features and Advantages
- The FPS simulator supports different implementations of lag compensation, including the traditional approach, the dual frame history time (FHT) approach, and the adaptive approach. The dual FHT approach is now being used in Battlefield 4 to mitigate the problems of the traditional approach, which contributed to its launch fiasco. The proposed adaptive approach improves upon the dual FHT approach.
- The FPS simulator built for the project’s experiments uses many mechanisms that are implemented in the same way as FPS games commonly do.

Achievements

Collaborators and Funding Body
- PolyU

Project 3: IRate: Initial Bitrate Selection System for HTTP Streaming

IRate is a novel system to enhance the quality-of-experience of video by measuring the network at the pre-stream stage. IRate can determine the best initial bitrate with 80% of accuracy with 10-second lightweight network measurement. We further show that IRate can improve the overall and initial user-perceived quality by 4.4% and 20%, respectively.

Special Features and Advantages
- The design of IRate has considered large-scale video delivery architecture (e.g., CDN).
- IRate’s network measurement is more reliable and lightweight than flooding-based throughput measurement.
- A subjective assessment is conducted to illustrate the QoE enhancement to HTTP streaming.

Achievements

Collaborators and Funding Body
- PolyU
Project 1: Learning and Transferring Representations with Data from Multiple Domains 多域數據的學習與遷移表示

Representation learning, which concerns with learning representations to extract and organize discriminative information from the available data, is a recently developed and rapidly growing field in machine learning and computational intelligence. Transfer learning, also advocated in the past decade, deals with scenarios that the test and training sets have similar but pretty distinct distributions. In this project, we propose to develop methods for more effective transfer learning and/or deep representation learning, and to exploit new approaches to and benefits of combining these two learning paradigms. Such learning problem is studied in the context of multi-tasking learning, domain adaptation learning and co-clustering.

Special Features and Advantages
• Adding a cognitive aspect to the machine learning process
• Studying the theoretical problem of distance between domains/distributions
• Opening a new problem in transfer learning, i.e., why to transfer
• Applications include: text analytics, social media analytics, etc.

Achievements

Collaborators and Funding Body
• GRF

Project 2: Exploratory Domain Adaptation Learning: Getting Suggestions from Existing Domains 探索性領域適應學習: 從現有域獲取建議

Recently, there have been strong interests in investigating analytics techniques that allow users to interactively explore their data for something they do not know. In particular, we lack the means to explore and analyze databases of big scale. Rigorous research in domain adaptation learning (DAL) has been carried out to study the ability of a system to recognize and apply knowledge and skills learned in previous tasks to novel tasks. We hypothesize that domain adaptation learning and exploratory data analysis of large datasets have a mutual advantage in both conceptual development and applications, hoping that one can get suggestions from scalable data in the existing domains.

Special Features and Advantages
• Introducing an exploratory element to the learning process of DAL
• Studying DAL for data arising from multiple domains of large scale
• Opening up a new problem of DAL, i.e., adapting to new domains or partially unexplored domains and making DAL explore data ahead.
• Applications include any big data analytics task; particularly suitable for applications with design elements

Achievements

Collaborators and Funding Body
• GRF

Project 3: Inferring the Shape of Data by Density-based Clustering 採用基於密度的聚類進行推斷數據的形狀

Data analysis is of extreme importance in almost all areas of modern applied science. As a fundamental step, exemplar-based clustering attempts to infer the shape of data by identifying representative samples as exemplars of the obtained groups. We are investigating new exemplar-based clustering methods to cluster data with arbitrary shape by working on effective measures like density and competition. They collectively guide the clustering process to select exemplars coming from high-density samples that are not replaceable by nearby high-density samples. Furthermore, we develop an ultrafast exemplar search solution to make the new method scalable to large datasets. Several benchmarking datasets are used to demonstrate the power of the proposed method.

Special Features and Advantages
• Finding clusters with arbitrary shapes
• Determining the number of clusters automatically
• Providing an ultrafast exemplar solution for applications with a big data set

Achievements

Collaborators and Funding Body
• The project is collaborated with the group lead by Prof. Shitong Wang in Jiangnan University

Upon receiving his M.Phil. and Ph.D. degrees from the Chinese University of Hong Kong and a B.Sc. degree from the University of Manitoba, Dr Chung joined the Department of Computing, Hong Kong Polytechnic University and is now an associate professor. His primary research interests are in the study of intelligence, learning and recognition and their applications to a wide spectrum of tasks which involves text data (social media data), time series data, multimedia data, bioinformatics data, etc. Currently, he is working on research projects in the areas of transfer learning, deep learning, social network analysis and mining, big dimensionality feature learning, and big data analytics. Dr Chung published over 100 journal papers in major international journals, including IEEE Transactions on Neural Networks and Learning Systems, IEEE Transactions on Fuzzy Systems, IEEE Transactions on Knowledge and Data Engineering, Pattern Recognition and Neural Networks, and presented his works in major international conferences such as AAAI, SIGIR, CIKM, ECML, and ICDM. He also serves on program committees of top international conferences, including IEEE ICDM, AAAI and IJCAI.
Project 1: Parallel Real-Time Software on Multi-Core Processors

Real-time systems are those systems where the correctness not only depends on the logical results of the computation, but also the timing when the results are produced. For example, in automotive electronics, the computation controlling the anti-lock braking system must finish in a very short time pre-defined framework. Violating timing constraints may lead to catastrophic consequences such as loss of human life. At the same time, real-time systems are also becoming more and more computation-demanding. For example, the obstacle recognition system in an unmanned vehicle is subject to both rigorous real-time constraints and high computation demands. Multi-core processors are becoming essential to fulfill their rapidly increasing high computation demand of real-time systems. However, using multi-core processors is not a free lunch. In order to exploit the computation capacity of multi-core processors, the software must be properly parallelized. Unfortunately, existing real-time systems design methods are established based on single-core processors and sequential software, and are not applicable to multi-core based hardware platform. For example, currently in avionics industry, multi-core processors are used as single-core processors by only shutting off all the other cores, which leads to significant waste. The aim of this project is to provide an end-to-end development framework to develop parallel software for real-time systems on multi-core processors. The target users are real-time embedded software developers in telecommunication, automotive electronics, avionic electronics, among other applications. Using the results of this project, designers will be able to:

- Efficiently develop parallel software and analyze their functional, structural and timing characteristics in an interactive graphical environment
- Precisely analyze the timing behavior of the parallel software, in the presence complex multicore architecture features
- Deploy the parallel software on efficient runtime environment and dynamically optimize the performance (e.g., throughput) while meeting the timing constraints (e.g., deadlines)

Special Features and Advantages

- The first effort to develop an integrated development environment (IDE) for parallel software of real-time embedded systems
- Provided an interactive graphical interface to visualize the parallel programs, to help the designers to modeling, debugging and code synthesis
- Provide analysis functionalities to provide important end-to-end software timing information of common interests, e.g., the worst-case response time
- Automatic deployment of the parallel software on the runtime systems, to avoid the tedious manual integration procedure in previous methods

Achievements

- Previous work on multi-core processor oriented real-time system design won the Best Paper Award of IEEE Real-Time Systems Symposium (RTSS) 2009 and EDAA European Conference on Design Automation (DATE) 2013, and EDAA Outstanding Dissertation Award 2014

Collaborators and Funding Body

- PolyU

Project 2: Security-Aware Real-Time Systems in Automotive Electronic Systems

In cyber-physical systems the computation directly affects the physical world. The information leakage from and attacks to these systems may cause tragic consequences. For example, information leakage from the automotive driving system of an unmanned vehicle may facilitate the attackers to launch physical attacks to the vehicle such as making a traffic accident. In many cyber-physical systems, the timing of the monitoring/control tasks depends on the state of the affiliated physical plant. Therefore, the attackers may infer the states of the physical plants by observing the timing behaviors of the computing systems, which we called “timing side-channel”. Although the embedded software are usually developed with security mechanisms to prevent themselves from being functionally hacked, the timing side-channel issue has been largely ignored in the current computing system development practice, even in safe-critical domains such as automotive and avionic electronic systems. An example of timing side-channel is in the control system of automotive fuel injection, where the control tasks are triggered at certain rotation angles of the crankshaft. Therefore, the activation frequency directly reflects the engine rotation speed, and partially reflects the driving states of the vehicle. The attackers can obtain the execution sequence by measuring the electromagnetic signals of the computer system, and analyze the execution sequence to obtain the activation frequency, and eventually infer the engine rotation speed. The target of this project is to study the timing side-channel security issues in automotive electronic systems. The results obtained in this project will help the automotive electronic system designer to understand the potential security flaw caused by timing side-channels, and provide theories, techniques, and software tools to help them protect these threats in the design procedure.

Special Features and Advantages

- The first project in the world to address the critical security issues in cyber-physical systems due to timing side-channels. These critical security issues, if not properly addressed, may lead to catastrophic consequences such as loss of human life.
- The project is driven by Automotive Electronics applications. In particular, we cooperate with BMW Brilliance Ltd., to identify the potential security flaws in their existing products.

Achievements

- Preliminary theoretical results based on Response-time analysis, Discrete Fourier Transform and Period Transformation

Collaborators and Funding Body

- BMW Brilliance Ltd
- PolyU

Dr Guan is currently an assistant professor at the Department of Computing, The Hong Kong Polytechnic University. Dr Guan received his BE and MS from Northeastern University, China in 2003 and 2006 respectively, and PhD from Uppsala University, Sweden in 2013. Before joining PolyU, he worked as a faculty member in the Institute of Embedded Systems of Northeastern University, China. His research interests include real-time embedded systems and cyber-physical systems. He received the EDAA Outstanding Dissertation Award in 2014, the Best Paper Award of IEEE Real-Time Systems Symposium (RTSS) 2009 and EDAA European Conference on Design Automation (DATE) in 2013, and the Best Poster Award at the PhD forum of IPDPS in 2012. He was the program co-Chair of EMSOFT 2015, and has served for the TPC of RTSS, DAC, RTAS, EMSOFT, ECRITS, LCTES, RTCSA, ASP-DAC in recent years.
Dr GUO Song
BSc (HUST); MSc (BUPT); PhD (uOttawa); SMIEEE; SMACM

RESEARCH INTERESTS

Project 1: Self-Adaptive Platform for Big Spatial-Temporal Data Analytics
The exploration of big spatial-temporal data stimulates various location based services and applications. To fully exploit the values hidden in big spatial-temporal data, there is an urgent need for a high-performance software platform for data storing and processing. The proposed research can learn knowledge (data skew and access pattern) from data by using machine learning technology, and automatically optimize system configuration in runtime. It has wide applications including climate prediction, disaster management and social network analysis.

Special Features and Advantages
- Enable a two-way interaction between data/applications and software platform
- Enable automatic system configuration according to dynamic data characteristics

Achievements

Collaborators and Funding Body
- PolyU

Project 2: Health Tracking in Smart Home using RF Reflection and Big Data
The goal of this research is to develop a living activity and health condition monitoring and analyzing system in smart home. This system can identify human activities, such as walking, dining and sleeping, by collecting radio signals reflected by RFID tags that are widely attached to household appliances and furniture in smart home, without requiring any special devices worn by human. By using big data technology to extract unique patterns of human activities, it can quickly report emergent events, like sudden illness, elder falling, fire and intruders. By analyzing long-term human-activities, this system can monitor human health condition and discover latent disease.

Special Features and Advantages
- Low cost, ease of deployment
- Tremendous benefits for elderly people

Achievements
- Xiulong Liu, Keqiu Li, Song Guo, Alex X. Liu, Peng Li, Kun Wang, and Jie Wu, “Top-k Queries for Categorized RFID Systems”, IEEE Transactions on Networking, accepted.

Collaborators and Funding Body
- MIC

Project 3: Big Data for Disaster Management - Dynamic Evolution of Emergency Communications System
Emergency communications networks are crucial for monitoring and providing assistance to affected people during long-lasting disasters. Future emergency networks consist of ad-hoc links between mutually reachable smartphones in the disaster area, unfailed portions of the cellular network, and the communication capabilities provided by the specially deployed emergency equipment. All these components vary in their ability to provide necessary communications as the disaster unfolds. It is therefore essential to continuously monitor and ‘‘tune’’ the network to provide the best possible coverage and communications capability.

Special Features and Advantages
- An intelligent and adaptive deployment of movable communications centers to connect disconnected network components
- Dynamically forming coalitions among smart phones for conserving battery and other resources
- Data obtained from twitter during the disaster exploited for obtaining a global view of the situation and thus help network evolution

Achievements

Collaborators and Funding Body
- JST-NSF

Song Guo is a Full Professor at Department of Computing, The Hong Kong Polytechnic University. He received his Ph.D. in Computer Science from University of Ottawa and was a full professor with the University of Aizu, Japan. His research interests are mainly in the areas of big data, cloud computing, green communication and computing, wireless networks, and cyber-physical systems. He has published over 350 conference and journal papers in these areas and received 3 best paper awards from IEEE/ACM major conferences. Dr. Guo has served in editorial boards of several prestigious IEEE journals, including TPDS, TETC, TGPN, TSSC, and Communications. He is an active volunteer as General/TPC Chair/Co-Chair for 20+ international conferences and Chair/Vice-Chair for several IEEE Technical Committees and SIGs. He is a senior member of IEEE, a senior member of ACM, and an IEEE Communications Society Distinguished Lecturer.
Project 1: Algorithms for Consensus Trees

The phylogenetic tree is a classical data structure used by scientists to describe evolutionary history. Given a set of objects created by an evolutionary process (such as biological species or natural languages), a phylogenetic tree represents the objects by leaves and their common ancestors by internal nodes so that the resulting branching structure reflects the evolutionary relationships. For various reasons, inferring an accurate phylogenetic tree from experimental data can be a difficult task. For example, small errors in the input data may yield trees with totally different branching patterns. When faced with a collection of phylogenetic trees whose branching patterns contradict each other, scientists need to reconcile them into a single tree. Such a tree is called a consensus tree. Changing the rules for how to resolve conflicts between trees leads to different types of consensus trees, each one with its own set of advantages and disadvantages.

Special Features and Advantages

- We have developed faster algorithms for constructing many of the most popular consensus trees such as the majority rule consensus tree [Margush, McMorris; 1981], the loose consensus tree [Bremer; 1990], the Adams consensus tree [Adams; 1972], the R* consensus tree [Bryant; 2003], and the frequency difference consensus tree [Goloboff et al.; 2003].
- Our new algorithm for the majority rule consensus tree is worst-case optimal and thus resolves an open theoretical problem from the 1980s.
- Our freely downloadable prototype implementations outperformed some widely used commercial and academic software for many kinds of inputs.

Achievements


Collaborators and Funding Body

- Funded by The Hakubi Project at Kyoto University, Japan, and KAKENHI grant number 26330014.

Project 2: Fast Matrix Multiplication

Methods for multiplying matrices are useful tools for lots of mathematical and engineering-related problems such as solving a system of linear equations, computing the effect of applying a series of linear transformations, context-free grammar parsing, counting paths of a fixed length between two nodes in a network, estimating the relative importance of different links in Google’s PageRank algorithm (“the billion dollar eigenvector”), calculating the 3D coordinates of rotated objects in computer graphics and robotics, etc. Given two \( (n \times n) \)-matrices with nonnegative integer entries, the naïve algorithm for computing the matrix product runs in \( O(n^3) \) time. For large inputs, this is too slow. There exist algorithms that run in substantially subcubic time, e.g., a famous one due to F. Le Gall from 2014 uses \( O(n^{2.3729}) \) time, and a major open question is: Can it be done in \( O(n^2) \) time?

Special Features and Advantages

- We have developed a novel technique based on interpreting matrices as 3D histograms. To multiply two matrices, we decompose their 3D histograms into 3D blocks which are then manipulated in a pairwise manner using the interval tree data structure.
- This leads to an \( O(n^2 + rs) \)-time algorithm for matrix multiplication, where \( r \) and \( s \) denote the minimum number of 3D blocks into which the two input matrices can be partitioned, respectively.
- In case \( r \) and \( s \) are large then even the naive \( O(n^3) \)-time algorithm outperforms it. However, whenever the input admits a partition into a small number of 3D blocks (i.e., when \( r \) and \( s \) are small), our new algorithm is very efficient.

Achievements


Collaborators and Funding Body

- Peter Floderus, Christos Levcopoulos, Andrzej Lingas, and Dzmitry Sledneu.
- Funded by Swedish Research Council grant 621-2011-6179 and The Hakubi Project at Kyoto University, Japan.

Dr Jesper Jansson received the PhD degree in Computer Science from Lund University, Sweden. His research interests include graph algorithms, data structures, and bioinformatics, and he has published many peer-reviewed articles related to these topics in reputable journals. He has also contributed several entries to Springer’s “Encyclopedia of Algorithms”, served on the program committee of various international conferences (ISAAC 2017, BIBE 2017, IWOCA 2017, IWOCA 2016, AAIM 2016, ICALP 2015, CPM 2013, etc.), been an invited plenary speaker at the 2010 MSP Annual Convention, and evaluated grant proposals submitted to research organizations in New Zealand, the Netherlands, and Canada. Dr Jansson has been an Editorial Board member of the MDPI journal “Algorithms” since 2008 and a regular reviewer for American Mathematical Society’s “Mathematical Reviews” since 2007.
Dr LEONG Hong-va
BSc, MPhil(CUHK); PhD(California); MACM; MIEEE

RESEARCH INTERESTS
Parallel and Distributed Computing, Distributed Databases, Mobile Computing, Internet Computing

Project 1: Crossmodal Human-Computer Interaction: Linking Calligraphy with Art 跨模態人機交互：書法與藝術之連結*
Callipaint and MelodicBrush are innovative human-computer interaction systems that link together ancient Chinese art forms – namely, Chinese calligraphy, music and painting. Applying concepts from cross-modal interaction and synesthesia, we map writing characteristics such as force, speed, and stroke to characteristics such as tempo and note in music, and level of detail or blurriness in art. In real use, the user writes Chinese calligraphy using a brush. The written words are “translated” to graphics or music, and writing mechanics are analyzed and used to augment the graphics or the music to create a coherent piece of art. The goal is to facilitate self-expression and creativity to a wider audience.

Special Features and Advantages
• Links together different forms of art in a cross-modal approach
• Facilitates and supports self-creativity

Achievements
• ACM CHI 2013
• ACM Multimedia 2014

Collaborators and Funding Body
• PolyU
• GRF

Project 2: AffectTube *
This project applies the upcoming field of affective computing to a real life application. Using facial expression analysis, our system “watches” the user while he/she is watching a movie, and analyses his/her facial image for indicative landmarks, and calculates action units from these landmarks. These action units, put together, give the expression of a person’s face. Given this expression, and aligning with the temporal storyline of the movie, the system is able to deduce how much the user liked the movie. Aggregating results over multiple users gives us an overall feel of the ultimate rating of the movie.

Special Features and Advantages
• Automated Identification of Human Affects
• Linkage between human response and a common human-computer interaction activity

Achievements
• ACM Intelligent User Interfaces

Collaborators and Funding Body
• PolyU
• GRF

Project 3: Appropriate Technology: Lab in a Suitcase and PhotoEyeScreen 合宜科技：手提箱裡的實驗室和PhotoEyeScreen*
In this project, we look at technology with the view of “How can this be used to address problems in world as a whole, not just for the top 10% of the world’s population?” To this end, the Appropriate Technology projects (which address issues ranging from health care to education) look at low-cost, off-the-shelf repurposing of technology to make them appropriate for developing world situations. Examples of this approach are our “Lab in a Suitcase”, which has been deployed in Cambodia and will be deployed to Rwanda, Myanmar and Kyrgyzstan this summer, and the “cell-phone eye screening” project which has obtained good performance, even when compared against commercial, medical-grade equipment.

Special Features and Advantages
• Repurposes technologies to address real-life problems in the developing world
• Focus on sustainability and community-based research

Achievements
• IEEE International Symposium on Multimedia 2015
• HKICT Awards 2013

Collaborators and Funding Body
• PolyU Community Research Fund

* Project is co-investigated with Dr Hong-va Leong, Department of Computing, The Hong Kong Polytechnic University

Dr Leong is currently an associate professor at The Hong Kong Polytechnic University. He received his PhD degree in Computer Science from University of California, Santa Barbara in the United States. His research interests are in mobile computing, internet computing, distributed systems, distributed databases, and affective computing. He had been actively involved in the research community in organizing conferences, being the track chairs for ACM SAC Mobile Computing and Applications Track and IEEE COMP�SA Mobile Computing Track. He served as the program committee members for numerous conferences, including the prestigious VLDB, EDBT, ICDCS, MDM, CIKM, and many others. He also served as a reviewer for ACM Transactions on Computer Systems, IEEE Transactions on Parallel and Distributed Systems, on Knowledge and Data Engineering, on Mobile Computing, on Multimedia, and on Computers, Information Systems, and other journals. He published widely in his research areas. He is a member of the ACM and IEEE Computer Society.
Dr Li Shuai
BEng(HFUT); MEng(USTC); PhD(Stevens)

RESEARCH INTERESTS
Robotics, Dynamic Systems and Control, Recurrent Neural Networks, Distributed Control and Optimization

Project 1: Software Defined Battery: A Novel Architecture for Large-Scale Battery 軟體定義電池: 面向大尺度電池陣列的新型構架

Large-scale Lithium-ion batteries are widely utilized in electric vehicles (EVs). For instance, there are totally 7,104 lithium ion cells in a Tesla S Model. However, current technology on the management of such a huge array of cells is less efficient, and makes batteries suffering from various disadvantages, including high weight, high cost, low safety, low endurance, long charging time. This project aims to improve battery performance by breaking two major bottlenecks: 1. the imbalance in capacity between different cells. 2. the voltage mis-matching between the battery supply and load demanding. In this unified architecture, programmable switches and real-time cell monitoring are utilized for the isolation of power-weak or low-safety cells to address bottleneck 1; on-demand cell path reconnection are utilized to mitigate the voltage gap between supply and demand. Overall, it provides an architecture to dynamically change the cell connection topology in a battery. This technology is expected to reach low-weight, small size, low cost, long longevity, low charging time, and safe battery systems.

Special Features and Advantages
• The first software defined battery architecture allowing user customization
• Run-time optimization of cell connections
• A tool to improve battery performance with zero cost on hardware

Achievements
• Distributed Multi-robot Formation and Tracking Control in Cluttered Environment, ACM Trans. on Autonomous and Adaptive Systems
• CPS Oriented Control Design for Networked Surveillance Robots with Multiple Physical Constraints, IEEE Trans. on Computer-aided Design of Integrated Circuits and Systems

Collaborators and Funding Body
• PolyU

Project 2: Distributed Winner-Take-All for Competitive Control of Networked Systems 基於分散式贏者通吃策略的網絡系統競爭控制

In the past decade, dynamic consensus has significantly advanced the research on distributed control, leading to successful solutions of a variety of distributed cooperation problems. However, the research on the other side of cooperation, which is distributed competition, has been largely ignored. This project to explore a consensus-like distributed algorithm for competitive control problems. In this project, we study distributed winner-take-all algorithms, establish their convergence theorems, and investigate the fundamental problem of employing distributed algorithms for competitive control, aiming at paving the foundation of using distributed algorithms for the emergence of complex nonlinearity on a network of agents. The theoretical results of this research will benefit various applications, e.g., distributed outlier detection and distributed multi-robot multi-task allocation.

Special Features and Advantages
• The first distributed winner-take-all algorithm with theoretical proofs
• Competitive control jointly with optimization, robustification, and noise rejection
• A module for building complex networks with the competition behaviors

Achievements
• Distributed Winner-take-all in Dynamic Networks, accepted by IEEE Transactions on Automatic Control

Collaborators and Funding Body
• ECS

Project 3: Limited Communication Constrained Multi-Robot Cooperation based on Distributed Dynamic Neural Networks 通信局限下基於分散式動態神經網路的多機器人協作研究

Multi-robot cooperation plays an important role in applications, e.g., cooperative rescue, robotic surgery, cooperative painting and payload transportation, and is becoming a hot but tough topic in robotics. The conventional all-to-all communication based multi-robot cooperation scheme has the disadvantage of high communication load and large computational complexity, which imposes strong limitations to the scalability and robustness of multi-robotic systems. Motivated by this application appeal, targeting at solving multi-robot cooperation task under the constraint of limited communication, absorbing the advantage of constrained optimization and constrained game in multi-robot cooperation, we present dynamic neural network approach with guaranteed finite time convergence to solve this problem. This research is the first time to model dynamic neural networks in game theoretical approaches. The implementation of this project extends the modeling of dynamic neural networks from conventional optimization theory to game theory and enrich the theoretical framework of neural networks, and is applicable to various applications requiring multiple robots.

Special Features and Advantages
• A game theoretic approach for modeling robot cooperation with communication constraints
• A model-based dynamic neural network and an intelligent control framework, which does not require time-consuming pre-training
• A scalable approach applicable to a network of robots

Achievements
• Distributed Recurrent Neural Networks for Cooperative Control of Manipulators: A Game-Theoretic Perspective, IEEE Transactions on Neural Networks and Learning Systems.
• Inverse-free Extreme Learning Machine with Optimal Information Updating, IEEE Transactions on Cybernetics.
• Dynamic Neural Networks for Kinematic Redundancy Resolution of Parallel Stewart Platforms, IEEE Transactions on Cybernetics.

Collaborators and Funding Body
• NSFC

Dr Shuai Li received the B.E. degree in Precision Mechanical Engineering from Hefei University of Technology, China in 2003, the M.E. degree in Automatic Control Engineering from University of Science and Technology of China, China in 2008, and the Ph.D. degree in Electrical and Computer Engineering from Stevens Institute of Technology, USA in 2014. He is currently a research assistant professor with Department of Computing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong. His current research interests include dynamic neural networks, cyber-physical systems, multi-robotics, software defined battery.
Project 1: Making Sense of Social Media Streams through Text Summarization

This project aims to propose a novel summarization framework to address the problems raised by the less-informative and dynamic social media content. The objective is to develop adaptive models and scalable algorithms based up this framework to explore three key intrinsic dimensions of social media text streams, i.e., the temporal, social and content dimensions. We integrate together the content analysis and time-series modeling techniques to automatically determine “what and when is worth to summarize” by tracking and modeling the dynamic changes in the stream over time.

Special Features and Advantages

- Social media contains a great wealth of information and if explored well (e.g., via summarization), it offers significant opportunities for timely emergency response and appropriate actions.
- Social media text is often characterized by the short, noisy, large scale, and dynamic nature, therefore traditional summarization approaches are no longer adequate.
- We address the problem of summarization on social media text stream, and aim to dynamically generate a group of summaries about a topic with each summary describing a particular stage of topic development that attracts public attention.
- We integrate together the content analysis and time-series modeling techniques and emphasize on the temporal, social and content features of the social content.

Achievements

- The project just starts this year. Research-wise, we collected Twitter data to automatically generate training data for learning summarization models and published an AAAI paper this year. System-wise, we implemented a simple web-based online news summarization system.

Collaborators and Funding Body

- GRF

Project 2: Modeling Opinion Influence in Social Media Networks for Business Intelligence Applications

The explosive growth of social media has provided millions of people the opportunity to share their opinions about a multitude of topics, such as politics, sports and especially commercial products of companies. The relationships and interactions among people play a fundamental role for the spread of opinions through their social networks. Monitoring online public opinions and analyzing how people’s opinions are formed and change, and how people influence each other to propagate opinions through the networks can be extremely useful for various business intelligence applications, notably viral marketing and customer relationship management.

Special Features and Advantages

- Understand how people interact and how information propagates over social media network
- Model and Track User Behaviors, Hot Topics and Opinions
- Social Influence Modeling and Tracking
- Analyze Influence Among Individual and Group
- Capture How Influencers Changes Other’s Opinions and Behaviors
- Locate Influencers and Predict Opinion Changes, etc.
- Wide Range of Business Applications
- Social Influence Marketing Improves Brand Awareness and Sales
- Social Customer Relationship Management (CRM) Engage Customers in a Trusted and Friendly Environment

Achievements

- This is an ongoing project. Research-wise, we categorized the roles of social influences, developed time-series models for modeling interpersonal opinion influence and predicting user’s future opinions. Two papers have been published in SIGIR 2014 and IJCAI 2015 workshop. A journal paper and a conference paper are under review.

Collaborators and Funding Body

- GRF

Project 3: Content-Oriented Microblog Mining Based on Speech Act Recognition

As a social network, the microblogging service engages users in various communicative activities. According to the speech act theory from linguistics, we propose a microblog content-oriented research project based on the communicative patterns manifested by microblogging users. The project also aims to model user influence relations by building a speech act-based network.

Special Features and Advantages

- According to the speech act theory from linguistics, we propose a microblog content-oriented research project based on the communicative patterns manifested by microblogging users.
- Since speech acts are not directly retrievable from the microblog data, we are dedicated to the automatic recognition of speech acts, a classification task that is hampered by the high noisiness of the microblog text as well as the deficiency of annotated data.
- We are concerned with speech act-based information extraction, which does not rely on de-noising, and automatic summarization of microblogs, which leverages template-based generation techniques.
- We model user influence relations by building a speech act-based network.

Achievements

- Research-wise, we published 20 papers on top conferences and journals (including AAAI, ACL, SIGIR, IEEE TASLP, ACM ASLP, and Computational Linguistics). System-wise, we are implementing a machine conversion system (chatbot) based on deep learning technology.

Collaborators and Funding Body

- NSFC

Dr Li is currently an associate professor of the Department of Computing at the Hong Kong Polytechnic University, and the program leader of Double Degree in Computing and Management. Her research interests include natural language processing, text mining, social media analysis, information extraction and summarization. She has directed and participated in quite a number of research projects. As a principal investigator, she has received several fully supported grants from Hong Kong Research Grant Council and a grant from National Natural Science Foundation of China. She has co-authored a book in Chinese natural language processing, and published 3 book chapters and about 200 papers in major international journals and conference proceedings (including top journals IEEE TKDE, IEEE TNN, IEEE TASLP, ACM TOIS, ACM TALIP, ACM TSLP, CL, and top conferences like AAAI, IJCAI, ACL, COLING, WWW, SIGIR, CIKM). Dr Li has served as the information officer of SIGHAN, the associate editor of UCPOL and the reviewer of the journals, such as IEEE TKDE, IEEE TASLP, ACM TALIP, ACM TSLP, and TACL etc. She has also served as the publication chairs, tutorial chairs, area chairs and members of organizing and technical committees of many international conferences, including AAAI, ACL, and EMNLP etc.
Music can evoke strong emotions. This amazing ability has fascinated the researchers in different fields to discover the nature of music and emotion. Psychologists propose the hypotheses of the correlation between musical components and emotion types based on life experiences, for example, flowing rhythm elicits happiness, and then design psychological paradigms to testify their hypotheses. Psychological research in the last couple of decades has showed us that there exists high correlation between music signal and emotion responses. We intend to apply the findings of this project in music therapy in various mood disorders such as depression. We also want to provide support to the persons who suffer from mood sub healthy in modern society.

Special Features and Advantages
- Provide systematic and quantitative analysis of the relationship between music and emotion
- Provide evidence of music therapy from neuroscience by exploring brain imaging techniques
- Show great potentials in mood disorders rehabilitation

Achievements
- Publication in top conference of multimedia SIG MM
- Publications in top journals such as IEEE Trans. On Affecting Computing and IEEE Trans. On Autonomous Mental Development
- Ten invited talks in medical conferences and symposiums

Collaborators and Funding Body
- PolyU
- NSFC

Project 3: Learn Unconsciously - Model Implicit Visual Learning Using Dissipative Theory
無意識學習 — 基於耗散理論的視覺隱性學習建模

This project proposes to explore computational models of implicit learning, and aims at improving the accuracy and efficiency of computer vision. According to the degree of consciousness involvement, human learning involves information processing in both explicit and implicit manners. The explicit learning, with full involvement of consciousness, is guided by targets or/and rules, such as learning of mathematics in schools. The implicit learning, however, acquires new information without clear intention of doing it. Research on psychology indicates that implicit learning plays an important role in human visual perception. Due to limitation of cognitive resources, only a small subset of visual information is available to conscious awareness at any given moment while the large quantity is learned in implicit ways. However, the work of making computer automatically learn in implicit manner is limited compared with the extensive study of simulating explicit learning. Therefore, this project intends to fill in the gap in the field. Findings of this project will directly contribute to both multimedia content analysis and artificial intelligence. Moreover, the research outcomes can be used in many real world applications, such as automatic car and video surveillance.

Special Features and Advantages
- Model subconsciousness using computational model
- Introduce theory of complex system to artificial intelligence problem solving
- Great commercial potentials to influence human’s behavior without awareness

Achievements
- Publications in top journal ACM Trans. On Intelligent Systems and Technology
- Nanjing University

Collaborators and Funding Body
- PolyU
- NSFC

Dr Liu Yan is an associate professor in Department of Computing at The Hong Kong Polytechnic University. Dr Liu got her PhD from Department of Computer Science at Columbia University, majoring in multimedia computing in large scale dataset. Her recent research interests cover artificial intelligence, cognitive computing, brain imaging. She has been the investigators of several cross area project, such as deep learning for social media, and music therapy by emotion modeling.
Project 1: Novel Cross-layer Interference Resistant Multiple Access Approach for Wireless Networks 無線網絡抗干擾多路訪問的跨層技術

This work aims to design a novel cross layer protocol that can combat both hidden terminals and exposed terminals in wireless networks, both helping in achieving higher network throughput compared to the 802.11 standard and other state-of-the-art protocols. By observing that nodes in current protocols may cause high transmission collisions or waste many concurrent transmission opportunities in several typical network scenarios, this work proposes a novel multiple access method that relies on a signature detection method in the physical layer to combat control frames’ collisions and exploit transmission concurrents. The proposed approach can be integrated into current 802.11-based wireless devices.

Special Features and Advantages
- It exploits the concurrent transmission opportunities efficiently
- It avoids the transmission collisions effectively
- It can be integrated into current 802.11-based wireless devices easily
- It can improve the wireless network throughputs significantly

Achievements
- The findings of this work have been reported in several top international journal and conference papers (IEEE ICNP 2012, IEEE SECON 2012, IEEE TMC 2016, IEEE ICC 2017).
- One patent has been applied based on the findings of this work.

Collaborators and Funding Body
- GRF
- NSFC

Project 2: Energy-Saving Mechanism against Packet Overhearing in High Traffic Wireless LANs 高負載無線網絡中針對數據包泛聽的節能技術

Energy efficiency is a critical issue for wireless devices. The packet overhearing problem incurs high energy cost because all active neighboring devices need to spend their energy receiving the packets though the packets are not addressed to them, which accounts for the majority of the devices’ energy inefficiency in high traffic wireless local area networks (WLANs). This work proposes a novel scheme to solve the energy inefficiency of the packet overhearing problem. By adding a new header, which contains the critical information, in front of the data packet at the PHY layer, this new scheme enables the devices to discern the required information in the energy-saving downclocking mode. Consequently, the non-destination devices of the packet can switch to the sleeping mode to avoid the packet overhearing problem.

Special Features and Advantages
- It leverages the advantages of both the downclocking mode and sleeping mode for achieving energy efficiency for WLANs
- It can be integrated into current 802.11-based wireless devices

Achievements
- The findings of this work have been reported in a top international journal paper (IEEE TIFS 2015).
- One patent has been applied based on the findings of this work.

Collaborators and Funding Body
- PolyU

Project 3: Physical Layer Inter-symbol Obfuscation 物理層信標混淆編碼技術

This work explores the feasibility of inter-symbol obfuscation to defend against the passive eavesdropping attack and fake packet injection attack during the wireless communications. A novel scheme, which utilizes a set of artificial noisy symbols (symbols key) to obfuscate the original data symbols in the physical layer is proposed. The scheme can effectively enhance the wireless communications security. On the one hand, an eavesdropper, without knowing the symbols key, cannot correctly decrypt the obfuscated symbols from the eavesdropped packets. On the other hand, a legitimate receiver can easily check the integrity of the symbols key and then reject the fake packets from the received packets. The security analysis reveals that, without considering the initial key, the proposed scheme can achieve information-theoretic secrecy against the passive eavesdropping attack and computational secrecy against the fake packet injection attack, both leading to enhancing current wireless communications security.

Special Features and Advantages
- It combines the data encrypting and channel interfering at one step to make the scheme a location-free solution against the eavesdroppers
- It does not need any trusted third party to deploy the key - a two-party solution to wireless communications security
- It provides information-theoretic secrecy against the passive eavesdropping attack and computational secrecy against the fake packet injection attack

Achievements
- The findings of this work have been reported in a top international journal paper (IEEE TIFS 2015).

Dr Wei Lou is currently an associate professor in the Department of Computing, The Hong Kong Polytechnic University, Hong Kong, China. He received the B.E. from Tsinghua University, China in 1995, the M.E. from Beijing University of Posts and Telecommunications, China in 1998, and the Ph.D. in Computer Engineering from Florida Atlantic University, USA in 2004. His current research interests are in the areas of wireless networking cross-layer design, wireless ad hoc and sensor networks, mobile cloud computing, and smart city technologies and systems.
This project focuses on emotion analysis from text based on the multi-dimensional affective representation of the words. Such representation can be used in composition model so that higher level (phrase level, sentence level) affective representation can be computed through composition. First the word’s affective representation are constructed through crowdsourcing and automatic regression from word embedding. Then a semantic dependency based composition model that considers different semantic dependency roles is proposed to learn higher level representation for the sentence level emotion analysis.

**Special Features and Advantages**
- Different from previous emotion lexicons represented by discrete emotion labels, we use multi-dimensional representation that can be used in composition model.
- The initial affective lexicons are constructed through crowdsourcing rather than time-consuming expert-based annotation.
- Such affective lexicons can be extended automatically through a regression model from word embedding.
- A novel composition model that can learn the higher level (phrase and sentence level) affective representation from the word’s affective representation.

**Achievements**
- Short-term multi-dimensional affective lexicon construction.
- Long-term emotion analysis both for subjective and objective texts, which can be used in public opinion monitoring, automatic product review summarization, emotional recommendation, emotional human machine interaction, etc.

**Project 2: Cantonese Speech-To-Text as Turnkey Technology for Dyslexic Children**

In this project we aim to develop the turn-key technology for Cantonese Speech-To-Text (STT) Conversion system to help students with learning difficulties. The system includes two parts. The first part is the STT engine which will be produced as a software module that can be used by different applications. The second part is an auto-scribe software to help students with writing difficulties in taking tests through this assistive tool as a part of a new special examination arrangement. Hong Kong has over 16,000 students suffering from reading/writing disability (dyslexia). Dyslexic children with cognitive deficiency in writing skills, do have normal intellectual levels compared to other children and they have no problem expressing their ideas through speech. The use of modern computer technologies aims can greatly help enhance equal learning opportunities for our children with special educational needs and the system we develop will help them to reach their full potentials.

**Special Features and Advantages**
- The key technology to be developed is on obtaining Cantonese speech feature extractions and obtaining Cantonese training data for machine learning algorithms.
- Use of Onset-Nucleus-Coda as phonetic units for Cantonese with speaker adaptation.
- Leverage on the latest speech technology in deep learning to be processed using GPU to supply additional computing powers for the training of speech data – Use of Deep Neural Network and Hidden Markov Model.
- GUI as additional modules so that normal window applications can be used.

**Achievements**
- Achieved Word Error Rate below 10% [latest to 9.5%] comparable performance to state-of-the-art SST systems for other languages such as Mandarin Chinese.
- Use of both speaker adaption and ONC rather than Initial-Final model for over 13% improvement.
- Collection of Cantonese NLP resources.

**Collaborators and Funding Body**
- ITF: ITS/072/14
Dr LUK Wing Pong Robert
BSc & Dip. Eng.(Southampton); MSc(Warwick); PhD(Southampton); FBCS; SMACM; SMIEEE, CEng, CITP

RESEARCH INTERESTS
Information Retrieval, Pattern Recognition, Natural Language Processing, Data Structures and Algorithms

Project 1: Fast Retrieval with Blind/Relevance Feedback
快速盲式或相應式的回饋搜查
Feedback in Information Retrieval is the process of feeding back information from the initial retrieval to modify the original query, so that a second retrieval is done using the modified query in order to improve the retrieval effectiveness. Blind feedback refers to using the top 10 or 20 documents in the initial retrieval as feedback assuming all of them are relevant. Relevance feedback refers to giving the user top 10 or 20 documents in the initial retrieval for indicating relevance before the second retrieval is done. Blind Feedback or Relevance Feedback is slow for many search applications because its retrieval time is linearly dependent on the number of different words in the query, and effective queries typically have a sizeable number of query terms. As part of a general approach to reducing retrieval times, we designed specialized forward index for subsequent fast second retrieval. These specialized indices are for storing document vectors. The trade-off between retrieval effectiveness and retrieval time-space efficiency is investigated using benchmark data (e.g., using Text Retrieval Conference data).

Special Features and Advantages
• Use forward index for fast re-ranking
• Use specialized, patented dictionary data structure for fast matching
• Little loss of retrieval effectiveness improvement by re-ranking instead of re-retrieval

Achievements
• US8620900 B2 (USA patent)
• US6976025 B2 (USA patent)

Collaborators and Funding Body
• GRF B-Q23P

Project 2: Context-dependent Features for Text Categorization
以上文下理的特徵造文本分類
Text categorization is the process of identifying the category (e.g., politics or entertainment) of a document. It typically uses words as independent features for classification. However, in pattern recognition, it is well known that context-dependent features are highly effective. Therefore, we designed context-dependent features for text categorization in order to improve the classification performance. Here, context-dependent features are words in the documents but the feature values or the weights of those words are computed based on the surrounding words in the document contexts of those words or features. We have tested the idea of context-dependent features for three text categorization test collections: Reuters-21578, OHSUMED and Reuters Corpus Volume 1 – version 2. Results show that for all test collections, there were statistically significant improvement of the composite performance that combines both recall and precision, using the context-dependent features compared with independent feature based on using a state-of-the-art classifier.

Special Features and Advantages
• Design innovative context-dependent features for text categorization
• Achieve statistical significant improvement of classification performance for the test collections

Collaborators and Funding Body
• James Allan, University of Massachusetts

Project 3: A comparison of various state-of-the-art retrieval models
對TREC Web Track 的各種最先進的檢索模型進行比較
Retrieval model is the heart of ranking of documents for web search engines. Recently, there are a number of retrieval models that are being proposed and claimed to out-perform the well known retrieval models. However, these new retrieval models are tested with configurations that do not usually bring the best performance that can be compared with top TREC retrieval effectiveness. Therefore, it is unknown which retrieval model performs the best. In this study, we implemented various recent retrieval models and compared their performance using terabyte collections in high performance configurations. Results show that some recent retrieval models did not perform as well as claimed compared with the well known retrieval models. Therefore, claims about outperforming the well known retrieval models need to be done carefully using a high performance configuration.

Dr Robert Luk is mainly interested in information retrieval. He has participated in open search engine evaluation workshops like TREC and NTCIR. His search engine can index and search terabytes of web data. His search engine is also calibrated to perform similarly to the top TREC performers. He holds various search technology patents (US or PRC). He has been a consultant for the Hong Kong Judiciary for developing a search prototype for bilingual law retrieval. He has published over 100 refereed publications. He is a chartered fellow of BCS, a senior member of ACM and IEEE.

Collaborators and Funding Body
• GRF B-Q23P

Special Features and Advantages
• Use forward index for fast re-ranking
**Project 1: A System for Automatically Generating and Checking Privacy Policies for Android Apps**

**針對Android Apps隱私政策的自動化生成和檢查系統**

A privacy policy is a statement informing users how their information will be collected, used, and disclosed. Failing to provide a correct privacy policy may result in a fine. However, writing privacy policy is tedious and error-prone, because the author may not well understand the source code, which could be written by others (e.g., outsourcing), or does not know the internals of third-party libraries without source codes. Our system can automatically generate correct and readable privacy policy, easing the identification process, and reducing the manual-verification workload. Applying VulHunter to 557 randomly collected apps, we found that 375 apps (67.3%) had at least one vulnerability. Our system can benefit app developers, stakeholders of app markets, and anyone who is concerned with the privacy risks from apps.

**Special Features and Advantages**
- Does not need the source code of Android apps
- Generate correct and readable privacy policy templates for Android apps automatically
- Identity problems in existing Android apps’ privacy policies automatically

**Achievements**

**Collaborators and Funding Body**
- PolyU
- ITF

**Project 2: A New Static-Analysis System for Discovering Vulnerable Android Apps**

**基於靜態代碼分析的Android Apps安全漏洞挖掘系統**

With the mobile Internet’s prosperity, recent years have witnessed an unprecedented number of Android apps sold in app markets. However, short development cycles and insufficient security development guidelines have led to many vulnerable apps. For example, HP research recently found that 90 percent of apps are vulnerable. VulHunter is a new static-analysis framework that performs cross-layer dynamic taint analysis to collect control and data flow information, and another subsystem that conducts instrumentation on all layers. Our system can benefit security companies, app developers, and anyone who cares about the security and/or the performance of Android apps.

**Special Features and Advantages**
- Conduct dynamic taint analysis cross all layers (i.e., runtime, system, kernel) in Android
- Low overhead and high accuracy
- Identify performance and security issues

**Achievements**

**Collaborators and Funding Body**
- PolyU
- ITF

**Project 3: A Cross-layer Profiling System for Android Apps**

**針對Android Apps的跨層剖析系統**

Profiling Android apps is an important way to discover and locate various problems in apps, such as performance bottleneck, security loopholes, etc. Existing profiling systems for apps are limited in dealing with the multiple-layer nature of Android and thus cannot reveal issues due to the underlying platform or poor interactions between different layers. We propose and develop AndroidPerf, a cross-layer profiling system, including runtime layer, system layer, and kernel layer, for Android apps. AndroidPerf consists of one subsystem that performs cross-layer dynamic taint analysis to collect control and data flow information, and another subsystem that conducts instrumentation on all layers. Our system can benefit security companies, app developers, and anyone who cares about the security and/or the performance of Android apps.

**Special Features and Advantages**
- Conduct dynamic taint analysis across all layers (i.e., runtime, system, kernel) in Android
- Low overhead and high accuracy
- Identify performance and security issues

**Achievements**

**Collaborators and Funding Body**
- PolyU
- ITF

Dr Luo received his B.S. and M.S. from Wuhan University, and obtained his Ph.D. degree in Computer Science from the Hong Kong Polytechnic University. After that, he spent two years at the Georgia Institute of Technology as a post-doctoral research fellow. His current research interests include Android security and privacy, Network and System Security, Information Privacy, Internet Measurement, Cloud Computing, and Mobile Networks.
Project 1: sPADAP - Smart Parent Against Drug Abuse Platform

Our district-based project aims at altering parents and their children to be aware of potential drug abusers in their families and teaching youths about the serious consequences of drug abuse. The main activities include developing a mobile community of practice platform for parents to access timely anti-drug information, to have an intelligent alerting tool for detecting potential family drug abusers and to form a mutual support community between parents and other stakeholders such as social workers, anti-drug experts and teachers. In addition, this project enables us to disseminate anti-drug messages to the general public through booklets, videos and mobile platforms.

Special Features and Advantages

- An intelligent alerting tool utilizing artificial intelligence technologies with a mobile front end for assisting parents in possible early detection if there is a drug abuse case in the family
- Knowledge repository and information help centre for giving advice on how to manage the young family member with potential drug abuse

Achievements

- A platform for detecting potential drug abuse cases and a parent community
- A repository containing online information for parents in handling family drug abuse cases
- Publishing an electronic booklet including student works to disseminate anti-drug information

Collaborators and Funding Body

- Beat Drug Fund

Project 2: Consolidation and Redevelopment Work on Information Technology in Education

This consultancy service project was commissioned by the Quality Education Fund (QEF) to conduct a consolidation and redevelopment work on Information Technology (IT) in Education. The scope includes QEF projects related to IT in Education, and non-QEF related projects, namely the Centre of Excellence Scheme (CoE) Scheme and the e-Learning Pilot Scheme. The aim of this project is to consolidate and capitalize on worthwhile projects related to IT in Education and promote sustainability at multi-levels. A total of 79 projects have been reviewed using a multi-dimensional model, evaluating the learning quality and success factors of the use of e-Learning at primary, secondary and special schools in Hong Kong. Also, we have conducted a qualitative study and data analysis in this project (interviews and surveys), extracting the learning experience of both students and teachers in using the e-Learning tools/platforms. Based on the review of the given projects, we have observed many good practices related to IT in Education, and a teaching resource package has been produced with successful use of some pedagogies along with their associated IT tools (of the reviewed projects).

Special Features and Advantages

- A teaching resource package with selected good practices examples related to IT in Education and related teaching activities
- An intelligent web-based system for educators and teachers in searching and retrieving project resources related to IT in Education which facilitate course curriculum design and material preparation process

Achievements

- Produced a teaching resource package distilled from the good practices
- Developed a web-based resource system containing a list of QEF projects and non-QEF projects and a selection of well-developed e-Learning tools for efficient retrieval of project resources

Collaborators and Funding Body

- The Quality Education Fund

Project 3: Gen-YOU Net Gen-Y無毒城

The Gen-YOU-Net project was based on the success of the Gen-Y project with 2 new elements. The project aimed to develop effective digital communication with our young students as well as having new lives (avatars) in an online 3D virtual world for drug prevention. GEN-YOU-Net included two major components. The first component was a web portal called Gen-YOU-Portal. It served as a common portal for students, teachers, social workers, policeman and NGOs for sharing anti-drug information and communication. The second component was an online 3D Social Networking Community (called AD-Island) for students, social workers, mentors and volunteers to interact in a virtual world. The project targeted at students aged from 10 to 18 and will be supported by Police Community Relation Office, Tai Po District.

Special Features and Advantages

- A 3D online virtual world to serve as a safe and secure interactive social community for our young students. The virtual world is in the form of an island containing five different zones to learning about anti-drug messages.
- An intelligent portal for getting advice on how when there is a drug abuse incidence

Achievements

- A 3D interactive platform to encourage peer support for healthy lifestyle
- Intelligent robots utilizing AI techniques for enhancing user interactions
- Publishing 3D artifacts done by students to disseminate anti-drug information

Collaborators and Funding Body

- Beat Drug Fund

Dr Vincent Ng is the Associate Professor in the Department of Computing, The Hong Kong Polytechnic University. Prior to joining the Polytechnic in 1994, Dr Vincent Ng worked for many years in a cancer research hospital in Canada. During that time, he had been involved in the IT strategic development of his working units and the hospital as well. Besides teaching and research, Dr Ng is active in external activities, consultancy work and professional services since he returned to Hong Kong. He collaborates with different NGOs to help them in IT training, system development, web site designs and constructions, and advisory services. In addition to NGOs, he has been working with many government departments in the HK SAR, such as the Social Welfare Department, the Immigration Department, the Employment and Manpower Bureau, and the Civil Service Training and Development Institute. For the past few years, Dr Ng was a board member of the Public Examination Board of the HKEAA and also involved in the curriculum development of the information technology subject for the senior secondary schools in EDB. His research interests include social media analysis, data mining and health informatics.
Dr NGAI Grace
ScB(Brown); MSE, PhD(Johns Hopkins)

RESEARCH INTERESTS
Human Computer Interaction, Human Centered Computing, Pervasive Computing, Natural Language Processing

Project 1: Crossmodal Human-Computer Interaction: Linking Calligraphy with Art 跨模態人機交互：書法與藝術之連接
Callipaint and MelodicBrush are innovative human-computer interaction systems that link together ancient Chinese art forms – namely, Chinese calligraphy, music and painting. Applying concepts from cross-modal interaction and synesthesia, we map writing characteristics such as force, speed, and stroke to characteristics such as tempo and note in music, and level of detail or blurriness in art. In real use, the user writes Chinese calligraphy using a brush. The written words are “translated” to graphics or music, and writing mechanics are analyzed and used to augment the graphics or the music to create a coherent piece of art. The goal is to facilitate self-expression and creativity to a wider audience.

Special Features and Advantages
• Links together different forms of art in a cross-modal approach
• Facilitates and supports self-creativity

Achievements
• ACM CHI 2013
• ACM Multimedia 2014

Collaborators and Funding Body
• PolyU
• GRF

Project 2: AffectTube *
This project applies the upcoming field of affective computing to a real life application. Using facial expression analysis, our system “watches” the user while he/she is watching a movie, and analyses his/her facial image for indicative landmarks, and calculates action units from these landmarks. These action units, put together, give the expression of a person’s face. Given this expression, and aligning with the temporal storyline of the movie, the system is able to deduce how much the user liked the movie. Aggregating results over multiple users gives us an overall feel of the ultimate rating of the movie.

Special Features and Advantages
• Automated Identification of Human Affects
• Linkage between human response and a common human-computer interaction activity

Achievements
• ACM Intelligent User Interfaces

Collaborators and Funding Body
• PolyU
• GRF

Project 3: Appropriate Technology: Lab in a Suitcase and PhotoEyeScreen 合宜科技：手提箱裡的實驗室和PhotoEyeScreen* In this project, we look at technology with the view of “How can this be used to address problems in world as a whole, not just for the top 10% of the world’s population?” To this end, the Appropriate Technology projects (which address issues ranging from health care to education) look at low-cost, off-the-shelf repurposing of technology to make them appropriate for developing world situations. Examples of this approach are our “Lab in a Suitcase”, which has been deployed in Cambodia and will be deployed to Rwanda, Myanmar and Kyrgyzstan this summer, and the “cell-phone eye screening” project which has obtained good performance, even when compared against commercial, medical-grade equipment.

Special Features and Advantages
• Repurposes technologies to address real-life problems in the developing world
• Focus on sustainability and community-based research

Achievements
• IEEE International Symposium on Multimedia 2015
• HKICT Awards 2013

Collaborators and Funding Body
• PolyU Community Research Fund

* Project is co-investigated with Dr Hong-va Leong, Department of Computing, The Hong Kong Polytechnic University

Dr Grace Ngai got her BSc at Brown University and her MSE and PhD at Johns Hopkins University. She is currently an Associate Professor in the Department of Computing at The Hong Kong Polytechnic University. She has been active in service learning since 2003 and has led student teams to serve underprivileged groups such as low-income children, the elderly, special needs children, refugees and rural villagers at home in Hong Kong, in China and overseas in Cambodia, Rwanda and Myanmar. She is the recipient of a teaching award and a services award by The Hong Kong Polytechnic University. She is currently coordinator of the Subcommittee of Service Learning Subjects at The Hong Kong Polytechnic University, which is responsible for approving and monitoring academic service learning subjects. Her research interests are in human computer interaction, affective computing, natural language processing, educational computing technology and appropriate technology for developing regions.
Project 1: Low-Cost, Contactless and Accurate 3D Fingerprint Identification System

Traditional fingerprint identification by pressing or rolling of finger against the hard surface often results in partial or degraded images due to improper finger placement, skin deformation, slippages, or smearing. Therefore touchless 3D finger imaging can provide more accurate personal identification as rich information is available from 3D fingerprint images. This project designs and develops a low-cost, faster, more accurate and touchless 3D fingerprint identification system for high security applications. The advanced biometric identification using proposed system can enable the low-cost, faster, hygienic and more accurate identification of humans for wide range of civilian/forensic applications.

Achievements
• Superior Performance than state-of-the-art
• Low Cost 3D fingerprint recovery
• Compact and reduced bulk with single camera

Dr. PATHAK Ajay Kumar

Biometrics, Computer Vision-Based Industrial Inspection

Dr Ajay Kumar received Ph.D. degree from the University of Hong Kong, Hong Kong, in 2001. He completed his doctoral research at The University of Hong Kong in a record time of 21 months (September 1999 to May 2001). He was an Assistant Professor with the Department of Electrical Engineering, IIT Delhi, Delhi, India, from 2005 to 2007. He is currently working as Associate Professor in the Department of Computing, Hong Kong Polytechnic University, Hong Kong. Dr. Kumar holds several U.S. patents, and has authored extensively on biometrics and computer vision-based industrial inspection. He is an area editor for the Pattern Recognition Letters Journal and serves on the IEEE Biometrics Council as the Vice President (Publications). He was on the Editorial Board of the IEEE Transactions on Information Forensics & Security from 2010 to 2013, and served on the program committees of several international conferences and workshops in the field of his research interest. He was the Program Chair of the Third International Conference on Ethics and Policy of Biometrics and International Data Sharing in 2010, the Program Co-Chair of the International Joint Conference on Biometrics held in Washington, DC, in 2011, the International Conference on Biometrics held in Madrid, in 2013, CVPR 2013-2015 Biometrics Workshop held in Portland, Columbus, and Boston respectively. He has also served as General Co-Chair of the Second IEEE International Joint Conference on Biometrics (IJCB 2014) held in Tampa and of IEEE International Conference on Identity, Security and Behaviour Analysis (ISBA 2015) held in Hong Kong. His current research interests are on biometrics with an emphasis on hand biometrics, vascular biometrics, iris, and multimodal biometrics.
Project 1: Programs that Fix Themselves 具備自我修復功能的軟體

Fixing is the process of correcting faults in programs, and it is notoriously expensive, tedious and time-consuming when done manually. Previous research, however, has shown that a significant amount of faults admit simple fixes which may be generated automatically. Given the enormous cost of program fixing, we will be able to save a lot of resources to be used for other purposes by automatically generating fixes for even a small portion of the faults. In this project, we aim to develop techniques and tools to automatically propose fixes to faults in programs. Particularly, we exploit contracts, or runtime assertions, in the code to make more accurate diagnosis of the fault and generate fix suggestions of higher quality.

Special Features and Advantages
- The approach exploits contracts in the code to propose fixes of high quality
- The approach automates the whole debugging process from fault detection to fix suggestion
- The implementation has been integrated into an Integrated Development Environment (IDE) for better usability

Achievements
- A fully automatic approach to proposing fixes to program faults and the corresponding tool implementation;
- Publications in top international journal and at top-tier conferences

Collaborators and Funding Body
- Collaborative work of the Chair of Software Engineering, ETH Zurich, Switzerland and Software Engineering Chair, Saarland University, Germany
- Funded by Hasler-Stiftung (Grant no. 2327), Deutsche Forschungsgemeinschaft (Ze509/4-1), Swiss National Science Foundation (Project 200021-13497/6)

Project 2: Model Checking Reactive Systems for Specifications in Interval Logics

反應式系統中時段性質的模型檢驗

A reactive system does not terminate and its behaviors are typically defined as a set of infinite sequences of states. In formal verification, a specification is usually expressed in a logic and, when the models of the logic are also defined as infinite sequences such as the case for Linear Temporal Logic, the satisfaction relation between a reactive system and a specification can simply be defined as the containment relation between their respective sets of infinite sequences. This satisfaction relation, however, does not work for specifications in interval logics, whose models are defined as sets of finite sequences. In this project, we study the satisfaction relation between reactive systems and interval logic specifications with the goal to extend model checking of reactive systems to support also interval logics as specification languages.

Special Features and Advantages
- The general satisfaction relation unifies two different satisfaction relations
- The adoption of interval logics as specification languages makes certain system properties more straightforward to specify and easier to understand

Achievements
- A general satisfaction relation between reactive systems and specifications in interval logics
- A model checking algorithm to check the satisfaction relation automatically and a tool that implements the algorithm
- Publications in top national journals and at international conferences

Project 3: Model Checking Hybrid Automata

混成自動機的模型檢驗

Hybrid systems are dynamic systems that allow both continuous and discrete state changes, and they are often modeled as hybrid automata in model checking against desired properties. Although the model checking problem for hybrid automata is undecidable in general, there are subclasses of hybrid automata that can be model checked efficiently. Knowledge about such subclasses and the corresponding tool support are essential to the application of model checking on hybrid systems. In this project, we aim to identify hybrid automata that can be efficiently verified using model checking techniques as well as develop algorithms and tools to conduct the checking.

Special Features and Advantages
- Positive loop-closed automata are general enough to model real-world hybrid systems, yet specific enough to be efficiently model-checked against interesting real-time properties
- An important subclass of linear hybrid automata, called positive loop-closed automata, whose satisfaction problem for linear duration properties can be solved using linear programming
- A model checking tool that can automatically identify positive loop-closed automata, check them for interesting real-time properties, and generate diagnostic information when the properties are not satisfied
- Publications in top national journals and at international conferences

Collaborators and Funding Body
- Supported by the National Natural Science Foundation of China (No. 60733031), the National High Technology Research and Development Program of China (863 Program) (No. 2001AA113203), and the Natural Science Foundation of Jiangsu Province (No. BK2001033)

Dr Pei received his bachelor’s degree in Computer Science in 1999 and his first PhD in Computer Science in 2004, both from Nanjing University, China. From 2004 to 2009, he was an Assistant Professor of the Faculty of Information Technology in Macau University of Science and Technology. In 2015, he obtained his second PhD in Computer Science from ETH Zurich, Switzerland.

Dr Pei’s primary research goals aim at facilitating the production of high quality software systems in the real world. During his study at Nanjing University, he devised techniques to specify temporal properties of systems and implemented tools to help check software systems against such properties. During his PhD at ETH Zurich, he co-developed techniques and tools to automatically generate quality corrections to faults in programs with contracts. Dr Pei has published over a dozen of peer reviewed papers in journals like IEEE TSE, and top tier conferences including ICSE, IJST, ASE, FASE and VMCAI. His future research plans are directed towards advancing the techniques to automatically test and repair software systems developed in mainstream programming languages and providing tool support for their practical application.
Dr SHAO Zili
BEng, MEng(Electronic Science & Technology of China); MSc, PhD(Texas at Dallas)
RESEARCH INTERESTS
Embedded Systems, Real-time Systems

Project 1: Storage Optimization for Embedded Systems
嵌入式系統中NAND Flash轉換層的優化技術

NAND flash has been widely used as storage in embedded systems such as USB, eMMC cards and SSDs. In this project, we have developed various techniques to enhance the performance of NAND flash storage systems from various aspects such as the system response time, lifetime and reliability.

Special Features and Advantages
- Improve the performance of NAND flash
- Extend the lifetime

Achievements
- 一种基于移动设备虚拟化环境的数据存储方法及装置, China, 2014 (Patent)
- 计算器子系统及在其中实现闪转换层的方法, China, 2013 (Patent)

Collaborators and Funding Body
- High level consultancy project (with Info Source Storage Media Limited, HK), PI, Management Software Development for A Large Scale Optical Disk Based Data Storage System, HKD 390,000, 2014-2015.

Project 2: Improving I/O Performance with NVDIMM for Big Data Applications
大數據中優化I/O系統的NVDIMM技術

Long I/O latency posts big problems for I/O-intensive big data applications. NVDIMM (Non-Volatile Dual In-line Memory Module) technologies provide a promising direction to solve this problem. By using non-volatile NAND flash memory as storage media and connecting through DIMM (Dual In-line Memory Module) slots, NVDIMM devices go on memory bus so the I/O overhead caused by I/O controllers can be avoided. In this project, we develop new, enabling mechanisms for NVDIMM techniques to unleash their maximum benefits on big data applications.

Special Features and Advantages
- Improve the I/O performance for big data applications

Collaborators and Funding Body

Project 3: Mobile Virtualization Optimization Using Emerging Non-Volatile Memory
基於非動態記憶體的移動虛擬化技術

By allowing a mobile device to host multiple virtual machines (VMs), mobile virtualization can help reduce development cost and shorten the time to market with code reuse, and enhance privacy and security with VM isolation. Mobile virtualization posts new challenges to the design of the underlying memory and storage systems. In this project, we develop various techniques to optimize mobile virtualization by utilizing emerging non-volatile memory.

Special Features and Advantages
- Improve the system performance of mobile virtualization and enable mobile virtualization systems to leverage emerging device technologies and architecture design

Collaborators and Funding Body

Dr Shao has been an Associate Professor with the Department of Computing, Hong Kong Polytechnic University, Hong Kong, since 2010. He received the B.E. degree in electronic mechanics from the University of Electronic Science and Technology of China, Sichuan, China, in 1995, and the M.S. and the Ph.D. degrees from the Department of Computer Science, University of Texas at Dallas, Dallas, TX, USA, in 2003 and 2005, respectively. His current research interests include embedded software and systems, real-time systems, and related industrial applications. He is an associate Editor for IEEE Transactions on Computers, IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, ACM Transactions on Design Automation of Electronic Systems, ACM Transactions on Cyber-Physical Systems and Journal of Systems Architecture: Embedded Software Design (subject area: Memory Systems). He serves/served the technical program committees of many top conferences in the real-time embedded system field (such as DAC, RTSS, ICCAD, IPDPS, RTAS, DATE, CODES+ISSS, EMSOFT, ISLPED, ASP-DAC, ICCD and LCTES).
Project 1: Research on Maximum Potential Power of Team and Opponent Strategy Identification in Real Time Strategy Games

Google’s artificial intelligent GO-playing system has defeated Korean grandmaster Lee Sedol, and similar game AI systems have been developed in research centers, by e-Commerce and game giants, like Tencent, Alibaba, Sony and Microsoft. Game data describes complex elements, such as tasks, characters, resources, and there are complicated feature interactions and uncertain knowledge within them. Our research focuses on new AI techniques in modeling player behaviors, developing gaming strategies, improving funnity and testing new game design ideas. For example, our work on discovering distribution structures and complex relations in games integrates probability distribution, fuzzy boundaries and feature interaction into a coherent model. It represents a distributed approximation of the original game data, and knowledge about players. Extreme learning machines are investigated for solving adversarial planning problems in real time strategy games. Feature interactions are addressed by fuzzy measure and integral theory. The uncertainty and computational complexity aspect are tackled by newly designed ELM models for fast determination of fuzzy measures. Novel sets selection algorithms for different fuzzy integrals are developed and tested with real data. Processing times are reduced by data compression techniques through the use of interval-valued centers and ranges.

In this research, optimization of potential power of a group of game units and their best combinations is investigated. The evaluation of fighting power for a group of individuals with different units will be measured by a non-linear integral with respect to a non-additive set function in which interaction among the different units is shown. The game data will be clustered for feature interaction analysis. Fuzzy class labels and discretization for continuous valued attributes will be formulated, and finally a multi criteria decision model will be developed to evaluate a set of alternatives that maximize the generalization ability.

Special Features and Advantages
- A number of new fuzzy integrals for game data
- An Architecture selection algorithm for ELM
- A discretization method for compressing interval data

Achievements
- Conference papers at PReMi, SCIS&ISIS, ICMLC, Fuzz-IEEE, ICIMT, ICNC

Collaborators and Funding Body
- PolyU

Project 2: Designing smart Virtual Reality (VR) experience for elderly people’s mental wellness: A “Rehabtainment” approach

Virtual Reality (VR) systems have been successfully deployed in two main application areas, one is digital entertainment and the other is health rehabilitation. Can these two types of systems be integrated so that a “Rehabtainment” system could be developed for aging people? This research aims to find out a formal, abstract representation through which the process of designing these Rehabtainment systems might be elevated and unified. This helps designers work with theory, representations and materials that are more tangible for building systems for elderly people. Successful design lies within the nature of optimizing a set of complex, sometimes unable to measure as well as interacting features, and yet delivers the best final result to users. As computer games have been shown to have many positive cognitive and social benefits for younger people, it is a natural extension to investigate whether the same benefits can be gained by older adults. The success of this project can demonstrate how the VR-based experience benefit older adults both from cognitive and social perspectives that emphasize mental wellness, social interaction, physical activities and happiness. It also offers opportunities, challenges and training possibilities that has important implications to improve quality of life for older people, reduce their risks that caused by cognitive decline and at the same time provide game developers new perspectives of designing their products for our aging population.

Special Features and Advantages
- A formal framework for designing Rehabtainment systems
- Improving quality of life for aging population through cognitive rehabilitation
- Provide game developers new perspective of product design

Achievements
- PhD students graduated
- Conference and Journal papers published
- Prototypes of some Rehabtainment systems

Collaborators and Funding Body
- PolyU

Dr Shiu obtained his degrees from City University of London, Newcastle Upon Tyne University and The Hong Kong Polytechnic University in 1985, 1986 and 1997 respectively. Dr Shiu’s main research interest is Game Artificial Intelligence (Game AI). He has over 30 years of working experience, written a textbook “Foundation of Soft Case-Based Reasoning”, and successfully supervised 30 graduate students including 4 PhD and 4 MPhil students. He has published over 100 research papers and carried out consultancy projects with organizations such as the Hong Kong Police and the Hong Kong Marine Police Force, Tuen Mun Yan Oi Tong and a number of departments in the HKSAR Government. He also served as external examiner and moderator for the HK College of Technology, Hong Kong Institute of Vocational Education (IVE) and Hong Kong Examinations and Assessment Authority (HKEAA), as well as a programme committee member for many international conferences, and guest editor for several journal special issues. Dr Shiu received the President’s Award for Excellent Performance and Achievement - Team Award, for his consultancy services to the community and computer games education.
Project 1: Urban Traffic Prediction using Big Building Data
大資料環境下的交通預測
Traffic prediction, particularly in urban regions, has tremendous practical value. In this project, we report a novel case study of urban traffic prediction in Central, Hong Kong. The novelty of our study is that we make good second use of inexpensive big data collected from the Hong Kong International Commerce Centre (ICC). As building environment data are much cheaper to obtain than traffic data, we demonstrate that it is highly effective to estimate building occupancy information using building environment data, and then to further use the information on occupancy to provide traffic predictions in the proximate area.

This is a research project targeting on future cities. This is a early proof of the concept on applying big data (building data) to city applications (traffic prediction).

The future research of this project has many directions. On the data side, we will study in depth on building data. Building is concentrated with data and it is expected that we can have more in the future given the development of ICT technologies on data collection. We will also study data analytic techniques. On the system and networking side, we will study what will be the future architecture in data storage, delivery, and computation, both within a building and between buildings and the other side world. On the business side, we are interested in data valuation, data exchange and data collaboration, given the multiple data participants, each of which represents independent players with self-interests.

Special Features and Advantages
• High accuracy in traffic prediction
• True big data application for smart city, i.e., the improvement is possible only when the data is big

Project 2: ICT Technology for Smart and Green Buildings
綠色智能樓宇中的訊息技術
Commercial building is one of the major energy consumers worldwide and the heating ventilation and air-conditioning system dominates the total energy consumption. To minimize complaints, the current practice of facility management is to adopt relatively conservative temperatures, leading to massive waste of energy.

In this project, we have actively taken thermal comfort into consideration. We propose a participatory approach allowing the occupants to provide feedback regarding their comfort levels. Our novel design reduces intrusiveness of the system by developing a model that can build a profile for each occupant. The decision of set-point temperature is primarily model-driven. We have implemented our design and conducted field experiments at The Hong Kong Polytechnic University and a commercial office in Cyberport. Results showed that our algorithm can successfully maintain high thermal comfort, while reducing 18% of energy consumptions.

Special Features and Advantages
• Non-intrusiveness
• High thermal comfort
• Energy conservation

Achievements
• Commercial offices in high-end buildings

Collaborators and Funding Body
• Internal Competitive Research Grant funded by RGC Direct Allocation of The Hong Kong Polytechnic University
• National Natural Science Foundation of China

Dr Dan Wang received his B. Sc from Peking University, Beijing, M. Sc from Case Western Reserve University, Cleveland, OH, and Ph. D. from Simon Fraser University, Vancouver, Canada, all in Computer Science. He is an Associate Professor of Department of Computing, The Hong Kong Polytechnic University, Hong Kong. His current research interest includes Smart Building, Big data, network economics. He is a senior member of the IEEE.
Project 1: Smart Construction Site Progress Monitoring System Using Consumer UAVs 基於消費類無人機的智慧建築工程進度監理

Construction site progress monitoring is critical to effective management of a construction project. However, currently such monitoring is mainly carried out manually. Such heavy labor cost makes frequent monitoring difficult. What is more, there can be hard to reach view points in the construction site. To address these problems, we propose to use consumer UAVs to carry out construction site monitoring. Consumer UAVs are cheap, fast, and able to reach places inaccessible to humans. Their onboard cameras can take high quality photos to cover the entire construction site. With UAVs, daily monitoring can become a low cost routine. Target users are the site managers and inspectors of construction sites.

Special Features and Advantages
- Reduce construction site monitoring workload by 80%
- Reduce construction site monitoring cost by 80%

Achievements
- Ardu-mucopter Source Code and Documentation: https://github.com/Ardu-mucopter/Ardu-mucopter-all_in_one

Collaborators and Funding Body
- Collaborators:
  - Prof. Neeraj Suri, Chair Professor, Department of Computer Science, TU Darmstadt, Germany
  - Dr Xue Liu, Associate Professor, School of Computer Science, McGill University, Canada
  - Dr Lei Bu, Associate Professor, Department of Computer Science and Technology, Nanjing University, China

Project 2: Risk Confinement, Assessment, and Mitigation Framework for Wireless Medical Systems 無線醫療系統的風險限制 - 評估 - 消滅

Medical Cyber-Physical Systems (CPS), systems that tightly integrate computerized medical devices, medical procedures, healthcare personnel, and patients, have received much attention recently. In medical CPS, one inevitable trend is the increasing use of wireless-enabled medical devices. However, new risks may arise from the complex communications between system components and environment over wireless channels, as wireless communications tend to be unreliable. To address this new challenge, we propose to build a novel framework to confine, assess, and mitigate the risks of wireless failures to medical CPS. Target users are medical device manufacturers, hospitals, clinics, etc.

Special Features and Advantages
- Packet reception rate of a ZigBee WPAN can increase by up to 116% in case of heavy WiFi interference
- Bounding ECG signal distortion within 2% even under heavy WiFi interference

Achievements

Collaborators and Funding Body
- RGC Early Career Scheme
- Collaborators:
  - Dr Rong Zheng, Associate Professor, Department of Computing and Software, McMaster University, Canada
  - Dr Lei Bu, Associate Professor, Department of Computer Science, and Technology, Nanjing University, China
  - MD. Tao Bai, Associate Professor, Department of Anesthesiology, China Medical University; Anesthesiologist, The First Hospital of China Medical University, China

Project 3: Real-Time Switch 實時交換器

Current mainstream Internet switches are best effort, which means they cannot guarantee end-to-end (E2E) delay bound, neither can they guarantee total isolation between the flows transmitted. In this project, we discover that by simplifying instead of complicating the legacy architecture of a mainstream Internet switch architecture (ISLIP), we can guarantee E2E delay bound, as well as isolating flows. Such real-time switch can serve as the infrastructure for real-time mission/life critical applications, such as avionics, industrial fieldbuses etc.; as well as Software Defined Networks (SDN). Target users are switch manufacturers, industrial fieldbus manufacturers, SDN manufacturers, etc.

Special Features and Advantages
- Hard network end-to-end delay guarantee
- Complete isolation between network flows, benefitting network virtualization schemes, such as SDN
- Simplifies instead of complicates a mainstream Internet switch architecture, hence guarantees smooth evolution path

Achievements

Collaborators and Funding Body
- Prof. Lui Sha, Department of Computer Science, UIUC

Dr WANG Qixin BE, ME(Tsinghua); PhD(UIUC)

Dr WANG Qixin is an associate professor in the Department of Computing, The Hong Kong Polytechnic University. He received the BE and ME degrees from the Department of Computer Science and Engineering, Tsinghua University, Beijing, China, in 1999 and 2001, respectively, and the PhD degree from the Department of Computer Science, University of Illinois at Urbana-Champaign in 2008. Dr Wang` s research interests include Cyber-Physical Systems, Real-Time Systems, and Wireless Sensor Networks. He has published (include accepted for publication) 14 first/lead author refereed papers on top journals and conferences, and 40 papers/articles on various academic venues, such as TPDS, TMC, TII, RTSS, INFOCOM, DSN, ICCPS etc. He has won an IEEE Transactions on Industrial Informatics Best Paper Award in 2008, and has one paper chosen as the featured article by IEEE Transactions on Mobile Computing 2008 May issue. He has served several top conference organization committees, such as INFOCOM, RTCSA, as well as many top conference TPCs, such as RTSS, INFOCOM, ICCPS, etc. He is currently serving the editorial board of Taylor & Francis’ journal of Cyber-Physical Systems. He has won over HK$1.2 million grants from external funding agencies so far. He is a member of the IEEE and the ACM.

Dr WANG Qixin

BE, ME(Tsinghua); PhD(UIUC)

RESEARCH INTERESTS

Real-time/Embedded Systems, Cyber-physical Systems

Dr WANG Qixin

BE, ME(Tsinghua); PhD(UIUC)

RESEARCH INTERESTS

Real-time/Embedded Systems, Cyber-physical Systems
Project 1: Learning on Graphs with Partially Absorbing Random Walks

Exploiting the cluster structure is of vital importance for a wide range of graph-based applications such as web search, community detection, collaborative recommendation, spam detection, text analysis, image segmentation, and gene clustering. In this project, we present a unified stochastic framework called partially absorbing random walks (ParWalk) for analysing the graph structure of data. ParWalk is an absorbing Markov chain which unifies various popular graph models including PageRank, hitting times, label propagation, and regularized Laplacian kernels, which opens the door for model selection and design. Our analysis on ParWalk induces principles for model selection, and reveals important unknown properties of existing models. For example, it justifies the use of hitting times and the pseudo-inverse of graph Laplacian, but points out that the former is better for sparse clusters while the latter is better for dense ones. Our analysis also motivates designing a new and robust model combining their strengths. The theoretical insights further guide us in designing new applications for object segmentation and superior algorithms for label propagation. Extensive experiments demonstrate the benefits of our theory and analysis.

Special Features and Advantages

- A new perspective for learning on graphs
- A unified framework for multiple popular existing models.
- Supports model selection and design.
- Generates new insights into existing models and algorithms.
- Proposes new and robust models for learning on graphs.
- Motivates new applications in social network analytics and computer vision.

Achievements

- Other than making theoretical contributions to the community, the research of this project has also been adopted in industry.

Collaborators and Funding Body

- Columbia University, Office of Naval Research (ONR) grant #N00014-10-1-0242

Project 2: Inference and Learning on Large Knowledge Networks

Knowledge networks such as Google Knowledge Graph are vast information sources of multi-relational data, which power a wide range of high-impact applications including web search, recommender systems, question answering systems, digital assistants etc. Typical tasks in knowledge graph mining include link prediction, entity classification, entity disambiguation, and link-based clustering. In this project, we will address the fundamental challenges in knowledge graph mining, including handling the large size of knowledge networks, modelling many heterogeneous relation types, dealing with the incomplete and erroneous data, and overcoming the data sparsity issue. Our goal is to develop new insights and design new models for robust inference and learning on knowledge graph, as well as motivates new applications in natural language processing and computer vision. This project just started.

Special Features and Advantages

- Accurate methods for link prediction and entity classification.
- Scalable algorithms.
- Robust to noisy data.

Collaborators and Funding Body

- PolyU

Project 3: Large-Scale Manifold Learning

High dimensional real-world data, such as a collection of natural images, typically lies in multiple manifolds of possibly different low dimensions. Finding a compact representation of data while preserving the local and global neighbourhood structure is a critical feature extraction step for machine learning. However, existing non-linear feature mapping methods are either inefficient or ineffective in capturing the underlying manifold structure. In this project, we investigate fast algorithms for speeding up existing manifold learning algorithms, as well as design new and superior embedding methods for large-scale image retrieval.

Special Features and Advantages

- A hashing method for nearest neighbor search on image manifolds improves the performance of state-of-the-art by 28-74% typically.
- A fast algorithm for manifold embedding which speeds up over previous approaches by several orders of magnitude.

Achievements


Collaborators and Funding Body

- The Chinese University of Hong Kong & Columbia University, GRF grants CUHK 2150603, CUHK 414307 and GRF grant CUHK2/06C from the Research Grants Council of the Hong Kong SAR, China, and the NSFC-RGC joint research grant N CUHK411/07.

Dr Wu is currently an assistant professor in the Department of Computing of The Hong Kong Polytechnic University. She received her PhD in Electrical Engineering from Columbia University in 2016. She received her bachelor degree in Applied Mathematics and master degree in Computer Science, both from Peking University, and her MPhil degree in Information Engineering from the Chinese University of Hong Kong. Her research interests are in the broad areas of machine learning, pattern recognition, and data mining, with focus on graph algorithms and their applications. She has strong interests in both fundamental and applied research, and publishes in prestigious venues such as NIPS and CVPR. Her doctoral thesis research has contributed to new understanding and significant improvement of state-of-the-art methods on various applications, and has been currently adopted in industry.
Dr XIAO Bin  
BSc, MSc(Fudan); PhD(UT Dallas)  

RESEARCH INTERESTS  

Project 1: A Novel Privacy-Preserving Mechanism for Facility Sharing in Smart City IoT
智慧城市物聯網中設備的一種新的且保護隱私的授權機制

In an open IoT infrastructure of smart city, the permission of shared device can be transferred among different users, such as friends or friends of friends. The conventional security mechanism is unable to control permission propagation and privacy preservation for users and owners. This project proposes a novel owner-controllable and anonymous delegation authorization mechanism for IoT facility sharing. The mechanism allows partial permission propagation under owner’s control, and provides privacy-preserving authentication and fine-grained access control. This project can be applied in many multi-users scenarios, such as the sharing of car parking, apartment, warehouse, electronic locker, exhibition room and other IoT smart devices.

Special Features and Advantages
• Design a controllable partial delegation protocol of permission propagation based on proxy signature with hiding warrant  
• Design a privacy-preserving user-to-device authentication protocol based on extended Direct Anonymous Attestation and biometric authentication  
• Design a flexible fine-grained access control module based on social relationship  
• Implement a demonstration system that includes software and hardware development for IoT facility sharing

Achievements
• Patent: A novel anonymous partial delegation authorization mechanism for IoT device based on bilinear maps  
• Demo system: A lock can be opened by different users’ smartphones once the permission is given to them

Project 2: Effectively Constructing Labelled Indoor Floor Plans Using Smartphones
通過智慧手機構建室內地圖標識的高效方法

The indoor floor plans are the critical foundations of flourishing indoor location-based services. However, even with the popular crowdsourcing approach, the wide construction of indoor floor plans has yet to be realized due to the intensive time consumption. This project proposes a novel system that enables the user to construct his own facility-labelled and highly fine-grained indoor floor plans by himself. This project can be applied in many indoor scenarios, such as indoor floor plan construction in shopping mall, exhibition center, university and hospital.

Special Features and Advantages
• Design novel landmark recognition approaches to detecting various landmarks from the inertial sensing data, WiFi signals and images  
• Design traverse-independent hallway construction algorithms to construct the topology of hallways with high fine-granularity  
• Design the facility labeling method to calculate the entrance positions and orientations of facilities to accurately label them in the constructed hallway plans  
• Implement a demonstration system to support various indoor floorplan based applications, such as localization, navigation, and environment tagging

Achievements
• Paper: A novel mechanism for indoor floor plans construction with facility labels  
• Demo system: An indoor floor plan can be constructed when a user holds a smartphone and walks through an indoor environment

Project 3: Vulnerability Analysis, Attack Detection and Mitigation in Software-Defined Networks
軟體定義網路控制層的漏洞分析、攻擊檢測和防範

The separated control and data planes in software-defined networks (SDN) introduce a more flexible way to manage and control network traffic. However, the communications between the two planes can be a bottleneck of the network, and be leveraged by an adversary to launch different kinds of attacks, e.g. data-to-control plane saturation attack and network topology disturbance. This project proposed a more secure SDN system with the detection scheme and newly proposed mitigation techniques to enhance the security. The secure system includes novel detouring technique to mitigate data-to-control plane saturation attack, and new authentication schema to resist network topology disturbance. This project can be applied in real-world OpenFlow networks, including data centers and enterprise networks.

Special Features and Advantages
• Propose new attacking methods to bypass the existing detection and mitigation solutions  
• Introduce a novel detouring technique to mitigate data-to-control plane saturation attack  
• Design a new switch-switch authentication schema to resist network topology disturbance  
• Implement a demonstration security system for OpenFlow networks

Achievements
• Paper: FloodDefensor: Protecting Control-Data Plane bandwidth under SDN-aimed DoS Attacks  
• Demo system: FloodDefensor that can protect the bandwidth, computation resources, and memory of OpenFlow network devices under data-to-control plane saturation attack

Dr Bin Xiao is an associate professor in the Department of Computing in The Hong Kong Polytechnic University. He received the B.Sc and M.Sc degrees in Electronics Engineering from Fudan University, China, and Ph.D. degree in Computer Science from University of Texas at Dallas, USA. After his Ph.D. graduation, he joined The Hong Kong Polytechnic University as an assistant professor. His research interests include distributed wireless systems, mobile cloud computing, network security, and software-defined networks (SDN), with the focus on wireless protocol design in sensing networks and RFID systems, energy-saving and accurate information processing for smartphones, attack detection and prevention in wired/wireless networks. He has published more than 100 technical papers. Currently, he is the associate editor of Journal of Parallel and Distributed Computing.
Dr YANG Lei
Bsc, Msc, PhD(Xi’an Jiaotong University)

RESEARCH INTERESTS
RFID system, Pervasive and Wireless Computing, Internet of Things, Smart Home

Project 1: Real-Time Tracking of Mobile RFID Tags to High Precision Using COTS Devices

In many applications, we have to identify an object and then locate the object to within high precision (centimeter- or millimeter-level). Legacy systems that can provide such accuracy are either expensive or suffering from performance degradation resulting from various impacts, like occlusion for computer vision based approaches. In this project, we design and implement an RFID-based system, Tagoram, for object localization and tracking using the Commercial off-the-shelf RFID tags and readers. Our system can track mobile RFID tags in real time with high precision.

Special Features and Advantages
- Tagoram proposes a novel tracking algorithm called ‘RF Hologram’
- Tagoram can achieve mm-level tracking accuracy
- Tagoram can be applied purely using the COTS RFID products like ImpinJ R420
- Tagoram can successfully limit the most negative impacts such as multipath, noise and diversity
- Tagoram has been evaluated in two international airports (BCIA T1 and SIA) for over two years

Achievements
- Best Paper Award at MobiCom’14 (It is the first time for Asian researchers to receive this award since 1994.)
- Customized Track machines, called as TrackPoint

Collaborators and Funding Body
- PolyU, NSFC
- Collaborator: Tsinghua University

Project 2: See Through Walls with RFID Systems

Through-wall tracking has gained a lot of attentions in civilian applications recently. Many applications would benefit from such device-free tracking, e.g. elderly people surveillance, intruder detection, gaming, etc. In this project, we present a system, Tadar, for tracking moving objects without instrumenting them using COTS RFID readers and tags. It works even through walls and behind closed doors. It aims to enable a see-through-wall technology that is low-cost, compact, and accessible to civilian purpose.

Special Features and Advantages
- Tadar redefines RFID systems.
- Tadar can separate the target’s reflections from the strong and uncontrollable surrounding reflections.

Achievements
- Customized prototype

Collaborators and Funding Body
- PolyU, NSFC
- Collaborator: Tsinghua University

Project 3: Synchronizing Social Television Using Hidden Sound Markers

In many applications, we have to identify an object and then locate the object to within high precision (centimeter- or millimeter-level). Legacy systems that can provide such accuracy are either expensive or suffering from performance degradation resulting from various impacts, like occlusion for computer vision based approaches. In this project, we design and implement an RFID-based system, Tagoram, for object localization and tracking using the Commercial off-the-shelf RFID tags and readers. Our system can track mobile RFID tags in real time with high precision.

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Collaborators and Funding Body
- PolyU, NSFC
- Collaborator: Tsinghua University

Project 4: Making Sense of Mechanical Vibration Period with Sub-millisecond Accuracy Using Backscatter Signals

Traditional vibration inspection systems, equipped with separated sensing and communication modules, are either very expensive (e.g., hundreds of dollars) and/or suffer from occlusion and narrow field of view (e.g., laser). This project brings forward a concept of ‘communication is sensing’, which is to make sense of the world purely based on communication carrier rather than specialized sensors. We present an RFID-based solution, Tagbeat, to inspect mechanical vibration using COTS RFID tags and readers. Making sense of micro and high-frequency vibration using random and low-frequency readings of tag has been a daunting task, especially challenging for achieving sub-millisecond period accuracy.

Special Features and Advantages
- Tagbeat can inspect the vibration period with a mean accuracy of 0.3μs and a relative error rate of 0.03%
- Tagbeat can successfully amplify the micro-vibration with 1cm-radius by 20x while keeping the period error within 0.5ms
- Tagbeat can exactly recover the signal of high-frequency vibration feeding with over 1-second samples
- Tagbeat can exactly track the centrifuge of blood samples (e.g. 6,000 PRM) in real-time

Achievements
- We have already developed the prototype.
- We have published the findings at MobiCom’16
- We won the Best Video Award (Runner-Up) at MobiCom’16

Collaborators and Funding Body
- PolyU
- Collaborators: Tsinghua University, SXBTV

Project 5: Making Sense of Mechanical Vibration Period with Sub-millisecond Accuracy Using Backscatter Signals

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Collaborators and Funding Body
- PolyU
- Collaborators: Tsinghua University, SXBTV
Dr YIU Man Lung Ken
BEng, PhD(HKU)

RESEARCH INTERESTS
Data Engineering, Query Processing, Spatial Database Systems

Project 1: Accelerating Searching on Time Series Data by Utilizing Modern CPUs
利用現代CPU加速搜索時間序列

Many applications, e.g., medical analysis, economic analysis, climatology, environmental science, generate a massive amount of time series data. Their users, e.g., scientists and data analysts, need to search for particular patterns in time series data. For example, stock analysts may search for typical patterns in a stock time series, or identify similar patterns between two stock time series. Hospitals may conduct searching for certain patterns on ECG or EEG data, in order to assist doctors in diagnosing patients.

Nevertheless, the lengths of time series can reach the billion scale in the above applications, rendering existing solutions expensive and preventing users from conducting timely analysis on data. It turns out that the state-of-the-art searching solutions have not considered the features of modern CPUs carefully.

In this project, we will examine the features of modern CPUs (e.g., CPU cache, data-parallel instructions, multi-core processing) to accelerate searching solutions on time series. First, we will exploit data parallelism opportunities on modern CPUs (e.g., SIMD, single-instruction-multiple-data) to process multiple data values per instruction. This would help alleviate the first challenge. In order to fully unlock the power of SIMD, it is important to redesign distance computation functions by converting control flow instructions (e.g., if-then-else statements) into data flow instructions (e.g., +, -, *, /, min, max). This would reduce the branch misprediction penalty and benefit from the hardware prefetching mechanism in CPU. Second, we will investigate thread parallel querying methods for time series. We will take skewed data into account and handle the load balancing of searching tasks among threads.

The outcome of this research project will advance the query processing techniques for time series data. Also, our techniques will benefit the data analysts in various applications, e.g., medical analysis, economic analysis, climatology, environmental science. Our techniques enable data analysts to obtain query results rapidly and perform timely analysis. In addition, we will release our source codes to the public so that other researchers can reproduce and verify our experimental results. Also, our codes will raise other researchers’ awareness in exploiting modern CPUs for computational problems in their respective domains.

Special Features and Advantages
- Reduce the running time of searching
- Preserve the accuracy of searching

Collaborators and Funding Body
- RGC General Research Fund (GRF)
- Joint work with Aalborg University, Denmark

Project 2: Optimizing Location-based Applications by Automatic Performance Tuning
基於位置的應用程序的自動性能優化

Many location-based applications like inventory management and fleet management deal with massive amounts of data updates and queries, e.g., location data updates from vehicles and queries from operators. Such applications face potentially massive workloads containing: (i) location updates that are issued from objects (e.g., containers) as they move and (ii) spatial queries that are issued by users (e.g., warehouse staff) to find objects in specified regions. As such, it is important to tune the database performance.

The current practice is to rely on database administrators, who would analyze the characteristics of updates and queries in the application manually, and then select appropriate indexing structures for the data. The conventional rule is that the administrator should build an index when the workload is query-intensive and should drop the index when the workload becomes update-intensive.

This project aims at developing automatic performance tuning techniques for spatial indexes. The dynamic nature of spatial workloads poses new challenges to the traditional “build-or-drop index” approach. The challenges are: (i) the amount of queries and updates in the workload varies along time and across different regions, (ii) the bursts of updates and queries in the workloads, (iii) road network events and traffic updates may further complicate the problem.

Our project aims to develop automatic techniques for optimizing the performance of location-based applications. Real workloads will be collected for evaluating the execution time and workload throughput of our techniques. This project will benefit location-based applications and will result in index tuning techniques of relevance for commercial spatial databases.

Special Features and Advantages
- Optimize the performance of location-based applications
- Avoids tedious performance tuning by database administrators

Collaborators and Funding Body
- RGC General Research Fund (GRF)
- Joint work with Aalborg University, Denmark

Dr Man Lung Yiu received the bachelor’s degree in computer engineering and the PhD degree in computer science from The University of Hong Kong in 2002 and 2006, respectively. Prior to his current post, he worked at Aalborg University for three years starting in the Fall of 2006. He is now an associate professor in the Department of Computing, The Hong Kong Polytechnic University. His research focuses on the management of complex data, in particular query processing topics on spatiotemporal data and multidimensional data.
Prof. YOU Jia Jane  
BEng(Xi’an Jiaotong); PhD(La Trobe); Dip(Beijing Foreign Language); MIEEE

RESEARCH INTERESTS  
Image Processing, Pattern Recognition, Computer-aided Diagnosis and Monitoring

Project 1: Mobile Retinal Imaging for Smart Diabetic Care  
基於移動視網膜圖像分析的智能糖尿病監護系統

Diabetic retinopathy (DR) is one of the common complications of diabetes. It is crucial to detect DR as early as possible and provide timely treatment to minimize further deterioration. It is also very important to monitor the disease progression and evaluate the effect of treatment. A new mobile retinal imaging system is developed for non-intrusive diabetic retinopathy detection and monitoring.

Achievements  
- First runner-up for Innovation Award of Excellence (Hong Kong, 25 Nov 2015)  
- The 2nd place of SPIE Medical Imaging ‘2009 Retinopathy Online Challenge (ROC’2009)  
- Pattern Recognition [vol. 43, no. 6, pp. 2237-2246, 2010]

Collaborators and Funding Body  
- PolyU Central Research Grant (2012)  
- School of Optometry (SO), PolyU  
- Skyview Company (HK)  
- Wealth Billion International (HK) Ltd  
- VisionaMedtech International Ltd.  
- The Hong Kong Diabetes Association  
- Shenzhen Unicare Electronic Technology Co. Ltd

Project 2: Smart Fetal Monitoring Belt 智能胎兒監護帶

Fetal movement is an important index of fetal well-being. The timely detection of abnormalities in fetal movement is vital to the avoidance of fetal loss, perinatal morbidity and maternal distress. The newly developed fabric sensor pad can detect fetal movement automatically in a non-intrusive manner. It is able to enhance fetal care by monitoring fetal heart and screening abnormalities with quantitative measurements. The innovation of the wearable, waterproof radiation free monitoring belt are featured by its movement automatically in a non-intrusive manner. It is able to enhance fetal care by using a handheld fundus camera in mobile computing environment. It offers a non-intrusive computerized healthcare service to doctors and diabetic patients by conducting retina condition checking and tracking with a low-cost handheld fundus camera without any constraints of manpower, environment, and time.

Special Features and Advantages  
- New adaptive algorithms for heterogeneous image enhancement  
- Cloud computing paradigm to facilitate personalized healthcare  
- A new system workflow for automated DR detection and quantitative assessment using a low cost handheld device with flexibility, mobility and easy to operate  
- Reliable performance with security and privacy protection mechanism

Achievements  
- Product available in use  
- Hong Kong ICT Expo ’2014  
- “Incremental semi-supervised clustering ensemble for high dimensional data clustering,” IEEE. Trans. on Knowledge and Data Engineering (TKDE), vol. 28, no. 3, pp. 701-714, 2016

Collaborators and Funding Body  
- PolyU  
- Collaborators : SZJOINT Sensor Technology Ltd, Shenzhen, China

Project 3: Automated Truck Loading Monitoring for Smart Logistic Management and Road Safety Control

This project develops an automated truck loading monitoring system by integrating sensing, mobile communication, global position system [GPS] and logistic management for high performance. Unlike the existing systems with limited functions, the new vehicle-mounted dynamic monitoring tool-kit offers a wide range of services on a new platform including fast truck status checking, weight recording, loading data transmission/ tracking/monitoring, position localization, logistic scheduling, user interface, security control and emergency management. The new system has demonstrated its advantages and potentials to improve traffic control, enhance road safety, reduce maintenance costs on transportation, and increase logistic efficiency.

Special Features and Advantages  
- Low-cost and reliable sensors for load weight measurement  
- On-board monitoring system for fast data recording, transmission, tracking and analysis  
- Truck status monitoring and position tracking  
- Optimized logistic scheduling

Achievements  
- Product available in use  
- Hong Kong ICT Expo ’2014  
- Hong Kong Innovation Award of Excellence 2016  
- Special Prize and Silver Medal, The 44th International Exhibition of Inventions of Geneva, 2016

Collaborators and Funding Body  
- PolyU  
- Collaborators : SZJOINT Sensor Technology Ltd, Shenzhen, China

Professor Jane You is currently a professor in the Department of Computing at The Hong Kong Polytechnic University. Prof. You obtained her BEng in Electronic Engineering from Xi’an Jiaotong University in 1986 and Ph.D in Computer Science from La Trobe University, Australia in 1992. Before joining PolyU, she held academic positions at different universities in Australia till 2002. Prof. You was awarded French Foreign Ministry International Fellowship in 1993 and worked at Universite Paris XI.

Prof. Jane You has worked extensively in the fields of image processing, medical imaging, computer-aided detection/diagnosis, pattern recognition. She is a team member for three successful US patents. Her work on retinal imaging led to a US patent issued on 28 July, 2013, the first runner-up for Innovation Award of Excellence (Hong Kong, 25 Nov 2015). In 2016, she was the first runner-up for Innovation Award for Excellence (Hong Kong, 23 Nov 2015). Her research output on retinal imaging is further evidenced by the technology transfer with clinical applications. Prof. You is also an associate editor of Pattern Recognition and other journals.
Prof. ZHANG Dapeng David
BSc(Peking); MSc, PhD(Harbin IT); PhD(Waterloo); FIEEE; FIAPR

RESEARCH INTERESTS
Biometrics, Pattern Recognition, Image Processing, Information Security, Neural Networks

Project 1: Novel Human Body Information Perception and Fusion Techniques for human Health
面向人類健康的體外診察信息感知與計算方法研究

“Perceived health, medical wisdom” is an important direction for the development of national health, and an important part of the new deal of the national health care reform. However, currently, human body information perception is in a limited condition, and has some bottleneck problems, such as standardization, repeatability and scalability problems. We will start from the multi-source and multi-mode information perception, and to realize the all-round-aware information fusion. Finally, we will establish a platform based on the calculation and analysis of the human body information.

Special Features and Advantages
• Learning body information perception is non-invasive, painless, high accuracy, low cost, etc.
• Will help to promote a modern source of innovation in the field of medical diagnosis, which has important social and economic significance

Achievements
• D. Zhang, W. Zuo and N. Li, 2015, Medical Biometrics—Computerized TCM Data Analysis, World Scientific/Higher Education Press.
• K. Wu and D. Zhang, 2015, "Robust tongue segmentation by fusing region-based and edge-based approaches", Expert Systems with Applications, 42(21), 8027-8038.

Collaborators and Funding Body
• National Natural Science Foundation of China, 01/2014-12/2018, RMB3,000,000.

Project 2: Facial Beauty Objectification Research
人臉美麗客觀化研究

Facial beauty objectification aims to build the computational model between facial traits and the perceived attractiveness. It requires the variety of faces for analysis, and aims to explain the general character of facial beauty perception. This project will build a large scale face database including beautiful and common faces from different races and an aesthetic evaluation database including judgments from hundreds of human raters. Then a facial attractiveness related feature set will be defined and automatic and high precision feature extraction techniques will be developed. Facial beauty modeling is the core of this project. We will propose a model evaluation criterion first, and then learn the model using statistical pattern recognition, data mining, etc. In this way, quantitative rules of facial beauty perception will be found.

Special Features and Advantages
• The results of this project are applicable in aesthetic surgery, arts, intelligent image editing, etc.
• It supplies new idea and new evidence to human cognition research on facial beauty perception

Achievements

Collaborators and Funding Body
• National Natural Science Foundation of China, 01/2013-12/2016, RMB810,000.

Prof. Zhang is a Chair Professor at the Hong Kong Polytechnic University where he is the Founding Director of the Biometrics Research Centre (UGC/CRC) supported by the Hong Kong SAR Government in 1998. He also serves as Visiting Chair Professor in Tsinghua University, and Adjunct Professor in Peking University, Shanghai Jiao Tong University, HIT, and the University of Waterloo. He is Founder and Editor-in-Chief, International Journal of Image and Graphics (IJIG); Founder and Series Editor, Springer International Series on Biometrics (ICB); Associate Editor of more than ten international journals including IEEE Transactions and so on. So far, he has published over 20 monographs, 400 international journal papers and 40 patents from USA/Japan/UK/China. According to Google Scholar, his papers have got over 41,000 citations and H-index is 91. He was listed as a Highly Cited Researcher in Engineering by Thomson Reuters in 2014, 2015 and 2016, respectively. Professor Zhang is a Croucher Senior Research Fellow, Distinguished Speaker of the IEEE Computer Society, and a Fellow of both IEEE and IAPR.
**Project 1: See Your Age from Your Face - Human Facial Attributes Estimation via Deep Learning**

We develop an automatic human facial attribute analysis system which can estimate the gender, age and expression of persons in a static image reliably. This system is built on a deep neural network, and powered by a large amount of data. User just needs to upload an image to the system, and the system will detect the faces in the image automatically and estimate the attributes of each person. It can be used for targeted advertising and setting customer age limits for certain products. For instance, if the system predicts that the user is a female of 25 years old, we can recommend cosmetics products to her.

**Special Features and Advantages**
- Fast face detection and analysis: powered by Graphics Processing Unit (GPU)
- Reliable analysis: the system is built on a deep neural network model trained on a large amount of data
- Easy to use: user just needs to upload an image and will obtain analysis results quickly

**Achievements**

**Collaborators and Funding Body**
- PolyU

**Project 2: Transform Your Smart-Phone into a High-End Camera - Robust Multi-Exposure Image Fusion**

Multi-exposure image fusion (MEF) could produce an image with high dynamic range (HDR) effect by fusing multiple images with different exposures, which is widely adopted in mobile devices. Most existing MEF methods in the literature require significant pre/post-processing steps to improve the visual quality by reducing spatial artifacts. These methods may produce unwanted artifacts due to the limited computational resources of mobile devices and complexities of real scenes. Our proposed method decomposes an image patch into three conceptually independent components: signal strength, signal structure and mean intensity. By fusing these components separately, our approach can produce fused images with more vivid color appearances and fewer artifacts in both static and dynamic situations. The proposed technology can be used in various digital imaging devices, ranging from high-end cameras, to smartphones, and to webcams.

**Special Features and Advantages**
- Accuracy: reconstruct HDR images with detailed structures
- Robustness: produce visually appealing results with very few artifacts
- Flexibility: can be applied to both static and dynamic scenes

**Achievements**

**Collaborators and Funding Body**
- Collaborators: Kede Ma, Zhou Wang, University of Waterloo, Canada
- GRF
- PolyU
- Donation from DJI

**Project 3: Real-time Robust Visual Tracking**

It is a challenging task to develop efficient and robust models for object tracking due to factors such as pose variation, illumination change, occlusion, and motion blur. We propose a series of simple yet effective tracking algorithm by using random projections and correlation filters to extract distinctive image features. During the tracking process, the projections and filters will be updated adaptively to the target being tracked. The proposed algorithms run in high speed and perform favorably against state-of-the-art algorithms on challenging sequences in terms of efficiency, accuracy and robustness. It can be used in high speed target tracking, video surveillance, and video editing, especially for devices with limited computational resources.

**Special Features and Advantages**
- High speed (up to 350 frames/second in Matlab)
- Robust to various target variations
- Easy to be extended and combined with other algorithms

**Achievements**

**Collaborators and Funding Body**
- PolyU
- GRF

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**Prof. ZHANG Lei**

MSc, PhD (Northwestern Polytechnical)

**RESEARCH INTERESTS**

Image and Video Processing, Computer Vision, Pattern Recognition, Biometrics
Project 2: Multimodal Deep Learning for Intelligent Video Analytics

Dr ZHAO Miao
BS, MS(HUST); PhD(SUNY)
RESEARCH INTERESTS
Big Data Analytics, Artificial Intelligence, Recommender Systems, Social Networks, Multimedia Analytics and Networking, IoT, Wireless Communication and Networking

Project 1: Multimodal Recommender Systems for Social Media

Project 3: Data Gathering Optimization and Data Analytics in IoT Systems

Special Features and Advantages
- Optimization on data gathering using mobile robotics
- Enable intelligence in IoT system by big data analytics
- Multi-variant time-series analysis for various tasks in IoT, such as prediction, classification, segmentation and indexing

Achievements

Collaborators and Funding Body
- PolyU

Dr Zhao is now assistant professor at Department of Computing, The Hong Kong Polytechnic University (PolyU). Before joining PolyU, she was a researcher at future networks lab and media lab of Huawei US Innovation Research Center, Santa Clara, California, USA.

She received her Ph.D. from Department of Electrical and Computer Engineering, State University of New York, Stony Brook in 2010. She received her bachelor and master degrees from Department of Electronics and Information Engineering of Huazhong University of Science and Technology, Wuhan, China.

Dr Zhao’s research interests include Big Data Analytics, Artificial Intelligence, Recommender Systems, Social Networks, Multimedia Analytics and Networking, IoT, Wireless Communication and Networking. She has published extensively on various academic venues, such as TMC, TC, TON, TCOM, TVT, JPDC, and INFOCOM, etc. She has served as technical program committee for several well-known conferences, including ICC, Globecom and WCNC, and as the reviewer for premier journals, including TON, JSAC, TMC and TCOM. Dr Zhao is the author of one issued US patent and another five pending US patents. She is a member of IEEE and IEEE Women in Engineering.
Project 1: Design and Implementation of Efficient RFID Protocols

RFID technology has recently attracted many attentions from the academia and industry. Due to the small size and low cost of RFID tags, the RFID technology provides us an economic and competitive method for object management. An RFID tag harvests various energy and transmits data to RFID readers. RFID tags can label items which allows RFID readers to identify and track the items. RFID technology supports various applications, including inventory management, transportation and logistics, object tracking, etc. In Hong Kong, a well-known application of RFID technology is the smart card system for contactless payment. The Octopus cards are used for payment in convenience stores, fast-food restaurants, and on-street parking meters. Having been adopted in many applications, RFID is growing as a major enabling technology of the Internet of Things. However, opposed to the stringent needs for operational efficiency, due to the resource constraints, the working efficiency of some key RFID operations is severely restricted, concerning identification and tracking. Different from traditional efforts and application specific solutions, we target at fundamentally improving the operational efficiency of the basic RFID operations like tag identification and tag searching.

Special Features and Advantages
- Concurrent transmissions of RFID tags: the RFID tags can transmit data in parallel with other RFID tags, and the reader can recover collisions and read the transmitted data.
- Searching interested RFID tags: we can quickly find the interested RFID tags and items in large inventory management systems.
- RFID protocol design and testing platform: we build an RFID protocol prototyping and testing platform to carry protocol design and system evaluation.

Achievements
- Yuanqing Zheng, Mo Li, “Read Bulk Data from Computational RFIDs”, IEEE/ACM Transactions on Networking, accepted to appear.

Collaborators and Funding Body

Project 2: Monitor Your Breathing Rates with Smartphones, WiFi, and RFIDs

Recent years have witnessed a surge of a great variety of smart devices - everyday items in small form factors and diverse wireless communication and computation capabilities - such as smart watches, iBeacons, and computational RFIDs. Those devices are equipped with various types of sensors enabling a wide variety of applications such as bio-signal recording, fitness tracking, urban life sensing, etc. Although the rapid development may relax some constraints on sensing and communication capability, we still lack a unified sensor fusion and analytics framework to capture the sensor data, manage the data, and perform insightful analytics to enable smart healthcare, and eventually improve the quality of human life. This study aims to close the gap between the limited sensing capability of ubiquitous mobile and RF sensing technologies and the stringent demand for in-situ bio-signal and activity tracking for healthcare. To this end, we explore the design space of multi-dimensional sensor fusion to combine multiple sensing sources and enrich our understanding of human daily activities and extracting valuable insights.

Special Features and Advantages
- Non-intrusive sensing of vital signs: we aim to sense the vital signs such as heart rate and respiration rate with mobile data and RF signals without any work of users.
- Low cost and in-situ sensing for everybody: we aim to reduce the sensing and deployment cost leveraging our mobile phones’ sensors and WiFi radios as the bio-signal sensors and provide the healthcare services to everybody.
- Unified sensor fusion and analytic platform for research and healthcare: we aim to build a sensor fusion and analytic platform for researchers and doctors and enrich our understanding of human daily activities.

Collaborators and Funding Body
- PolyU

Dr Zheng is an assistant professor of the Department of Computing at The Hong Kong Polytechnic University. He received the Ph.D. degree in Computer Science from Nanyang Technological University, Singapore. He received the B.S. degree in Electrical Engineering and the M.E. degree in Communication and Information System both from Beijing Normal University, Beijing, China. Dr Zheng’s research interests include human centered computing, mobile and network computing, wireless networks, and RFID systems. He has published several papers in premier journals including IEEE/ACM TON, IEEE TMC, ACM TOIS, and top conferences including ACM MobiCom, MobiSys, MobiHoc, SenSys, IEEE INFOCOM, ICNP, ICDCS, etc. He won the Best Demo Award in IEEE SECON 2014. Dr Zheng serves as reviewers for the top journals including TON, TMC, TPDS, TCOM, TDS, JSAC, and conferences including INFOCOM, ICNP, ICDCS, etc. He is a member of IEEE and a member of ACM.