<u>The four CUHK scholars who received funding from the Excellent Young Scientists Fund (Hong Kong and Macao) and their research projects</u>

1. **Professor Dou Qi, Assistant Professor, Department of Computer Science and Engineering**

Project title: Image-based Robotic Surgery Intelligence

Intelligence is a key component of the new generation of surgical robots. Visual perception has been an essential driving force for environment understanding and automated decision-making for the robotic systems. Focusing on image-based robotic surgery intelligence, Professor Dou has accumulated solid research outputs in this frontier interdisciplinary area, including the representation learning from high-dimensional multi-modal medical images, advancing deep learning methods for complex real-world data, and dynamic modelling of robotic endoscopy scenes. She also established and open-sourced an embodied intelligence platform for surgical robot learning to facilitate research in this community. The proposed project aims to incorporate robotic kinematics and visual data for multi-sensory learning, and achieve AI-assisted decision-making for surgical robots at a higher level of autonomy.

2. **Professor Feng Gangyi, Associate Professor, Department of Linguistics and Modern Languages**

Project title: Cognitive Neuroscience of Language Learning

Professor Feng and his team have conducted novel and systematic research on cognitive neural mechanisms of language learning. Their original findings include the brain networks responsible for language learning and representation, the neural basis for individual differences in language learning, and the neural predictive modeling of children's language development. In this project, they plan to integrate various technologies and analytical approaches to examine the dynamic spatiotemporal neural changes involved in language learning. Moreover, they aim to uncover the causal neural mechanisms of language learning and identify predictive neural markers that can help determine an individual's likelihood of success in learning a language. Ultimately, this research aims to provide a scientific basis for precisely predicting language development and personalised language training for both healthy and special populations.

3. **Professor Ng Chun-yu, Assistant Professor, Department of Physics**

Project title: Astroparticle Physics

Astro-particle physics is an area of cross-disciplinary study involving astrophysics and particle physics. Professor Ng is a researcher in high-energy astrophysics and dark matter indirect detection. He has contributed to a series of groundbreaking observations and theoretical works in high-energy solar emission, X-ray searches of dark matter and others. With this project, he proposes performing physical analysis and interpretations of future solar gamma-ray observations, performing dark matter searches with LHAASO (Large High Altitude Air Shower Observatory) and eROSITA (extended ROentgen Survey with an Imaging Telescope Array), as well as exploring the production of photon polarization via inverse Compton scattering.

4. **Professor Wang Haitian, Associate Professor, The Jockey Club School of Public Health and Primary Care**

Project title: Innovative bioinformatics methods for vaccine antigen optimization

Professor Wang's research focuses on the interdisciplinary area of developing computational biology methods to design vaccine antigens. She has contributed: 1) the first in silico method (the VE-GD model) to predict vaccine effectiveness against COVID-19 through genome analysis, enabling rapid evaluation of the effect of vaccines before vaccination or infection; 2) Novel computational methods that can track virus mutation patterns and predict evolution; 3) A novel angle to dissect human disease susceptibility through the Prism Vote method, enabling more accurate prediction of disease in multi-population data; 4) A number of new bioinformatics methods and software for genome interpretation, including more powerful test for epistasis, rare variants and high-order interactions. In this project, Professor Wang aims to develop methods for predicting SARS-CoV-2 evolution and optimising COVID-19 vaccine antigen design, providing useful bioinformatics tools for developing more effective vaccines.

The 11 CUHK scholars who received funding from the Young Scientists Fund and their research projects

1. **Professor Chen Xiaona, Research Assistant Professor, Department of Orthopaedics and Traumatology**

Project title: Functional and Mechanistic Investigation of DNA G-quadruplexes in Skeletal Muscle Stem Cells during Muscle Regeneration

Skeletal muscle has a robust regenerative capacity, and muscle stem cells (also known as muscle satellite cells, or SCs) play the central role in the regeneration process. Upon injury, SCs go through myogenic lineage progression, which impairs their regenerative capacity, causing muscle diseases and age-related decline of muscle mass and function. This study proposes to investigate the regulatory role of DNA G-quadruplexes (dG4) in SCs during muscle regeneration and decipher the underlying molecular mechanisms. It will be the first to reveal the dG4 landscape dynamics in SCs during regeneration and uncover the mechanistic role of dG4 regulation of 3D genome and gene transcription in SCs and muscle lineage progression, unveiling a new layer of regulatory mechanism for SCs functions that involves DNA secondary structures and interacting proteins. In the long run, this will benefit the development of dG4-based therapeutic strategies to treat muscle diseases.

2. **Professor Chen Ye, Assistant Professor, Department of Chemistry**

Project title: Synthesis of metalloid-doped in noble metal nanomaterials and their electrocatalytic hydrogen evolution properties

Noble metal materials play critical catalytic roles in electrochemical water splitting to produce clean hydrogen energy. However, the high price and low reserves of noble metal elements limit their large-scale applications. Development of intrinsically more active noble metal catalysts at nanometer scale with lower loading requirements has become one of the most promising solutions. This project aims to promote the intrinsic catalytic properties of noble metal nanomaterials by doping metalloid elements (B, Si, and Te) to modulate the electronic structures of noble metal atoms and engineer their lattice strain or even crystal structure, leading to a series of novel noble metal-based nanocatalysts.

3. **Professor Chen Yue, Assistant Professor, Department of Mechanical and Automation Engineering**

Project title: Real-time Aggregation and Operation Methods for Distributed Energy Resources Based on an Energy Sharing Mechanism
Continuous development of renewable energy and enhanced electrification of energy consumption endpoints are two critical pathways towards the global green and low-carbon energy transition. However, with the proliferation of distributed energy resources (DERs) such as rooftop photovoltaic (PV) panels and electric vehicles, the distribution system is now facing many challenges, including the difficulty in centralised management and increased operational uncertainty. To address these challenges, this project focuses on the coordinated, optimal operation of DERs. Research will be conducted into energy sharing mechanism design, operational flexibility evaluation and robust optimal operation. This project will help to explore, integrate and unlock the flexibility of DERs, and improve the operational efficiency and new energy accommodation level of the power system.

4. **Professor Chow Hei-man, Assistant Professor, School of Life Sciences**
Project title: ATM as a critical mediator of insulin-regulated metabolic flexibility and the related implications in cerebellar ataxia
The flexibility to switch between catabolic and anabolic metabolic flux induced by insulin is critical in mammals. However, the mechanisms that underlie such switching remain unclear. Professor Chow has identified Ataxia Telangiectasia Mutated (ATM) kinase as the critical mediator. She will perform in-depth investigations on the metabolic regulatory roles of ATM phosphorylation targets under the influence of insulin. She will also dissect details in the ATM loss-associated metabolic network, such that a precise metabolic remodelling strategy will be devised specifically to target cerebellar degeneration. She envisages that this project will eventually lead to new treatments for managing the progression of ataxic conditions associated with ATM functional loss. Furthermore, the knowledge of ATM as a critical metabolic switch that mediates the effect of insulin will also provide new drug development possibilities for insulin resistance and type 2 diabetes.

5. **Professor Hu Guohua, Assistant Professor, Department of Electronic Engineering**
Project title: Physical realisation of reservoir computing from solution-processed molybdenum disulfide
Reservoir computing is a recurrent neural network designed to approximate dynamics in, for instance, temporal pattern recognition, motion tracking, and time series chaotic forecasting. Realising physical reservoir computing with nonlinear devices to directly map the input into a high-dimensional space is an emergent approach to evade the heavy computation. We propose solution-processed two-dimensional (2D) material devices hold promise for this, given the nonlinear characteristics of 2D materials and the scalable, low-cost manufacturability of solution processing. Our preliminary study has demonstrated the feasibility: we developed nonlinear devices from solution-processed molybdenum disulfide (MoS2) with ferroelectric modulation, and showed implementation of reservoir computing via simulation. In this project, we aim to 1) understand the underlying mechanism of the ferroelectric modulation, 2) optimise the devices for highly nonlinear and stable switching, and 3) investigate physical realisation of reservoir computing using the nonlinear devices. We believe the project will shed light on the engineering of solution-processed MoS2 and the related 2D materials and, importantly, pave the way towards physical reservoir computing.

6. **Professor Kan Zihan, Assistant Professor, Department of Geography and Resource Management**

Project title: Sensing "flow patterns" of activities in urban road networks
Taking "human-vehicle-things" activity flows in road network space as its research subject (referred to as "network activity flows"), this project will construct a multi-scale model of network activity flows, which will advance beyond the traditional understanding of point-based models. It will then propose a multi-modal clustering detection method for network activity flows, extending the current methodological system of activity flow analysis. Lastly, it will advance the current technologies of regularity and anomaly detection of activity flow in urban road network space, and improve the dynamic sensing of regularities and anomalies of urban complex systems. It will provide a theoretical and methodological foundation for understanding activity patterns in urban network space and the underlying mechanism, and provide theoretical tools to address urban issues of transportation, planning and public facilities.

7. **Professor Li Zhong, Assistant Professor, Department of Biomedical Engineering**

Project title: Investigating Infrapatellar Fat Pad-mediated Knee Osteoarthritis Pathogenesis and Progression and Associated Mechanisms Using miniJoint Organ-on-a-chip Systems
Osteoarthritis (OA) is the most common form of joint disease, but the mechanisms underlying its pathogenesis remain elusive. This project proposes to develop a "microJoint" microfluidic chip that effectively integrates the infrapatellar fat pad (IFP), synovium, and osteochondral tissue modules, and enables tissue crosstalk via a simulated synovial fluid. By inducing IFP inflammation, Professor Li will explore the potential mechanisms by which IFP modulates OA pathogenesis. After creating cartilage injury, he will analyse the effect of IFP on OA progression, unveiling the mechanisms by which IFP accelerates it. This project offers a novel in vitro platform that is highly relevant to joint physiology and pathology. The findings are expected to facilitate future research into OA pathophysiology and accelerate drug development, reducing the burden of joint diseases associated with an ageing population.

8. **Professor Wang Zhen, Research Assistant Professor, Department of Mechanical and Automation Engineering**

Project title: Highly sensitive gas sensing based on mid-infrared doubly resonant photoacoustic spectroscopy
Photoacoustic spectroscopy (PAS) is an important trace gas analysis method, which has the advantages of being background-free and low cost, and having a small footprint. However, the technology cannot fulfil the need for ultrasensitive gas detection for specific applications such as climate monitoring and energy security. This project intends to study the principles and methods of mid-infrared doubly resonant PAS and break through this technical bottleneck in ultrasensitive gas detection. It will establish a theoretical model of doubly resonant PAS, and investigate the locking method and coupling mechanism between mid-infrared laser and high-finesse optical resonator. At the same time, it will reveal the interaction mechanism between the acoustic field distribution, resonator structure and cantilever beam excitation mode. Finally, it will study the influence of the molecular saturation absorption and relaxation process on photoacoustic signals.

9. **Professor Wu Xixin, Research Assistant Professor, Stanley Ho Big Data Decision Analytics Research Centre**

Project title: Research on Key Technologies of Speech Synthesis for Older Adults

Intelligent voice interaction is widely used in different scenarios and products. However, conventional speech synthesis technologies fail to fully consider the characteristics of older adults' auditory perception and speech comprehension, which makes the synthesized speech difficult for them to understand and seriously reduces the effectiveness of their human-machine speech interactions. This project studies speech synthesis for older adults from two perspectives: text style conversion and acoustic model adaptation. The text style conversion module can transform the complex text style that does not meet the characteristics of older adults' speech comprehension into one that is easy to understand. Acoustic model adaptation can generate an acoustic style that meets the real auditory perception needs of older adults. The project outputs can promote the research and development of speech synthesis technologies for older adults, and can be applied in various older adult-facing intelligent services.

10. Professor Yue Xiangyu, Assistant Professor, Department of Information Engineering
Project title: Multi-modality Fusion for Domain-Adaptive Image Recognition in Complex Environments
Image recognition based on deep neural networks is essential for many applications, including autonomous driving. In this project, Professor Yue aims to tackle domain adaptive image recognition with a multi-modal approach. 1) For image modality, it proposes a novel multi-level optimal transport for both coarse-grained and fine-grained adaptive image recognition. 2) For natural language, it uses textual domain descriptions to guide image recognition adaptation, so that the model can be transferred to unseen domains without access to any target sample. 3) For LiDAR point cloud data, it hopes to exploit the information that is missing in images, e.g. depth information, to better align source and target domains. This project will not only have a significant impact on various image recognition applications in complex environments, but will also shed light on how to develop adaptive computer vision learning methods in a multi-modal manner.

11. Professor Zhu Xiaobai, Assistant Professor, Department of Finance
Project title: Socioeconomic differentials in mortality: implications on the fairness of the public pension system
Socioeconomic differences in mortality rates imply that higher income classes have a higher life expectancy compared with lower ones. Unfortunately, the existing notional account plan under China's first pillar pension system potentially leads to an undesirable redistribution of wealth, such that people with lower incomes are subsidising those with higher ones. This project studies the optimal annuity divisor (the ratio between the notional account balance and the annuity payment) that takes socioeconomic differentials into account. Professor Zhu will construct a multi-population stochastic mortality model based on China's data under a Bayesian framework. By maximising the social welfare function along with several fairness constraints, he will derive the optimal structure of the annuity divisor using the optimal control approach. The project will provide important insights into the trade-off between welfare improvement and the intra-generational fairness of the retirement system.