HKUST-MIT Research Alliance Consortium

Call for Proposal

Lead Universities

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Massachusetts Institute of Technology

Participating Universities

香港中文大學
The Chinese University of Hong Kong

香港城市大學
City University of Hong Kong

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

The University of Hong Kong

Call for Proposal: Biomedical Systems

Background

According to the most recent report issued by the Department of Health of the Hong Kong government, the top five leading causes of death in Hong Kong are **cancer**, **pneumonia**, **heart diseases**, **cerebrovascular diseases**, and **chronic lower respiratory diseases (for male) /nephritis, nephrotic syndrome and nephrosis (for female)**. Each year, Hong Kong spends about 127.8 billion Hong Kong Dollars on health care, mainly to fight these complex and life-threatening diseases. For healthcare professionals and biomedical researchers, effectively preventing, diagnosing and treating complex diseases, while maintaining the quality of life of patients are the major challenges.

The population in Hong Kong is known to have the highest life expectancy in the world (81.2 years for male and 86.9 years for female) thanks to the effective healthcare system in Hong Kong. But the situation becomes more demanding as Hong Kong is entering an ageing society. According to the Census and Statistics Department (C&SD) of the Hong Kong government, "The proportion of elderly persons aged 65 and over is projected to rise markedly, from 15 per cent in 2014 to 36 per cent in 2064. Population ageing is expected to be most rapid in the coming 20 years with the proportion of over 65 reaching 23 per cent in 2024 and 30 per cent in 2034. This is mainly attributable to the post-war baby boomers entering old age." Given that the financial and personnel resources (i.e., medical doctors and nurses) in Hong Kong cannot keep increasing forever, the healthcare system in Hong Kong needs to adapt itself to the quickly increasing demand from the ageing population.

In ageing societies around the world, complex diseases (such as cancer and cardiovascular disease) and chronic diseases (such as diabetes and hypertension) are major healthcare burdens. According to the latest world health report by WHO, the top ten leading diseases claimed over 30.3 million lives in 2015. These diseases include **ischemic heart disease**, **stroke, lower respiratory infections, chronic obstructive pulmonary disease, lung cancer,** and **diabetes**. Counting diabetes alone, for example, the healthcare system in Hong Kong currently needs to handle 1.2million out-patient attendances and 280,000 hospital admissions per year. The estimated medical cost is around 2 billion Hong Kong Dollars. The prevalence rate still keeps increasing, largely due to the greater longevity and increased risk factors (such as overweight or obesity) among the younger population. At the global scale, it is estimated that about 371 million people are affected by diabetes. The cost of treating diabetes is about 471 billion USD, making it a "major threat to global development".

More importantly, traditional diagnosis and treatment methods cannot effectively cope with complex diseases. Too often have we heard the story that someone has been diagnosed with cancer, unfortunately at the late stage. The doctors then have to regretfully inform the family members that there is not much they can do to save the patient's life.

Accurately monitoring people's health status, preventing diseases, non-invasively diagnosing diseases at early stages, and finding effective treatment or even the cure are the ultimate dream of biomedical researchers. Towards this end, a lot has to be done in biomedical research. Currently, bio-medical research has changed from the traditional "deep-and-narrow" style to the large-scale system study. Especially, the fast development of high-throughput instruments has enabled us to systematically measure bioactivities and functions at the molecular/cellular level. In the medical field, the widespread use of electronic medical record (EMR) together with the emerging machine learning-based data analytics is revolutionizing healthcare practice. For example, several recent reports on artificial intelligence (AI) outperforming professional pathologist/radiologist in breast cancer diagnosis, liver cancer diagnosis, skin cancer diagnosis, autism diagnosis, and magnetic resonance image (MRI) analysis have attracted a lot of attention beyond the science and engineering community.

In summary, new design of biomedical instruments, information extraction from large-scale biomedical data, and novel applications arisen from new understanding are emerging themes in biomedical research. This call-for-proposal invites pre-competitive research contributions in the following three interdisciplinary areas that will revolutionize biomedical research and healthcare practice. Combining topics from the three themes is permitted and encouraged.

Theme 1: New design of biomedical instruments.

The current trend of precision medicine and/or personalized medicine vividly reflects our desire to study biological systems with sufficient coverage of their component systems and functions. Cellular imaging, next-generation sequencing, and other omics-related instruments are good examples of such a development at the molecular level, reflecting the trend that biology has become more and more quantitative.

In the field of medical imaging, emerging modalities (such as photoacoustic tomography) have enabled us to have new functional or anatomical measurements of the human body. Medical doctors are very excited to have new perspectives of the biological systems that cannot be imagined before.

This theme aims at boosting research along the direction of developing new biomedical instruments to enable observing biological systems at finer scale, capturing dynamic behavior, and measuring live functions.

Topics of Interest:

Proposals are sought for cross-disciplinary projects with an emphasis on new instrument/device design and development. The list below is a sampling of research topics relevant to new designs of instruments that can facilitate biomedical data generation and is by no means exclusive:

- New biomedical imaging systems: New systems or devices that can non-invasively acquire anatomical and functional data of subjects in a real-time fashion with improved spatial or temporal resolution, or capturing different types of *in vivo* information.
- New bio-molecular imaging systems: New systems or devices that can measure the molecular activities of tissues/cells.
- Portable household biomedical imaging device used for early detection of breast cancer and heart disease. (e.g. Wireless and portable ultrasonic probe & device).
- Robotic surgical products: leverage new technologies and materials to enhance robotic surgical procedures.
- Personal health monitoring systems: Integrated sensing systems to measure physiological signals of individuals.
- Digital health: Non-invasive home-based tests for health status monitoring and alarm reporting.
- Personalized omics-data collection devices: Portable and easy-to-use omics data acquisition devices that can facilitate personalized medicine.
- Point-of-care tests to obtain physiological information quickly, inexpensively, and at the point of care.
- Automated blood collection device (minimally invasive) to collect blood sample for health monitoring.
- Ultra-High Speed MRI/CT/PET-MR for rapid screening cancer and cardio-cerebrovascular disease.
- Microfluidic device to separate single cell used for subsequent single cell omics analysis.
- Prenatal MRI Imaging for detection of birth defects (malformation or neurodevelopmental disease).
- Remote ultrasonic robot with intelligent imaging analysis algorithm to detect birth defects or parasitic disease in remote area.
- Portable colposcope or remotely controlled colposcope to collect pathological imaging data for cervical cancer screening.
- Low-cost mass spectrometry to provide solutions for the rapid analysis of proteins and metabolites.

- Liquid biopsy technique to detect cell-free DNA methylation for cancer diagnosis.
- Liquid biopsy technique to detect trace pathogen DNA/RNA in blood for rapid diagnosis of infectious disease.
- High throughput array technique to digitalize human immune status for health evaluation.

Theme 2: Data analytics with the biomedical context.

The high-throughput instruments and widespread adoption of electronic medical record systems have generated large-scale biomedical data at an accelerating pace. Handling such a big-data has become a major analysis issue. Unlike webpage-based big data, biomedical data has a much higher number of features (i.e., measurements), while the sample size is still limited. Consequently, extracting useful information from biomedical data remains an analysis challenge. Besides, there is evidence that many new disease biomarkers could be discovered using traditional biomedical instruments such as Electrocardiography (ECG) and sphygmomanometer through innovative data analytics. The outcomes of past patient cases can also help to create decision support systems that recommend treatments that have been useful for previous patients. Developing new data analytics has become an important research field in its own right.

This theme aims at boosting research along the direction of developing new analytics to provide clinically relevant decision support and to extract actionable information from biomedical data.

Topics of Interest:

Proposals are sought for projects with an emphasis on new data analytics with the biomedical context. The list below reflects our interests:

- Automatic analysis of biomedical image data: Enable automatic and early diagnosis of complex diseases and monitoring of disease development.
- Computational modeling of complex diseases using genetic or proteomic data: Aim at gaining deeper and systematic understanding of complex diseases at both genetic and proteomic level.
- Analyzing the relationship between intervention choices and clinical outcomes in previous patients' records, as a basis for future decision support to optimize personalized medical care.
- Integrated biomedical image and omics-data analysis: Provide a holistic view of complex diseases at both tissue/organ level and cellular function level.
- Machine learning based methods to analyze biomedical data: Take advantage of the big data available and make use of current new development in machine learning and big data analytics.
- Medical AI: Leverage machine learning, big data analytics and computational science in the development of medical chat bots and the AI doctor.
- Machine learning applications for the analysis of genomic, epigenetic, proteomic or metabolomics data. Produce actionable information that will enhance the practitioners' diagnostic intuition.
- Novel therapeutics/diagnostics: Enhanced diagnostic and treatment using novel techniques and new technologies.
- Trans-omics big data mining – Correlate genomics data (from next-generation sequencing) with proteomics and imaging data. Develop AI application in radiogenomics for detection, diagnosis of cancer and birth defects. Using radiogenomics approach to dynamically monitoring cancer progression.

Theme 3: Novel applications in healthcare.

The need in healthcare is very diversified, ranging from portable sensors for continuous health monitoring to novel biomaterial for smart drug delivery, from biomedical microelectromechanical systems (bioMEMS) for efficient point-of-care testing to artificial organs for regenerative medicine, …

This theme focuses on applications of novel ideas that can revolutionize the healthcare practice. The projects can be interdisciplinary in nature with emphasis on engineering systems.

Topics of Interest:

- New biomaterials: effective and long-lasting drug delivery and smart disease treatment.
- BioMEMS: Biomolecular engineering tools at the micro/nanoscale for automatic laboratory tests.
- Tissue engineering: Fabrication of artificial tissue/organs and replacement.
- Systems biology: Applications of biomarkers in disease diagnosis and treatment using omics-based understanding.
- Using Multi-omics Approach to Study Neurodegenerative Diseases and Ageing: Harnessing large-scale omics platforms (gene sequencing platform + mass spectrometry platform + neuroimaging modalities platform together with advances in bioinformatics and computational programming) to generate 'big-data' information (epigenetics, transcriptomic, proteomic, metabolomics, lipidomic and imaging) from Alzheimer's disease(AD) patients and age-matched healthy cohorts. This topic aims to use multi-omics approach to advance study of AD at multiple levels.
- Use blockchain technology for personal health data storage and exchange. Blockchain does offer a promising new distributed framework to amplify and support integration of health care information across a range of uses and stakeholders. It will enable personal health data to be encrypted and shared with security, privacy, immutability and interoperability. It will create a trustless, and collaborative ecosystem of health information sharing to enable new scientific insights in healthcare.