SCHOOL OF ENGINEERING

DEPARTMENT OF CHEMICAL AND BIOLOGICAL ENGINEERING 化學及生物工程學系

School of Engineering Distinguished Workshop:
The Future of Health Technology in Modern Medicine

The Hong Kong University of Science and Technology

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ABSTRACT

AI & Data Science

Unsupervised Clustering Methods and Applications for Genes, Cells, and Tissues

Prof. Hongmin CAI

South China University of Technology

Abstract

The emergence of complex diseases is a process that evolves from the micro to the macro level. Unsupervised clustering methods can analyze the evolution patterns of complex diseases from three scales: genes, cells, and tissues. However, traditional unsupervised clustering methods encounter challenges such as the inseparability of single-omics sequencing data, misalignment of multi-omics network data, and inaccurate matching of multimodal imaging data. To address these issues, we have created a range of clustering techniques for high-dimensional single-omics data, multi-omics network data, and multi-modal medical image data. At the genetic level, single-omics sequences are grouped to identify gene differences; at the cellular level, multi-omics networks are aligned to quantify spatial regulation and mine for early screening targets; at the tissue level, multimodal images are registered to identify consensus lesions, providing an in-depth and accurate panoramic analysis for tumor diseases.

About the Speaker

Hongmin Cai, a professor at the School of Future Technology at the South China University of Technology, is a recipient of the National Science Fund for Distinguished Young Scholars. He currently serves as an executive committee member of the *CAA Intelligent Health* and *Bioinformatics Professional Committee* and the *CCF Bioinformatics Professional Committee*. He is an editorial board member of international journals such as *IEEE Transactions on Emerging Topics in Computational Intelligence and Fundamental Research*. He has long been engaged in biomedical artificial intelligence data analysis, with related research results published in journals including *IEEE Transactions on Pattern Analysis and Machine Intelligence, Nature Communications*, and *IEEE Transactions on Medical Imaging*. He has presided over more than ten projects, including the *National Natural Science Fund for Distinguished Young Scholars*, the *National Natural Science Joint Fund*, and the *International Cooperation Projects of the Ministry of Science and Technology*, and holds 20 authorized patents. He has received the First Prize in Natural Science from the Guangdong Artificial Intelligence Industry Association, the Gold Award in the Internet+ Innovation and Entrepreneurship Competition, and the Second Prize in Educational and Teaching Achievement in Guangdong Province.

Towards Developing AI Foundation Models for Medical Imaging

Prof. Shanshan WANG

Chinese Academy of Sciences

Abstract

Foundation models for generalist medical artificial intelligence (AI) have gained huge attention lately and presented great potential to transform healthcare. Different from current medical AI models, foundation models are expected to solve diverse and challenging tasks while requiring little to even no labels for specific tasks. Medical imaging is a research field that remains plenty of technical and clinical challenges. AI, particularly Deep Learning (DL), has demonstrated high potential to resolve such challenges. However, the current DL approaches are still task specific and lack generalization capabilities. This talk will investigate foundation models for medical imaging. Topics covered fast MR imaging and a variety of downstream tasks.

About the Speaker

Dr. Shanshan Wang is a professor at the Paul C Lauterbur Research Center, Chinese Academy of Sciences, where she targets to develop novel adaptive learning methods and applications for fast medical imaging and intelligent medical analysis. With dual Ph.D. degrees in Biomedical Engineering (BME) and Computer Science (CS), she pioneered the integration of core CS methodologies with imaging sciences. Her innovative approaches led to pioneering key contributions to the field of AI-fast MR imaging. Dr. Shanshan Wang has been a Gordon Plenary Lecturer, NIBIB New Horizons Plenary Lecturer, IEEE senior member, OCSMRM BoT/Life member, Deputy editor of Magnetic resonance in medicine, Associate editor of IEEE Transactions on Medical Imaging, Pattern Recognition and Biomedical Signal Processing and Control, etc. She also got selected as the World's Top 2% of Scientists by Stanford University, USA several times.

Prior Knowledge-Guided Self-Supervised Learning for DR Grading

Prof. Xiaoying TANG

Southern University of Science and Technology

Abstract

Self-supervised learning (SSL) has emerged as a powerful method for learning representations from unlabeled images, with contrastive learning being one of the most promising paradigms. Despite its success in computer vision, the medical imaging domain has not fully benefited from such advances due to the domain gap between natural and medical images. In this talk, I will present two frameworks that leverage prior knowledge to guide SSL for diabetic retinopathy (DR) grading. The first framework employs lesion detection to guide self-supervised learning, ensuring the model focuses on DR-relevant features. The second framework builds on this by employing saliency maps to highlight lesions. These approaches aim to make SSL more effective for medical imaging by emphasizing lesion-focused feature learning.

About the Speaker

Xiaoying Tang, PhD from Johns Hopkins University, Tenured Associate Professor and Researcher at Southern University of Science and Technology; Guangdong Province Outstanding Youth; Shenzhen Outstanding Youth; Overseas High-level Talent Introduced to Shenzhen; Visiting Professor at Johns Hopkins University and Carnegie Mellon University; Young Scientist Project Leader for the "14th Five-Year Plan" Key Research and Development Plan of the Ministry of Science and Technology, Principal Investigator for more than ten research projects under the "13th Five-Year Plan" Key Research and Development Plan of the Ministry of Science and Technology; Editorial Board Member for Neural Networks and IEEE TCDS journals; Domain Chair, Session Chair, and Local Chair for the International Conference MICCAI; Senior Member of IEEE; Secretary-General of IEEE EMBS Shenzhen Chapter. Published 55 papers in high-level SCI journals such as IEEE TMI, 98 papers in top international conferences, and 2 book chapters. Holder of one international invention patent, ten Chinese invention patents, and eight registered software copyrights. Participated in drafting the national guideline "Guideline for Intelligent Screening Systems for Diabetic Retinopathy Based on Fundus Photography". Received the First Prize in Science and Technology Progress Award of Guangdong Province.

Intelligent Spatial Transcriptomics: Methods and Applications

Prof. Shihua ZHANG

Chinese Academy of Sciences

Abstract

Technological advances in spatial transcriptomics are critical for a better understanding of the structures and functions of tissues in biological research. The combination of intelligent or statistical algorithms and spatial transcriptomics has emerged to pave the way for deciphering tissue architecture. We have made great efforts to advance intelligent spatial transcriptomics and developed a group of STA- tools. For example, we first developed a graph attention auto-encoder tool STAGATE to identify spatial domains by learning low-dimensional latent embeddings via integrating spatial information and gene expression profiles. Second, we introduced STAligner for integrating and aligning ST datasets across different conditions, technologies, and developmental stages to enable spatially aware data integration, simultaneous spatial domain identification, and downstream comparative analysis. Third, we designed STAMarker for identifying spatially domain-specific variable genes with saliency maps in deep learning. Fourth, we developed a spatial location-supervised auto-encoder generator STAGE for generating high-density spatial transcriptomics. Fifth, we developed STASCAN for deciphering fine-resolution cell-distribution maps in spatial transcriptomics.

About the Speaker

Shihua Zhang received a PhD in applied mathematics and bioinformatics from the Academy of Mathematics and Systems Science, Chinese Academy of Sciences (CAS) in 2008 with the highest honor. He joined the same institute as an Assistant Professor in 2008 and is currently Professor. His research interests are mainly bioinformatics, computational biology, machine learning, and deep learning. His main papers have been published in prestigious journals including Cell, Nature Computational Science, Nature Communications, Advanced Science, National Science Review (2 papers), Nucleic Acids Research, IEEE TPAMI, IEEE TKDE, and IEEE TNNLS. His two papers have been selected as Top Ten Bioinformatics Advances in China (2021, 2022). He has won various awards and honors including the Ten Thousand Talent Program (2018, 2022), NSFC for Excellent Young Scholars (2014), Outstanding Young Scientist Program of CAS (2014), and Youth Science and Technology Award of China (2013). Now he serves as an Editorial Board Member of PLOS Computational Biology, and so on.

Deep Reinforcement Learning Identifies Personalized Intermittent Androgen Deprivation Therapy for Prostate Cancer

Prof. Qingpeng ZHANG

The University of Hong Kong

Abstract

The evolution of drug resistance leads to treatment failure and tumor progression. Intermittent androgen deprivation therapy (IADT) helps responsive cancer cells compete with resistant cancer cells in intratumoral competition. However, conventional IADT is population-based and ignores the heterogeneous phenotypes of individual patients. To address this challenge, we developed a time-varied, mixed-effect, and generative Lotka-Volterra (tM-GLV) model to account for the heterogeneity of the evolution mechanism and the pharmacokinetics of individual patients. Then, we proposed a reinforcement learningenabled individualized IADT framework, namely, I2ADT, to learn the patient-specific tumor dynamics and derive the optimal drug administration policy. Experiments with clinical trial data demonstrated that the proposed I2ADT can significantly prolong the time to progression of prostate cancer patients with reduced cumulative drug dosage. This research elucidates the application of reinforcement learning techniques to identify personalized adaptive cancer therapy.

About the Speaker

Dr. Qingpeng Zhang is an associate professor in the Musketeers Foundation Institute of Data Science and the Department of Pharmacology and Pharmacy at HKU. His research interests are complex networks and medical informatics. He obtained his bachelor's degree in automation from Huazhong University of Science and Technology in 2009, his PhD degree in systems and industrial engineering from the University of Arizona in 2012, and conducted postdoctoral research in the Department of Computer Science at Rensselaer Polytechnic Institute. He previously taught at City University of Hong Kong. His research results have been published in top journals such as Nature Human Behavior, Nature Communications, PNAS, MIS Quarterly, and have been reported by many domestic and foreign media such as the Washington Post, the New York Times, and the Guardian. He has won awards such as the IEEE Andrew P. Sage Best Transactions Paper Award, the President's Award and the Outstanding Research Award from City University of Hong Kong. His current research focus is to develop knowledge-based predictive decision analysis methods, using high-dimensional biological, clinical and behavioral data for drug discovery, precision medicine and public health research.

Unravelling the Complexities of Biological Aging

Prof. Linyan Li

City University of Hong Kong

Abstract

The mechanisms underlying aging are increasingly viewed as therapeutic targets. In this study, we used longitudinal brain imaging and physiological phenotypes from the UK Biobank to create models of biological age for various brain and body systems. Our objective was to identify non-linear alterations in the structure of the human brain associated with aging. Our observations revealed waves of structural changes in the brain. These changes showed differential associations with age-related diseases. Our findings may pave the way for the discovery of unexpected biological signatures and pathways that could serve as potential targets for the treatment of age-related diseases.

About the Speaker

Dr. Linyan Li is an Assistant Professor at the School of Data Science with a joint appointment in the Department of Infectious Disease and Public Health at City University of Hong Kong. She holds a bachelor's degree in building science from Tsinghua University, China, and a doctoral degree from the Department of Environmental Health at Harvard T.H. Chan School of Public Health. Her research interest lies in using a data-driven approach to understand complex relationships in precision medicine, environmental health, and other related fields.