香港中文大學理學院
FACULTY OF SCIENCE
THE CHINESE UNIVERSITY OF HONG KONG

2025 SCIENCE FACULTY POSTGRADUATE RESEARCH DAY

27 May 2025

Science *Empowers* Your Dreams

Learn Science to *Better* the World

PROGRAMME

09:30 - 09:45	**Welcome Remarks & Opening Ceremony** ***Professor SONG Chunshan,*** Dean of Science
09:45 - 10:00	**Impact of *Lhx1/5* Inactivation on Purkinje Cell Function: Ataxia and Disruption of Neurotransmitter Homeostasis** ***SHEN Le*** (Year 3 PhD Student in Cell & Molecular Biology)
10:00 - 10:15	**Impacts of Mercury Exposure on Human Reproductive Health** ***YUAN Mengwei*** (Year 3 PhD Student in Biochemistry)
10:15 - 10:30	**Bioorthogonally Activated Photosensitizers for Precise Photodynamic Therapy via Degradation of Epidermal Growth Factor Receptor** ***WANG Shuai*** (Year 3 PhD Student in Chemistry)
10:30 - 10:45	**Hydroacoustic Monitoring of Earthquake Swarms and Foreshock-Mainshock-Aftershock Sequences along Oceanic Transform Faults in the Northeast Pacific Ocean** ***LIU Hui*** (Year 4 PhD Student in Earth & Atmospheric Sciences)
10:45 - 11:00	**Break (15 minutes)**
11:00 - 11:15	**An Onsager-Type Theorem for General 2D Active Scalar Equations** ***ZHAO Xuanxuan*** (Year 3 PhD Student in Mathematics)
11:15 - 11:30	**Understanding Multi-Length Scale Fractal Networks in Organic Photovoltaic Active Layers and Their Impact on Charge Trapping** ***FU Yuang*** (Year 3 PhD Student in Physics)
11:30 - 11:45	**Temporal Dependence in Decision Making: A Unified Learning-Optimization Framework** ***WU Zhuogen*** (Year 2 MPhil Student in Risk Management Science)
11:45 - 12:00	**Online Difference-Based Variance Estimators in Time Series** ***SHEN Zhuohua*** (Year 1 MPhil Student in Statistics)
14:00 - 15:30	**Poster Pitching & Poster Presentation**

Welcome Message from the Dean of Science
Professor Chunshan SONG

It is my great pleasure to welcome you to the 2025 Science Faculty Postgraduate Research Day at The Chinese University of Hong Kong.

Since its establishment in 2021, this annual event has served as a vibrant platform for our postgraduate students to showcase their research, exchange ideas, learn from others, improve and strengthen their skills for high-quality research and effective presentation for their research projects. One can learn a lot by carefully observing. This year, we are also introducing a new element: a pitch presentation format for the poster session. Presenters are required to deliver a concise, two-minute pitch to effectively convey the key ideas of their poster presentations.

Research is a critically important part of postgraduate education at leading research universities. Good research challenges conventions, drives progress, and shapes the future. Richard P. Feynman indicated that "*If science is to progress, what we need is the ability to experiment, honesty in reporting results—the results must be reported without somebody saying what they would like the results to have been—and finally—an important thing—the intelligence to interpret the results*". Edward Teller said that "*The science of today is the technology of tomorrow*". At the same time, we remain steadfast in our pursuit of global and regional partnerships to advance research excellence. With strong support from the University, our Faculty proudly leads CUHK efforts in establishing the Joint Institute of Advanced Materials and Green Energy Research (JIAMGER) in collaboration with Great Bay University, backed by the Municipal Government of Dongguan. The inauguration ceremony, held on 26 November 2024, marked a significant milestone. We are also pleased to have completed the second round of PhD student recruitment for the 2026 intake in conjunction with JIAMGER. Through this regional collaboration in the Greater Bay Area (GBA), we are strengthening ties with Great Bay Area and creating more opportunities for our postgraduate students to engage in impactful research. These efforts contribute to transforming GBA into an innovation and technology hub of global significance.

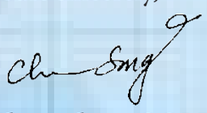
To strengthen the Faculty's efforts in global engagement and explore international collaborative opportunities, our Faculty delegation, for the first time last year, visited four countries: Czech (Prague), Poland (Krakow), Thailand (Bangkok) and Vietnam (Ho Chi Minh City). These visits provided valuable insights and laid a strong foundation for attracting global talent to our postgraduate programmes. We look forward to continuing these efforts in 2025, further enriching the diversity of our Faculty and expanding our global scientific community.

Guided by our motto, "*Science empowers your dream. Learn Science to Better the World,*" we are proud to foster a vibrant research culture that empowers our students to ask bold questions and seek meaningful answers. The Postgraduate Research Day reflects our Faculty's deep commitment to educating and inspiring the next generation of scientific innovators and leader. Today, we are proud to witness the remarkable work of our postgraduate students. Their originality, dedication, and excellence reflect the vibrant research culture we strive to uphold.

I would like to extend my heartfelt thanks to Professor NGAI To, our event coordinator, as well as all presenters, panel members, Faculty members, and staff whose efforts have made this event possible. Your contributions are deeply appreciated.

I wish you all a fruitful day on the 2025 Postgraduate Research Day. Thank you.

Yours sincerely,



Chunshan SONG
Dean of Science and
Wei Lun Professor of Chemistry

Oral Presentation
Abstract

Impact of *Lhx1/5* Inactivation on Purkinje Cell Function: Ataxia and Disruption of Neurotransmitter Homeostasis

SHEN Le
Year 3 PhD Student in Cell and Molecular Biology
Principal Supervisor: Professor KWAN Kin Ming

The cerebellum is primarily known for its role in motor coordination, but its connections with other brain regions are often underestimated. Developmental issues in the cerebellum can lead to various diseases, particularly those involving Purkinje cells, which have a complex morphology enabling them to receive signals from numerous neurons and serve as the sole output from the cerebellar cortex. Degeneration of these cells is associated with spinocerebellar ataxias (SCA), a group of inherited conditions that can severely impact motor function.

Previous research has identified *Pcp2-cre Lhx1/5* double conditional knockout (DKO) mice exhibited significant motor deficits and decreased cerebellum size due to reduced dendritic lengths. The purkinje cells in DKO mice showed abnormal electrophysiological properties.

To investigate the mechanism, we selected EAAT4, a purkinje cell-specific excitatory amino acid transporter, as a potential candidate from the microarray analysis, since it was notably decreased in our DKO mutant and other ataxia models. This reduction was found to correlate with defects in Purkinje cell dendrites temporally and spatially, suggesting a critical link between EAAT4 expression and dendritic development. Chromatin immunoprecipitation (CHIP) assay demonstrated that Lhx1/5 could directly bind to EAAT4 promoter, indicating a transcription regulatory relationship between them.

Besides, our study also revealed disruptions in glutamate and GABA homeostasis within the cerebellum of DKO mutants. Altered expressions of multiple glutamate and GABA transporters, receptors, and their metabolic enzymes were observed in the DKO mutant cerebellum.

These molecular changes may contribute to an imbalance in excitatory and inhibitory signaling within the cerebellum, resulting in the dendritic defects and abnormal electrophysiological properties of purkinje cells, which ultimately leads to the motor deficits observed in the DKO mutants. This study highlights the complex interplay between neurotransmitter transport and Purkinje cell function in cerebellar development and motor coordination.

Acknowledgement: This work was supported by the Hong Kong Research Grants Council (HKRGC) GRF (14114921), the Areas of Excellence AoE (AoE/M-05/12), and the Chinese University of Hong Kong Direct Grant for Research.

Impacts of Mercury Exposure on Human Reproductive Health

YUAN Mengwei
Year 3 PhD Student in Biochemistry
Principal Supervisor: Professor TSUI Tsz Ki Martin

Mercury (Hg), a heavy metal with widespread distribution and extensive human exposure through food consumption, has been implicated in numerous adverse health effects. Developing fetuses are particularly vulnerable due to the efficient transfer of neurotoxic methylmercury (MeHg) across the placental and blood-brain barriers. Therefore, understanding how maternal factors affect fetal Hg exposure is essential for formulating effective preventive strategies and public health interventions.

This study involved 15 mother-infant pairs in Hong Kong to investigate placental Hg transfer and dietary influences on the fetal exposure. For each pair, tissue samples were collected from three sites of umbilical cord from fetus to placenta and six random regions of placental basal and chorionic plates for various analyses, and alongside maternal and cord blood for complete blood count. Total Hg (THg) and MeHg levels were quantified by cold vapour atomic fluorescence spectrometer. Stable isotopes ratios of nitrogen and carbon in tissues were measured via continuous flow-isotope ratio mass spectrometry to infer maternal dietary sources.

Isotopic analysis revealed that umbilical cord THg and MeHg levels were strongly associated with cord $\delta^{15}N$ (adjusted $R^2 = 0.58$, $p < 0.0001$). Each 1‰ increase in $\delta^{15}N$, equivalent to ~25% of a trophic level elevation, was linked to an average of 20.4 ng/g increase in THg and 13.3 ng/g increase in MeHg. Cord $\delta^{13}C$ exhibited a significant positive correlation with THg (adjusted $R^2 = 0.18$, $p < 0.01$), reflecting Hg inputs from $\delta^{13}C$-enriched diets (e.g., seafoods). Placental tissue comparisons further demonstrated a 15% reduction in THg ($p < 0.001$) with a 32% reduction in MeHg ($p < 0.001$) from the maternal-facing basal plate to the fetal-facing chorionic plate, may underscore partial but incomplete placental filtration of Hg species in the Hg transfer. Furthermore, concentrations of all blood Hg species were positively associated with erythrocyte count ($p < 0.01$), and THg level increased from maternal blood to cord blood (1.92 to 3.40 ng/mL) in parallel with rising haematocrit (35.7% to 47.8%). Conversely, markers of microcytic anaemia (MCH < 27 pg; MCV < 80 fL) were associated with increased placental THg, indicating that association of low hemoglobin production with the fetal Hg exposure.

These findings highlight the critical roles of maternal diet and haematological health in shaping fetal Hg burdens, and potentially its risk. Public health strategies should integrate dietary guidance for pregnant women, particularly in coastal regions with high Hg exposure, and RBC indices to identify high risk pregnancies. Future work in larger cohorts will be key to refining these recommendations and inform global guidelines.

Bioorthogonally Activated Photosensitizers for Precise Photodynamic Therapy via Degradation of Epidermal Growth Factor Receptor

WANG Shuai
Year 3 PhD Student in Chemistry
Principal Supervisor: Professor NG Kee Pui Dennis

Targeted degradation of epidermal growth factor receptor (EGFR) represents a pivotal strategy for suppressing cancer cell proliferation and metastasis. In this study, we developed a bioorthogonally activatable EGFR-targeting photosensitizer, labeled as EBP-BDP-TCO, by conjugating a distyryl boron dipyrromethene (BDP) core with a trans-cyclooctene (TCO)-caged ester group and an EGFR-binding peptide with the sequence CMYIEALDKYAC. Its photoactivity was specifically triggered via inverse electron-demand Diels-Alder (IEDDA) cycloaddition between the TCO moiety and a tetrazine derivative. By using a tetrazine-modified erlotinib, which is a tyrosine kinase inhibitor (TKI), we achieved significant suppression of EGFR phosphorylation in EGFR-overexpressed cancer cells and enhanced cellular ubiquitin ligase activity. Upon target-mediated internalization, the bioorthogonal reaction removed the TCO cap, initiating an "ester-to-carboxylate" transformation that restored the fluorescence and reactive oxygen species (ROS) generation. The ROS-induced EGFR damage facilitated ubiquitination and the subsequent proteasomal degradation via the ubiquitin-proteasome system (UPS). This dual-action mechanism is expected to address the drug resistance of traditional TKIs and the self-repair and recurrence of cancer cells caused by the activation of the EGFR pathway during photodynamic therapy.

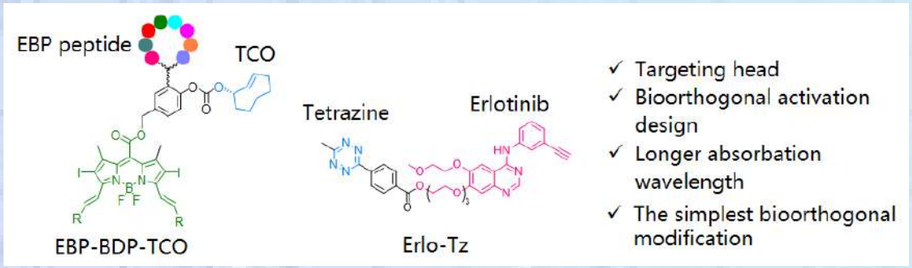


Figure 1. Molecular structure of the EBP-BDP-TCO, Erlo-Tz

Acknowledgement: This work was supported by a General Research Fund from the Research Grants Council of the Hong Kong Special Administrative Region, China (ref. no. 14307321).

Hydroacoustic Monitoring of Earthquake Swarms and Foreshock-Mainshock-Aftershock Sequences along Oceanic Transform Faults in the Northeast Pacific Ocean

LIU Hui
Year 4 PhD Student in Earth and Atmospheric Sciences
Principal Supervisor: Professor TAN Yen Joe

A significant portion of slip along oceanic transform faults (OTFs) occurs aseismically, but the relationship between seismic and aseismic slip remains poorly understood. Monitoring earthquake swarms and foreshock-mainshock-aftershock sequences along OTFs is crucial for investigating how these two modes of slip interact and influence the initiation of large earthquakes. In this study, we present an automated envelope-cross-correlation-based workflow for detecting and locating submarine earthquakes using hydroacoustic T-phases recorded by cabled seafloor observatories in the Northeast Pacific Ocean. Our catalog comprises 25,681 earthquakes from 2015 to 2024, eight times more than the National Earthquake Information Center (NEIC) catalog compiled based on land-based seismic data, with approximately one unit improvement in magnitude of completeness. Distinct earthquake activity patterns are observed along the Blanco Transform Fault (BTF) with higher seismicity rate in the western segment, whereas seismicity rate along the Sovanco Transform Fault (STF) is more uniform and lower. Our catalog also reveals numerous energetic swarms such as the 2021 Western Blanco swarm which comprises 319 events potentially driven by aseismic slip or fluid migration. We further quantify how the foreshock and aftershock activities of magnitude greater than 5.0 mainshocks along both STF and BTF compare with continental strike-slip faults. These foreshock-mainshock-aftershock sequences and swarms offer valuable insights into the initiation process of large earthquakes and the partitioning of seismic and aseismic slip along OTFs.

An Onsager-Type Theorem for General 2D Active Scalar Equations

ZHAO Xuanxuan
Year 3 PhD Student in Mathematics
Principal Supervisor: Professor XIN Zhouping

This paper concerns the Onsager-type problem for general 2-dimensional active scalar equations of the form: $\partial t\theta+u\cdot\nabla\theta=0$, with $u=T[\theta]$ being a divergence-free velocity field and T being a Fourier multiplier operator with symbol m. It is shown that if m is a odd and homogeneous symbol of order δ: $m(\lambda\xi)=\lambda\delta m(\xi)$, where $\lambda>0,-1\leq\delta\leq0$, then there exists a nontrivial temporally compact-supported weak solution $\theta\in C0tC2\delta3-x$, which fails to conserve Hamiltonian. This result is sharp since all weak solutions of class $C0tC2\delta3+x$ will necessarily conserve the Hamiltonian (which is proved by P. Isett and A. Ma in arXiv:2403.08279, 2024.) and thus resolves the flexible part of the generalized Onsager conjecture for general 2D odd active scalar equations.

Also, in the appendix, analogous results have been obtained for general 2D and 3D even active scalar equations. The proof is achieved by using convex integration scheme at the level $v=-\nabla\perp\cdot\theta$ together with a Newton scheme recently introduced by V. Giri and R. O. Radu (2D Onsager conjecture: a Newton-Nash iteration. Invent. math. (2024).). Moreover, a novel algebraic lemma and sharp estimates for some complicated trilinear Fourier multipliers are established to overcome the difficulties caused by the generality of the equations.

Acknowledgement: This is part of my PH.D. thesis written under the supervision of Professor Zhouping XIN at the Institute of mathematical sciences, the Chinese University of Hong Kong. I would like to express my gratitude to my Ph.D. advisor, Zhouping XIN, for his guidance and valuable discussions. I also thank Han CUI for helpful discussions on the part of multilinear Fourier multiplier estimates related to this paper. This research is supported by Hong Kong RGC Research Grants CUHK-14301421, CUHK-14301023, CUHK-14302819, CUHK-14300819, and the key project of NSFC Grants No. 12131010 and No. 11931013.

Understanding Multi-Length Scale Fractal Networks in Organic Photovoltaic Active Layers and Their Impact on Charge Trapping

FU Yuang
Year 3 PhD Student in Physics
Principal Supervisor: Professor LU Xinhui

A comprehensive understanding of active layer morphology is crucial for establishing the structure-performance relationship in high-performance organic photovoltaics (OPVs). However, similar chemical structures of donor (D) and acceptor (A) materials constituting the OPV active layer make conventional morphology characterization techniques ineffective. Additionally, it remains challenging to correlate device performances with phase-separated structures at different length scales. Herein, we understand the active layer morphology from a new angle, focusing on the fractal nature of donor and acceptor networks. The unique feature of a fractal structure is its self-similarity within a range of length scales, allowing us to understand the variation in mesoscale phase-separated structures from subtle changes in local intermolecular packing patterns. A detailed morphology characterization is performed using a combination of grazing-incidence X-ray and neutron scattering techniques. Firstly, we deuterate Y6, a prototypical acceptor molecule, to enhance its contrast with the donor molecules under neutron beams. This allows us to probe a hitherto hidden short-range aggregation of Y6 molecules and identify its vital role in assisting electron percolation within amorphous D:A intermixed domains. Having understood the detrimental impact of isolated acceptor domains on electron trapping, we then explore the role of domain shapes on inter-domain connectivity, unraveling a robust positive correlation between the fractal dimension (*Df*) of acceptor domains and the density of deep electron traps. We propose that forming highly-crystalline acceptor domains while maintaining a low *Df* is essential for maintaining interconnected electron transport channels, thus passivating deep electron traps. Taking advantage of the multi-length scale self-similar nature of the fractal networks, we further develop effective strategies to control inter-molecular aggregation patterns, which in turn determine the mesoscale fractal dimension of the acceptor domains through bottom-up effects. Our findings underscore the importance of controlling both crystalline and amorphous morphology at multi-length scales to enhance the performance of OPV devices, surpassing 20% photo-conversion efficiency and advancing towards industrialization.

Acknowledgement: This work is supported by the National Natural Science Foundation of China (No. 52122004), the Research Grants Council (RGC) of Hong Kong (No. 14304723), and the Guangdong-Hong Kong-Macao Joint Laboratory for Neutron Scattering Science and Technology (No. TC2116291). We thank the beam time and technical support provided by BL01 SANS group at CSNS, the 23A1 SWAXS beamline at NSRRC, and the BL19U2 beamline at SSRF.

Temporal Dependence in Decision Making: A Unified Learning-Optimization Framework

WU Zhuogen
Year 2 MPhil Student in Risk Management Science
Principal Supervisor: Professor Tony SIT

A wide range of optimization problems arising in practice involve unknown parameters whose underlying distributions can be inferred from contextual information. Conventional predict-then-optimize (PTO) approach employ machine learning techniques for forecasting, focusing solely on prediction accuracy without considering their impact on the subsequent optimization task. In contrast, we propose a unified learning-optimization (ULO) framework that seamlessly integrates both learning and optimization into a single comprehensive step, enhancing decision quality through better prediction design. Acknowledging the temporal dependence structure inherent in real-world stochastic phenomena, we establish finite sample performance guarantees for ULO framework under non-i.i.d. settings, emphasizing the realism and necessity of moving beyond i.i.d. assumptions. We characterize the asymptotic consistency of model generalization and learned hypotheses under moderate regularity conditions, providing insights into the convergence properties of non-i.i.d. versus i.i.d. processes within concrete hypothesis classes. Utilizing mean-variance portfolio selection as a case study, we corroborate our theoretical findings through both numerical experiments and empirical analyses. Numerical results reveal that the performance advantage of ULO approach amplifies with increasing model misspecification and limited data availability, while empirical evidence confirms its superiority over PTO approach, particularly during periods of high volatility in financial markets.

Online Difference-based Variance Estimators in Time Series

SHEN Zhuohua
Year 1 MPhil Student in Statistics
Principal Supervisor: Professor CHAN Kin Wai

Online time series data has become increasingly prevalent in recent statistical inference of the means, where the long-run variance (LRV) estimation is important. The sequential nature of this data introduces noises with (1) stochastically temporal dependence; (2) time-varying means possibly exhibiting smooth trends and abrupt jumps; and (3) rapid arrival of new data, making the LRV estimates non-consistent, inflated, and computationally slow, respectively.

In this talk, we address the three aforementioned problems by proposing a data-driven online differencing procedure as a building block for estimating LRV in O(1)-time. The proposed difference statistics have time-dependent lags, and employ a new type of kernel called M-shaped modified Bartlett kernel. Derivation and implementation of the MSE-optimal differencing procedure will be discussed. As illustrated via asymptotic theory and Monte Carlo experiment, the proposed online LRV estimator is statistically efficient, and invariant to a large class of non-constant mean structures.

Poster Presentation

Abstract

Poster No.	Graduate Division	Presenter	Presentation Title
SLS-01	Life Sciences	CHAN Long Yiu	**Investigation of the Role of *GmERF023* in Salt Stress Priming in Soybean**
SLS-02	Life Sciences	CHENG Jiahui	***In Vivo* Synthesis and Incorporation of D-Pra-ε-Lys in HER2 Nanobody for Site-Specific Nanobody Drug Conjugates Targeting Breast Cancer Cells**
SLS-03	Life Sciences	CHUNG Pan Yu Ethan	**Development of an *In Vitro* Reconstitution System for FREE1-Mediated Peroxisome Tubulation in *Arabidopsis thaliana***
SLS-04	Life Sciences	ZHUANG Jingru	**Impact of Rice Protein Addition on Long-Term Retrogradation Kinetics and *In Vitro* Digestibility of Rice Starch Depends on Starch Molecular Size and Chain-Length Distributions**
CHM-01	Chemistry	DONG Tao	**Synthesis and Application of New Pentafluoroethylation Reagents**
CHM-02	Chemistry	QIN Shiwei	**Beyond Air Conditioning: The Future of Energy-Efficient Passive Radiative Cooling**
EAS-01	Earth & Atmospheric Sciences	WANG Peifeng	**Source Mechanism of Impulsive Seafloor Events That Track Submarine Lava Flows**
EAS-02	Earth & Atmospheric Sciences	YU Zheng	**Relating Aerosol Optical Depth (AOD) to Surface Fine Particulate Matter (PM2.5) Under a Fast-Changing Environment**
PMA-01	Mathematics	XU Zhehao	**Quasiconformal Geometry Meets Deep Learning: Solving Spherical Mapping Problems**
PMA-02	Mathematics	YI Tianhan	**Homogeneous Non-Rajchman Self-Similar Measures on the Line**
PHY-01	Physics	CAI Zhijun	**Regulating the Zn Electrode/Electrolyte Interface Toward High Stability–Insights From the Resting Time Impact on Zn Electrode Performance**
PHY-02	Physics	ZHANG Weizhen	**Constrain Decaying Dark Matter Lifetime Using KM2A and WCDA Data**
RMS-01	Risk Management Science	LEE Chak Ming	**Difference-Based Variance Estimators With Repeated Measurements**
RMS-02	Risk Management Science	HUNG Kim Pong	**Explainable Time Series Modeling Using Neural Network-Driven ARMA Selection**
STA-01	Statistics	DANISH Muhammad	**Dementia Risk Prediction Using Electronic Health Records Data From the Hong Kong Hospital Authority**
STA-02	Statistics	GE Muyang	**TIVelo: RNA Velocity Estimation Leveraging Cluster-Level Trajectory Inference**

Investigation of the Role of *GmERF023* in Salt Stress Priming in Soybean

CHAN Long Yiu
Year 2 PhD Student in Molecular Biotechnology
Principal Supervisor: Professor LAM Hon Ming

Salt stress severely threatens crop production. In China, soybean production is greatly limited by the large area of saline land. Therefore, it is important to study salt tolerance mechanisms in soybean. When plants encounter stress, they elicit different stress tolerance mechanisms through extensive transcription reprogramming. Transcription factors play important roles in stress response by regulating the expression of downstream genes. Moreover, transcription factors can recruit histone modifying enzymes to regulate histone modifications at their target genes.

In a process known as priming, plants gain enhanced tolerance to subsequent stress when they are pre-exposed to a similar stress. Epigenetic changes, including histone modifications, are suggested to be one of the underlying mechanisms. Furthermore, it is also reported that transcription factors are involved in priming by regulating transcriptional memory of stress-related genes. Through salt stress priming, soybean seedlings pre-treated with mild salt stress gain an enhanced tolerance to subsequent high salt stress, and this process is mediated by priming-induced changes in histone modifications. To further understand the mechanisms of salt stress priming in soybean at the molecular level, candidate key transcription factors are selected for further investigation. *GmERF023*, which is up-regulated in primed soybean exposed to subsequent high salt stress, is an AP2/ERF transcription factor closely related to the A-4 subgroup of the DREB subfamily. We hypothesize that *GmERF023* is involved in salt stress priming in soybean through regulating histone modification such as acetylation at its target genes.

In this study, we investigate the function of *GmERF023* in salt stress priming in soybean by studying the priming phenomenon in *GmERF023*-OE and *GmERF023*-KO soybean lines. Yeast transactivation assay and subcellular localization study are performed to examine the transcription activity of GmERF023. To identify downstream target genes of GmERF023, RNA-seq will be performed to identify DEGs in *GmERF023*-OE and *GmERF023*-KO soybean lines and ChIP-seq will be performed to identify GmERF023 binding sites. We will also study the role of GmERF023 in regulating histone acetylation at its target genes.

Acknowledgement: I would like to thank my supervisor, Prof. Lam Hon Ming, for his guidance and my thesis committee members, Prof. Hui Ho Lam, Jerome and Prof. Chan Ting Fung, for their comments on this project. I would also like to thank my fellow labmates who have helped and supported me a lot.

In Vivo Synthesis and Incorporation of D-Pra-ε-Lys in HER2 Nanobody for Site-Specific Nanobody Drug Conjugates Targeting Breast Cancer Cells

CHENG Jiahui
Year 3 PhD Student in Biochemistry
Principal Supervisor: Professor CHAN Michael Kenneth

Breast cancer is the second most common type of cancer in the population and the leading cancer risk among women. Approximately 1 in 5 patients express human epidermal growth factor receptor 2 (HER2) on the surface of their breast cancer cells, this protein promotes cancer cell growth and is associated with a more aggressive form of the disease.

Following the discovery of the 22nd amino acid pyrrolysine and its incorporation mechanism, the PylRS/tRNA^{Pyl} orthogonal pair has been established as a powerful tool for incorporating non-canonical amino acids (ncAAs) into various proteins for site-specific modification. Based on the previous study, the wild-type PylRS can recognize D-Pra-ε-Lys, a pyrrolysine analog with a terminal-alkyne side chain, and charge it onto tRNA^{Pyl}, enabling its incorporation into the CaM-M13 complex. The terminal-alkyne group can undergo a CuAAC click reaction with NHS-azide modified proteins as well as alkynylation addition reaction catalyzed by 6-membered ring Gold (III)-complex.

However, only *in vitro* chemical synthesis of D-Pra-ε-Lys has been reported. Based on my published result, the PylC enzyme can catalyze the conversion of L-Lysine and D-Cysteine into D-Cys-ε-Lys. By replacing D-Cysteine with (R)-2-Aminopent-4-ynoic acid, it is also possible to synthesis D-Pra-ε-Lys in cells. With co-expression of PylRS/tRNA^{Pyl} pair, the D-Pra-ε-Lys can be site-specifically installed into the surface of HER2 nanobody yielding a targeting protein with a reactive handle. The fluorescent labeling of HER2^{+} cancer cells will be achieved through direct alkynylation mediated by 6-membered ring Cyclometalated Dansyl-Gold (III) complexes [Au(C^N)Cl_2] with terminal alkyne incorporated HER2 nanobody under mild conditions. Subsequently, the plan is to change the cargo to anti-cancer small molecules such as Doxorubicin for breast cancer treatment.

Acknowledgement: I would like to express my deepest gratitude to my supervisor, Michael Kenneth CHAN, and Wing Ngor Shannon AU, for their invaluable guidance, continuous support, and encouragement throughout the course of this research. I am also sincerely thankful to the members of my committee for their insightful feedback and constructive suggestions, which greatly contributed to the development of this project. This research was made possible through the generous support of the GRF founding and I am truly grateful for their confidence in this work.

Development of an *In Vitro* Reconstitution System for FREE1-Mediated Peroxisome Tubulation in *Arabidopsis thaliana*

CHUNG Pan Yu Ethan
Year 2 PhD Student in Biochemistry
Principal Supervisor: Professor JIANG Liwen

The Arabidopsis FYVE DOMAIN PROTEIN REQUIRED FOR ENDOSOMAL SORTING 1 (FREE1) is a plant-unique component of the endosomal sorting complex required for transport (ESCRT) machinery. In addition to functioning as an ESCRT component in regulating formation of multivesicular body, FREE1 also regulates formation of the vacuole and autophagosome in. Furthermore, FREE1 is also involved in lipolysis during germination, in which lipid droplet (LD) triacylglycerols are broken down into free fatty acids by peroxisomal lipases such as SUGARDEPENDENT1 (SDP1). This was established by *free1* knockdown (kd) mutant which exhibits impaired LD lipolytic degradation and engulfment by tubular peroxisomes. These results suggested that lipolysis and LD engulfment are likely mediated by FREE1 via interactions with both PEX11e, a peroxisomal specific peroxin which facilitates peroxisome elongation and proliferation, and SDP1. However, the underlying mechanism remains elusive.

This study aims to identify the minimal components required and the molecular mechanisms of FREE1-mediated peroxisome tubulation via the development of an *in vitro* system, adapting from the previously developed *in vitro* reconstitution system for COPII vesicles in. First, using transgenic *Arabidopsis* seedlings expressing either the peroxisomal lipase marker, GFP-SDP1, or the peroxisomal peroxin marker, mCherry-PEX11e, we will study the dynamics of peroxisomes *in vivo* to give insight into their functions in peroxisome tubulation. Next, we will identify other potential interactors of FREE1-mediated peroxisome tubulation via Co-IP pulldown of transgenic Arabidopsis seedlings expressing, followed by LC-MS/MS. Lastly, to develop an *in vitro* reconstitution system for peroxisome tubulation, we will generate transgenic *Arabidopsis* and tobacco cultured cell lines expressing peroxisome markers GFP-SDP1 or mCherry-PEX11e. The newly generated transgenic cell lines stably expressing the peroxisome markers will be used for peroxisome purification for use in *in vitro* reactions with the addition of cytosolic contents, along with energy sources in the form of ATP or GTP, to recapitulate peroxisome tubulation. Last, the budding peroxisomes will be investigated by both confocal imaging of dynamics, and cryo-electron microscopy (Cryo-EM) for structural analysis of the morphology of peroxisome budding and tubulation.

To study the possible involvement of cytoskeleton in peroxisome dynamics and tubulation, we have conducted drug treatments on mCherry-PEX11e transgenic plants with the microtubule inhibitor Oryzalin and the actin inhibitor Latrunculin B, respectively. Preliminary results showed that Latrunculin B treatment but not Oryzalin treatment results in impaired peroxisome dynamics and tubulation, indicating that peroxisome tubulation in seedlings is likely actin-dependent. However, pre-existing peroxisomal tubules persisted under Latrunculin B treatment, suggesting that while tubule extension and retraction are actin-dependent, the stability of peroxisome tubules is independent of actin-polymerization.

Impact of Rice Protein Addition on Long-Term Retrogradation Kinetics and *In Vitro* Digestibility of Rice Starch Depends on Starch Molecular Size and Chain-Length Distributions

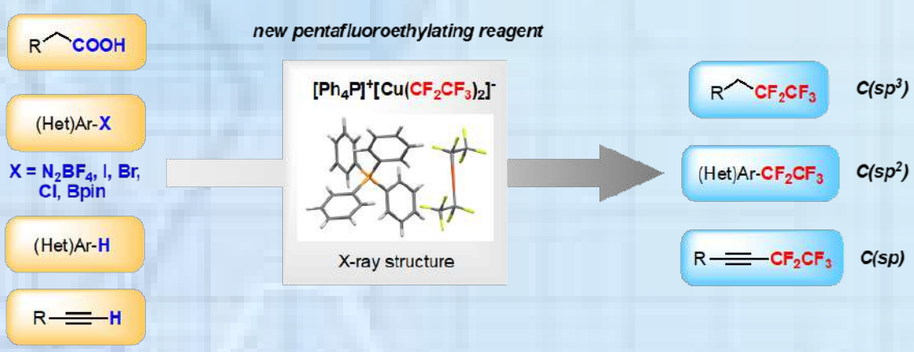
ZHUANG Jingru
Year 2 PhD Student in Food and Nutritional Sciences
Principal Supervisor: Professor LI Cheng

Starch and protein are two major constituents of rice grains, while the influence of rice protein on the retrogradation kinetics and digestibility of rice starch with distinct fine molecular structures is unknown. To this end, ten rice varieties were selected, and their starch retrogradation and digestion were analyzed with or without rice protein. Results showed that although rice protein retarded retrogradation, the degree of reduction depended on rice varieties. Especially, Panjin rice showed a 2.7 times slower nucleation rate constant after incorporating the protein. Whereas, rice protein addition did not affect the thermal stability of the re-associated starch crystallites. Furthermore, the protein addition inhibited the formation of B-type crystallinity while promoting the formation of V-type crystallinity. The pore size in the gel network decreased after protein addition. As a result, the maximum starch digested extent was significantly decreased, with Wuchang rice showing a 27% reduction of digested extent at 120 min. Correlation analysis suggested that rice protein has a preference to interact with long amylose chains with DP 5000 – 20000 during retrogradation and thicker walls of the gel network could elevate the formation of resistant starch. These findings could facilitate the development of rice products with slow starch digestibility.

Synthesis and Application of New Pentafluoroethylation Reagents

DONG Tao
Year 4 PhD Student in Chemistry
Principal Supervisor: Professor TSUI Chit Gavin

We herein describe the preparation and application of a new bispentafluoroethylated organocuprate $[Ph_4P]^+[Cu(CF_2CF_3)_2]^-$. This complex has demonstrated a remarkable range of reactivities towards carboxylic acids, diazonium salts, organic halides, boronic esters, terminal alkynes and (hetero) arenes as a versatile pentafluoroethylating reagent. The construction of $C(sp^3)$-/$C(sp^2)$-/C(sp)-CF_2CF_3 bonds can therefore be achieved using a single reagent.



Scheme 1. $[Ph_4P]^+[Cu(CF_2CF_3)_2]^-$ complex as a versatile pentafluoroethylating reagent

Acknowledgement: We thank the Research Grants Council of Hong Kong and the Chinese University of Hong Kong (Faculty of Science – Direct Grant for Research), We also thank Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences for funding.

Beyond Air Conditioning: The Future of Energy-Efficient Passive Radiative Cooling

QIN Shiwei
Year 2 PhD Student in Chemistry
Principal Supervisor: Professor NGAI To

Compared with air conditioning, passive radiative cooling (PRC) is a more promising green cooling technology without any energy consumption and CO_2 releasing. However, recent PRC technology is hindered by complicated synthetic process and high cost. In this work, a scalable waterborne lightweight PRC paint has been prepared facilely by combing low-density silica hollow spheres (SH) and wide-band $BaSO_4$ pigments with water-based polyacrylate emulsion binder. We experimentally proved that SH with ~1 um diameters provided the highest reflectivity, comparing with other sizes (300 nm, 4 um and 20 um). As shown in Figure 1(a) and (b), without sacrificing much solar reflectivity, the higher the SH addition ratio, the lower the final dry coating density and the higher the coating emissivity. The lightweight paint presented good sedimentation resistance in the half-year storage test. With the appropriate estimated pigment volume concentration (ePVC) and $BaSO_4$: SH ratio, the final dry coating presented high solar reflectivity up to 95% and high emissivity up to 0.93. In the outdoor experiments, the cooling temperature was around 5 oC (Figure 1d).

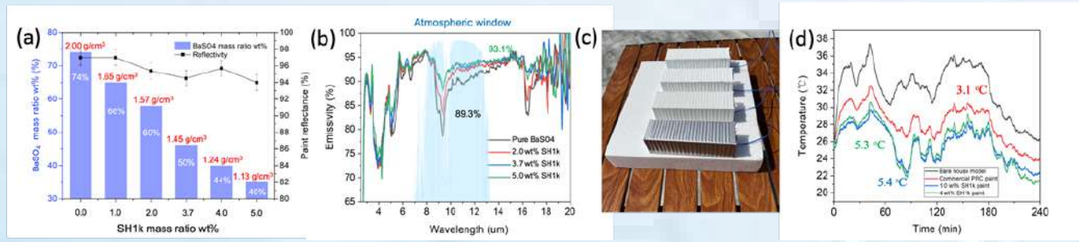


Figure 1. (a) the effect of SH1k addition ratio on total pigment weight percentage and dry coating reflectivity; (b) the effect of SH1k addition on paint emissivity (c) the bare uncoated, commercial white paint coated, our 1.0 wt% and 2.0 wt% SH1k paints coated metal models under sunlight; (d) the temperature measurement of four models respectively.

This water-based, mass-producible PRC paint provides a theoretical foundation and research approach for the widespread application of PRC technology in the future, replacing traditional energy-consuming and environmentally harmful air conditioning technology.

Source Mechanism of Impulsive Seafloor Events That Track Submarine Lava Flows

WANG Peifeng
Year 3 PhD Student in Earth and Atmospheric Sciences
Principal Supervisor: Professor TAN Yen Joe

Most of Earth's volcanic eruptions are hidden beneath the ocean in complete darkness. Recent studies suggested that a type of impulsive event can track submarine lava flows, but their source mechanism remains uncertain. We analyze >20,000 impulsive events from the 2015 Axial Seamount eruption and find that their seismo-acoustic waveform characteristics suggest an implosive source mechanism. Integrating constraints from their spatiotemporal evolution with heat transfer estimates and geological observations, we propose that while the largest events might be related to volatiles degassed from magma, most events are generated by the implosion of bubbles formed from the vaporization of entrapped seawater by hot erupted lava. Similar events have been detected at other seamounts and slow to fast-spreading mid-ocean ridges, although eruptions at >3,000m depth have proportionately fewer events because seawater vaporization is inhibited. Therefore, these impulsive seafloor events can be leveraged to remotely characterize eruption dynamics in most submarine volcanic settings.

Relating Aerosol Optical Depth (AOD) to Surface Fine Particulate Matter (PM2.5) Under a Fast-Changing Environment

YU Zheng
Year 1 PhD Student in Earth and Atmospheric Sciences
Principal Supervisor: Professor ZHAI Shixian

Satellite AOD is widely used in mapping surface $PM_{2.5}$ mass concentration, and aerosol size distribution is one key factor affecting aerosol extinction efficiency. Our previous work showed that the differences in aerosol size distribution between South Korea and North America yielded an over 20% difference in aerosol extinction efficiency. Further investigations show that the aerosol effective radius positively correlates with its mass at an ambient concentration ranging from 1ug/m^3 to 30 ug/m^3.

With the implementation of Clean Air Actions, surface $PM_{2.5}$ in China decreased by 60 % from 2013 to 2023, indicating a possible change in aerosol size distribution. This change in aerosol size distribution could possibly affect the AOD-$PM_{2.5}$ relationship. However, no study has ever evaluated how the AOD-$PM_{2.5}$ relation changes under a fast-changing environment, driven by possible changes in aerosol size distribution.

Here, our study finds that from 2014 to 2022, surface $PM_{2.5}$ concentrations in Beijing have decreased almost twice as fast as AOD, at rates of approximately -10% per year for $PM_{2.5}$ and -6% per year for AOD. This faster decline in $PM_{2.5}$ indicates that changes in other factors, including aerosol size distribution, RH, and aerosol composition, are driving the changes in AOD together with aerosol mass changes. We find that the GEOS-Chem failed to reproduce the observed slower AOD decrease, and that the current aerosol size parameterization does not apply to the aerosol loadings in China, which is three times higher than that in South Korea.

Currently, we further use in situ observations in China to upgrade the aerosol size distribution parameterization, hoping to be able to simulate the AOD-$PM_{2.5}$ relationship under a fast-changing environment in China. Our work also has important implications for heterogeneous chemistry and joint control of $PM_{2.5}$ and O_3 air pollution.

Acknowledgment: This research was funded by the National Natural Science Foundation of China (NSFC) and the University Grants Committee (UGC). I would like to express my sincere gratitude to them for their support.

Quasiconformal Geometry Meets Deep Learning: Solving Spherical Mapping Problems

XU Zhehao
Year 2 PhD Student in Mathematics
Principal Supervisor: Professor LUI Lok Ming Ronald

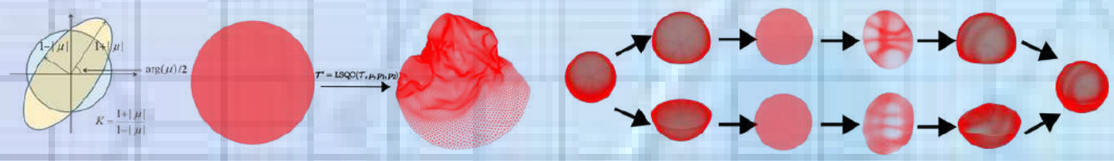
Genus-0 surface mappings underpin applications from cortical registration to surface meshing. Classical conformal or quasi-conformal solvers deliver bijective sphere self-maps, yet they require fixed boundaries, which may lead to suboptimal mapping results. Recent deep alternatives improve speed but typically ignore manifold structure and provide no theoretical guarantee of diffeomorphism, potentially resulting in fold-overs.

We present **Free-Boundary Quasiconformal Network FBQCNet**, the first neural MODELthat (i) simulates the Least-Square Quasi Conformal (LSQC) energy with explicit free-boundary capability and (ii) exposes gradients with respect to Beltrami coefficients and pinned points. The architecture couples a multiscale message-passing hierarchy with a lightweight Mesh Spectral Layer, injecting global Laplacian-eigen information and enabling faithful recovery of LSQC solutions on unstructured triangle meshes. Quantitative evaluation on 10 000 random Beltrami samples shows that FBQCNet reduces mean non-injective-triangle rate from 3.28 % (Fourier-neural operator), and 0.90 % (MeshGraphNet) to 0.09 %, while cutting node-wise L2 error by >60 %.

Moreover, We embed FBQCNet into a variational optimisation pipeline for spherical surface parametrization. During optimization, the sphere is split into two unit disks via stereographic projection; FBQCNet distorts each disk according to trainable Beltrami fields, and inverse projections "glue' the deformed hemispheres without overlap. Task-specific losses (e.g., landmark alignment) combine seamlessly with regularization on geometric distortion and smoothness on the equator, and the entire pipeline is optimized end-to-end by standard backpropagation. Several experiments are conducted to show the capacity of our model and its potential to be applied in real world scenarios.

FBQCNet therefore offers a manifold-aware, free-boundary and computationally efficient tool for spherical parametrization, opening new avenues for fast, theoretically sound geometric learning across science and engineering.

Acknowledgement: The author gratefully thanks Prof. Ronald Lok Ming Lui for mentorship, the Center for Mathematical Artificial Intelligence (CMAI) for computational resources, and fellow lab members for valuable discussions.



Homogeneous Non-Rajchman Self-Similar Measures on the Line

YI Tianhan
Year 3 PhD Student in Mathematics
Principal Supervisor: Professor FENG Dejun

Rajchman measures are those Borel measures whose Fourier transform vanishes at infinity. In fractal geometry, it is important to determine whether a self-similar measure is Rajchman or not. In 1940, Erd˝os showed that Bernoulli convolutions with Pisot contraction ratios are not Rajchman measures. His argument applies to homogeneous self-similar measures with integer translations as well. In this talk, I will present a result on homogeneous non-Rajchman selfsimilar measures under a more general setting. It is based on joint work with Prof. Dejun Feng.

Regulating the Zn Electrode/Electrolyte Interface Toward High Stability–Insights From the Resting Time Impact on Zn Electrode Performance

CAI Zhijun
Year 4 PhD Student in Materials Science and Engineering
Principal Supervisor: Professor LI Quan

The resting period, commonly performed prior to cycling, is known to have a significant impact on the cycling performance of acidic aqueous zinc-ion batteries (AZBs). We have demonstrated that even without electrochemical cycling, the resting time significantly influences the cycling performance of the Zn electrode and is closely related to the evolution of zinc hydroxide sulfate (ZHS) byproducts formed on the Zn electrode, whose presence not only affects the corrosion of Zn but also determines the plating/stripping characteristics of Zn. As shown in the upper part of Figure 1, a short resting time (1 day) results in incomplete ZHS coverage on Zn, leading to a reduction in the electrode's lifespan due to short-circuit failures. A moderate resting time (3 days) allows for complete ZHS coverage on Zn and helps improve the cycling lifespan. However, a further prolonged resting time (7 days) leads to an excessive amount of ZHS, suppressing effective charge transfer at the interface and thus reducing the electrode's cycling lifespan.

The uniformity and quantity of ZHS are crucial factors determining the electrode's cycling stability. Therefore, controlling the ZHS at the Zn interface can prevent corrosion and promote uniform Zn stripping/plating during the cycling, effectively enhancing the cycling performance of the Zn electrode. Based on this understanding, we have developed a ZHS layer with an appropriate quantity and coverage on the Zn surface (ZHS-Zn) using a one-step hydrothermal method. As shown in the lower part of Figure 1, the fine ZHS layer can protect the Zn electrode from resting-induced damage, enabling a long lifespan of over 3800 hours at 1 mA cm^{-2}/1 mAh cm^{-2}. The ZHS-Zn layer also exhibits stable cycling performance when assembled into MnO2//Zn full cells, maintaining capacity stability over 6000 cycles.

In summary, this work emphasizes the importance of standardized resting time in evaluating the electrochemical performance of Zn anodes. It also deepens the understanding of the relationship between the resting period, ZHS evolution, and the cycling performance of Zn electrodes, providing guidance for further interface design strategies for AZBs of long stability.

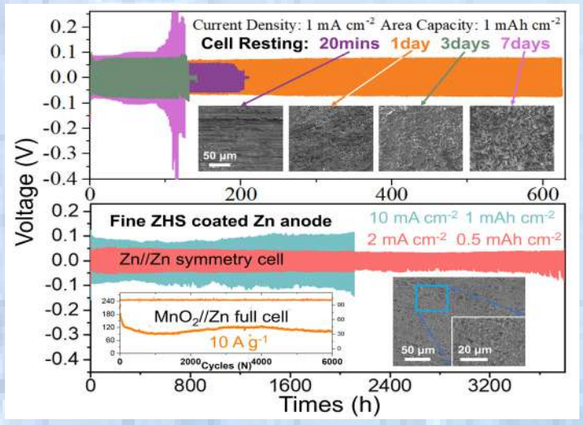


Fig1. The upper part of the figure shows SEM images of Zn foils with different resting durations (20 mins, 1 day, 3 days and 7 days) and the corresponding cycling performance of Zn//Zn symmetrical cells. The lower part of the figure displays SEM images of ZHS-Zn, as well as the cycling performance of ZHS-Zn//ZHS-Zn symmetrical cells and MnO2//ZHS-Zn full cells.

Acknowledgement: This work was supported by CUHK direct grant under project No.4053530.

Constrain Decaying Dark Matter Lifetime Using KM2A and WCDA Data

ZHANG Weizhen
Year 4 PhD Student in Physics
Principal Supervisor: Professor NG Chun Yu Kenny

High-energy gamma rays serve as a crucial method for the indirect detection of dark matter, which may originate from its annihilation or decay. The LHAASO project offers leading sensitivity in high-energy cosmic ray detection. In this study, we utilized 438 days of data from the full-array KM2A of LHAASO. After performing gamma/hadron separation, we placed constraints on the decay lifetime of dark matter with a mass of ≥10 TeV. Additionally, we employed data from WCDA to constrain the decay lifetime of dark matter with masses ranging from a few TeV to several tens of TeV. Our results are preliminary, and we plan to improve our analysis in the future. Furthermore, we will focus on dark matter annihilation searches within the WCDA energy range in future work.

Difference-Based Variance Estimators with Repeated Measurements

LEE Chak Ming
Year 2 MPhil Student in Risk Management Science
Principal Supervisor: Professor CHAN Kin Wai

In this paper, we formulate a general differencing framework for variance estimation across a range of settings. We demonstrate that conventional difference-based noise variance estimators cannot achieve the desired bias-correcting power in nonparametric regression with repeated measurements. A new high-order bias-corrected differencing scheme, adapted to repeated measurements, is proposed by interlacing inter-group and intra-group differencing. The theoretical properties of the new sequences and estimators are studied. Our proposals are particularly efficient in finite samples and under high signal-to-noise ratio scenarios, where asymptotic convergence has not yet fully taken effect, due to their strong bias-correcting power.

Explainable Time Series Modeling Using Neural Network-Driven ARMA Selection

HUNG Kim Pong
Year 1 MPhil Student in Risk Management Science
Principal Supervisor: Professor YAU Chun Yip

Neural networks (NNs), such as Recurrent Neural Networks (RNNs) and Long Short-Term Memory Networks (LSTMs), have shown significant potential for achieving high predictive accuracy in time series modeling. However, their inherent "black box" nature poses challenges in critical domains such as credit risk assessment and healthcare, where explainability is essential. This lack of interpretability can make it difficult to trust the results or understand the underlying reasons behind predictions.

To address this, we propose a hybrid approach that leverages the strengths of both neural networks and traditional statistical models. Instead of replacing the entire modeling process with NNs, we use NNs exclusively for model selection, identifying the optimal parameters (e.g., AR and MA orders) for ARMA models. This allows us to retain the high accuracy and flexibility of NNs for the selection process, where explainability is less critical. Ensure the interpretability of predictions by using ARMA models for the actual forecasting, which benefits from well-established theoretical foundations and diagnostic tools.

Acknowledgment: Professor YAU, Chun Yip (Thesis Supervisor).

Dementia Risk Prediction Using Electronic Health Records Data From the Hong Kong Hospital Authority

DANISH Muhammad
Year 2 PhD Student in Statistics
Principal Supervisor: Professor WEI Yingying

Dementia is the most common neurological degenerative disease among the elderly and severely impacts life quality. However, the mechanism of dementia is complicated and unclear. In this project, we leverage the rich electronic health records data collected by the Hong Kong Hospital Authority from 2000 to 2020 to systematically survey the risk factors of dementia. The Hong Kong Hospital Authority covers over 90% of the healthcare services in Hong Kong, thus providing an unprecedented opportunity for studying the dementia risk at a population level. Nevertheless, despite the unified health care system, the data provided by the Hong Kong Hospital Authority face various challenges of missing data as electronic health data always do. By taking four birth cohorts separated by 10 years, we use landmark analysis to investigate how the age-dependent associations between the onset of dementia and cardiovascular-related comorbidities and prescriptions vary across cohorts. Moreover, for different landmark ages, we build survival random forest models to dynamically predict the dementia risk according to the evolving disease histories for the Chinese population.

Keywords: Electronics Health Records, Cox Model, Landmark Analysis, Aging Population, Dementia, Cardiovascular Diseases

TIVelo: RNA Velocity Estimation Leveraging Cluster-Level Trajectory Inference

GE Muyang
Year 3 PhD Student in Statistics
Principal Supervisor: Professor LIN Zhixiang

RNA velocity inference is a valuable tool for understanding cell development, differentiation, and disease progression. However, existing RNA velocity inference methods typically rely on explicit assumptions of ordinary differential equations (ODE), which prohibit them from capturing complex transcriptomic expression patterns. In this study, we introduce TIVelo, a novel RNA velocity estimation approach that first determines the velocity direction at the cell cluster level based on trajectory inference, before estimating velocity for individual cells. TIVelo calculates an orientation score to infer the direction at the cluster level without an explicit ODE assumption, which effectively captures complex transcriptional patterns, avoiding potential inconsistencies in velocity estimation for genes that do not follow the simple ODE assumption. We validated the effectiveness of TIVelo by its application to 16 real datasets and the comparison with five benchmarking methods.

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