



The Hong Kong University of Science and Technology

Department of Mathematics

PhD THESIS EXAMINATION

**Statistical and Computational Methods for Genetic and
Cellular Omics Data Analysis**

By

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ABSTRACT

Advances in genome-wide association studies (GWAS) and cellular omics technologies are generating increasingly rich but heterogeneous data at population and cellular scales. Despite their different biological resolutions, reliable inference in both fields depends on integrating information from multiple data sources while addressing source-specific structures and biases. This thesis develops two methods for principled information integration and demonstrates their effectiveness through comprehensive simulations and biological applications. In the first part of the thesis, we propose XMR, a statistical method for cross-population Mendelian randomization (MR) designed to enhance causal inference in underrepresented populations. By leveraging auxiliary GWAS summary statistics from large populations, XMR improves the statistical power of causal effect estimation while accounting for confounding factors. Extensive simulations and real-data analyses show that XMR achieves higher power, better control of type I error rates, and more replicable findings than existing methods. In the second part of the thesis, we propose ANCHOR, a cell type annotation framework for single-cell and spatial datasets with jointly measured RNA and protein. Using a labeled scRNA-seq reference and a hierarchical protein marker tree as complementary sources of supervision, ANCHOR consistently produces more accurate and robust annotations than existing methods in simulations and across platforms, from CITE-seq and AbSeq to the emerging Xenium Protein spatial platform.

Date : 14 July 2026, Tuesday

Time : 3:30 pm

Venue : Rm 4503 (Lifts 25/26), 4/F Academic Building, HKUST

Thesis Examination Committee:

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| Chairman | : | Prof. Jin WANG, SOSC/HKUST |
| Thesis Supervisor | : | Prof. Can YANG, MATH/HKUST |
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<i>(Open to all faculty and students)</i> |

The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).