



The Hong Kong University of Science and Technology

Department of Mathematics

MPhil THESIS EXAMINATION

**A Utility-Based Framework for Multiple Testing:
Validity, Optimality and Interpretability**

By

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ABSTRACT

Abstract Multiple testing refers to the statistical process of evaluating multiple hypotheses simultaneously and it is widely used in scientific research. Traditional multiple testing typically makes decisions by ranking p-values. Although such methods possess good statistical properties, the p-value-based multiple testing has its limitations since p-values mainly reflect the signal strength. In modern scientific research, besides signal strength, there exist many other considerations, such as sample size, safety and preference suggested by domain experts or even large language models (LLMs). Traditional p-value-based methods fail to naturally incorporate these covariates, often leading to practically suboptimal results. As data and scientific objectives become increasingly complex, researchers recognize that not all hypotheses carry equal scientific or clinical value. In multiple testing, relying solely on p-values makes it difficult to (1) prioritize high-value hypotheses and (2) maximize power weighted by each hypothesis's practical value. To address these limitations, we propose a utility-based framework for multiple hypothesis testing that integrates practical and regulatory considerations with the p-value through a utility function and ranks the hypotheses accordingly. This framework resolves the key limitation of traditional methods, which overlook the actual "utility" of each hypothesis. Built on the proposed utility-based multiple testing framework, we develop novel testing procedures and analyze the statistical properties of utility functions, which achieves (1) strict control of the false discovery rate (FDR) to ensure validity, (2) selection of the optimal utility function to maximize the weighted power to achieve optimality, and (3) provision of clear statistical interpretations for any given utility function to enhance interpretability. Simulation studies and a reanalysis of the panitumumab clinical trial data demonstrate that the proposed utility-based framework produces more interpretable and practically useful subgroup selection results than that from traditional methods.

Date : 8 May 2026, Friday

Time : 9:00 am

Venue : Room 4503 (Lifts 25-26)

Thesis Examination Committee

Chairman : Prof. Can YANG, MATH /HKUST

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(Open to all faculty and students)

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