

S E M I N A R

A Quantum-Inspired Approach to Supervised Multi-Class Classification

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Venues: NITheCS Seminar Room, Stellenbosch University; and Online

ABSTRACT:

We present a general quantum-inspired framework for supervised classification in which classical data are represented using concepts from quantum information theory, while all algorithms run on conventional computers. Classical feature vectors are encoded as density operators, each class is represented by a quantum centroid, and binary classification is performed using the Helstrom minimum-error state-discrimination strategy.

The framework is extended to multi-class classification using the Pretty Good Measurement (PGM), avoiding conventional one-versus-one and one-versus-rest approaches by discriminating multiple classes within a single quantum-state-discrimination protocol. We also introduce the k-copy (kkk-PGM) classifier and its implementation via quantum circuits, and show how PGM-based classifiers can be combined with quantum-inspired oversampling methods such as QSMOTE to address highly imbalanced datasets.

Two main application areas are presented. In biomedical imaging, the framework supports automated analysis of clonogenic assays using spatial, colour and texture features, and has been applied to radiomic data for lung-cancer subtyping and prostate-cancer risk stratification. In quantum physics, it classifies quantum states by distinguishing entangled, separable and product states, and is evaluated on ensembles of randomly generated mixed states.

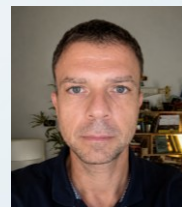
This framework establishes quantum-state discrimination as a unified paradigm for supervised learning, applicable to both classical and quantum data while addressing practical challenges such as multi-class classification and class imbalance.

SPEAKER BIOGRAPHIES:

Giuseppe Sergioli is Full Professor of Logic and Philosophy of Science at the University of Cagliari. His research focuses on quantum information theory, quantum computational logic and quantum-inspired machine learning, particularly quantum-state representations and classification. He has published more than 80 scientific papers, led several research projects, and serves as Associate Editor of *Soft Computing* and *Quantum Machine Intelligence*.

Roberto Giuntini is Full Professor of Logic and Philosophy of Science at the University of Cagliari, and a former Alexander von Humboldt Fellow. His research focuses on mathematical logic, quantum computation, quantum machine learning and quantum-inspired classification.

He has led numerous research projects, received the Birkhoff-von Neumann Prize, is a member of the European Academy of Sciences and Arts, and serves on the editorial boards of leading journals and book series.



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