Engineering and Physical Sciences Research Council

University of Exeter

Engineering and Physical Sciences Research Council Doctoral Landscape Award

PROJECT TITLE: Quantum uncertainty quantification-QUQ

Lead Supervisor: Hussein Rappel

Co-Supervisors: Gavin Tabor

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Project details: The phenomenal advances in computational engineering and science since the 1950s have accompanied an exponential increase in computing power. For example, problems in computational mechanics have grown in size from those with 100 degrees of freedom to those with hundreds of billions of degrees of freedom. However, the consensus is that future improvements in computing power will be limited as the size of transistors gets smaller approaching the limits of Moore's Law and physical limits of classical computing. Therefore, to overcome this physical barrier, a new way of computing is essential. Quantum computing and quantum information, as alternative ways of thinking and computing, have gained significant attention at the forefront of scientific fields from physics to engineering.

Theoretically, it has been demonstrated that quantum computational algorithms can significantly outperform the best or optimal classical algorithms in solving challenging computational problems posed by big data, machine learning, and artificial intelligence. Consequently, companies like Google, Amazon, and Facebook have joined forces with Intel and Nvidia to develop specialized chips for these problems. Although large-scale quantum computers are not available at the moment for the implementation of faster quantum algorithms, it is important to demonstrate quantum supremacy and provide algorithms that can be implemented on these computers in the near future. Despite all the advances in scientific computing and applied mathematics, a large number of uncertainty quantification problems in complex systems such as computational mechanics, financial risk models, and climate models remain formidable. Uncertainty quantification of these systems often requires solving partial differential equations (PDEs) a large number of times ($M >> 1$), leading to the curse of dimensionality.

This project aims to leverage the computational gains of quantum computing for Bayesian computation and develop new algorithms for efficiently solving high-dimensional problems. By integrating quantum algorithms with Bayesian methods, we seek to enhance the accuracy and speed of uncertainty quantification in complex systems. The key scientific objectives of the project are: Formulating quantum Bayesian inference for uncertainty quantification and inverse problems in PDE models Developing quantum sampling algorithms to enable a large number of simulations for Monte Carlo methods Directing the development of the project towards computational mechanics and its applications.

This project will be a world-class international collaboration between the University of Exeter (Dr. Hussein Rappel and Prof. Gavin Tabor), the University of Cambridge, (Prof. Fehmi Cirack, a world-leading researcher in computational mechanics), the California Institute of Technology (Caltech), and the University of Bonn (Prof. Michael Ortiz, a leading authority in computational engineering and a pioneer in quantum computational mechanics).

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Project Specific requirements: N/A

Potential PhD programme of study: PhD in Engineering

Department: Engineering

Location: Harrison Building, Streatham Campus

Please direct project specific enquiries to: h.rappel@exeter.ac.uk

Please ensure you read the entry requirements of programme to which you are applying.

To apply for this project please click here.