Quantum Algorithms for Computer Vision

Background

Quantum computers are gradually moving from the realms of theory towards actual devices. IBM has constructed a device with 17 qubits and other devices are in development. D-Wave have constructed a computer based on *quantum annealing*, which is claimed to be a quantum computer, although this is not confirmed at this time. Quantum computers offer speed-ups on certain specific algorithms including well-known examples such as Shor's algorithm, the quantum fourier transform (QFT), and, in the case of quantum annealing, the optimisation of certain cost functions.

Computer vision and image processing algorithms are often computationally expensive as they have to compute results on millions of pixels. The application of quantum computation to computer vision is very interesting because of the speed-up it may offer on these operations. For example, fourier transforms are heavily used in image processing so the application of the QFT to feature detection has great potential. Image region detection is often posed as a minimum-cost problem, where quantum annealing may be useful.

Project

The aim of this project is to explore the possibilities that quantum algorithms offer in the area of computer vision and image processing. There are three key areas that the PhD will look at:

- The representation of image pixels as a superposition of quantum states in a quantum RAM [1] or other representation.
- The extraction of image features from multiple pixels in parallel using the QFT and related quantum signal processing algorithms [2].
- The use of quantum annealing to solve important computer vision problems which are normally solved via optimisation, such as image segmentation and motion detection.

The student will explore these areas and develop new algorithms for exploiting quantum speed-up on computer vision problems. The work on quantum annealing will also explore which problems can be posed in this way and investigate whether this gives any clues as to the quantum nature of these algorithms.

The research is related to the Computer Science Department's research theme "Beyond Human Vision" but is also connected to some of the work of the University's Quantum Communications Hub. It is suitable for a student with a strong technical background and mathematical skills. Some interest in quantum mechanics would also be beneficial.

[1] V. Giovannetti, S. Lloyd, L. Maccone, "Quantum random access memory", Phys. Rev. Lett. 100, 160501 (2008)

[2] Y. Zhang, K. Lu, K. Xu, Y. Gao and R. Wilson, "Local feature point extraction for quantum images", Quantum Information Processing, 2014