Quantum computer vision algorithms for sensor-based robot localisation

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Research team

CHORALE is an Inria robotic team that studies autonomous robotics systems (autonomous vehicles, mobile robots, UAV, and groups of them in an heterogeneous multi-robot system) from both the perception and control point of view, interacting in dynamic and complex environments that are often unknown a priori. The research objective is to develop and study new paradigms and concepts allowing autonomous systems i) to acquire and share a compact representation of the environment taking explicitly into account the constraints of the task to be done, ii) to act and interact in a collaborative way in order to realize safely and efficiently the task in environments shared with humans, also respecting social behavior rules. The team members skills mainly concern perception, control, autonomous navigation and architecture for the control of the interactions with the environment.

Context

Quantum computing is revolutionizing several scientific disciplines and their applications, such as cryptography or scientific computing [6]. Even if research efforts are currently more focused on the physical realization of quantum computers, research on programming languages [9] and algorithms [3] is already underway because a quantum computer would make it possible to carry out certain calculations inaccessible to current supercomputers in humanly reasonable time (quantum supremacy) [2].

Without waiting for the emergence of universal quantum computers there is a definite interest in identifying which perception problems in robotics could be solved by quantum machines available nowadays or in the near future and to propose new quantum algorithms [7]. Indeed, modern autonomous robots require fast vision capabilities in order to perceive and assess their environment. Computer vision and image processing algorithms are computationally expensive as they have to compute results on millions of pixels. The study of quantum computing applied to image processing has given rise to a new sub-discipline called Quantum Image Processing [1]. Current ongoing research on quantum image processing required for robotic perception concerns for example quantum image representations [10], detection and tracking of moving objects [11].

However, image processing only deal with two dimensional images, which is not sufficient when dealing with robotic perception problems like for example the precise robot localisation in a complex and dynamic environment [4]. This high-level understanding from digital images or videos is provided by computer vision algorithms: scene reconstruction and 3D pose estimation [8]. Similarly to quantum image processing, we want explore a new sub-discipline that can be called Quantum Computer Vision. Indeed, only few methods exist to express a three-dimensional image by quantum representation in the form of quantum point cloud [5]. As with other quantum technologies, we believe that Quantum Computer Vision will surpass the capabilities and performance of it’s traditional equivalents by far.

PhD subject

The main objective of this phd is to investigate new Quantum Computer Vision algorithms and demonstrate that they are superior to conventional computer vision algorithms by presenting high impact applications in robot localization and by providing a software toolkit to the community.

The theoretical part of this PhD research will be to study which classical localisation algorithms for pose estimation are best suited to be accelerated by quantum computing and to design and validate these algorithms on a remote quantum computer. The candidate will have first choose the best suited quantum image representation [12], then investigate how to extract useful features from quantum images [13]. Finally the candidate will propose a new 3D pose estimation and will compete it against classical algorithms.

∗https://project.inria.fr/chorale/
The practical part of this PhD research will consider the implementation of the computer vision algorithms into a software toolkit and the experimentation on a real robot. The privileged application will be the robot localisation (i.e. 3D pose estimation) in its environment since this information is needed for autonomous navigation tasks. The candidate will have first choose the best suited programming language for quantum computing [9] then implement the algorithms using a quantum computing services in the cloud that can be remotely accessed (similar approaches are currently available for GPU-based processing).

Skills

The candidate is expected to have a Master in Computer Vision, as well as solid skills in software development (MATLAB/Simulink, C/C++, Python, LINUX, ROS, Git, OpenCV). Knowledge about quantum informatics will be a plus. He/she is expected also to be endowed with a pronounced passion for research and fundamental work, and always opens to multidisciplinary studies. Finally, a good level of written/spoken English is also important.

How to apply

Interested candidates must send a detailed CV with a motivation letter, their Master’s results (1 and 2) and one or more recommendation letters to Philippe. Martinet@inria.fr.

References


