COORDINATION WITHOUT COMMUNICATION:
QUANTUM-ASSISTED RENDEZVOUS STRATEGIES

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Application instructions:
https://research.kent.ac.uk/pqm/2023/02/03/phd-project-coordination-without-communication-quantum-assisted-rendezvous-strategies/

Rendezvous is a classic problem in operations research first formulated by Alpern in 1976 [1]. There are many variations by they all revolve around the need for two or more parties to find each other without communicating between them. Applications include search-and-rescue, telecommunications and covert operations.

Rendezvous problems are an active area of research and various versions have been tackled by the game theory, computer science, and operations research communities. Numerous algorithms have been developed, including some that are conjectured to be optimal for certain classes of problems, though rigorous proofs exist in precious few instances [2].

Recently, it has been noted that Physics has something to add to the mixture: if two parties trying to solve a rendezvous problem share a quantum resource (in other words, they are in possession of physical systems that are quantum-mechanically entangled) then there are algorithms they can use that beat the optimal non-quantum strategies [3]. This is an example of so-called "quantum pseudo-telepathy" and is potentially game-changing for rendezvous research. In this project we will use quantum computers to explore the potential of this new approach to solve real-world rendezvous problems.

Our project will extend this new, quantum perspective on rendezvous problems in three directions: firstly, we will develop quantum algorithms tackling a broader class of rendezvous problems than have so far been considered (for example, problems where players do not have a map of the search space); secondly, we will extend the reach of the new quantum approach to realistic search space sizes (for instance, graphs with hundreds or even thousands of possible locations, rather than just a handful); thirdly, we will study the feasibility of practical implementations, laying the groundwork for real-world applications.

In order to succeed we will need to design new algorithms and complex wave functions that are optimised for solving specific problems. For complex rendezvous problems in sizeable search spaces an exhaustive search is out of the question. Instead, we will develop a new approach inspired by variational eigensolvers, which are a new, quantum computer based approach to the many-body problem [4]. In our scheme, a quantum processor and a classical computer will work in *tandem*. The quantum processor tries different wave functions and the classical computer attempts to find optimal algorithms drawing on those wave functions as quantum resources. The result of this part of the project will be a new application of quantum computers and new optimal solutions for rendezvous problems.

Once we have gained a good understanding of how much quantum advantage can be gained for different types of realistic-sized rendezvous problems we will examine existing quantum-communication and quantum-memory technologies to produce a practical assessment of the benefits of deploying quantum rendezvous strategies. The result of this final part of the project will be a technology assessment which could form the basis for subsequent, more applied projects, potentially involving industrial partners.

REFERENCES

[1] Alpern, Steve. "Rendezvous search games." *Wiley Encyclopedia of Operations Research and Management Science* (2010).
[2] Weber, Richard. "Optimal symmetric rendezvous search on three locations." *Mathematics of Operations Research* 37.1 (2012): 111-122. https://doi.org/10.1287/moor.1110.0528
[3] Mironowicz, Piotr. "Entangled Rendezvous: A Possible Application of Bell Non-Locality For Mobile Agents on Networks." *arXiv preprint arXiv:2207.14404* (2022). https://arxiv.org/abs/2207.14404
[4] Kandala, Abhinav, et al. "Hardware-efficient variational quantum eigensolver for small molecules and quantum magnets." *Nature* 549.7671 (2017): 242-246.