Cambridge Quantum Computing
Posts Foundational Scientific Papers on
'Meaning Aware' Quantum Natural Language Processing

'Quantum native' attributes of natural language processing exploited in experiments on IBM quantum computers

CAMBRIDGE, UNITED KINGDOM, December 10, 2020 – Cambridge Quantum Computing (CQC) today announced that it has built on earlier advances in "meaning-aware" Quantum Natural Language Processing (QNLP), establishing that QNLP is quantum-native with expected near-term advantages over classical computers.

Natural language processing (NLP) is at the forefront of advances in contemporary artificial intelligence, and it is arguably one of the most challenging areas of the field. "Meaning-aware" NLP remains a distant aspiration using classical computers.

The steady growth of quantum hardware and notable improvements in the implementation of quantum algorithms mean that we are approaching an era when quantum computers might perform tasks that cannot be done on classical computers with a reasonable amount of resources in a repeatable manner, and which are important and suitable for everyday use.

In papers posted on arXiv - the scientific e-print repository, CQC's scientists provide conceptual and mathematical foundations for near-term QNLP in quantum computer scientist-friendly terms. The foundational paper is written in an expository style with tools that provide mathematical generality.

Aiming to canonically combine linguistic meanings with rich linguistic structure, most notably grammar, Professor Bob Coecke (Oxford University) and his team have proven that a quantum computer can achieve "meaning aware" NLP, thus establishing QNLP as quantum-native, on par with the simulation of quantum systems. Moreover, the leading Noisy Intermediate-Scale Quantum (NISQ) paradigm for encoding classical data on quantum hardware - variational quantum circuits - makes NISQ exceptionally QNLP-friendly.

CQC's team has previously established a quantum speed-up for QNLP tasks and demonstrated potential quantum advantage for NLP in various ways including by algorithmic speed-up for search-related or classification tasks, which are among the most dominant tasks within NLP, by utilising exponentially large quantum state spaces

that allow for accommodating complex linguistic structures, and finally; by novel models of meaning, employing density matrices.

In the experimental paper that accompanies the foundational exposition, CQC describes in detail how it performs the first implementation of an NLP task run on two premium IBM quantum computers, which CQC has access to as a hub in the IBM Quantum Network. Sentences are instantiated as parameterised quantum circuits, and word-meanings are encoded in quantum states. CQC's scientists explicitly account for grammatical structure, which even in mainstream NLP is not commonplace, by faithfully hard-wiring it as entangling operations. This makes CQC's approach to QNLP particularly NISQ-friendly. This novel QNLP model shows concrete promise for scalability as the quality of quantum hardware improves.

"CQC's work on quantum Natural Language Processing is a very encouraging example of one of our partners using access to IBM's quantum systems to push the boundaries of quantum information processing toward new and important applications," said Dr. Anthony Annunziata, Director of the IBM Quantum Network.

"This is the first evidence that NLP is quantum native, meaning this is something that quantum computers can do well, and possibly better than classical methods in the long-term," said Ilyas Khan, CEO of Cambridge Quantum Computing. "We believe this is one of the most important foundational papers published in the NISQ era and establishes the fact that NLP is finally possible in a meaning-aware manner."

Professor Coecke's team in Oxford that contributed to the papers includes Konstantinos Meichanetzidis, Giovanni de Felice and Alexis Toumi. The papers can be found on arXiv through the following links:

The Foundational Paper is available here

The Experimental results is available here

About Cambridge Quantum Computing

Founded in 2014 and backed by some of the world's leading quantum computing companies, CQC is a global leader in quantum software and quantum algorithms, enabling clients to achieve the most out of rapidly evolving quantum computing hardware. CQC has offices in the UK, USA and Japan with a team of over 130 professionals. For more information, visit CQC at http://www.cambridgequantum.com.

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