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From Quantum in Pictures to Quantum AI

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This talk requires no particular technical background. We start with an overview of the history of the quantum formalism and fundamental quantum concepts, leading into the quantum picturalism program [1, 2, 3], the use of which has recently become wide-spread in quantum industry. At the same time, we report on compelling empirical evidence on its educational value [4]. Meanwhile, some governments around the world are already starting to adopt Quantum in Pictures [3] as a basis for secondary school quantum education.

One particular new application that has emerged from quantum picturalism is interpretable quantum AI [5]. Basically, linguistic structures have canonical representations as quantum processes: one could say that language is quantum-native, a bit like chemistry. The same analogy also has resulted in BQP-hard quantum algorithms for things like question-answering [6]. We also have experimental demonstrations of these on our H2 quantum computers [7], where in particular we witness 'compositional generalisation'when training, hence avoiding issues many QML approaches have to deal with. We end with a musical note [8].

[1] Bob Coecke (2010) Quantum picturalism. Contemporary physics, 51(1), 59-83.

[2] Bob Coecke and Aleks Kissinger (2017) Picturing Quantum Processes. Cambridge University Press.

[3] Bob Coecke and Stefano Gogioso (2022) Quantum in Pictures. Quantinuum.

[4] https://www.theguardian.com/science/2023/dec/16/physicist-bob-coecke-its-easier-to-convince-kids-than-adults-about-quantum-mechanics

[5] https://www.forbes.com/sites/moorinsights/2021/10/13/cambridge-quantum-makes-quantum-natural-language-processing-a-reality/

[6] Tuomas Laakkonen, Konstantinos Meichanetzidis and Bob Coecke (2024) Quantum Algorithms for Compositional Text Processing. Forthcoming.

[7] Tiffany Duneau, Saskia Bruhn, Gabriel Matos, Tuomas Laakkonen, Katerina Saiti, Anna Pearson, Konstantinos Meichanetzidis and Bob Coecke (2024) Scalable and interpretable quantum natural language processing: an implementation on trapped ions. Forthcoming.

[8] Eduardo Miranda, Richie Yeung, Anna Pearson, Konstantinos Meichanetzidis and Bob Coecke (2022). A quantum natural language processing approach to musical intelligence. In Quantum Computer Music: Foundations, Methods and Advanced Concepts (pp. 313-356). Springer.

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