Quantum-Like Influence Diagrams: Incorporating Expected Utility in Quantum-Like Bayesian Networks

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It has been established in the literature that quantum-like models provide an alternative way of explaining and accommodating paradoxical findings that are unexplainable through classical probability models (Busemeyer and Bruza, 2012; Bruza et al., 2015)

Quantum-like models tend to explain the probability distributions in several decision scenarios where the agent (or the decision-maker) tends to act irrationally. By irrational, we mean that the agent chooses strategies that do not maximize or violate the axioms of expected utility. However, it is not enough to explain these irrational decisions through probability distributions. It would be desirable to use these probability distributions to help us act upon a real world decision scenario. For instance, it is not enough for a doctor to find out the disease of a patient. The doctor needs to decide which treatment to give to the patient, based on the disease and on the patients tolerance towards different medications.

Following this line of thought, in this work, we extend the previously Quantum-Like Bayesian Network proposed by Moreira and Wichert (2016) by incorporating the framework of expected utility, this way presenting a graphical decision model called Quantum-Like Influence Diagram.

Generally speaking, an Influence diagram is a compact graphical representation of a decision scenario, which consists in three types of nodes: random variables (nodes) of a Bayesian Network, action nodes representing a decision that we need to make, and an utility function. The goal is to make a decision, which maximizes the expected utility function by taking into account probabilistic inferences performed on the Bayesian Network. However, since influence diagrams are based on classical Bayesian Networks, then they cannot cope with the paradoxical findings reported over the literature.

It is the focus of this work to study the implications of incorporating Quantum-Like Bayesian Networks in the context of influence graphs. By doing so, we are introducing quantum interference effects that can disturb the final probability outcomes of a set of actions and affect the final expected utility. We will study how one can use influence diagrams to explain the paradoxical findings of the prisoners dilemma game based on expected utilities. Moreover, since influence diagrams are widely used over the

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literature (for instance, in finance to determine the net present value of a project), we will also study the implications of using quantum probability inferences in such scenarios where violations of classical probability theory are not evident (or not present).

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