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Mapping Embedded Process Matrices to Spacetime Games

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Abstract

In 1935 Einstein first stated that quantum theory, as we know it, is an incomplete theory. In fact, quantum theory, as given by the Born rule, has an inherently random component, restricting it to providing probabilities for a certain measurement outcome rather than specific predictions of outcomes.

We explore a new approach that aims to lift this restriction with the help of game theory. It has been shown that Nashian game theory is incompatible with quantum theory. Hence, a new non-Nashian equilibrium has been introduced. This equilibrium is attained by relaxing the free choice assumption commonly found in quantum theory in favour of Einstein's localism. The use of such a method is thought to enable making deterministic predictions over the outcomes of quantum experiments.

There already exists a method for solving games with non-Nashian theory. It does, however, require as input a game in extensive form with imperfect information and therefore still misses the link to quantum experiments.

We present a practical framework for representing quantum experiments mathematically based on the process matrix framework. This transition, from a physical experiment to the mathematical representation, makes use of the Choi-Jamiołkowski representation of quantum channels and states, as well as the process matrix representation of quantum processes.

The implementation detailed in this report includes both a JSON storage format and a Python library. This library comprises an algorithm for mapping a quantum experiment to a game in extensive form with imperfect information, as well as other (visualisation) utility functions.

This report lays the way for future work to advance our understanding of non-Nashian game theory and to prove its consistency with quantum theory.

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