Quantum Supremacy, the game*

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Text-based adventures dominated the earliest days of classical computer gaming. In analogy to this, we have developed Quantum Supremacy - a text-based game for the earliest days of quantum computer gaming. This game intends to let players get intimately familiar with the concepts of gate-model quantum computing, quantum entanglement, and measurement. The game assigns each player a qubit, and allows players to lay circuit elements in turn, with the goal of maximizing their excitation while minimizing those of others. The player with the highest expected excitation probability wins.

I. MOTIVATION

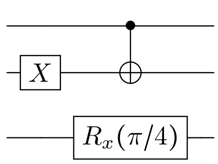
The last few decades have seen quantum computing go from a theoretical curiosity to a real, albeit primitive, computing platform. In classical computing, the development of video games has always paralleled the technological advancement of electronics as a whole, from the days of 8-bit floppy disk games and CRT TVs, to VR movie quality video games and smartphones. As quantum computing is well in it's early infancy, we wanted to provide an homage to one of the earliest forms of computer games using the IonQ quantum computer: text based games! Can you guide your qubit to victory, or will you be lost in the entanglement?

II. GAMEPLAY

The number of players and number of rounds is initially set. For clarity, we will outline playing through a game with 3 players and 2 rounds. The game begins with each player choosing an initial state, unknown to the other players, from $|0\rangle, |1\rangle, (|0\rangle + |1\rangle)/\sqrt{2}$. Let us have player 0 choose $|0\rangle$, player 1 choose $|1\rangle$, and player 2 choose $(|0\rangle + |1\rangle)/\sqrt{2}$:

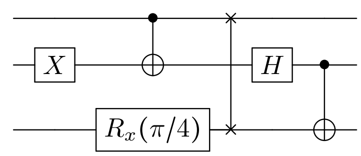
$$\begin{array}{r} |0\rangle \; - \\ |1\rangle \; - \\ (|0\rangle + |1\rangle)/2 \; - \end{array}$$

Then, each player takes a turn placing one gate anywhere on the circuit, from the following choices: X,Y,Z,$R_x(\pi/4)$, CNOT, CPHASE, SWAP. Note, there are both 1-qubit and 2-qubit entangling gates present. In this demonstration game, suppose player 0 places X on qubit 1, then player 1 places CNOT on qubits 0,1, and then player 2 places $R_x(\pi/4)$ on qubit 2:



Now, round 1 is complete. A measurement will be sampled of the final wavefunction produced by this circuit, resulting in a bitstring, for example, 001. This measurement will give an idea of the state at this point in the circuit, and can help them with strategizing for the next round. But, the measurement operators will not remain in the circuit moving forward.

The next round, suppose player 0 chooses to place a swap on their qubit and qubit 2, then player 1 places an H on qubit 1, and player 2 then places a CNOT on qubits 1 and 2:



Now, the second round is complete, and single-shot measurements of the circuit will be performed many times to gather statistics on the final wavefunction, calculating the excitation probability for each qubit. The player with the most excitation mass wins! Results in the game are displayed in a bar graph of excitation probabilities.

III. OUTLOOK

The gameplay mechanics rely on knowledge of quantum gates, entangelement, and measurement. Those who play will get more familiar with these concepts, and use this in their favor when choosing which gates to place, which state to start with, and how to counteract the actions of other players.

The game quickly becomes complicated if more complex gates are available to players - arbitrary rotations, controlled gates with more than two qubits, etc. This, and more intense game mechanics, e.g. adding $R_x(\pi/4)$ gates to all qubits after each round, could lead to more rich gameplay, and more in-depth understanding and intuition by the players to form winning strategies.

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