QUANTUM TIC TAC TOE

Results Report

Protocol Reference :

Sagole, Sai & Dey, Anurit & Behera, Bikash & Panigrahi, Prasanta. (2019). Quantum Tic-Tac-Toe: A Hybrid of Quantum and Classical Computing. 10.13140/RG.2.2.18883.76320.

Rules of Measurement:

Protocol 1 Setting up of quantum circuit

setup()

The Protocol:

- Creates the quantum circuit with nine quantum bits and nine classical bits
- Adds a Hadamard gate to each of the nine qubits
- Prints Legal Moves and Rules

Protocol 2 Player's Turn

turn()

The Protocol:

- Checks and prints whether it is Player X's turn or Player O's turn
- Asks the user to choose between quantum move and classical move
- Calls function cmove() if user inputs 'c' and qmove if user inputs 'q'
- Asks the user to enter the position of the move

Protocol 3 Quantum Move

qmove()

The Protocol:

- Stores target position and control position of the move in a variable so that cmove() could use it.
- Prints 'control move' and 'target move' linked

Protocol 4 Classical Move

cmove()

The Protocol:

- Calls the Aer() function in qiskit library
- Simulates the circuit on qasm simulator
- Checks if the given position is already a control position for any quantum move
  - Then adds a CNOT or Anti CNOT gate depending on the input from qmove()
- Measures the position entered by the user and stores in a variable called 'result'
- Fixes the qubit's state according to the result of the simulation
- Calls mark()

Results:

```
PROBABILITY OF FIRST PLAYER WINNING THE GAME = 0.584582
PROBABILITY OF SECOND PLAYER WINNING THE GAME = 0.288597
PROBABILITY OF THE GAME ENDING IN A DRAW= 0.126821

PROBABILITY OF THE GAME ENDING IN 5 MOVES= 0.095032
PROBABILITY OF THE GAME ENDING IN 6 MOVES= 0.087945
PROBABILITY OF THE GAME ENDING IN 7 MOVES= 0.264327
PROBABILITY OF THE GAME ENDING IN 8 MOVES= 0.200652
PROBABILITY OF THE GAME ENDING IN 9 MOVES (WIN)= 0.225223
PROBABILITY OF THE GAME ENDING IN 9 MOVES (DRAW)= 0.126821

PROBABILITY OF FIRST PLAYER WINNING THE GAME (P(terminal position reached in 5, 7, 9 moves))= 0.584582
PROBABILITY OF SECOND PLAYER WINNING THE GAME (P(terminal position reached in 6, 8 moves))= 0.288597
TOTAL PROBABILITY = 1.000000
```

Simulation over 10000 games :

In a random implementation of the classical game when the first player starts over 10000 runs:

```
PROBABILITY OF FIRST PLAYER WINNING THE GAME = 0.582290
PROBABILITY OF SECOND PLAYER WINNING THE GAME = 0.289630
PROBABILITY OF THE GAME ENDING IN A DRAW= 0.128080
```

Image 2

In our implementation of quantum tic-tac-toe when first player starts the game:

```
PROBABILITY OF FIRST PLAYER WINNING THE GAME = 0.485893
PROBABILITY OF SECOND PLAYER WINNING THE GAME = 0.483638
PROBABILITY OF THE GAME ENDING IN A DRAW= 0.030469
```

Image 3

We see that while in classical tic-tac-toe, the first player is usually at an advantage if it occupies a corner or central position, this advantage isn't as apparent in the quantum version of the game.