QCI

Day 7: Surpassing classical computers [0]: The Deutsch Oracle

Speaker notes

Heavily drawn (basically stolen) from https://www.youtube.com/watch?v=F_Riqjdh2oM

What are the 4 single-bit operations?

Which are constant? Which are variable?

The Oracle

Speaker notes

I give you a black box with a function in it. (draw on iPad)

You cannot see inside, but you can put bits through it and see the output.

How many queries on a classical computer does it take to determine which of the 4 functions it is? (answer: 2)

How about on a quantum computer? (answer: also 2 -- there are 4 possible states, so we need at minimum 2 bits of information)

How many queries does it take on a classical computer to find if it's variable/constant? (answer: 2 -- go through the queries)

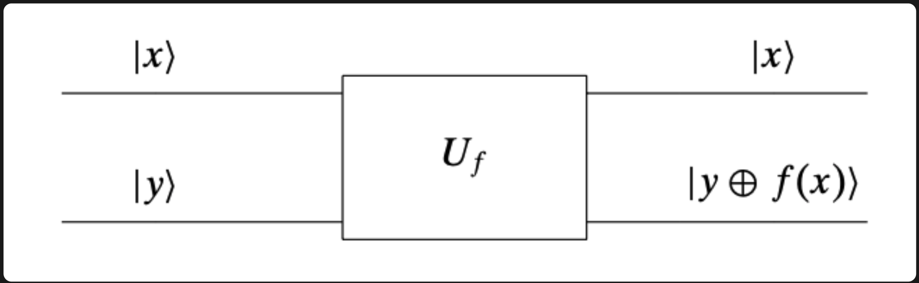
How about on a quantum computer? (answer: 1 -- this is our first example of quantum outperforming classical)

What is the issue with some of our single-bit operations?

Speaker notes

(answer: not reversible)

Quantum Oracle



Reversible

Requires a spare qubit

Speaker notes

We can always tell the input from the output.

Show how this oracle works with a spare bit. Assume that $|y\rangle$ starts at 0 (but we will break this assumption later)

Show on IBM Quantum Composer: Writing the 4 functions reversibly. Assume that Output starts at 0 (but we will break this assumption for our algorithm)

Image from the Quantum Computing for Computer Scientists video

Coding Time!

Speaker notes

Hadamards on both qubits, then apply the "black box function" (pick one for the sake of implementation). Hadamard the top (input) qubit after the black box and then measure. If it's constant we get $|1\rangle$, otherwise we get $|0\rangle$ if it's variable.

References

- Yanofsky, Mannucci. Quantum Computing for Computer Scientists
- https://www.youtube.com/watch?v=F_Riqjdh2oM