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Deutsch-Jozsa Algorithm

The Deutsch-Jozsa Algorithm was one of the first examples of a quantum algorithm being exponentially faster than any possible classical algorithm. The function implemented by the algorithm takes n single-bit binary values as an input and for each returns for each value either a 0 or 1, and given that the function is either constant (always 1 or always 0) or balanced (one 1 and one 0), can determine if the function is constant or balanced. The reason the Deutsch-Jozsa algorithm is more efficient than classical is that to end up with no possibility of error, only a single evaluation of f is needed, whereas an ideal classical solution would require anywhere from one evaluation to a worst-case scenario of 2^(n-1) + 1 evaluations, thus demonstrating increased quantum efficiency in a classical problem. Due to the nature of quantum computation and the problem, various calculations are necessary for running the algorithm, resulting in the following probability of measuring k = 0 (if outputs is 1, constant, else balanced):

$$\left|\frac{1}{2^n}\sum_{x=0}^{2^n-1}(-1)^{f(x)}\right|^2$$

For further information on the computation required (such as implementing the Hadamard gates) view the section titled "Algorithm" on the attached Wikipedia link.

For our project, we want to compare the implementations of the Deutsch-Jozsa Algorithm with classical algorithms and compare their runtimes. To do this, it will be necessary for one person to implement the Deutsch-Jozsa Algorithm in Mathematica code, and for the other to implement one or more classical algorithms to achieve the same result. We can then analyze the differences in time between the Algorithms and determine how much more powerful Quantum computing is compared to deterministic classical computing. We can also learn why Quantum computing is more powerful. Potential pitfalls we could face could be found in learning how to implement the different Algorithms into Mathematica. We could also face challenges with the limited power of our own personal computers in computing taxing algorithms. To overcome this, it will likely be necessary to understand the quantum computing functions in Mathematica on a very deep level.

Wikipedia for more information:
https://en.wikipedia.org/wiki/Deutsch%E2%80%93Jozsa_algorithm