Quantum Computing: Minimum Search by Groover algorithm

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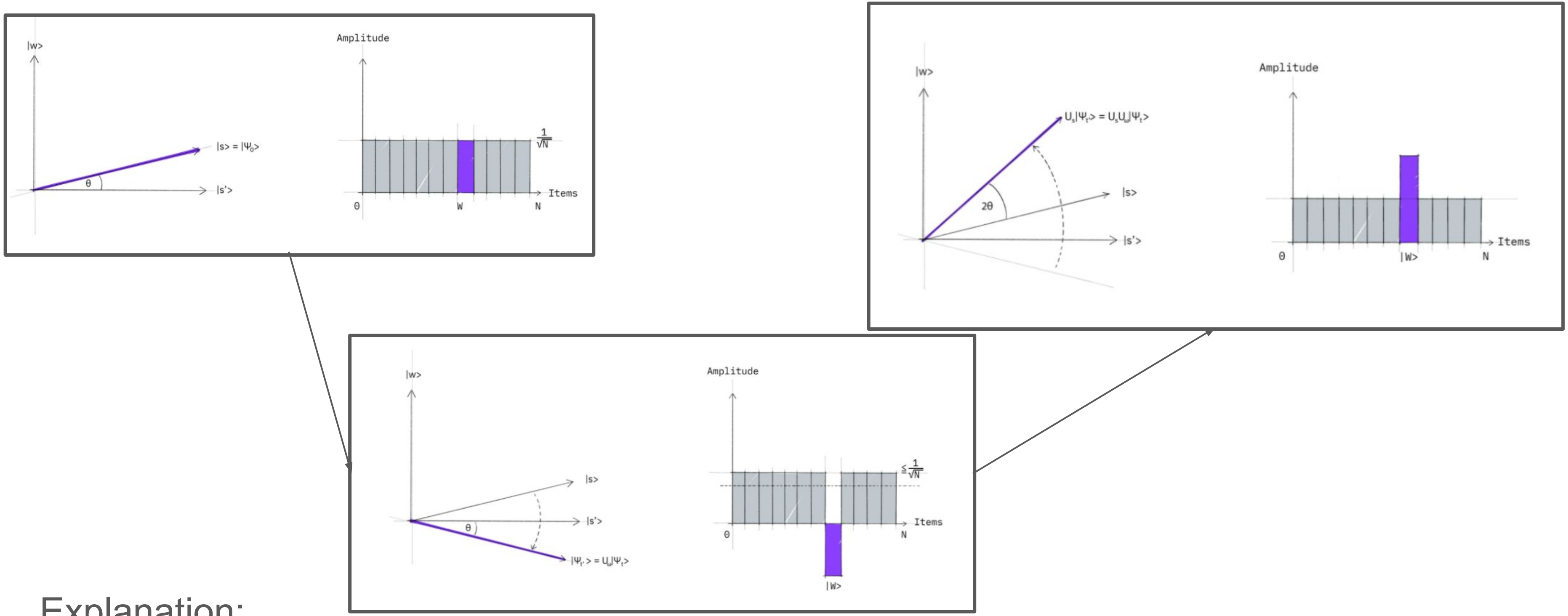
Problem definition:

Given function f: int -> int

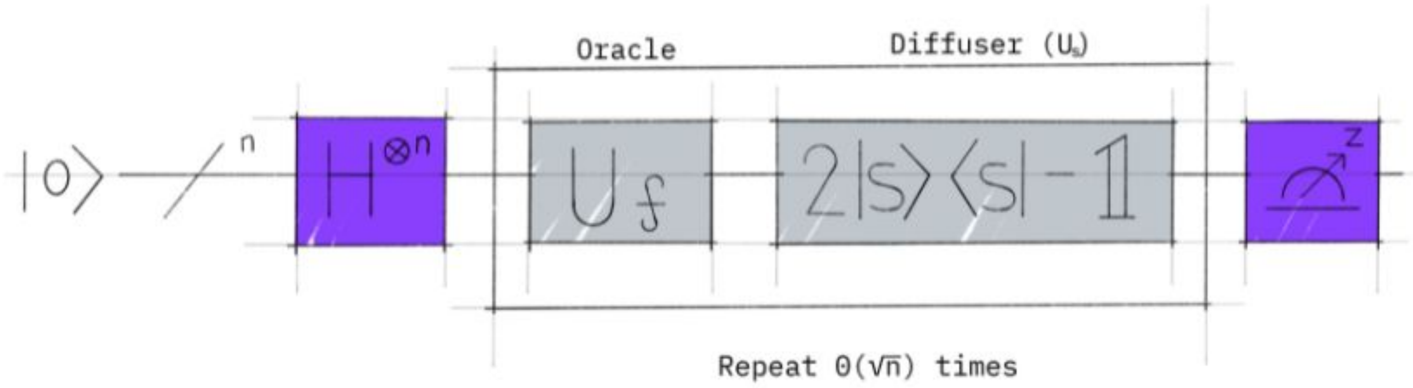
Problem: $argmin_x(f(x))$

Pre Requirements: Groover Algorithm



Explanation:
https://colab.research.google.com/drive/1cIusyX6rjEca-9UeBedZCenJ7H0MIoVC?usp=sharing

Pre Requirements: Groover Algorithm



Explanation:
https://colab.research.google.com/drive/1cIusyX6rjEca-9UeBedZCenJ7H0MIoVC?usp=sharing

Argmin search

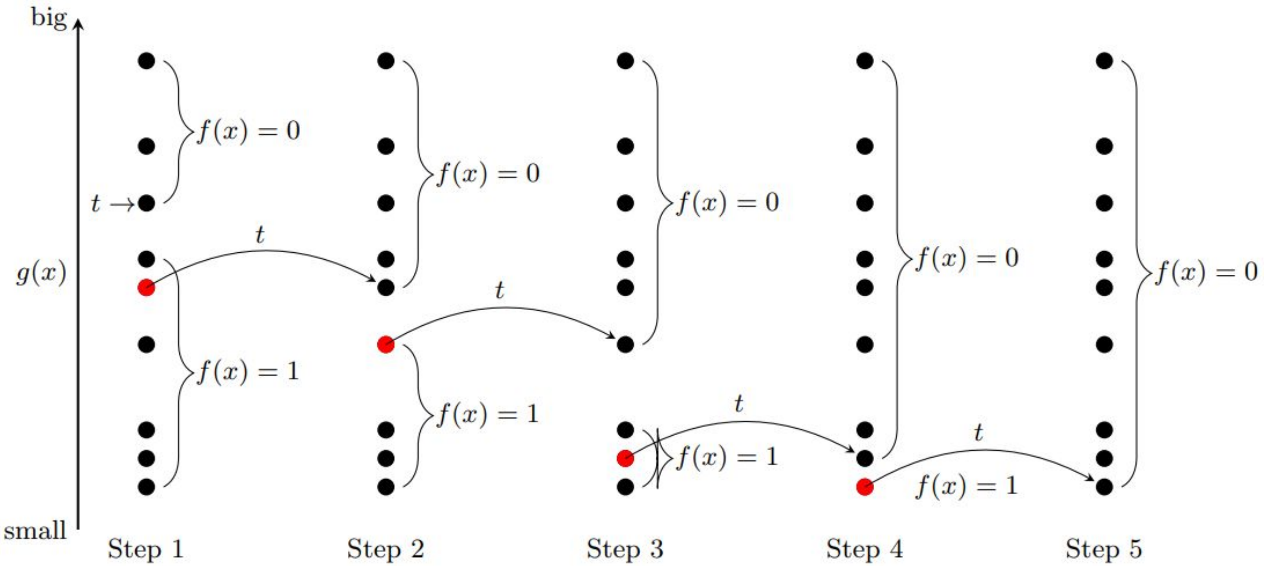
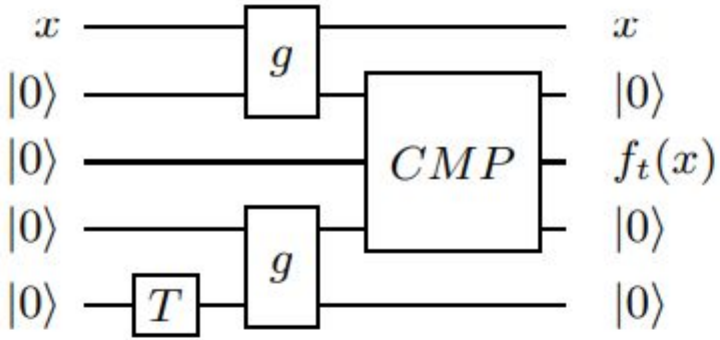


FIG. 9. The updating process of threshold t in FM algorithm. The vertical axis represents the value of indices. When the first threshold t is selected, all points are divided into two. One is $f(x) = 0$ and the other is $f(x) = 1$. AA randomly selects one of the points such that $f(x) = 1$. The selected point, drawn in red, is used as a new threshold index t in the next step. The number of points satisfying $f(x) = 1$ decreases as the step goes. Finally (at the Step 5 in this example), the algorithm ends as no points satisfy $f(x) = 1$.

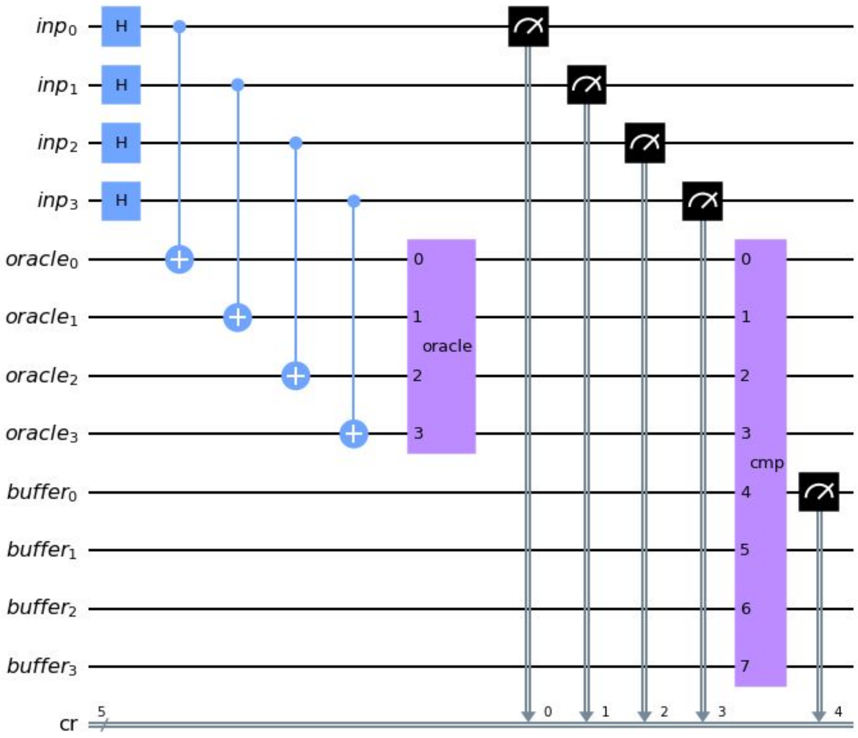
Arxiv https://arxiv.org/pdf/1907.03315.pdf

Special Oracle for Groover algorithm



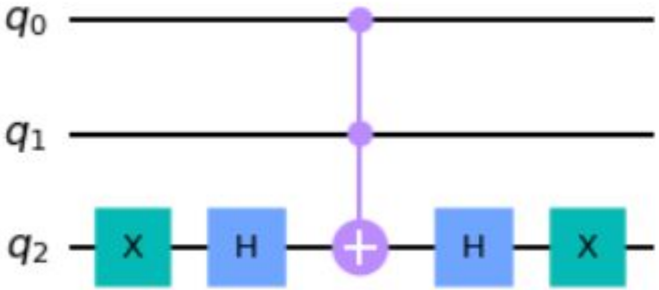
Arxiv https://arxiv.org/pdf/1907.03315.pdf

Bit Flip Oracle: Sampling



Convert Bit Flip Oracle to Phase Flip Oracle: Example

Oracle:
Good State - (1,1)



$$|q_0>|q_1>|0>->\begin{cases} -|q_0>|q_1>|0> \text{ if } |q_0>|q_1>=|1>|1> \\ |q_0>|q_1>|0> \text{ otherwise} \end{cases}$$

Results

Reference

```
['00001111', '00001010', '00001000', '00001011', '00001110', '00001001']
```

Filtered algo output

```
{'00001011': 29,
 '00001010': 28,
 '00001000': 25,
 '00001111': 24,
 '00001110': 24,
 '00001001': 21,
 '00000111': 1,
 '00001101': 1,
 '00001100': 1,
 '00000000': 1}
```

Further Work - Quantium KNN

“One of the simplest and most effective classical machine learning algorithms is the **k nearest neighbors algorithm (kNN)** which classifies an unknown test state by finding the **k nearest neighbors from a set of M train states**. Here we present a quantum analog of classical kNN – quantum kNN (QkNN) – based on fidelity as the similarity measure. We show that the QkNN algorithm can be reduced to an instance of the quantum k maxima algorithm; hence the query complexity of QkNN is **$O(\sqrt{kM})$**. The non-trivial task in this reduction is to encode the fidelity information between the test state and all the train states as amplitudes of a quantum state. Converting this amplitude encoded information to a digital format enables us to compare them efficiently, thus completing the reduction. Unlike classical kNN and existing quantum kNN algorithms, the proposed algorithm can be directly used on quantum data, thereby bypassing expensive processes such as quantum state tomography.”

https://arxiv.org/pdf/1907.03315.pdf -