Quantum Wordle (QCHack 2022)

IBM Quantum Challenge

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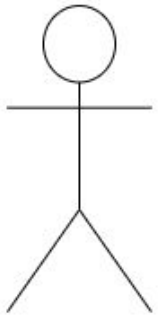
Introduction

- The quantum version of the very popular game - "wordle", Qwordle

QWordle



Human

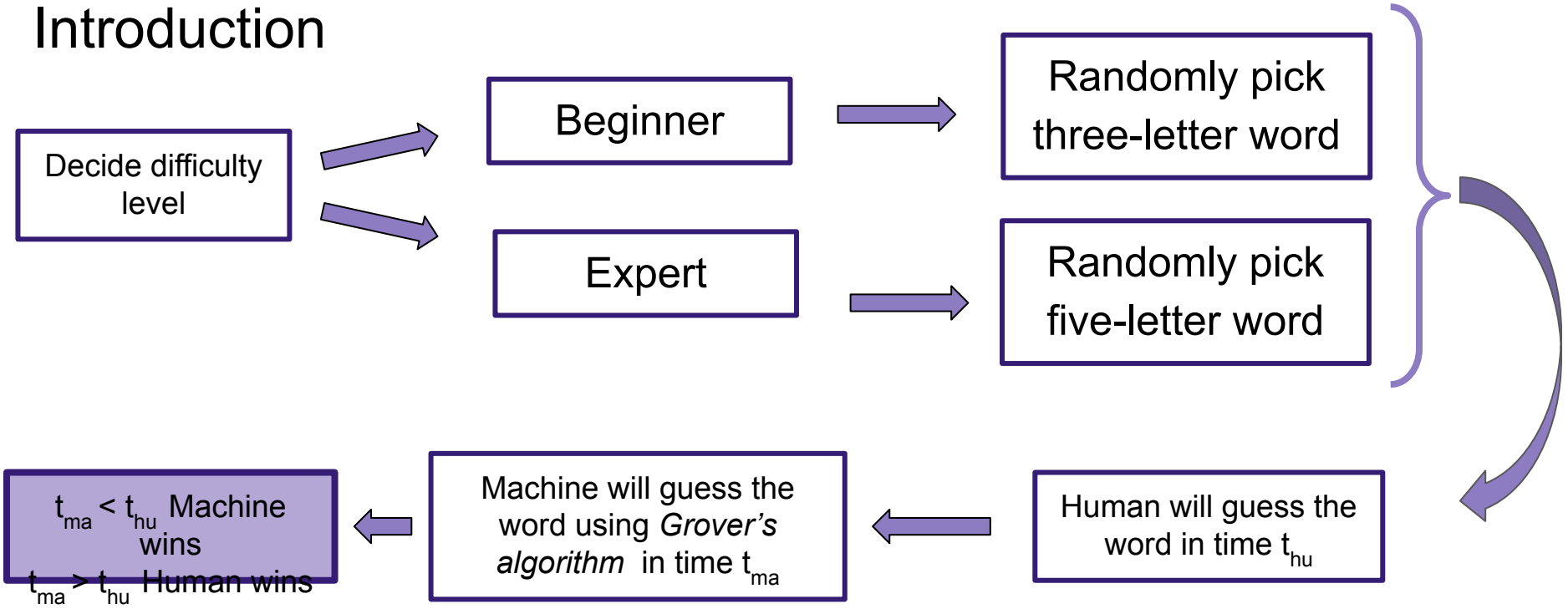
Vs

Qiskit

Introduction

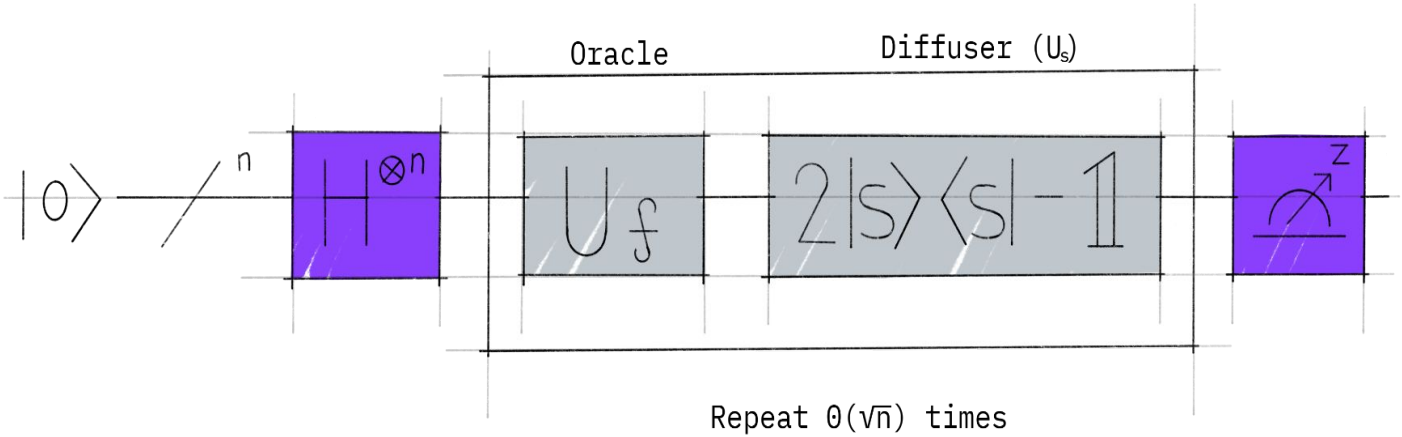
- The quantum version of the very popular game - "wordle", Qwordle
- Based on Grover's algorithm
- The quest of this game is two fold:
  - both human and quantum computer will be guessing a randomly picked word and
  - they will compete against each other based on the time it takes both of them to guess the word correctly and independently.
- As an added feature to our game we have created two different levels, beginner and expert, based on the difficulty of a word

Introduction



Grover’s Algorithms

- Quantum algorithm to solve unstructured search problems



REF: https://qiskit.org/textbook/ch-algorithms/grover.html

Grover’s Algorithms

0 1 2

```
Step 1: We initialize the 5 qubits into a uniform superposition
q_0: ┤ H ├
q_1: ┤ H ├
q_2: ┤ H ├
q_3: ┤ H ├
q_4: ┤ H ├
Step 2: We apply the oracle
q_0: ┤ H ├┤0                    ├
q_1: ┤ H ├┤1                    ├
q_2: ┤ H ├┤2 circuit-29560      ├
q_3: ┤ H ├┤3                    ├
q_4: ┤ H ├┤4                    ├
Step 3: We apply the diffuser
q_0: ┤ H ├┤0                    ├┤0                    ├
q_1: ┤ H ├┤1                    ├┤1                    ├
q_2: ┤ H ├┤2 circuit-29560      ├┤2 circuit-29563      ├
q_3: ┤ H ├┤3                    ├┤3                    ├
q_4: ┤ H ├┤4                    ├┤4                    ├
Step 4: We repeat steps 2 and 3 iteratively on the simulator until we find the
desired letter
The bit string is 00000
The letter 0 is a
```

Human word guessing

```
Enter difficulty level - Beginner (0) or Expert (1)0
Guess the three letter word:cat
The position of letter c [2]
The position of letter a [1]
The position of letter t []
Try again: mac
The position of letter m []
The position of letter a [1]
The position of letter c [2]
Try again: lac
The position of letter l []
The position of letter a [1]
The position of letter c [2]
Try again: tac
The position of letter t []
The position of letter a [1]
The position of letter c [2]
Try again: pac
The position of letter p []
The position of letter a [1]
The position of letter c [2]
Try again: sac
Correct Answer:  sac
Time taken to guess the correct word by human (in sec): 22.280947699999995
Now machine will guess
The word is : s a c
Time taken by the machine 0.8688567999999961
```

0	1	2

1. The human started with “cat”

   This means that c is on position 2 and a is on position 1

2. From the 1st attempt, human knows that

	a	c

3. After few guesses, human finds the correct answer

s	a	c

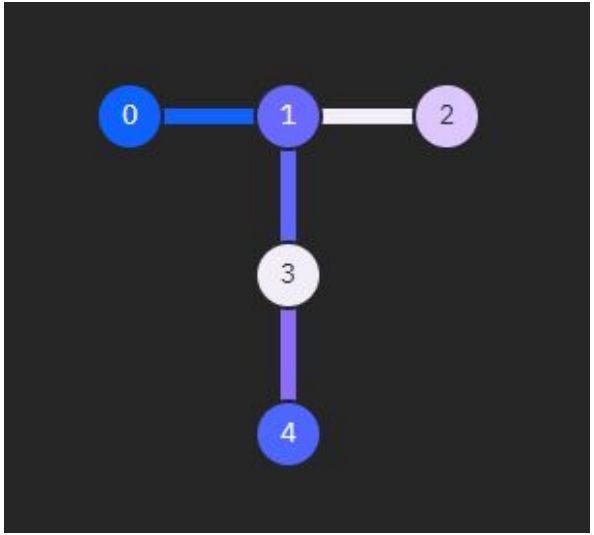
Challenges faced:

- Because we were dealing with 26 letters, we had to consider large qubits system: 5-qubit system

- Due to that there were huge errors in hardware run for example,
  desired word - CAT
  hardware word - BFR (on IBM Q device - ibm_lima)

- It was hard to find common word database especially for three-letter words

ibm_lima



REF:https://quantum-computing.ibm.com/services?services=systems

Possible next steps:

- Expand this algorithm further by adding more complexity and limitations on the number of guesses
- This will mimic the actual wordle game
- Also Information Theory concept can be used to enhance the searching capabilities along with Grover's Algorithm for example, using Sigmoid function

REF:https://static01.nyt.com/images/2022/01/31/crosswords/wordle-art/wordle-art-mediumSquareAt3X.jpg

Thank You