Quantum Pattern Matching Using IBM Qiskit

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Abstract. There are several classical algorithms for pattern matching like KMP but to harness the advantages of quantum there needs a similar kind of algorithm. Researchers from IonQ and University of Maryland College Park proposed a quantum algorithm to search pattern in a string or other databases. In this work, an effort was given to verify the algorithm in circuit level using IBM qiskit for a length of 8 string. To avail the quantum performances for pattern searching we implemented a general oracle of grover's algorithm. To proof our circuit developed in Qiskit we plotted the pattern matching with string in histogram.

Keywords: Algorithm, IonQ, Qiskit, Grovers algorithm, Pattern Matching.

1   Introduction

In computer sciences pattern matchings has a wide range of applications in image processing, protein/ bio-molecular sequencing, pattern matching etc. Typically, in pattern matching a length of N string is given to search for a pattern of length M, and pattern length is less than the string. A programmable circuit-level quantum algorithm is proposed by IonQ and UMD where the time complexity $O(\sqrt{N})$ along with $O(N+M)$ space complexity is expected. In this work, we tried to verify the mentioned paper by developing a programmable circuit and to show proof of demonstration we implemented the whole circuit using Qiskit, a IBM backed quantum programming language.
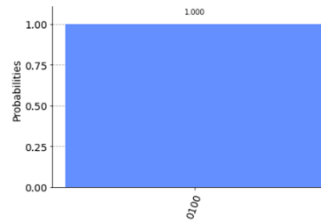
2   Implementation

One of the key features of the proposed quantum pattern algorithm was developing a left cyclic shift operator. Cyclic shift property has been achieved for by implementing a controlled Fredkin gate on conditional bit string. We achieved this by introducing a conditional bit index.

Algorithm for cyclic shift operator:

1. Calculate necessary index value from pattern bit string in logarithm scale
2. **For** every index shift the string position $2^{index\ value}$
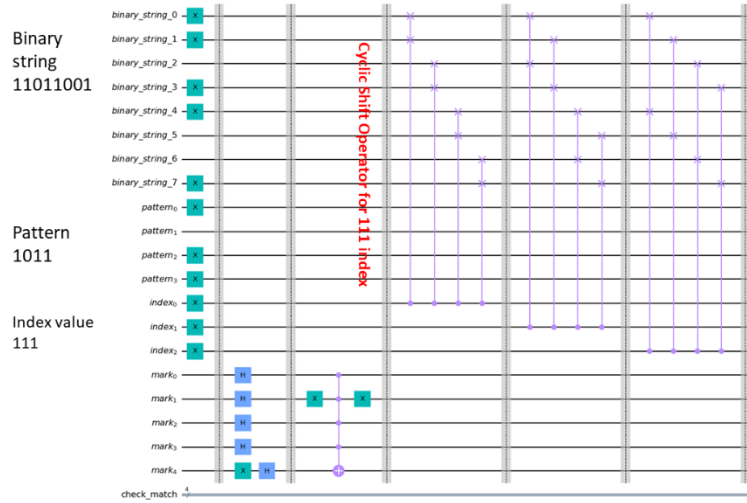
(a)

(b)

Fig.1 : (a) Implementing Cyclic shift operator using Qiskit for 11011001 and 1011 bit string and pattern matching respectively (b) Matching histogram, the result says our implementation been able to successfully match 3 bits out of 4, hence the result is 0010, all 0 means properly matched according to the paper but a single 1 means that bit is mismatched

All related codes are available in the following Github repository: https://github.com/SakibulIslamSazzad/Quantum-Pattern-Matching