Report on Quantum Computing exploratory research

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Chapter 1

Introduction

1.1 Abstract

1.2 Background and purpose of the document

1.3 Some notions on Quantum Computing

Here we will mention the key concepts useful to understand the rest of the document. It cannot be considered neither a complete nor an exhaustive explanation on the basics of Quantum Computing.

We assume the reader will already know the basic concepts about linear algebra and elementary quantum gates. For more information on these basic topics, we recommend [10].

Chapter 2

Quantum Development Kit

2.1 Example: Grover Search implementation

Chapter 3

Maximum Flow Analysis

3.1 Feasibility analysis

Chapter 4

Insights on Grover Search Algorithm and its implementation

4.1 Introduction

4.1.1 Premise

Our Quantum Max Flow Analysis algorithm described in 3, bases its reason to exist in the fact that a small routine of the algorithm (the search for the next arc to be considered among those coming out of a given node) is done by a quantum computer. It is in fact nothing more than a search in a list (or more generally in a database) of one or more elements that satisfy a certain condition (the arcs that have not been visited yet, i.e. having infinite weight value).

4.1.2 The problem

As shown in Section 2.1, the implementation of Grover Search is done on a virtual database.

Alike real databases, virtual (or implicit) databases are not really a databases, they can be implemented as quantum registers initialized so that when measured they collapse to one of all the possible combinations of bits of the register itself, being these combinations all equally probable.

Actually the implementation described in Section 2.1 complies with most of the available literature [9, 11]. It is evident that currently most of the works someway related to Grover Search Algorithm are devoted to quantum search on virtual databases. [7]

Apparently some people agree that Grover is limited to implicit databases, therefore not convenient or even not useful at all for real databases. [13, 14, 3, 1, 2]

On the other hand, someone had a deeper study on the algorithm, understanding the mechanism and implementing (at least mathematically) the encoding and the search on a real database. [5]

We will build on this last paper to answer the questions:

- Is it correct to use Grover Search for a real database search?
- Is it feasible? (i.e. could an algorithm be devised to do so?)

4.2 Feasibility analysis

Chapter 5

Other ways explored during the research

Grover's Algorithm was originally devised to work with functions that are satisfied by a single input. Actually it has also been "generalized to search in the presence of multiple *winners*". [6]

It turns out that Grover's Algorithm can be more useful in "speeding up the solution to NP-complete problems such as 3-SAT" than actual search. [12]

We also considered spatial database search as a possible way of exploiting Grover's Algorithm, in the specific case of graphs with costs on arcs [4, 8].

Although there are some points of contact with Grover, none of them seemed to me of any use for our Max Flow Analysis problem.

Chapter 6

Conclusions

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