

ACA 2015

Applications of Computer Algebra
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A Web-based Quantum Computer Simulator with symbolic extensions

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Outline

Introduction

Quantum Computer Simulator

Example of using the web-based quantum computer simulator

Symbolic Extensions



- The objective is to present a quantum computer simulator with a web interface based on the circuit model of quantum computation. This is the standard model for which most quantum algorithms have been developed.
- Quantum algorithms are expressed as circuits of quantum registers (series of qubits) and quantum gates operating on them. Each quantum gate, is a unitary transformation on the Hilbert space, determined by the quantum register.

- The quantum computer simulator is a useful tool for studying and understanding quantum circuits, quantum computations and well known quantum algorithms, such as Grover's algorithm and Quantum Fourier Transform. It may also be very useful for the development of new quantum algorithms and the construction of new quantum gates.



- The quantum computer simulator is developed in Python, using some extra libraries for our purposes. The fundamental library that is used is Numpy: the package for scientific computing with Python.




- Because of the limitations of GUI for a large number of qubits, we propose another version of quantum computer simulator without a user interface, which could simulate quantum computations for larger inputs. The inputs of the simulator are the number of qubits, the number of computation steps, the initial state of quantum register and the gates applied at each step. The outputs of the simulator are the quantum register state at each step (the probability of measuring each one of the possible states and the phases of each state).

- The simulator gives a number of gates that the user can apply on each step:
 - Identity
 - Hadamard
 - Cnot
 - CCNot
 - Phase
 - Controlled Phase
 - Fredkin



- The web-based quantum computer simulator is free accessible from:

<http://tinyurl.com/wcl-quantum>



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<http://tinyurl.com/wcl-quantum>

Home - Demo: Quantum Computer Simulator

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Demo: Quantum Computer Simulator

This diploma dissertation presents the development of a library for quantum calculation and the implementation of a graphic interface that uses this library. Initially, the quantum computers and the programming language python were studied. After the comprehension on the two above fields the quantum library and the graphic interface which uses that library were created. Another graphical interface also created for the presentation of the graphs that showing the results of the quantum computation. The program is written in Python language. Read instructions [here](#) (Greek)

1

2

3

Please select starting state of qBits and gates, and then select 'Simulate Now'.

	Starting State	Step 1
qBit 1	<input checked="" type="radio"/> 0> <input type="radio"/> 1>	I ▼
qBit 2	<input checked="" type="radio"/> 0> <input type="radio"/> 1>	I ▼
qBit 3	<input checked="" type="radio"/> 0> <input type="radio"/> 1>	I ▼

4

5

When you click "Simulate Now", the results will be shown here.

For more information please contact: Dr Kyriakos Sgarbas or Petroula Mavridi
You can find the whole pdf file here.
Web based demo created by: Charalampos Tsimpouris

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Number of qbits: Number of Computation Steps:

Please select starting state of qbits and gates, and then select "Simulate Now".

	Starting State	Step 1	Step 2	Step 3	Step 4
qBit 1	<input type="radio"/> 0> <input type="radio"/> 1>	<input type="button" value="I"/> <input type="button" value="A"/>	<input type="button" value="I"/> <input type="button" value="A"/>	<input type="button" value="H"/> <input type="button" value="A"/>	<input type="button" value="I"/> <input type="button" value="A"/>
qBit 2	<input type="radio"/> 0> <input type="radio"/> 1>	<input type="button" value="H"/> <input type="button" value="A"/>	<input type="button" value="I"/> <input type="button" value="A"/>	<input type="button" value="I"/> <input type="button" value="A"/>	<input type="button" value="I"/> <input type="button" value="A"/>
qBit 3	<input type="radio"/> 0> <input type="radio"/> 1>	<input type="button" value="I"/> <input type="button" value="A"/>	<input type="button" value="H"/> <input type="button" value="A"/>	<input type="button" value="I"/> <input type="button" value="A"/>	<input type="button" value="I"/> <input type="button" value="A"/>

Measure

	Starting State	Step 1	Step 2	Step 3	Step 4
qBit State 1	1.00	0.50	0.25	0.13	0.13
qBit State 2	0.00	0.00	0.25	0.13	0.13
qBit State 3	0.00	0.50	0.25	0.13	0.13
qBit State 4	0.00	0.00	0.25	0.13	0.13
qBit State 5	0.00	0.00	0.00	0.13	0.13
qBit State 6	0.00	0.00	0.00	0.13	0.13
qBit State 7	0.00	0.00	0.00	0.13	0.13
qBit State 8	0.00	0.00	0.00	0.13	0.13
	Starting State	Step 1	Step 2	Step 3	Step 4

Phase

	Starting State	Step 1	Step 2	Step 3	Step 4
qBit State 1	0.00°	0.00°	0.00°	0.00°	0.00°
qBit State 2	0.00°	0.00°	0.00°	0.00°	0.00°
qBit State 3	0.00°	0.00°	0.00°	0.00°	0.00°
qBit State 4	0.00°	0.00°	0.00°	0.00°	0.00°
qBit State 5	0.00°	0.00°	0.00°	0.00°	0.00°
qBit State 6	0.00°	0.00°	0.00°	0.00°	0.00°
qBit State 7	0.00°	0.00°	0.00°	0.00°	0.00°
qBit State 8	0.00°	0.00°	0.00°	0.00°	0.00°
	Starting State	Step 1	Step 2	Step 3	Step 4

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- **Future approach:** Developing a quantum computer simulator in Python, using Sympy python library (Symbolic Python), instead of Numpy.



- The advantage of this change is that you can represent **very large numbers**, as a result of using arbitrary precision arithmetic. On the other hand, Numpy uses machine arithmetic, which imports limitations.
- Because of arbitrary precision arithmetic we can represent very large, very small, or very precise numbers.



- The basic idea of this approach is:
 - to use Sympy library of Python to do symbolic manipulation of quantum computations
 - to use mpmath library of Sympy for the numerical computations at the final step that we get the final quantum register (output), in order to compute the measure and phase of each state of quantum register.



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THANK YOU ! ! !



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