Quantum Circuit Simulator for Mobile Devices Running Android OS

SE 360 Advances In Software Development Final Project Proposal

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1 Introduction

Quantum computers use the parallel computation power that is hidden within objects that are governed by quantum physics rather than classic physics. Due to its power to solve primitive problems such as prime factorization significantly faster than current silicon based computers. Quantum computation is getting more and more attention every day and its field of research is expanding exponentially. As more people are getting interested in the topic a tool is needed to make life easier for people who are trying to learn and study quantum computation and quantum information processing.

With these in mind the proposed plan is to build an application that can simulate quantum circuits and runs on the widely popular Android mobile operating system.

1.1 Target Devices

Mobile devices that are running Android 3.0 or above such as tablets or cellphones with a screen larger than 5 inches.

1.2 Target Users

Students studying mathematics, physics or computer engineering is the main targeted user group of this application however it might be a useful tool for researchers and professionals aswell.

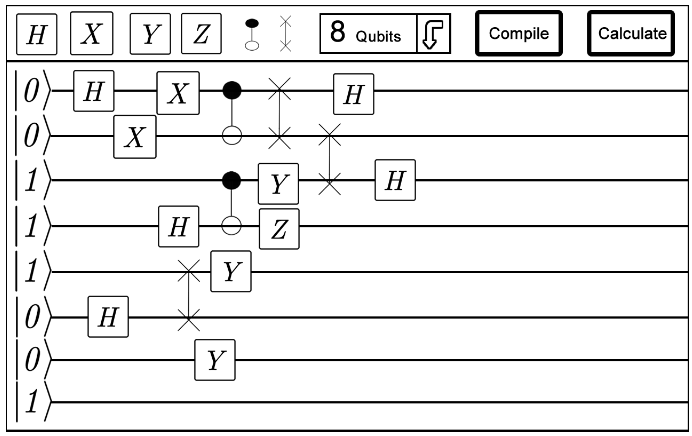
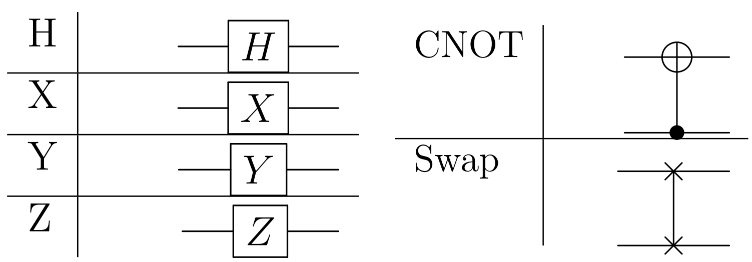


Figure 1: Sample user interface envisioned for the application.

2 Application Description

A quantum gate is represented with a square matrix that has size 2^n where n is the number of qubits the gate takes as input. A qubit is represented as a 2D vector. Both the gate matrix and qubit vector has complex entries.



Gates and their representations

On top of the application is the toolbar where the basic gates such as Hadamard,Pauli-X, Pauli-Y, Pauli-Z, Swap and Cnot are. Next to the gates is there is a spinner that lets the user select how many qubits he/she would like to work on. The qubits will start with state $|0\rangle$ and on click will swap to $|1\rangle$ and go back to state $|0\rangle$ with the second click. The gates on the toolbar can be dragged and dropped to the main area where the circuit will be defined. Gates can be removed from the circuit by dragging them back to the toolbar. By clicking a button on the toolbar the calculation will start and multiply the qubit which is represented by a 2D vector with complex entries. Gates are represented with matrices with dimensions $2^n x 2^n$ where n is the number of qubits the gate takes as input. The result of this multiplication is the 2D output vector. An example of such operation is shown below.

$$|0\rangle = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, H = \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{bmatrix}$$

Hadamard transformation H applied to the given qubit in state $|0\rangle$

$$H|0\rangle = \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{1}{\sqrt{2}} \\ \frac{-1}{\sqrt{2}} \end{bmatrix} = \frac{1}{\sqrt{2}}|0\rangle + \frac{-1}{\sqrt{2}}|1\rangle$$

Quantum computations are done in complex plane and in order realize gates that have complex entries such as the Pauli-Y gate shown in Figure 2. Apache Commons Mathematics Library for Complex Numbers will be used.

$$Y = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}$$

Figure 2: Pauli-Y gate

After the computation a list will be shown to the user with 2^n entries which are probability amplitudes of every state qubit can be measured in. The list will extend beyond the screen size but will be scrollable vertically.

3 Objectives

There are 3 main objectives of this project apart from not missing the deadline and providing a bug-free, working application.

3.1 Ease of Use

First of all application will be fairly easy to use with a clean and simple GUI. Drag/drop which is an intuitive action on a touch screen will be implemented with the framework included in Android API 11.

3.2 Functionality

This project aims to be able to simulate behaviour of any quantum gate or circuit that acts on up to 8 qubits or possibly less depending on screen resolution of the device running.

3.3 Scalability

Users will be able to compile the current circuit into a newly composed gate that is reusable. A new gate icon will be generated on the toolbar for use.