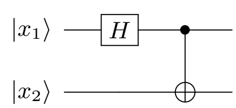
Quantum Computing Tutorial

Quantum Circuits

Peter Röseler

Bell State - Simple

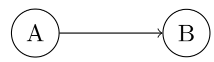
1. Implement the following circuit



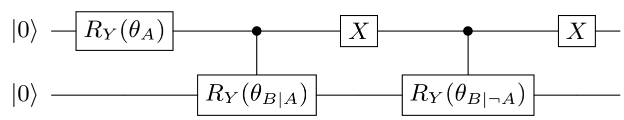
2. Run the circuit for 10,000 shots with the Aer simulator
3. Collect the results and plot them in a histogram

Quantum Bayesian Network - Simple

1. Given is the following Bayesian network:



The quantum circuit for the network is represented by:



, where the R_Y gate represent the rotation

$$R_Y(\theta) = \begin{pmatrix} cos(\frac{\theta}{2}) & -sin(\frac{\theta}{2}) \\ sin(\frac{\theta}{2}) & cos(\frac{\theta}{2}) \end{pmatrix}$$

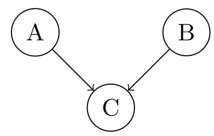
Use the following rotational angles and simulate the circuit with Aer simulator for 10,000 shots:

$$\theta_A = 2 * arcsin\sqrt{0.2}$$

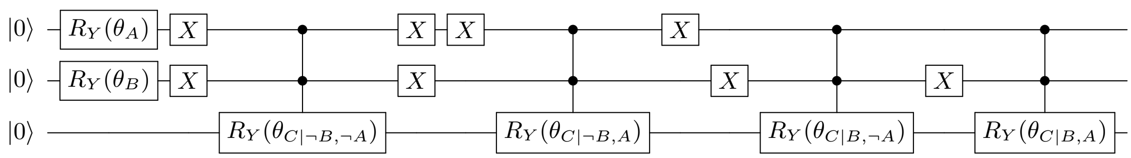
$$\theta_{B|A} = 2 * arcsin\sqrt{0.9}$$

$$\theta_{B|\neg A} = 2 * arcsin\sqrt{0.3}$$

2. Now consider the following network:



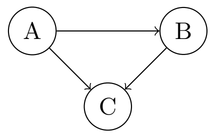
The quantum circuit for the network is represented by:



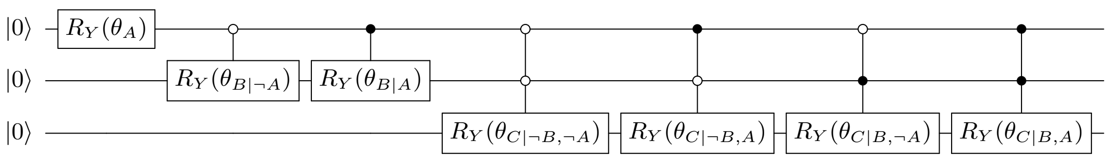
Use the knowledge from before with these new rotation angles to simulate the circuit with the Aer Simulator for 10,000 exposures:

$$\theta_A = 2 * arcsin\sqrt{0.2}$$
$$\theta_B = 2 * arcsin\sqrt{0.2}$$
$$\theta_{C|\neg B,\neg A} = 2 * arcsin\sqrt{0.5}$$
$$\theta_{C|\neg B,A} = 2 * arcsin\sqrt{0.25}$$
$$\theta_{C|B,\neg A} = 2 * arcsin\sqrt{0.75}$$
$$\theta_{C|B,A} = 2 * arcsin\sqrt{0.5}$$

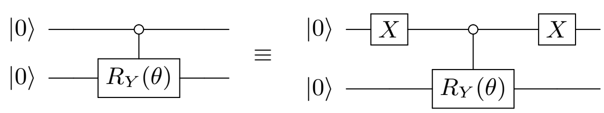
3. Now consider the following network:



The quantum circuit for the network is represented by:



, where

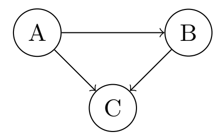


Use the knowledge from before with these new rotation angles to simulate the circuit with the Aer Simulator for 10,000 exposures:

$$\theta_A = 2 * arcsin\sqrt{0.25}$$
$$\theta_{B|\neg A} = 2 * arcsin\sqrt{0.6}$$
$$\theta_{B|A} = 2 * arcsin\sqrt{0.7}$$
$$\theta_{C|\neg B,\neg A} = 2 * arcsin\sqrt{0.1}$$
$$\theta_{C|\neg B,A} = 2 * arcsin\sqrt{0.55}$$
$$\theta_{C|B,\neg A} = 2 * arcsin\sqrt{0.7}$$
$$\theta_{C|B,A} = 2 * arcsin\sqrt{0.9}$$

Quantum Rejection Sampling - Medium

1. Use the third circuit from the Quantum Bayesian Network tasks.



Implement rejection sampling for the circuit for:

$$P(B = 1|A = 0, C = 0) = \frac{\#|010\rangle}{\#|000\rangle + \#|010\rangle}$$

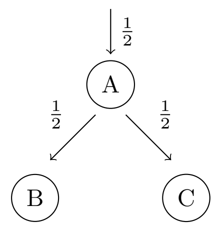
Use the following number of runs:

$$N \in \{1000,\ 5000,\ 10000,\ 20000,\ 50000,\ 100000\}$$

2. Implement quantum rejection sampling with Grovers algorithm

Quantum Pachinko - Medium

1. Implement a quantum circuit for the following Pachinko game



2. Simulate the circuit with 10,000 shots and Aer simulator

3. Repeat steps 1 and 2 for a pachinko game with a depth of 4 and consider an implementation that can be used for an arbitrary depth.