

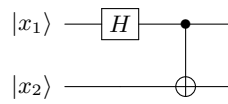
# Quantum Computing Tutorial

## Quantum Circuits

Peter Röseler

### Bell State - Simple

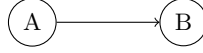
1. Implement the following circuit



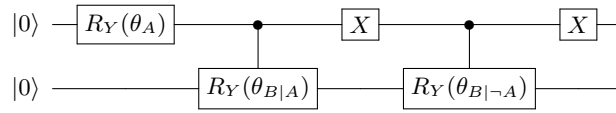
2. Run the circuit for 10,000 shots with the Aer simulator
3. Collect the results and plot them in a histogram

### 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

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

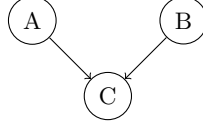
Use the following rotational angles and simulate the circuit with Aer simulator for 10,000 shots:

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

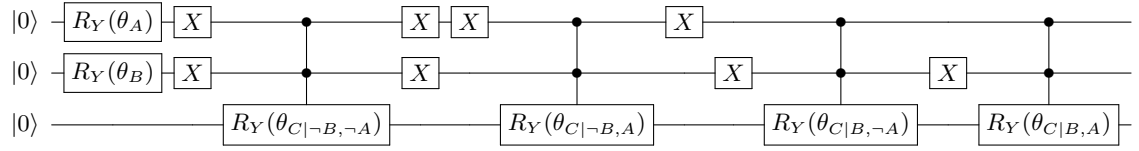
$$\theta_{B|A} = 2 * \arcsin\sqrt{0.9}$$

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

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:

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

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

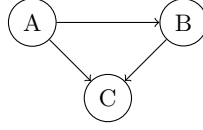
$$\theta_{C|\neg B, \neg A} = 2 * \arcsin\sqrt{0.5}$$

$$\theta_{C|\neg B, A} = 2 * \arcsin\sqrt{0.25}$$

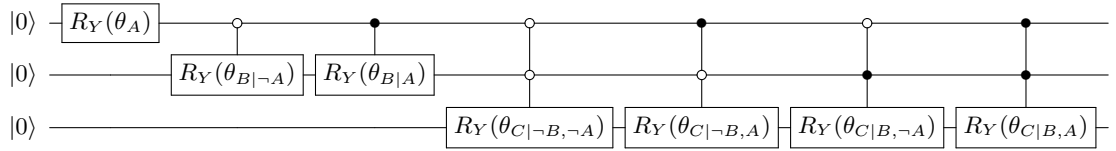
$$\theta_{C|B, \neg A} = 2 * \arcsin\sqrt{0.75}$$

$$\theta_{C|B, A} = 2 * \arcsin\sqrt{0.5}$$

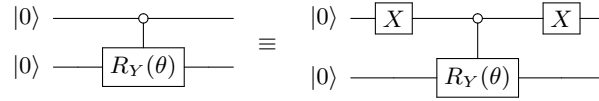
3. Now consider the following network:



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:

$$\theta_A = 2 * \arcsin\sqrt{0.25}$$

$$\theta_{B|\neg A} = 2 * \arcsin\sqrt{0.6}$$

$$\theta_{B|A} = 2 * \arcsin\sqrt{0.7}$$

$$\theta_{C|\neg B, \neg A} = 2 * \arcsin\sqrt{0.1}$$

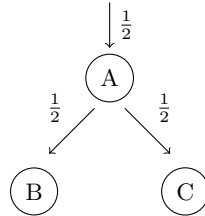
$$\theta_{C|\neg B, A} = 2 * \arcsin\sqrt{0.55}$$

$$\theta_{C|B, \neg A} = 2 * \arcsin\sqrt{0.7}$$

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

**Quantum 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.

