Introduction to Classical and Quantum Computing

Chapter 2 One Quantum Bit

Introduction

Concepts in quantum information and computation are easier to understand by drawing parallels to classical computing.

2.1 Qubit Touchdown: A Quantum Computing Board Game

* 1. Superposition
     1. Zero or One

A ***quantum bit***, or ***qubit*** is both similar to and different from a classical bit.

Like a classical bit, a qubit can take on one of two values when measured 0 and 1. In ***bra-ket*** or ***Dirac*** notation 0 is written as **|0>** and 1 as **|1>**. This is the ***ket*** component. We visualize |0> and |1> as located on the north and south poles of the unit-radius ***Bloch sphere***.

In cartesian coordinates |0> is located at (0, 0, 1) and |1> at (0, 0, -1).

* + 1. Superposition

The laws of quantum mechanics allow a qubit to take on a combination of |0> and |1> when the qubit is in ***superposition***.

Superposition is generalized by putting coefficients in front of both kets as follows *a* |0> + *b* |1>. The qubit can move around on the Bloch sphere by changing its ***relative phase***. The table below summarize six important locations on the Bloch sphere.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ket | Cartesian | *a* | *b* | *a* |0> + *b* |1> |
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We can reach any point on the equator by using complex phases. Also, a qubit in superpositions is not restricted to the equator; it can favor (probabilistically speaking) |0> or |1> by being in the northern or southern hemisphere.

* + 1. Review of Complex Numbers

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* 1. Measurement

2.3.1 Measurement in the Z-Basis

2.3.2 Normalization

2.3.3 Measurement in Other Bases

2.3.4 Consecutive Measurements

* 1. Bloch Sphere Mapping

2.4.1 Global and Relative Phases

2.4.2 Spherical Coordinates

2.4.3 Cartesian Coordinates

* 1. Physical Qubits
  2. Quantum Gates

2.6.1 Linear Maps

2.6.2 Classical Reversible Gates

2.6.3 Common One-Qubit Quantum Gates

2.6.4 General One-Qubit Gates

* 1. Quantum Circuits

2.2.1 Circuit Diagrams

2.2.2 Quirk

2.2.3 Review of Complex Numbers

* 1. Summary