Spring 2018 CS 410/510 - Intro to Quantum Computing

About

- **Instructor**: Fang Song @ FAB 120-07. Email: fsong“AT”pdx.edu.
- **Lectures**: MW 2:00 - 3:50 pm @ FAB 10
- **Office hours**: M 4 - 5pm, Th 1 - 2pm, and by appointment.
- **Course webpage**: http://www.fangsong.info/teaching/s18_4510_qc/. Please check regularly for updates and announcements.
- **Text**: no required ones. We will primarily follow lecture notes and read research papers. See the **resource** page http://www.fangsong.info/teaching/s18_4510_qc/resource/ for recommended books and other useful materials related to the course.
- **Piazza**: This term we will be using Piazza for class discussion. Find our class page at https://piazza.com/pdx/spring2018/cs410510/home. The system is highly catered to getting you help fast and efficiently from classmates and myself. I encourage you to post your questions on Piazza.

Course Description

The law of quantum physics enables **quantum computing**, a revolutionary paradigm of computation. A host of fundamental problems can be solved efficiently on a quantum computer, sometimes expoentially faster than what is possible on a classical computer. The power of quantum computing has promising applications such as in chemistry, machine learning, and cryptography (security backbone of the Internet will be **broken** by quantum attackers!).

In this course, we will study the basic principles and techniques of quantum computing, and discuss some of the applications. The goal is to equip you with the essential tools to appreciate, further explore and (even better) devote to this exciting research area. Tentative topics include: quantum states and circuits, entanglement, quantum algorithms (e.g., Grover's search and Shor's factoring algorithms), quantum complexity theory, quantum error correction, and applications in cryptography.

Recommended texts (not required)

- An Introduction to Quantum Computing by by Phillip Kaye, Raymond Laflamme, Michele Mosca. Online access available through PSU library. A hard copy is also on reserve at the the PSU libary Circulation desk.
- Quantum Computing since Democritus by Scott Aaronson.

Prerequisites

Maturity in algorithm analysis and mathematics (espeically linear algebra, basic probability thoery and group thoery). Quantum mechanics is helpful, but **NOT** required. This course will be theory-oriented involving reading and writing lots of mathematical proofs. I **strongly** recommend you skimming through the first few lectures of these notes by Watrous PDF and by Vazirani link to get a sense what we will be dealing with. If you feel uncertain, please email me to set an appoinment, and I'd be happy to discuss with you.

Main topics

- Part I (~1 week): **Basics**. Qubit, quantum circuit model.
- Part II (~4 weeks): **Quantum algorithms**
  - quantum query model, Deutsch and Deutsch-Josza algorithms
  - Simon's problem, Quantum Fourier Transform

  - phase estimation, order finding, quantum factorization algorithm
  - Grover's search and lower bound
- Part III (~2 weeks): **Quantum information theory**
  - entanglement, Bell's inequality
  - quantum information formalism
  - entropy, Holevo's theorem
  - quantum error correction codes
- Part IV (~2 weeks): **Quantum complexity theory & topics**
  - BQP, QMA
  - quantum cryptography, post-quantum crypto, quantum simulation, etc.

Policy

- **Grading Policy**: Homework 50%, Project 40%, Participation 10%.
- **Homework**: You must turn in hard copies of your assignments before the class begins on the due date. The solutions must be intelligible. I encourage you to type your homework with Markdown or Latex (and submit the printouts). *Late homework* is acceptable, but there will be a penalty of 30% (<1 day), 60% (1-2 days), 100% (>2 days).
- **Collaboration** in small group on homework problems is *highly encouraged*. However, each person must write up their solutions independently. For each problem that you have collaborated with others, you must list the names of your collaborators.
- **Course project**: you will form a group of 3 people maximum and explore research topics related to this course. You may choose to survey a specific topic or take on original research problems. It will be evaluated progressively: proposal (5%), mid-term report (5%), oral presentation (15%), and final report (15%). Details such as suggested topics will be provided after the class begins.
- **Academic integrity**: Students will be responsible for following the PSU Student Conduct Code.
- **Students with disabilities**: If you need academic accommodations, you should register with the Disability Resource Center and notify the instructor immediately to arrange for support services.