Spring 2020 CS 410/510 - Intro to Quantum Computing

About

- **Instructor**: Fang Song @ .
- **Lectures**: F 12:45 - 16:25 @
- **Office hours**: F 11:30 - 12:30 & 4:30 - 5:30pm.
- **Course webpage**: http://www.fangsong.info/teaching/s20_4510_qc/. Please check regularly.
- **Text**: no required ones. We will primarily follow lecture notes, read articles and research papers. See the **resource** page http://www.fangsong.info/teaching/s20_4510_qc/resource/ for recommended books and other useful materials related to the course.
- **Piazza**: We will use Piazza (link will be provided when class starts) for class communication. Post your questions and participate in discussions there.

Course Description

The law of quantum physics enables quantum computing, a new paradigm of computation. It allows for solving certain problems that are intractable on classical computers. In this course, we will study the basic principles and techniques of quantum computing, and discuss some exciting applications.

For the tech-savy students, this would prepare you for future exploration in this emerging field. Aside from the training in analytical skills, another goal of this course is to make you a more critical reader so you have a better idea when flooded with news articles on quantum computing.

Recommended texts (not required)

- An Introduction to Quantum Computing by by Phillip Kaye, Raymond Laflamme, Michele Mosca. Online access available through PSU library.
- 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, and it involes reading both technical and non-technical articles, and writing 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.

Main topics

- Part I (~1 week): **Basics**. Linear algebra review, 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, quantum error correction
- Part IV (~2 weeks): **Selected topics**

  - complexity theory and quantum supremacy
  - quantum-safe cryptography, quantum simulation, etc.
- Part V (~1 week) Project presentation
- In every part (except the last), we will host a special session "Reading and discussion: what does public media say?"

Policy

- **Grading Policy**: Homework 50%, Project 40%, Participation 10%.
- **Homework**: we will use Gradescope to collect assignments (details will be given early in class). I encourage you to type your homework with Markdown or Latex (e.g., use online editor overleaf). *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 small group and carry out some form of research related to this course. This could be (but not limited to) synthesis and criticsm of a set of news articles on a topic which help clear misinformation, or surveying a research topic, or take on original research problems. 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.