Spring 2017

EE214: Quantum Computing

Instructor: Prof. Alexander Korotkov, 827-2345, korotkov@ee.ucr.edu
Office Hours: Tuesday, 4 pm – 5 pm, WCH 434

Time: Lectures: Tuesday, Thursday, 12:40 pm – 2:00 pm, LFSC 2418
Discussion: Friday, 12:10 pm – 1:00 pm, INTS 1132

Prerequisite: a course on Quantum Mechanics or consent of instructor

Description:
This is a 4-unit course, which provides an introduction to quantum computing. Topics include qubits, entanglement, quantum gates, quantum circuit diagrams, simple quantum algorithms, quantum teleportation, quantum cryptography, Shor's factorization algorithm, Grover's search algorithm, and quantum error correction.

Grade type: Letter grade or S/NC

Background:
Students are expected to be familiar with linear algebra and basic concepts of quantum mechanics.

Textbook:
N. D. Mermin, Quantum computer science (Cambridge Univ. Press, 2007)
(errata at http://www.lassp.cornell.edu/mermin/errata-1-12-12.pdf);
http://www.lassp.cornell.edu/mermin/qcomp/CS483.html (lecture notes)

Other resources:
M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information* (Cambridge Univ. Press, 2000);
http://www.theory.caltech.edu/~preskill/ph219/ (lecture notes for the course "Quantum Computation" at Caltech);
http://inst.eecs.berkeley.edu/~cs191 (lecture notes for the course "Qubits, Quantum Mechanics and Computers" at UC Berkeley);
G. Benenti, G. Casati, and G. Strini, *Principles of Quantum Computation and Information*, Vol. I: Basic Concepts (World Scientific, 2005);
C. H. Bennett, *Quantum Information and Computation*, Physics Today, October 1995, pp. 24-30.

Exams, assignments:
There will be two homework assignments (for a letter grade), midterm exam, and final exam.

Course grading (approximate): 25% assignments (for a letter grade), 30% midterm, and 45% final exam.

Covered topics

- Brief overview of quantum mechanics
- General structure of a quantum computer
- Quantum circuit diagrams
- One-qubit logic gates (X, Y, Z, H, S, T, etc.)
- Bloch sphere
- Two-qubit logic gates (CNOT, CZ, SWAP, etc.)
- Three-qubit gates (Toffoli, Fredkin)
- No-cloning theorem
- Quantum parallelism
- Deutsch-Jozsa algorithm
- Bernstein-Vazirani algorithm, Simon's algorithm
- Quantum garbage collection
- EPR paradox, Bell inequality, CHSH inequality
- Quantum teleportation
- Superdense coding
- Quantum cryptography (BB-84 protocol, Ekert protocol, privacy amplification)
- Bit commitment, GHZ puzzle
- Calssical RSA algorithm, factoring via period finding
- Quantum Fourier transform
- Shor's algorithm for integer factorization (period finding)
- Phase estimation algorithm
- Grover's algorithm for searching
- Quantum error correction
- 9-qubit code (Shor), 5-qubit code, 7-qubit code (Steane)
- Fault-tolerant quantum computation
- Classical computational complexity and quantum algorithms
- Scalable quantum computer