CSCI 599 Quantum computing and quantum cryptography

Units: 4
Time: 2021 Fall, MW 3:30-5:20pm
Location: CPA 202
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Course Description

For decades considered a controversial mathematical and theoretical model of Physics, quantum mechanics is now the basis upon which revolutionary computing devices and communication systems are being designed and developed. Quantum computing has emerged as a prominent research area with tremendous potential for practical applications. The quest for practical large scale quantum computation and information processing has become more pressing and competitive. This course serves as an introduction to the fundamental ideas and techniques in quantum computing and quantum cryptography. Background material in mathematics, computer science and quantum mechanics is discussed at a level suitable for beginning graduate students in the three disciplines. our exploration will be guided by the following questions: What are the quantum mechanical principles as they apply to computation? How is quantum computation different from or better than classical computation? What does it take to realize quantum computation? Topics of study and investigation include quantum Fourier sampling, with applications to search, peiord finding, factoring and discrete logarithm problems, and quantum key distribution, with connection to EPR paradox and Bell's inequalities.

Learning Objectives

The main objective of this course is to provide students with the fundamental tools to explore the feasibility and the possibilities of quantum computing and quantum cryptography. The objective is achieved through the combination of lectures, discussions, readings (textbook and selected papers), homework assignments, midterm paper and final project (paper and presentation).

Prerequisite(s): csci 570
Recommended Preparation: linear algebra

Course Notes

Lecture slides and other class information will be posted on Blackboard.

Required Readings and Supplementary Materials

Textbook: Quantum computation and quantum information, Michael A. Nielsen and Issac L. Chuang. Cambridge.
Selected papers.

Description and Assessment of Assignments

About 5 homework assignments will be given throughout the semester. There will be midterm exam and midterm paper. There will be a final project which includes paper and presentation.

Grading Breakdown

Assessment Tool (assignments)	Points	% of Grade
Homework		40
Midterm and paper		30
Final project		30
TOTAL		100

Assignment Submission Policy

Assignments are submitted through Blackboard on or before due times.

Grading Timeline

Assignments will normally be graded and returned within a week

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	What is in a bit? The classical vs quantum model of computing	1.1, 1.2	Homework 1 posted
Week 2	EPR paradox, Bell's inequality and quantum cryptography – First discussion	Papers on EPR and Bell theorem	Homework 1 due
Week 3	Quantum algorithms	1.3, 1.4	Homework 2 posted
Week 4	Quantum algorithms	4.1-4.4	Homewok 2 due
Week 5	Quantum computational complexity	4.5-4.7	Midterm paper abstract due

Week 6	Quantum Fourier sampling	5.1, 5.2	Homework 3 posted
Week 7	Group theory, Number theoretic computation	Appendix 2 and 4	Homework 3 due
Week 8	Quantum order finding, factoring, discrete logarithms	5.3, 5.4	Midterm paper due
Week 9	Quantum search	6.1, 6.2	Homework 4 posted
Week 10	Cryptography	Appendix 5	Homework 4 due
Week 11	Quantum key distribution (QKD)	12.6	Final paper abstract due
Week 12	QKD, Bell's theorem and EPR paradox	Bell's paper, EPR paper	Homework 5 posted
Week 13	Quantum computers	7.1, 7.2, 7.4, 7.6	Homework 5 due
Week 14	Quantum information	12.1, 12.2	Final abstract due
Week 15	Presentation		Paper presentation
FINAL	Final presentation and conclusion		Refer to the final exam schedule in the USC *Schedule of Classes* at classes.usc.edu.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 | Title IX – (213) 821-8298
equity.usc.edu, titleix.usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.