CS 766/QIC 820 Theory of Quantum Information

Description

This course presents a mathematical treatment of the theory of quantum information, with a focus on the development of concepts and methods that are fundamental to a broad range of studies in quantum algorithms and complexity, quantum cryptography, and quantum Shannon theory. The course is intended for graduate students at the Masters or PhD level that have previously taken an introductory course (at the undergraduate or graduate level) in quantum computation.

Outline

The course will cover the following topics. The number of lectures on each topic varies with the material, and additional topics may be added as time permits.

1. *Fundamentals of quantum information.* Quantum states, measurements, and channels, including representations and characterizations of measurements and channels; purifications and fidelity; notions of distance between states, measurements, and channels.
3. *Basic quantum Shannon theory.* Von Neumann entropy and noiseless quantum coding; Lieb's concavity theorem and strong subadditivity of von Neumann entropy; Holevo's theorem and related results.
4. *Theory of entanglement.* The LOCC paradigm; majorization and entanglement transformation; measures of entanglement; the partial transpose and bound entanglement.
5. *Additional topics (as time permits).* Semidefinite programming in quantum information theory; alternative characterizations of the completely bounded trace norm; permutation-invariant states and unitarily invariant measures; the finite quantum de Finetti theorem; approximate cloning of pure states.

Reference material

The primary reference material is a draft of a book to be provided by the instructor. The following books represent optional additional sources of information:

- M. Nielsen and I. Chuang. *Quantum Computation and Quantum Information*. Cambridge University Press, 2000.
- A. Kitaev, A. Shen, and M. Vyalyi. *Classical and Quantum Computation*, volume 47 of *Graduate Studies in Mathematics*. American Mathematical Society, 2002.
- R. Bhatia. *Matrix Analysis*. Springer, 1997.
- R. Horn and C. Johnson. *Matrix Analysis*. Cambridge University Press, 1985.

Grading

Course grade is based 80% on homework assignments and 20% on a final project. Four problem sets will be assigned at regular intervals throughout the course.