Information and Coding
Fall 2016 — Special Topics Course Offering

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OVERVIEW: Information theory is a young branch of mathematics created to study digital data and digital communications. One problem is that of data compression: how to rewrite a digitally encoded message so that it occupies less physical media, such as disk space or memory? Another problem is that of error correction: given a lossy communication channel how to rewrite a digital message so that the message can be accurately transmitted with high probability? The answers to both problems revolve around "Shannon entropy", a single number based on the distribution of symbols in the message, which determines how efficiently both problems can be solved. This course aims at covering topics in probability theory, mathematical modeling and algebra of finite fields. It will be demonstrated how these branches of mathematics work together in solving problems in compression and error correction. Every aspect of the course will be illustrated with short programs written in MATLAB.

COURSE CONTENT: The topics covered will include:

1. Fundamentals of Data Compression.
2. Fundamentals of Error-Correcting Codes.
3. Relevant Topics of Applied Probability.
4. Relevant Topics in Finite Fields.

PREREQUISITES: At least two upper-division courses of: Linear Algebra, Calculus and Probability, Numerical Methods. Ability to write simple programs in MATLAB.

TEXTBOOK AND CLASS MATERIALS: The freely downloadable book "Information Theory, Inference, and Learning Algorithms" by David J.C. MacKay, a Professor of Natural Philosophy at Cavendish Laboratory, University of Cambridge. Research papers and on-line resources.

HOMEWORK AND EXAMS: The grade in the course is based on 1 midterm, final exam and 5 homework assignments. The assignments involve programming in MATLAB, 50–200 lines per assignment.

INSTRUCTOR: Marek Rychlik is a Professor of Mathematics and member of the Applied Math Program. He is a recipient of the 4th Monroe Martin Prize for best paper in applied mathematics, and the solver of the Equichordal Point Problem. His interests range across dynamical systems, algorithm and software development, coding theory and computational algebra. His past experience includes leading a team of scientists and engineers which built data compression software and hardware. He directed 7 completed dissertation projects. His recent graduate students found exciting industrial positions in Silicon Valley (Facebook, Virtual Power Systems), in Tucson (Rayetheon, Metropia), and MathWorks (makers of MATLAB).

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