Course Syllabus: CPSCI 650

Applied Information Theory – Fall 2014

(Thanks to Ben Marlin for this syllabus template.)

Lectures: M/W 9:05-10:20, CS 142.

Course Staff		
	Instructor	**Teaching Assistant**
Name:	Prof. Erik Learned-Miller	Cheni "Henny" Chadowitz
Office Hours:	By appointment.	10am-12pm, Thursdays (check web page for updates)
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Course Description: This course will introduce you to the basic concepts of information theory: entropy, relative entropy (KL-divergence), mutual information, channels, source codes and channel codes. It will explore a range of applications of these concepts in both traditional information theory and in other areas such as computer vision and machine learning. Applications from information theory will include source coding (also known as compression) and channel coding for communication across noisy channels (e.g., cell phone communications, hard drive storage). Additional applications will include image alignment, blind source separation, structure finding in graphical models, and feature selection. Because many of the applications require the estimation of information theoretic quantities from data, learning about these estimators will also form a substantial portion of the course.

Prerequisites: Probability (at the level of CS240). Statistics (at the level of Stats 515). Ability to write simple programs in C++, Matlab, Java, Python, or some similar language.

Textbook (NOTE: We will use the **SECOND EDITION**)**:** *Elements of Information Theory, 2nd Edition.* By Thomas Cover and Joy Thomas. However, you can probably get by with the first edition if that's what you have.

Course Website: http://people.cs.umass.edu/~elm/Teaching/650_F14/

The course website will host lecture notes, assignments, pointers to readings and videos, and announcements.

Announcements: Email will be sent to your *official UMass email address* (@student.umass.edu, @cns.umass.edu, etc...).

Grading Plan: The coursework will consist of homework assignments (written and programming), one midterm exam and a final exam. The grading plan is given below:

Written homeworks	20%
Programming hmwrk (pick best 3 out of 4)	30%
Midterm Exam	20%
Final Exam	30%

Course Policies:

- **Homework Submission:** Written homework assignments may be submitted to the CS650 drop box in the CS main office before 2:00pm on the day they are due, or emailed to the TA before 2pm on the same day. Email failure is not an excuse for lateness, so if you are worried about email, hand your assignment in early.
- Programming assignments must be emailed to the TA by the due time.
- **Late Homework:** If homework is turned in after the due time, it will be docked 10% for the first 24 hours. After that, in general, it won't be accepted. In the case of an extraordinary situation documented by suitable evidence (doctor's note, etc...), an extension or exemption will be granted. **If the situation is predictable (planned travel, for example), you need to get an extension in advance.**
- **Homework Collaboration:** You are encouraged to discuss solution **ideas** for assignments and other course material with other students. However, you must write solutions to written problems and code for programming problems **individually**. Copying is not permitted. Neither is collaboration so close that it looks like copying. If identical homework solutions are detected, all will receive a grade of 0. A good practice is to divide your work into an **ideas phase** where you collaborate, followed by a **writeup or coding phase** where you work alone. You must write a list of all your collaborators at the top of each assignment. This list should include anyone with whom you have discussed the assignment.
- **External Resources:** If you make use of any printed or online reference sources while working on an assignment (other than specific course materials such as the textbook or slides), these must be listed as references in your write-up or code. **Copying written solutions or code from the web is not permitted and is considered cheating.**
- **Re-grading Policy:** If you believe you've found a grading error, submit a **detailed written request** along with your assignment or exam to the instructor (not an email) explaining where you believe a mistake was made. Note that re-grading may result in your original grade increasing or decreasing as appropriate.
- **Attendance:** Students are expected to attend each class.

Approximate Schedule: (Subject to change over the semester)

Activity	Date	Topics
PART I		**Basic IT quantities and applications (except channel coding)**
Lecture 1	Wed, Sep. 3	Overview. History of IT. Discrete entropy, conditional entropy.
Lecture 2	Mon, Sep. 8	Relative entropy (KL divergence) and mutual information.
Lecture 3	Wed, Sep. 10	Jensen's inequality and the concavity of entropy.
Lecture 4	Mon, Sep. 15	Differential entropy. KL and MI of continuous distributions.
Lecture 5	Wed, Sep. 17	Estimating H, KL, MI from data. Basics of estimation.
Lecture 6	Mon, Sep. 22	Plug-in estimators, smoothing, and non-parametric dens. est.
Lecture 7	Wed, Sep. 24	Spacings estimates. KL->negentropy by change of measure.
Lecture 8	Mon. Sep. 29	Application 1: Compression
Lecture 9	Wed. Oct. 1	Compression continued.
Lecture 10	Mon. Oct. 6	Application 2: Independent Components Analysis.
Lecture 11	Wed. Oct. 8	ICA continued.
MIDTERM	**Tues. Oct. 14**	**Midterm 1**
Lecture 12	Wed. Oct. 15	Application 3: Alignment by MI maximization.
Lecture 13	Mon. Oct. 20	Application 4: Joint image alignment by entropy minimization.
Lecture 14	Wed. Oct. 22	Application 5: Finding structure in Graphical Models.
Lecture 15	Mon. Oct. 27	Application 6: Feature selection for classification.
PART II		**Channels and Channel Coding**
Lecture 16	Wed. Oct. 29	The channel formalism and statement of **channel coding thm**.
Lecture 17	Mon. Nov. 3	Common channels (BEC, erasure channel, etc.) , simple codes.
Lecture 18	Wed. Nov. 5	Linear codes (block and convolutional). (Ch. 11, Mackay)
Lecture 19	Mon. Nov. 10	Channel coding thm. Part 1.
Lecture 20	Wed. Nov. 12	Channel coding thm. Part 2.
	Mon. Nov. 17	**NO CLASS (Tuesday schedule)**
PART III		**Other topics (subject to change)**
Lecture 21	Wed. Nov. 19	Application 7: Lempel-Ziv and Universal Codes.
Lecture 22	Mon. Nov. 24	Gaussian channels
Lecture 23	Wed. Nov. 26	Rate distortion theory
Lecture 24	Mon. Dec. 1	Application 8: Maximizing info in biological networks.
Lecture 25	Wed. Dec. 3	Information bottleneck. Last day of class.
Alternatives		Structure of dreams? Info theory in AI.
		Sanov's theorem and bounding the mean from a sample