Formal Modeling in Cognitive Science 1

Lecture 0: Course Mechanics

Frank Keller

School of Informatics
University of Edinburgh
keller@inf.ed.ac.uk

January 6, 2006

Course Content

- *This is essentially a maths course, despite the title;*
- but: mathematical concepts taught from a cognitive science perspective, motivated with cognitive examples;
- emphasis on maths as a tool for understanding cognitive processes;
- emphasis on hand-on learning of mathematical concepts;
- computational tools will play an important role throughout the course.

Course Content

Part 1: Mathematics for Neural and Connectionist Modeling

- Vectors. Dimension of visual space. Norm, distance.
- Cluster plot of visual input. Inner product.
- Matrices, simple transformations.
- Perceptron. Input weighting, digit recognizer, weight matrices.
- Determinants, inverse, eigenvectors, correlation matrix.
- Differentiation, extrema. Cost function.
- Finding minima numerically. Learning algorithm.
- Differential equations. Rate based unit.
- Oscillators, reaction equations.
- Numerical integration, stability analysis.
- Filtering and convolution. Spatial temporal filters.
- Attractors and chaos.
- Coupled neurons, Hopfield network.

Course Content

Part 2: Mathematics for Behavioral and Cognitive Modeling

- Introduction to probability theory. Combinatorial methods.
- Sample spaces, events, probabilities.
- Conditional probability. Bayes' theorem.
- Applications of Bayes' theorem: reasoning, learning.
- Discrete random variables and distributions.
- Marginal and conditional distributions. Continuous random variables.
- Expectation and variance. Chebyshev's theorem.
- Special distributions. Application: eye-movement data.
- Probability theory and logic.
- Entropy.
- Mutual information.
- Codes. Kraft inequality. Source coding theorem.
- Application of information theory: discovering structure.

Target Audience

- The course is primarily designed for students in year 1 of the *MA in Cognitive Science;*
- however, also recommended for students on combined degrees (AI/Psychology, Linguistics/AI, Mind and Language);
- also suitable for other informatics students and for external students;
- formally: FMCS1 is a 1st year undergraduate course at level 8, worth 20 points.

Prerequisites

- There are no formal prerequisites or co-requisites.
- However, it will be advantageous if you attend Informatics 1 at the same time.

Related Courses

Related courses in Informatics:

- **Informatics 1A and 1B:** some of the logic material from Informatics 1A is useful for FMCS1; some of the corpus linguistics material from Informatics 1B is also useful.
- **Mathematics for Informatics 1 and 2:** FMCS1 is designed to be taken *instead* of MI1 and MI2. This means that there will be some overlap with these course; however, FMCS1 takes a different perspective (more cognitive, less mathematical).

Contact Hours

This course consists of:

- 3 lectures per week (in weeks 1–10);
- 1 tutorial per week (in weeks 2–10);
- 1 two-hour lab session, every other week (in weeks 2–10).

Please sign up for tutorials and lab sessions now. State your first and second preference on the sign-up sheet.

The Cast

- **Lecturers:** Frank Keller (course organizer) and Mark van Rossum.
- **Tutor:** Frank Keller.
- **Teaching assistants and lab demonstrators:** Manuel Marques-Pita; Gaurav Malhotra.

Course Infrastructure

- Course *web site* will constantly be updated: `http://www.inf.ed.ac.uk/teaching/courses/fmcs1/`;
- it lists contact details, time/place, schedules of lectures, tutorials, labs;
- for questions of general interest: please post to *newsgroup* `eduni.inf.course.fmcs1`;
- for specific questions: email TAs or course organizer;
- announcements regarding the course will be sent to *mailing list* `fmcs1-students@inf.ed.ac.uk`; all students are subscribed automatically.

Readings

- The main course material are the *lecture notes and slides;* these will appear on the course web site;
- a *reading list* with additional readings for each lecture can be found on the web site;
- a *reader* is available which contains one chapter of each book (copyright restrictions prevent further photocopying);
- all the books on the reading list are in stock in the library in multiple copies.

Readings

- *Greenberg, Michael. 1998. Advanced Engineering Mathematics. 2nd edition.* Main textbook for Part 1. Expensive, but very useful reference.
- *Hertz, J., Krogh, A., and Palmer, R. G. 1991. Introduction to the Theory of Neural Computation.* Background on neural nets for Part 1.
- *Miller, Irwin and Marlys Miller. 2004. John E. Freund's Mathematical Statistics with Applications.* Main textbook for Part 2.
- *Manning, Christopher D. and Hinrich Schtze. 1999. Foundations of Statistical Natural Language Processing.* Background on information theory. Only one chapter needed.

Assessment

The assessment on this course will consist of:

- 4 assessed *assignments,* worth 6.25% each (i.e., 25% in total).
- A final *exam* (120 minutes), worth 75%.

All assignments are due at 16:00 on the due date, and are to be handed in as hardcopies at the ITO. Deadlines for assignments are listed on the course web page.

The assignments include material from the labs and the tutorials, both practical exercises and mathematical problems.

Software

- In the lab sessions, you will learn to solve mathematical and cognitive problems with Matlab;
- Matlab is a *mathematical modeling language;*
- general background in programming as acquired in Informatics 1 is useful (but not essential);
- Matlab tutorials can be found on the course web page;
- Matlab is available on the *Dice system;* if you don't have an account yet, apply now through the ITO.