ORF 557 Syllabus/Hidden Markov Models (Fall 2008)

Abstract. A Hidden Markov Model is the quintessential example of a partially observed system. Such models have consequently found a wide array of applications in topics ranging from target tracking and communications theory, where they are used to model signals corrupted with noise, to speech recognition, bioinformatics, and financial mathematics, where they are used as flexible time series models. Despite that the subject is almost 50 years old, several significant advances have been achieved only in the last decade, both on the theoretical side and in the development of computationally tractable Monte Carlo algorithms for estimation and statistical inference in continuous state spaces. The goal of these lectures is to give a basic introduction to this area. The material includes classical topics such as filtering, smoothing, and parameter estimation, as well as recent topics such as Monte Carlo filtering algorithms and their remarkable convergence properties.

Prerequisites. Some basic familiarity with probability theory and stochastic processes.

Lectures. There are two lectures per week for six weeks (Mondays and Wednesdays from 12:30 to 1:20pm in the Bendheim Center classroom 103; the first lecture is on September 15). I will aim to cover the following topics:

Wk 1: Introduction to hidden Markov models; examples and applications; review of discrete time Markov processes; formal definition of a hidden Markov model.

Wk 2: Filtering, prediction, and smoothing recursions.

Wk 3: Finite state space models; transition and occupation counts; the Viterbi algorithm.

Wk 4: Monte Carlo filtering algorithms and basic convergence.

Wk 5: Filter stability; uniform convergence of Monte Carlo filters.

Wk 6: Maximum likelihood estimation; the EM algorithm; model order estimation.

If time permits, we will discuss some theoretical properties of the maximum likelihood estimates (consistency, etc.) at the end of the course.

Lecture notes. I will follow the lecture notes which can be found here:

http://www.princeton.edu/∼rvan/orf557/hmm080728.pdf

The aim is to cover chapters 1–6 at the rate of roughly one chapter per week.