# MAS 622J: Pattern Recognition and Analysis

**Problem Set 4**
**Date:** Lecture 10,11 **Due:** ¦ Lecture 13

1. Consider the following two 2-state Hidden Markov Models where both states have two possible output symbols $A$ and $B$.

   **Model 1:**

   Transition probabilities: $a_{11} = 0.7$, $a_{12} = 0.3$, $a_{21} = 0.0$, $a_{22} = 1.0$
   ($a_{12}$ is the probability of going from state 1 to state 2)

   Output probabilities: $b_1(A) = 0.8$, $b_1(B) = 0.2$, $b_2(A) = 0.4$, $b_2(B) = 0.6$

   Initial probabilities: $\pi_1 = 0.5$, $\pi_2 = 0.5$.

   **Model 2:**

   Transition probabilities: $a_{11} = 0.6$, $a_{12} = 0.4$, $a_{21} = 0.0$, $a_{22} = 1.0$

   Output probabilities: $b_1(A) = 0.9$, $b_1(B) = 0.1$, $b_2(A) = 0.3$, $b_2(B) = 0.7$

   Initial probabilities: $\pi_1 = 0.4$, $\pi_2 = 0.6$.

   (a) Sketch the state diagram for the two models.

   (b) Which model is more likely to produce the observation sequence $\{A, B, B\}$? Check that your answer is the same when using the forward algorithm, the backward algorithm, and a brute force enumeration of possible state sequences.

   (c) Given the observation sequence $\{A, B, B\}$ find the Viterbi path for each model. Would your answer in (b) differ if you used the likelihood of the Viterbi paths to approximate the likelihood of the model?

2. This is a MATLAB® problem. Download the dataset from the course webpage.

   Implement the Baum-Welch training algorithm for training a discrete HMM. Try training HMMs with one, three and five states with transitions in a strictly left-to-right configuration (see figure below for a 3-state HMM in left-to-right configuration).