Final Examination

CS 540: Introduction to Artificial Intelligence

August 10, 2006

LAST NAME: ______________________________

FIRST NAME: ______________________________

Problem	Score	Max Score
1	______	15
2	______	10
3	______	15
4	______	15
5	______	15
6	______	15
Total	______	85

1. [15] **Perceptrons**

(a) [4] Can a Perceptron learn the "SAME" function of three binary inputs, defined to be 1 if all inputs are the same value and 0 otherwise? Either argue/show that this is impossible or construct a Perceptron that correctly represents this function.

(b) [4] Can a Perceptron learn to correctly classify the following data, where each consists of three binary input values and a binary classification value: (111,1), (110,1), (011,1), (010,0), (000,0)? Either argue/show that this is impossible or construct such a Perceptron.

(c) [4] Consider a Perceptron with 3 inputs and one output unit that uses a linear threshold activation function with threshold 0.7, learning rate 0.2, and initial weights W1=0.2, W2=0.7, W3=0.9.

(i) [1] What is the output of the Perceptron given the inputs I1=1, I2=0, I3=1?

(ii) [3] What are the weights' values after applying the Perceptron Learning Rule with the above input and desired output 0?

(d) [3] Briefly describe a good way to determine when to stop the Perceptron Learning algorithm.

2. [10] **Probabilistic Reasoning**
A barrel contains many plastic eggs. Some eggs are painted red and some are blue. 40% of the eggs in the barrel contain pearls, and the rest contain nothing. 30% of eggs containing pearls are painted blue, and 10% of eggs containing nothing are blue. What is the probability that a blue egg contains a pearl? Use Boolean random variables B for a blue egg, and P for contains a pearl. Show your work.

3. [15] **Naive Bayes**

You are given some documents, each specified by a feature vector, $(X1, X2, X3)$, where each component has a binary value. There are two possible classifications of a document, $C = 0$ or 1. It is 3 times more likely that a document is in class 1 than in class 0. You also know: $P(X1 = 1 \mid C = 0) = 0.25$, $P(X2 = 1 \mid C = 0) = 0.5$, $P(X3 = 1 \mid C = 0) = 0.4$, $P(X1 = 1 \mid C = 1) = 0.5$, $P(X2 = 1 \mid C = 1) = 0.25$, and $P(X3 = 1 \mid C = 1) = 0.3$.

(a) [3] Draw the Bayesian network (with CPTs) that represents this as a Naive Bayes model.

(b) [9] Given a new document with feature vector $(X1 = 0, X2 = 1, X3 = 1)$, determine the classification of this document using the Naive Bayes model represented in (a). Show your work.

(c) [3] Which of the following express the conditional independence assumption that is used in defining Naive Bayes? Give your answer by listing 0 or more of these three.

(i) $P(C \mid X1, X2, X3) = [P(X1, X2, X3 \mid C)\ P(C)]\ /\ P(X1, X2, X3)$
(ii) $P(X1, X2, X3 \mid C) = P(X1 \mid C)\ P(X2 \mid C)\ P(X3 \mid C)$
(iii) $P(X1, X2, X3) = P(X1)\ P(X2)\ P(X3)$

4. [15] **Bayesian Networks**

We want to design a troubleshooting advisor for PCs. Let CF be a Boolean random variable representing whether the Computer Fails (CF = true) or not. Assume there are two possible causes of failure: Electricity-Failure and Malfunction-of-the-Computer, represented using the Boolean random variables EF and MC, respectively. Let $P(EF) = 0.1$, $P(MC) = 0.2$, $P(CF \mid \neg EF, \neg MC) = 0.0$, $P(CF \mid \neg EF, MC) = 0.5$, $P(CF \mid EF, \neg MC) = 1.0$, and $P(CF \mid EF, MC) = 1.0$.

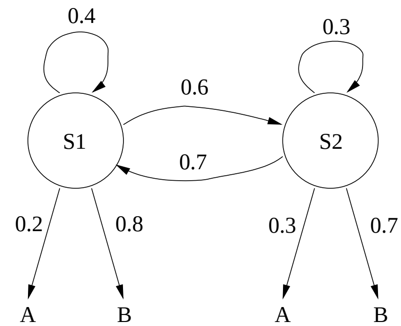
(a) [3] Draw the Bayesian Network (with CPTs) for this problem.

(b) [4] Compute $P(CF, \neg EF, MC)$

(c) [4] Compute $P(MC \mid EF)$

(d) [4] Compute $P(EF \mid CF)$

5. [15] **Hidden Markov Models**
Consider the following HMM with 2 hidden states, S1 and S2, and two possible observation values, A and B, at each time in an observation sequence. Also assume the initial state probability is given by π(s1) = 0.2 and π(s2)=0.8.

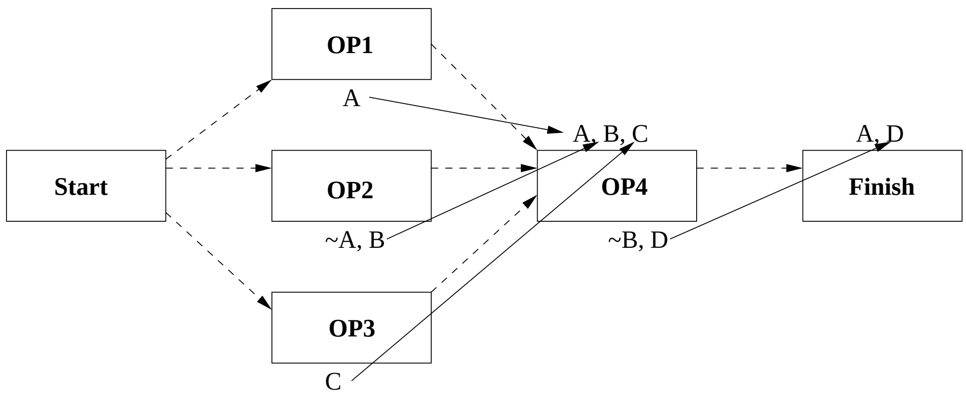


(a) [4] Compute the probability of the hidden state sequence q1=S1, q2=S1, q3=S2, q4=S1.

(b) [9] What is the probability of the observation sequence o1=A, o2=B?

(c) [2] State a problem for this HMM that would be appropriately solved using the Viterbi algorithm.

6. [15] **Partial-Order Planning**
Consider the following intermediate state of a partial-order planner that uses four operators, OP1, OP2, OP3, and OP4. Each operator's preconditions are listed above it's box, and its effects are listed below. Causal links are solid arcs; temporal links are dashed arcs.



(a) [10] Add causal links and temporal links to the above partial-order plan so that there are no open preconditions and no threats. In the case of a threat, also state what is threatening what.

(b) [3] Give all possible solution plans that are consistent with the final partial-order plan you produced in (a).

(c) [2] True or False: In general (i.e., not just the plan above), every partial-order plan with no open preconditions and no threats has a linearization that is a correct solution plan.