UIUC, CS498, Section EA - Autumn 04 - Final Sample (3 hours)

Given by: Eyal Amir

December 13, 2004

1 Short Questions (20%)

Circle the most appropriate answer

1. The Markov Blanket of a variable X within a Bayes Net consists exactly of
   (a) parents of X
   (b) children of X
   (c) (1a) and (1b)
   (d) (1a) and (1b) and parents of children of X

2. Let $\langle X_1, ..., X_n \rangle$ be a total ordering of the variables in a Bayes Net, where for all $1 \leq i \leq n$ all the members of $Pa(X_i)$ appear before X_i in the ordering. The following defines the semantics of the Bayes Net:
   (a) $P(X_i) = P(Pa(X_i))$
   (b) $P(X_i) = P(X_j)$ for all X_j in $Pa(X_i)$
   (c) $P(X_i) = P(X_j)$ for all X_j in the Markov Blanket of X_i
   (d) $P(X_1, ..., X_n) = \prod_{i=1}^{n} P(X_i | Pa(X_i))$

3. In a stationary Dynamic Bayes Net with n binary state variables and a transition model linking every variable at time $t+1$ to exactly one variable at time t, the number of parameters required for a belief state at time t with no observations (starting from a fully factored belief state at time 0) is
   (a) n
   (b) n^2
   (c) $2^n - n$
   (d) 2^n

4. A multi-variate gaussian with n variables takes the following time to compute a marginal over m variables
   (a) $O(mn)$
   (b) $O(m^2 n)$
   (c) $O(n^2 m)$
   (d) $O(n^3)$
   (e) other

5. Gibbs sampling may not converge

(a) over a Bayes Net that is fully factored

(b) over a Markov Field that is fully connected

(c) over a Bayes Net with an OR node (X takes the value $X = Y \vee Z$ deterministically)

(d) over a naive-Bayes model

2 The Hanks-McDermott shooting problem (20%)

The *Hanks-McDermott shooting problem* (sometimes refered to as the “Yale shooting Problem”) is the following story: A person can be either *ALIVE* or *DEAD*. A gun can be either *LOADED* or *UNLOADED*. At a known situation the person is alive. A gun becomes loaded whenever a *LOAD* action occurs. Any time a person is shot (i.e., a *SHOOT* action) with a loaded gun, he becomes dead.

1. Formalize the problem in Situation Calculus. Emphasize which are your Frame Axioms.
2. Write successor-state axioms instead of your Effect and Frame Axioms.
3. Show the process of LOAD;SHOOT as a chain of situations, emphasising what sentences are true in each situation.
4. Add the action WAIT (with the apropriate axioms) to your database. Show the process of LOAD;WAIT;SHOOT as a chain of situations, emphasising what sentences are true in each situation.

3 Probabilistic Graphical Models (20%)

1. Give an algorithm for deciding d-separation in a Bayes Network (with some variables observed).
2. Prove that your algorithm is correct (i.e., correctly reflects conditional independence) from the definition of Bayes Net semantics that you chose in problem 1.

4 Dynamic Probabilistic Graphical Models (20%)

1. Give an algorithm for smoothing in a DBN.
2. Suppose we relax the Markov assumption and make it a second-order Markov assumption. Describe briefly how you will change the algorithm above to compute the smoothed belief state at time k.

5 Paramodulation (20%)

Joe’s phone number is the same as Jill’s phone number. We know that this can happen only when the two people live in the same house. Mary lives in the same house as Bob, but they have different phone numbers. Finally, we also know that Joe’s house has exactly one phone line.

1. Represent this information using FOL (with equality).
2. Prove using paramodulation that Mary or Bob do not live in the same house as Jill.
3. Can you prove the same with demodulation? Is so, prove it. Otherwise, argue why not.