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Computer Science and Engineering 151
Introduction to Artificial Intelligence
May 6, 2003

MIDTERM EXAM

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO START!!!!

- Please DO NOT put your name at the top of each page:
 - This should prevent residual sexism, racism, favoritism lurking in the unconscious of your professor & TA from biasing grading!!
- THE EXAM IS CLOSED BOOK. IN FACT, PLEASE LEAVE YOUR BOOKS AT THE FRONT OF THE CLASS!
- Once the exam has started, SORRY, NO TALKING!!!
- No, you can't even say "later, dude!"
- There are 6 problems: Make sure you have all of them - AFTER I TELL YOU TO START!
- Read each question carefully.
- Remain calm at all times!

Problem	Type	Points	Score
1	True/False	15	
2	Bayes' Rule	15	
3	Probabilistic reasoning I	15	
4	Probability reasoning II	20	
5	Resolution in Propositional Logic	15	
6	Resolution in Predicate Calculus	20	
	Total	100	

True/False

1. (15 pts: +1 for correct, -1 for incorrect, 0 for no answer)

If you would like to justify an answer, feel free.

- _____ Probability theory (as we have described it) subsumes propositional logic as a special case.
- _____ Inference in Bayesian networks can be made efficient by variable elimination.
- _____ The number of entries in a complete joint probability table is exponential in the number of random variables represented.
- _____ The number of entries in a Conditional Probability Table (CPT) of a Bayesian network goes up as the square of the number of parents of the node.
- _____ There are particular formulations of Bayesian networks that support efficient inference – however, the expressibility is restricted.
- _____ A *query* of a Bayesian network consists of a variable that we want to know the marginal distribution of, and some evidence, which consists of particular settings of some of the variables.
- _____ Resolution in propositional logic is intractable.
- _____ Prolog uses Horn clauses, which, while of a restricted form, can represent any formula in FOPC.
- _____ *Modus ponens* is complete, but not sound.
- _____ A *term* in FOPC is something that can have a truth value.
- _____ A *predicate* in FOPC has a truth value, and may have arguments that are terms and other predicates.
- _____ A continuous variable may be more efficiently represented by a parameterized functional form than by a CPT of discretized values.
- _____ A *linear Gaussian* is a Gaussian distribution where the mean of the distribution depends linearly on some other variable.
- _____ An *interpretation* of a set of formulas is a *model* of the formulas if it makes the formulas true.
- _____ In an *interpretation* of a set of formulas, predicates pick out a *set* in the domain being modeled.
- _____ The MCMC method is a technique pioneered by MC Hammer in generating rap dialogues, which consists of a Markov model of rhyming language and a Monte Carlo sampling technique.

Bayes' Rule (15 pts)

2.(a) (6 pts) Explain what the Naive Bayesian assumption is. Do this in the context of deciding whether a face is happy given that the eyes are either angry,neutral and the mouth is either smiling,downturned. Write the formula for happiness given the evidence that the eyes are angry and the mouth is smiling. You may use the α notation.

2. (b) (4pts) Write down what α would be in the above equation.

2. (c) (5 pts) Suppose you have the following somewhat familiar-looking test for a disease that has the following properties, where T means the test came out positively, and D means the patient has the disease.

$$P(T|D) = .8 \text{ (true positive rate)}$$

$$P(T|\neg D) = .02 \text{ (false positive rate)}$$

Assume the test comes out positive. What is the probability that they actually have the disease, if they come from a high-risk group (Prior(D) = .2). You can round to the nearest two significant digits.

Probabilistic reasoning I (15 points)

3. (a) (8 points) Given the following Bayesian network:

Write down first, the general formula for the *semantics* of a Bayesian network, then, write down the specific form that it takes for *this* network (that is, write out the individual factors).

$$P(x_1, x_2, \dots x_n) =$$

3. (b) (7 pts) Given the following CPT's for the above network, write out the results of the query, give $P(C|D = T, B = F)$. As discussed at the review session, you do not actually have to multiply anything out.

Probabilistic Reasoning II (20 points)

4.(a) (8pts) Given the CPT below of two factors of a pointwise product, fill in the entries (don't bother multiplying them out) below.

ii) (8pts) How would you represent the following facts in a Bayesian network? Be as specific as possible. Consider the water generated by the sprinkler system as a continuous variable, while cracking the foundation is a boolean.

1. My sprinkler system can ruin my foundation if it runs too much, soaking the concrete.
2. Sometimes, the power goes out, and my sprinkler system is reset (so that it does not run at all until I reprogram it).
3. Runoff from my neighbor's sprinkler system may also ruin my foundation.
4. The doors in my house won't close if the foundation cracks.

iii) (4 pts) Suppose I come home after a very long vacation, and I find the VCR blinking 12:00, the programs I set it to record at the very beginning of my vacation aren't recorded, and my doors won't close. How would I assess my neighbor's contribution to my problem?

Resolution in propositional logic (15 points)

5. This problem is taken from (Rich and Knight, 1991). Given the following facts in propositional logic, convert them to clause form, and, using a resolution refutation proof, prove $\neg T$.

- P
- $(P \wedge Q) \rightarrow R$
- $(S \vee T) \rightarrow Q$

Resolution in predicate calculus (20 points)

6. This problem is taken from (Rich and Knight, 1991). Translate the following facts into FOPC, convert to clause form, and prove that John likes peanuts using a resolution refutation proof.

1. John likes all kinds of food.
2. Apples are food.
3. Chicken is food.
4. Anything anyone eats and isn't killed by is food.
5. Bill eats peanuts and is still alive.
6. Sue eats everything Bill eats.