Name:
Student ID:

CSE 473 Autumn 2013: Take-Home Final Exam

Total: 100 points, 4 questions
Open book, open notes
Due: Wednesday December 11, 2013 BEFORE 10:30AM
Submit to CSE 473 Dropbox

Instructions:

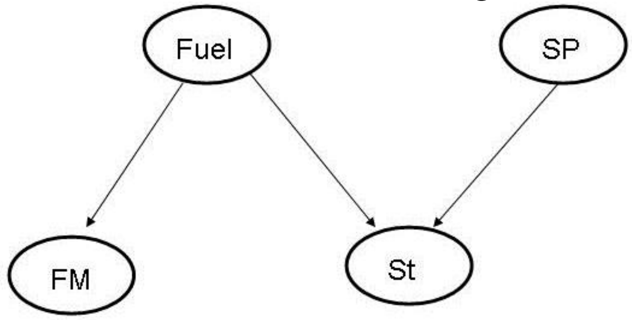
1. Type in your answers using your favorite word processor and/or scan and paste your neatly handwritten solution.
2. Type your name and student ID at the top.
3. Keep your answers brief but provide enough details and explanations to let us know you understand the concepts involved.
4. If you need to draw something or write equations by hand as part of your answer, be sure to scan or photograph the page and include the image as part of your answer.

1) (30 points: 5 points each) Important Concepts and Techniques in AI

Provide brief summaries (150-200 words each) of why the following concepts/techniques are important in AI:

a) Pattern databases
b) Simulated annealing
c) Expectiminimax algorithm
d) Skolemization
e) Ensemble classification techniques
f) *K*-fold cross-validation

2) **(25 points: 5, 3, 3, 6, 8 points) Bayesian Networks**
The following Bayesian network captures some of the causal dependencies pertaining to whether your professor's car will start in the morning:



The random variables *Start?* (St), *Fuel?* (Fuel), and *Clean-Spark-Plugs*? (SP) can each take on the values Yes or No, while *Fuel-Meter* (FM) can take on the values Full, Half, or Empty.
You know **P**(Fuel) = ⟨0.6,0.4⟩ and **P**(SP) = ⟨0.8,0.2⟩. You also know the following conditional probability tables (CPTs) for **P**(FM | Fuel) and **P**(St | Fuel, SP):

Fuel	P(FM = Full)	P(FM = Half)
Yes	0.40	0.40
No	0.05	0.10

Fuel	SP	P(St = Yes)
Yes	Yes	0.95
Yes	No	0.10
No	Yes	0.01
No	No	0

a) Use Bayes rule to compute P(Fuel = Yes | FM = Empty).
b) Write down an expression for the full joint distribution over all the four random variables as a product of conditional probabilities given the above Bayesian network structure.
c) Compute the joint probability P(Fuel = No, SP = Yes, FM = Half, St = No).
d) Use the full joint distribution in (b) and *inference by enumeration* to compute the probability that the car will start given that the fuel meter says "Empty." Show all the steps involved.
e) Use the *variable elimination* algorithm to compute **P**(FM | St = No) (this will consist of three values). Show all the steps involved.

3) (20 points) Decision Trees

Suppose a problem domain is described by the attributes A, B, and C, where A and B can each assume the values *Yes* or *No*, and C can assume the values *Yes*, *No*, or *Maybe*. Based on the decision tree learning algorithm discussed in class and in the textbook (best attribute at each step chosen according to information gain), construct a decision tree for this problem using the following set of training examples:

Example	**A**	**B**	**C**	**Output**
1	*No*	*Yes*	*Yes*	*Yes*
2	*No*	*No*	*Maybe*	*No*
3	*Yes*	*No*	*No*	*No*
4	*Yes*	*Yes*	*Maybe*	*Yes*
5	*Yes*	*No*	*Yes*	*Yes*
6	*No*	*No*	*Yes*	*No*

4) (25 points: 3, 5, 3, 6, 3, 5 points) Support Vector Machines

In class, we discussed how the XOR function is not linearly separable. In this problem, we will construct a support vector machine for XOR. Let x_1 and x_2 be the two inputs, taking on the values -1 or +1. The output is also either -1 or +1.

a) Write down the XOR function as a table. Now draw the function as a 2D plot, using the label "+" for the points with +1 outputs and the label "-" for the points with -1 outputs.

b) Suppose you map all inputs [x_1, x_2] to a new 2D space given by [x_1, x_1x_2]. Write down the table for the XOR function in this new 2D space. You should have one row for each combination of x_1 and x_1x_2.

c) Draw the XOR function in this new 2D space, using "+" for the points with +1 outputs and "-" for the points with -1 outputs.

d) The function should be linearly separable in this new 2D space. What is the maximum margin separating line? Draw it on your plot for (c) and write down an equation for it in terms of x_1 and x_2.

e) What is the value for the margin for your separating line in (d)?

f) Draw the XOR function again in the original 2D space of x_1 and x_2. What does your separating line in (d) correspond to in the 2D space of x_1 and x_2? Draw this (nonlinear) separator and shade the regions that would have an output of -1 for this separator.