Lunds Tekniska Högskola — EDA132
Institutionen för datavetenskap — VT 2012

Tillämpad Artificiell Intelligens
Applied Artificial Intelligence
Tentamen 2012-05-25, 08.00–13.00, Vic 1:D

You can give your answers in Swedish or English.
You are welcome to use a combination of figures and text in your answers.

1. (JM) Make a comparison of *best-first*, *greedy* and A^* algorithms and clarify the differences with figures and explaining text. Answer in particular the following questions: How much better result could you obtain by using A^*? What does it mean that A^* is optimal? (5p)

2. (JM) Make a comparison of *minimax* and *alpha-beta* algorithms and clarify the differences with figures and explaining text. Answer in particular the following question: How much better result could you obtain by using alpha-beta? (4p)

3. (JM) Explain the terms *local consistency*, *arc consistency*, *global constraint* and *local search* in the context of constraint satisfaction problems. Examples are welcome in explanations. (4p)

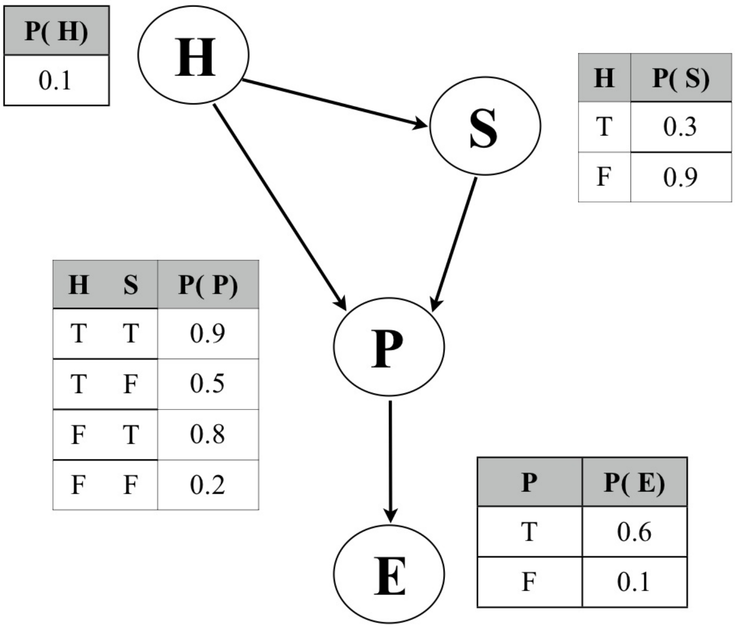
4. (JM) Reasoning
   (a) Describe the *modus ponens* inference rule. Give a concrete example of how it works. (2p)
   (b) What does it mean that resolution is a sound inference rule? (1p)
   (c) Explain the terms *forward chaining* and *backward chaining* in the context of logical reasoning. (2p)
   (d) Explain what SPARQL is and how is it related to reasoning.(2p)

5. (JM) Planning
   (a) Describe the vacuum-cleaning domain (sized 1000 $\times$ 1000) as a planning problem, using STRIPS-kind of operators and the first-order (predicate) logic for states. What should be the goal of your agent? (4p)
   (b) Explain what a *planning graph* is. (2p)

6. (JM) Explain the term *goal-based agent*. Name and describe its modules. (2p)

7. (EAT) Probabilistic representation

Consider the Bayesian network, shown in figure 1. It represents a politician who may or may not be honest (H) and / or slick (S), who is then (or is not) popular (P) and might or might not be elected (E).



P(H)
0.1

H	P(S)
T	0.3
F	0.9

H	S	P(P)
T	T	0.9
T	F	0.5
F	T	0.8
F	F	0.2

P	P(E)
T	0.6
F	0.1

Figure 1: A simple Bayesian net with Boolean variables H = Honest, S = Slick ($\sim$ smart), P = Popular, E = Elected.

a) Which, if any, of the following expressions are asserted by the network structure (ignoring the CPTs)? Explain your answer!

   i) $\mathbf{P}(\ H, S) = \mathbf{P}(\ H)\mathbf{P}(\ S)$

   ii) $\mathbf{P}(\ E \mid P, H) = \mathbf{P}(\ E \mid P)$

   iii) $\mathbf{P}(\ E) \neq \mathbf{P}(\ E \mid H)$ (3p)

b) Suppose we want to add the variable $L = LotsOfCampaignFunds$ to the network. Describe, with justifications, all the changes you would make to the network. It is sufficient to show, WHICH entries the CPTs will have afterwards, you do not need to give the new values. (2p)

8. (PN) Decision trees (7p)

   ID3 is a machine-learning algorithm:

   - ID3 uses a decision trees to classify the data. Describe what it is.
   - In Table 1, you have a simplified data set from the additional Weka collection (UCI). Create manually a decision tree that will separate the data set into two sets: fishes and mammals. The original complete data set can be downloaded from the Weka repository. Hint: One attribute can separate the data perfectly.
   - Give the mathematical formula of the entropy of a two-class set consisting of p positive elements and n negative ones.
   - Assuming a two-class set is partitioned into two subsets, give the formula of the information gain between the original set and the two subsets.
   - Write the ID3 algorithm. You can use a pseudo-algorithmic language or a real language.
   - Should you use the perceptron to classify the data, how would you represent the nominal values representing the individuals?

9. (PN) Perceptron (6p)

   The perceptron is a machine-learning algorithm:

   - In Table 2, you have a simplified data set from Fisher (1936), describing two types of iris: *Iris setosa* and *Iris versicolor*. For each individual plant, Fisher measured four properties: the sepal width and length as well as the petal width and length. You will represent the individuals in Table 2 on a two-dimensional plane using the petal width and length. Use dots of the *I. setosa* and crosses for the *I. versicolor*. The sepal of a plant is the petal cover. You will ignore it.
   - Is it possible to discriminate the individuals using a linear function?
   - Explain what is the objective of the perceptron.
   - Write the perceptron algorithm. You can use a pseudo-algorithmic language or a real language.
   - Should you use the ID3 algorithm to classify the data, how would you deal with numerical data instead of nominal values?

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@ATTRIBUTE animal {aardvark, antelope, bass, bear, boar, buffalo, calf, carp, catfish, cavy, cheetah, chicken, chub, clam, crab, crayfish, crow, deer, dogfish, dolphin, dove, duck, elephant, flamingo, flea, frog, fruitbat, giraffe, girl, gnat, goat, gorilla, gull, haddock, hamster, hare, hawk, herring, honeybee, housefly, kiwi, ladybird, lark, leopard, lion, lobster, lynx, mink, mole, mongoose, moth, newt, octopus, opossum, oryx, ostrich, parakeet, penguin, pheasant, pike, piranha, pitviper, platypus, polecat, pony, porpoise, puma, pussycat, raccoon, reindeer, rhea, scorpion, seahorse, seal, sealion, seasnake, seawasp, skimmer, skua, slowworm, slug, sole, sparrow, squirrel, starfish, stingray, swan, termite, toad, tortoise, tuatara, tuna, vampire, vole, vulture, wallaby, wasp, wolf, worm, wren}
@ATTRIBUTE hair {false, true}
@ATTRIBUTE feathers {false, true}
@ATTRIBUTE eggs {false, true}
@ATTRIBUTE milk {false, true}
@ATTRIBUTE airborne {false, true}
@ATTRIBUTE aquatic {false, true}
@ATTRIBUTE predator {false, true}
@ATTRIBUTE toothed {false, true}
@ATTRIBUTE backbone {false, true}
@ATTRIBUTE breathes {false, true}
@ATTRIBUTE venomous {false, true}
@ATTRIBUTE fins {false, true}
@ATTRIBUTE legs INTEGER [0,9]
@ATTRIBUTE tail {false, true}
@ATTRIBUTE domestic {false, true}
@ATTRIBUTE catsize {false, true}
@ATTRIBUTE type { mammal, fish}
@DATA
aardvark,true,false,false,true,false,false,true,true,true,true,false,false,4,false,false,true,mammal
antelope,true,false,false,true,false,false,false,true,true,true,false,false,4,true,false,true,mammal
bass,false,false,true,false,false,true,true,true,true,false,false,true,0,true,false,false,fish
bear,true,false,false,true,false,false,true,true,true,true,false,false,4,false,false,true,mammal
boar,true,false,false,true,false,false,true,true,true,true,false,false,4,true,false,true,mammal
buffalo,true,false,false,true,false,false,false,true,true,true,false,false,4,true,false,true,mammal
calf,true,false,false,true,false,false,false,true,true,true,false,false,4,true,true,true,mammal
carp,false,false,true,false,false,true,false,true,true,false,false,true,0,true,true,false,fish
catfish,false,false,true,false,false,true,true,true,true,false,false,true,0,true,false,false,fish
cavy,true,false,false,true,false,false,false,true,true,true,false,false,4,false,true,false,mammal
cheetah,true,false,false,true,false,false,true,true,true,true,false,false,4,true,false,true,mammal
chub,false,false,true,false,false,true,true,true,true,false,false,true,0,true,false,false,fish
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Table 1: A data set describing properties of the vertebrates.

@ATTRIBUTE sepallength REAL
@ATTRIBUTE sepalwidth REAL
@ATTRIBUTE petallength REAL
@ATTRIBUTE petalwidth REAL
@ATTRIBUTE class {Iris-setosa,Iris-versicolor}
@DATA
5.1,3.5,1.4,0.2,Iris-setosa
4.9,3.0,1.4,0.2,Iris-setosa
4.7,3.2,1.3,0.2,Iris-setosa
4.6,3.1,1.5,0.2,Iris-setosa
5.0,3.6,1.4,0.2,Iris-setosa
5.4,3.9,1.7,0.4,Iris-setosa
4.6,3.4,1.4,0.3,Iris-setosa
5.0,3.4,1.5,0.2,Iris-setosa
4.4,2.9,1.4,0.2,Iris-setosa
4.9,3.1,1.5,0.1,Iris-setosa
7.0,3.2,4.7,1.4,Iris-versicolor
6.4,3.2,4.5,1.5,Iris-versicolor
6.9,3.1,4.9,1.5,Iris-versicolor
5.5,2.3,4.0,1.3,Iris-versicolor
6.5,2.8,4.6,1.5,Iris-versicolor
5.7,2.8,4.5,1.3,Iris-versicolor
6.3,3.3,4.7,1.6,Iris-versicolor
4.9,2.4,3.3,1.0,Iris-versicolor
6.6,2.9,4.6,1.3,Iris-versicolor
5.2,2.7,3.9,1.4,Iris-versicolor

Table 2: Measurements of the flowers of two iris varieties.

10. (PN) Language Technology (4p)

(a) Describe what part-of-speech tagging is and illustrate it with the sentence *the waiter brought the meal* or alternatively with *kyparen kom med maten.*

(b) Describe how to model the part-of-speech tagging problem using the noisy channel.

(c) The model consists of a product of two terms:

- Write the formula describing the probability of a part-of-speech sequence.
  Approximate this probability using bigrams.
- Write the probability a word sequence given a part-of-speech sequence.
  Write a sensible approximation of this sequence.

Good Luck!