Introduksjon til Kunstig Intelligens (TDT4136)

30th November 2015 Tid:
09:00 – 13:00

Language: English-Bokmål-Nynorsk
Aid - Tillatte hjelpemidler:

No printed or hand written material is allowed. Simple calculator is allowed. Ingen trykte eller håndskrevne hjelpemidler tillatt. Bestemt, enkel kalkulator tillatt.

If you think some necessary information is missing from a question please explain what assumptions you find it necessary to make.

Problem 1   (20 pts, 2pts each question)

Answer the following questions with TRUE or FALSE.

a) Knitting is a fully observable, episodic, stochastic, static and exciting agent environment.

b) Procedural attachment is used in semantic networks.

c) Ontology is not a key component in simple-reflex agents.

d) *Recall* is an evaluation metric used in information retrieval that measures the proportion of returned documents that are truly relevant

e) Simulated annealing is a local search method.

f) Term Frequency (TF) defines the count of a term t in a collection of documents..

g) A common heuristic function for 8-puzzle game is Manhattan distance which is the sum of the distances of the tiles to their goal positions.

h) If both H1 and H2 are admissible heuristics for a problem and H2<H1, then H2 is a better heuristic.

i) An agent must think like a human in order to pass the Turing test..

j) Iterative deepening search is optimal if step-costs is a constant, the search-space is finite and a goal exists.

Problem 2 (15 pts, 3 pts each question)

Choose the correct answers (one for each question) to the questions below.

a) Suppose the following action schema in a planning system for 8-puzzle.

$Action(Slide(t,s_1,s_2),$
    PRECOND: $On(t,s_1) \wedge Tile(t) \wedge Blank(s_2) \wedge Adjacent(s_1,s_2)$
    EFFECT: $On(t,s_2) \wedge Blank(s_1) \wedge \neg On(t,s_1) \wedge \neg Blank(s_2))$

Which of the following needs to be removed from the action schema in order to get "number-of-misplaced-tiles" heuristic?

A. $Blank(s_1)$

B. $Blank(s_2)$

C. $Adjacent(s_1,s_2)$

D. $Blank(s_2) \wedge Adjacent(s_1,s_2)$

E. None of the above

b) We look at a Constraint Satisfaction Problem (CSP) with the three variables X, Y and Z. Let the domain for each of these variables be the set of integers from 1 to 3:

$D_x = D_y = D_z = \{1,2,3\}$

Let the following binary constraint $C_{X,Y}$ apply between X and Y, and $C_{Y,Z}$ between Y and Z:

$C_{X,Y}=[(1,1),(2,1),(2,2),(3,1),(3,2),(3,3)]$

$C_{Y,Z}=[(2,1),(3,1),(3,2)]$

After running AC-3, what is the domain of X?

   A. {1,2,3}   D. {1,2}   G. {3}

   B. {2,3}   E. {1}

   C. {1,3}   F. {2}   H. {}

c) Z is then set to 2 in the CSP from the previous question, and AC-3 is run again. What is now the domain of X?

   A. {1,2,3}   D. {1,2}   G. {3}

   B. {2,3}   E. {1}

   C. {1,3}   F. {2}   H. {}

d) Consider the following (incomplete) game tree for tic-tac-toe. Tic-tac-toe is a two-player game where players "x" and "o" take alternating turns to place their respective symbols in an empty cell on the 3 x 3 game board, with the goal of getting three in a row (horizontally, vertically or diagonally):
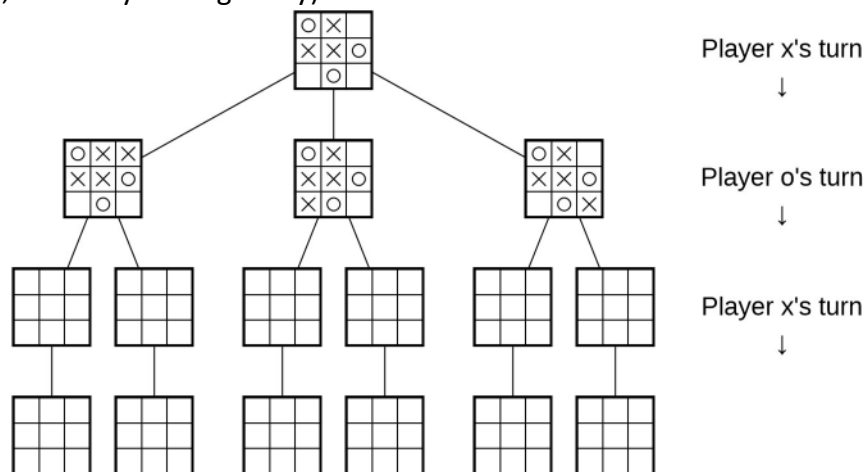
Which one of the following statements is true?

   A. Player x is guaranteed to win

   B. Player o is guaranteed to win

   C. Player x can win, but only if player o plays suboptimally

   D. Player o can win, but only if player x plays suboptimally

E. Either player can win, if the other player plays suboptimally F. Neither/none of the players can win

e) Which of the following may be most useful in generation of a semantic network automatically from documents?

    A. Information retrieval

    B. Sentiment analysis

    C. Syntactic parsing

    D. Information extraction

    E. none of the above.

Problem 3   (15 points)

a) (2 points) For the following sentence in English, is the accompanying sentence in first-order logic a good translation? If yes, answer yes. If no, explain why not.

No two NTNU students have the same ID number.

$\neg\exists x,y,z(NTNUStudent(x)\land NTNUStudent(y)\land \neg (x = y)) => (IDNum(x,z)\land IDNum(y,z))$

b) (2 points) For the following sentence in English, is the accompanying sentence in first-order logic a good translation? If yes, answer yes. If no, explain why not.

All mammals except whales are similar to humans.
$\forall x,yMammal(x)\land \neg Whale(x) => Mammal(y)\land Human(y)\land Similar(x,y)$

c) (2 points) Consider the following knowledge base containing four sentences in propositional logic:

$A => (B \lor C)$

$\neg A => (B \lor C)$

$\neg C$

$(B \lor D) => E$

Can these four sentences be converted to a set of Horn clauses? If yes, write them down; if not, explain why not.

d) (2 points) Consider the following knowledge base containing four sentences in propositional logic: $A \Rightarrow (B \lor C), \neg A \Rightarrow (B \lor C), \neg C, (B \lor D) \Rightarrow E$

Convert the four sentences above into conjunctive normal form(CNF) and show the result as a set of clauses.

e) (3 points) Is the following sentence (1) the correct skolemization (i.e., elimination of existential quantificator) of the sentence $\forall x Person(x) \Leftrightarrow \exists y Heart(y) \land Has(x,y)$?

(1) $\forall x\ Person(x) \Rightarrow Heart(H1) \land Has(x,H1)$.

Why not? Write down the correct one.

f) (4 points) Suppose the following facts are in the knowledge base:

- Pia works in a restaurant $R(Pia)$

- Georg works in a restaurant $R(Georg)$

- Anyone who works in a restaurant and makes a big mistake is fired
  $\forall x R(x) \land M(x) \Rightarrow F(x)$

- The restaurant owner is happy with anyone who doesn't make a big mistake
  $\forall y\ \neg M(y) \Rightarrow H(owner,y)$

- Anyone who is happy with Pia is unhappy with Georg
  $\forall w H(w,Pia) \Rightarrow \neg H(w,Georg)$

Using resolution refutation, prove that "there exists someone who makes a big mistake and is fired". Show your proof on a tree starting from the boxes in the figure below. Copy the boxes into your answer sheet and fill in the last box. Apply resolution and clearly indicate the clauses being resolved in each step. Show also the binding of variables in each step/link.

Problem 4   (10 points)

NOTE: There is a correction in the points of the sub-questions. (a) should be 4 points and (b) is 2 points.

We changed the rules of the wumpus world. First of all, we are dealing only with wumpuses, not with gold, breeze, stench, etc. There may be more than one wumpus in the grid and they may be in any square. In the beginning of the game all squares are blank and the agent does not know which square(s) contains a wumpus. When the agent clicks on a square with a wumpus, she loses the game. If the square that the agent clicked on does not contain a wumpus, a number will appear on that square indicating the number of wumpuses adjacent to the square. Adjacency here means the four squares to the immediate left, right, top and bottom, excluding the diagonals. The goal of the game is to click on all squares which do not have wumpuses. Suppose you are playing the game in the following figure showing the current state of the grid. In the figure, squares marked *a, b, c,* and *d* are not clicked on yet. You may refer to these squares by these variables. The upper-left square is labeled 1, meaning that it is adjacent to exactly one wumpus. The other squares show the number of wumpuses in their adjacent squares.

1	a
b	2
d	c

a) (4 points) Represent the current state of the grid using propositional logic. Use the predicate W(s) to express that square *s* contains a wumpus, and ¬$W(s)$ *s* not having a wumpus.

b) (2 points) Suppose you click on the lower-left square (which is a *d* in the beginning, see the figure) and number two (2) is revealed. This means that there is no wumpus in that square but two of squares adjacent to it have wumpuses. Represent this situation of the grid using propositional logic.

c) (4 points) Prove ¬$W(a)$, that is, the square labeled *a* does not contain a wumpus. For this use the combination of initial knowledge base and the new knowledge obtained by clicking on *d*. Show your proof by resolution refutation on a drawing.

a) Both b and c should have a wumpus. Therefore we can write

$W(b) \wedge W(c)$
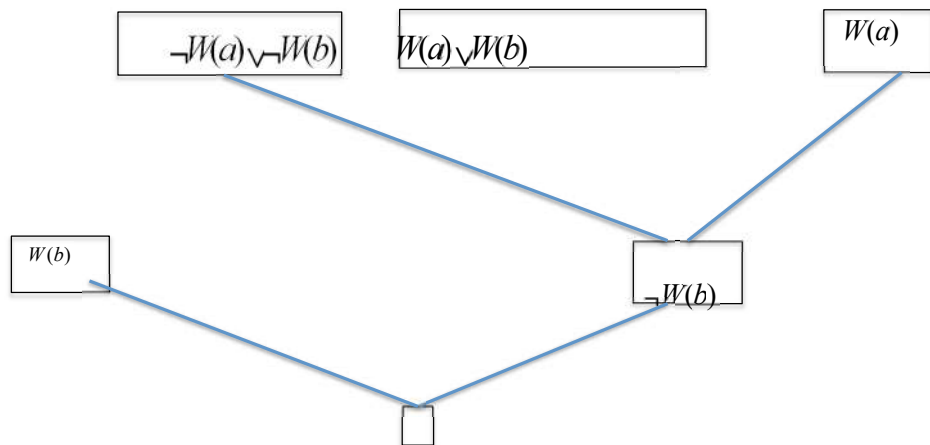
b) First convert the KB into CNF form. E.g.,

$(W(a) \vee W(b)) \wedge (\neg W(a) \vee W(b))$
In CNF form: $(W(a) \vee W(b)) \wedge (\neg W(a) \vee \neg W(b))$ etc.

To prove, add the contradiction (i.e. W(a)) of the query to the KB. Then resolve W(a) with ($\neg W(a) \vee \neg W(b)$) to conclude $\neg W(b)$.
Apply AND-elimination on W(b) $\wedge W(c)$ to get W(b). Resolve this with $\neg W(b)$ obtained above to get the contradiction.

Problem 5 (10 points)

This is a planning problem to be solved using GraphPlan algorithm. The initial state is represented as {R,H,Q}. The goal state is {D,P, ,¬R }. There are four actions (Cx, Wx, Tx, and Vx) of which preconditions and effects (in terms of add and delete) are shown in the following figure.

Action	Precond	Add	Delete
Cx	{H}	{D}	{}
Wx	{Q}	{P}	{}
Tx	{}	{}	{H, R}
Vx	{}	{}	{Q, R}

a) (1 point) Under which conditions does a plan graph level off (i.e., stops expanding)?

b) (3 points) Starting from state level zero (i.e., S_0) draw the graph of the plan (i.e, the state and the action levels with mutex relations) applying the GraphPlan algorithm. Expand the graph as long as it is necessary for obtaining a plan. Use "NOP" for the persistence (no operation/maintenance) actions.

c) (3 points) Is it possible to find a plan for this problem at state level S_1? In case it is possible, write down the plan. In case it is not possible, justify your answer by writing down the mutex relation(s) that hinders the extraction of a plan from the graph. Write down each mutex relation (both those between the states and between the actions) and explain why it is mutex.

d) (3 points) Are the following plans in (1) and (2) below valid plans, according to your answers above? Explain why or why not.

1. $Cx => Wx => Tx$

2. $Wx => Cx => Tx$

Problem 6   (10 pts, 2 pts each question)
Choose the correct answers (one for each question) to the questions below.

a) What is the primary drawback of hill-climbing search?

   A. The search can get stuck in a local maximum

   B. The algorithm requires a lot of memory

C. The search can get stuck in a global maximum

D. The result depends strongly on the temperature schedule

b) When we illustrate the Minimax algorithm, we use the symbols 4 and 5 for nodes in the search tree. A variation of the Minimax algorithm additionally uses the symbol for some of the nodes. What does this symbol represent?

A. A second opponent in a multiplayer game

B. A game rule has been broken

C. An element of chance in the game

D. An estimated score, due to cutoff

E. A tie between the players

c) Which of the following researchers did not participate in the Dartmouth conference where the name "artificial intelligence" was coined?

A. John McCarthy

B. Marvin Minsky

 C. Herbert Simon

D. Allen Newell

E. Alan Turing

d) Which of the following is the main inference mechanism in semantic networks?

A. Resolution refutation

B. Generalized modus ponens

C. Inheritance

D. Skolemization

E. De Morgan's law

e) Which of the following would you choose as the unifier for
UNIFY (*Loves*(*Per,x*),*Loves*(*y,z*))? Explain why. No points will be given without correct explanation.

A. (y/Per, x/z)

B. (y/Per, x/Per, z/Per)

C. (y/Per, x/z, z/Siri)

D. none of the above are suitable unifiers.

Problem 7   (10 points)

Consider the following search problem:
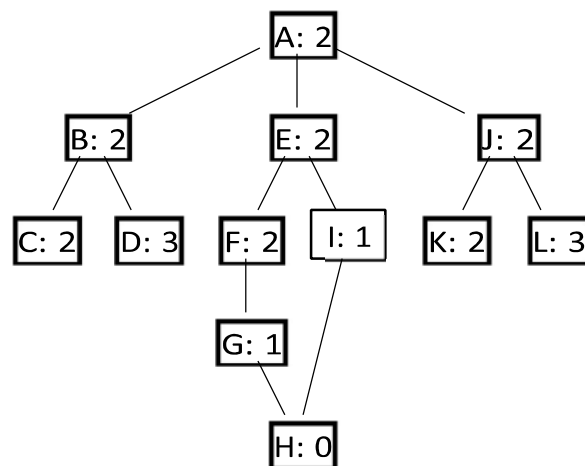
The initial node is A and the goal node is H. All step costs are 1, and a heuristic value is given for each node in the figure (for example, the heuristic value for node D is given as 3). Assume that there is a goal-test function which will be called by the search algorithm every time it needs to determine whether a node is a goal node.

a) (2 points) Using breadth-first search (BFS): What is the sequence of nodes for which the goal-test function will be called? Write the letters for each node, and in the correct order.

b) (1 point) Using breadth-first search (BFS): What will be returned as the shortest path to the goal?

c) (6 points) Using A*: What is the sequence of nodes for which the goal-test function will be called? Whenever several nodes have the same estimated cost, always choose the node that comes first alphabetically.

a) (1 point) Using A*: What will be returned as the shortest path to the goal?

Problem 8   (10 points)

Consider the following Minimax tree:
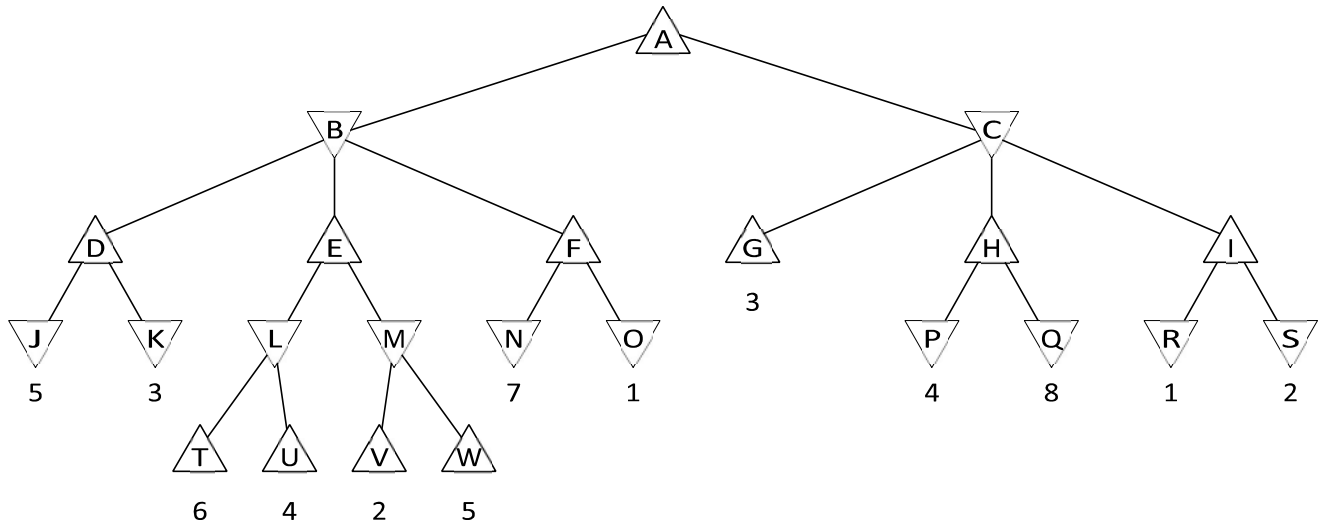
The leaf nodes have their final utility values given as numbers below them.

a) (2 points) What is the final value in node A, after running Minimax?

b) (3 points) What is the final value of the rest of the internal nodes, after running Minimax? Write the values for the nodes in alphabetical order, and do not include the root node or the leaf nodes. In other words, write the numbers in the order B, C, D, E, F, H, I, L, M.

c) (5 points) Which nodes will be pruned when using alpha-beta pruning on this tree (assuming nodes are evaluated from left to right)? Give the answer as a list of the nodes' letters in alphabetical order, and include *all* of the nodes in the branches that are pruned.

GOOD LUCK!