

Examination Intelligent Systems

"Antwoord puntenverdeling"

January 31st 2014. 12.00 – 14.45

- Use of a normal (not graphical) calculator is allowed
- Always show how you got to your answers
- Write READABLE. If we cannot read your answer, you will get no points
- You can get 100 points in total: distributed as follows:

E1	E2	E3	E4	E5	E6	E7	Free points	Total
15	15	15	10	15	10	10	10	100

- You may answer in English or Dutch
- This exam has 4 pages and 7 exercises. Do not lose too much time with one exercise!

Exercise 1: Search algorithms (15 Points)

A small university has just one room and teaches two courses IS and WT in 5 time-slots at 9.00, 11.00, 13.00, 15.00 and 17.00. It turns out that IS has originally been scheduled at 9.00 and 11.00, and WT at 15.00 and 17.00. Of course, the lecturer of IS wants this to be changed, so that both IS classes are scheduled **after** the WT classes.

Unfortunately, the scheduling system only allows at each step to reschedule a single course:

- either to an adjacent free slot (at cost 2), or
- to hop over several filled slots into an empty slot. This costs the number of slots you jump over.

Graphically, this can be represented as:

9	11	13	15	17
IS	IS		WT	WT

In this situation, the courses at 11.00 and 15.00 can be rescheduled to 13.00 at cost 2, the courses at 9.00 and 17.00 can be rescheduled to 13.00 at cost 1. (don't be confused by the fact that this is not necessarily the most logical cost model).

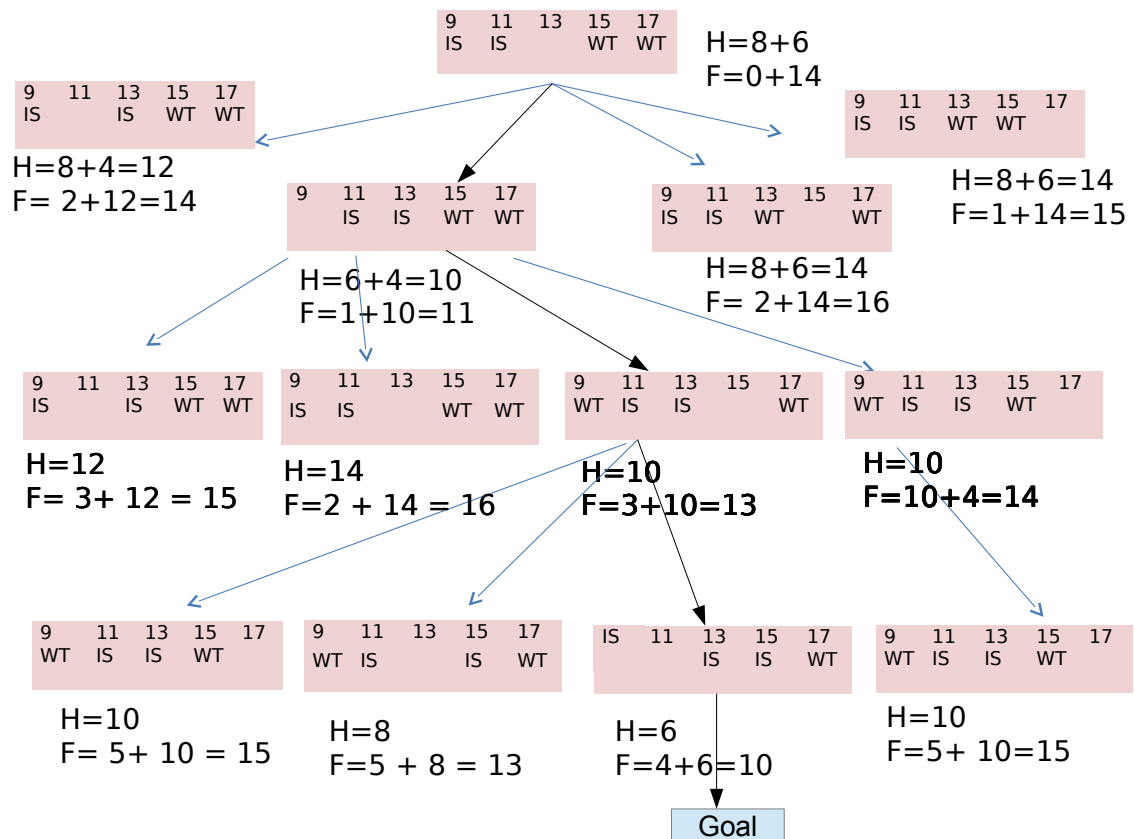
- a) Describe this problem as a state-space search problem. Remember the key elements of a search-space. A bullet point list will do.

Let h be a heuristics that counts the difference in starting time of the two IS classes from the students' most favourite timeslot, which is 17.00. So, the 9.00 slot has a value of $17-9=8$, the slot at 11 a value of $17-11=6$, and so forth. The value h for the situation given above (with one IS course at 9, the other at 11) is thus: $h(X) = 8 + 6 = 14$.

- b) Draw the beginning of the search tree for an A algorithm (the first 12 nodes). Include at each node the value for f, g and h , and give the order in which the nodes of the tree are visited.

c) Explain whether this A algorithm is also an A* algorithms or not.

Answers:



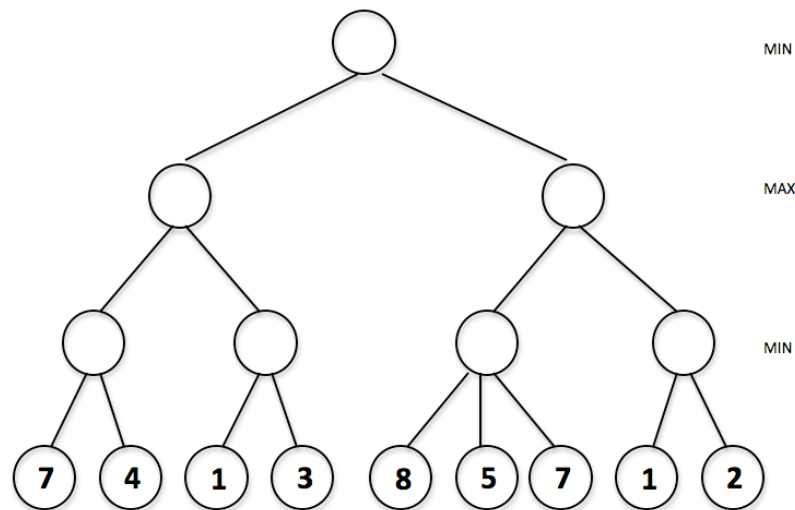
- 4 points for 1a) one each for a) what are the states, whats the goal state, transitions and initial state.

- 8 points for 1b) the tree. 4 for heuristics, 4 for correct tree.

- 3 points for 1c) 2 for explanation, 1 for correct answer

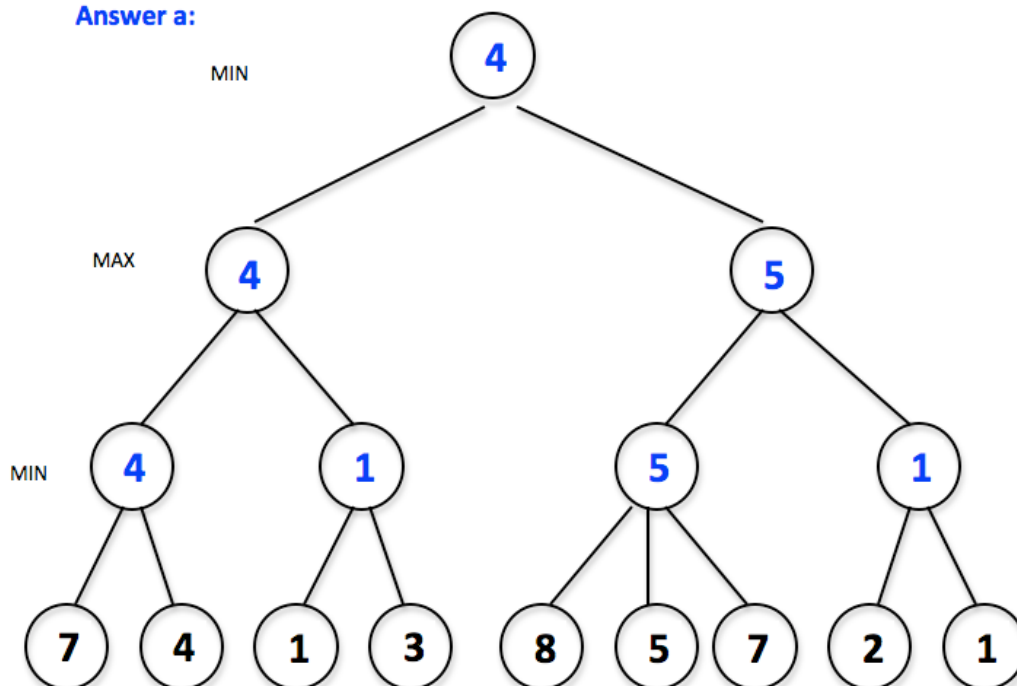
Exercise 2: Gaming (15 Points)

Consider the following Minimax-tree. Possible values in this tree are 1-8.



- a) Use the Minimax-algorithm to compute who is the winning player when both players play optimally. MIN wins the game with values 1,2,3 and 4 and MAX wins the game with values 5,6,7 and 8. Explain/Show how you made up your answer.

Answer a:

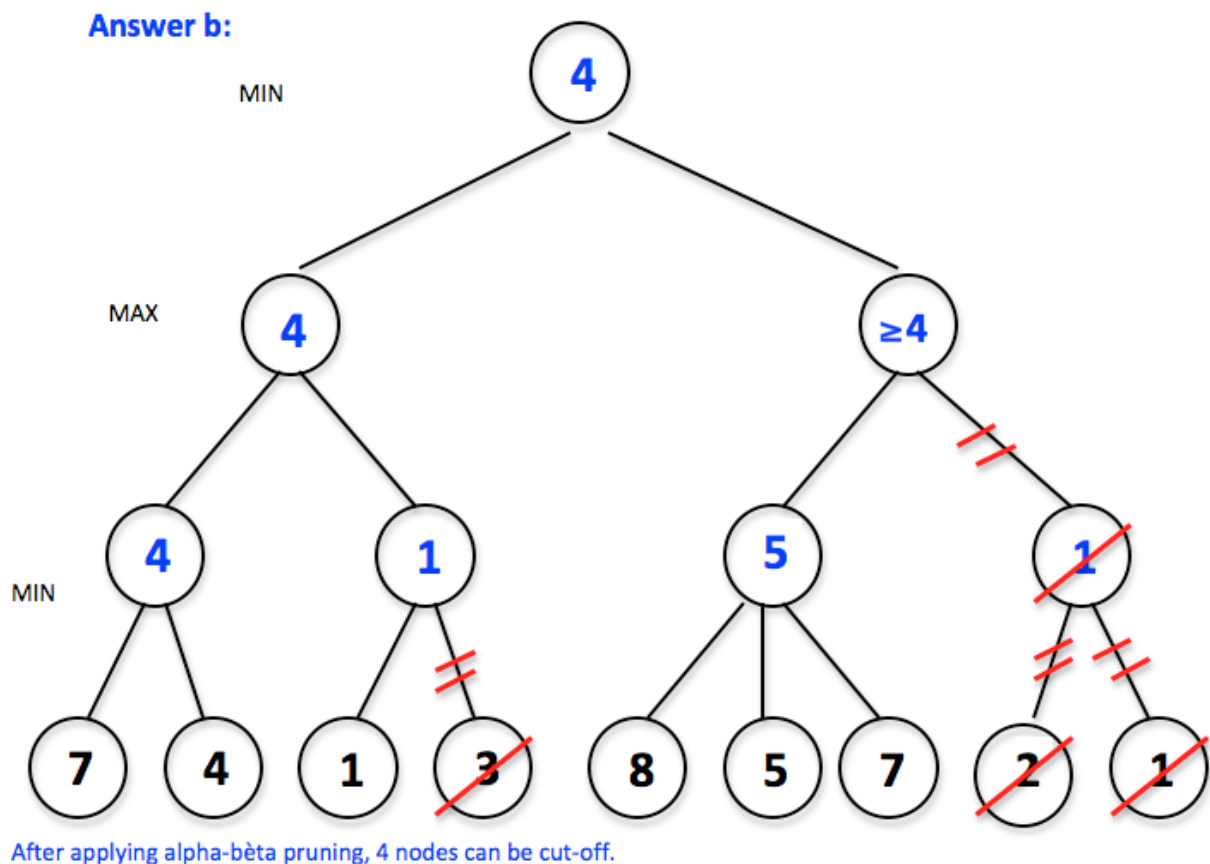


After applying the minimax algorithm, number 4 will be the root of the tree, which means that MIN is the winning player in this game.

- 5 points for the tree, 2 points for the conclusion.

- b) Use Alpha-Beta pruning to reduce the search space. The algorithm searches from the left to the right side and MIN aims at reaching the lowest possible value whereas MAX aims at reaching the highest possible value. If there are, how many nodes can be cut-off by

the algorithm? Write down not only a number, give also a drawing of the nodes that can be cut-off.



- 6 points for the tree, 2 points for the conclusion.

Exercise 3: Constraint Satisfaction Problem (15 Points)

We have four tasks to complete; we are trying to schedule them.

Task (A) “preparation at home” takes 3 hours and precedes the tasks “going to the lecture” (B) and “design-application” (C). Task “going-to-the-lecture” (B) takes two hours and precedes task “implementation” (D). Task “design-algorithm” (C) takes four hours and precedes task “implementation” (D). Task “implementation” (D) takes 2 hours.

We model this problem with a variable for each of the task start times, namely startA, startB, startC and startD. We'll also have a variable for the overall start time “start”, and a variable for the overall finishing time “finish”. The domain for variable start is {0}, and the domain for all the other variables is {0,1,...,11}.

- Translate the above problem into constraints in our formal model.
- Is the variable startA arc-consistent with respect to the variable startB?
If not, what is the new domain for startA?
- Are the variables {startA, startB} path-consistent with respect to the variable startD?
If not, give the new domains of the variables startA and startB.

ANSWERS:

a)

$\text{start} \leq \text{startA}$
 $\text{startA} + 3 \leq \text{startB}$
 $\text{startA} + 3 \leq \text{startC}$
 $\text{startB} + 2 \leq \text{startD}$
 $\text{startC} + 2 \leq \text{startD}$
 $\text{startD} + 4 \leq \text{finish}$

b) No, $\{0, \dots, 8\}$

c) No, $D_A: \{0, \dots, 8\}$, $D_B: \{3, \dots, 9\}$

puntenverdeling:

a) 8 (geen duration 5)

b) 4

c) 4

Exercise 4: Logical agents (resolution proof) (10 Points)

Given is the following information:

"If a lecture for IS at the VU University is scheduled at 9AM (L), then many students of the IS course will use the snooze button... (S). When the large rooms were already booked for 11AM (B), then the lecture for IS is scheduled at 9AM (L) and the lecturers are frustrated (F). When the lecturers are frustrated and many students use the snooze button, understanding of all theory will be more complicated (U)."

One lecturer claimed in November: 'Oh, no. If the large rooms are already booked for 11AM, many students of the IS course will use the snooze button!'

Use a resolution proof – with all necessary steps (!) – by using the information given above to determine the claim is entailed by the above information or not. Please use the abbreviations given in brackets.

Answer:

I used the following symbols:

L: a lecture for IS is scheduled at 9AM

S: many students of the IS course use the snooze button

B: large rooms are already booked for 11AM

U: understanding of all theory will be more complicated

Logical representation

$L \rightarrow S$

$B \rightarrow L \ \& \ F$

$F \& S \rightarrow U$

Claim: $B \rightarrow S$ Negation of claim in CNF: $\neg(B \vee S) = B \& \neg S = B \mid \neg S$

Clause Normal Form

1. $\neg L \vee S$
2. $\neg B \vee L$
3. $\neg B \vee F$
4. $\neg F \vee \neg S \vee U$
5. B
6. $\neg S$

Resolution	Resolution (other option):
7. $\neg L$ (1 and 6)	7. L (2 and 5)
8. $\neg B$ (2 (or 3) and 7)	8. S (1 and 7)
9 {} (5 and 8)	9 {} (6 and 8)

An empty clause is found when the negation of the claim is used, which means that the original claim ' $B \rightarrow S$ ' is true.

- 2 points for logical representation
- 3 points for clause normal form (incl. negation of claim)
- 5 points for resolution and right conclusion.

Exercise 5: Machine Learning (15 Points)

The lectures at the VU can be classified according to three criteria:

1. Time (9.00 or 11.00)
2. About Artificial Agents (A) or Logic (L), or
3. Master (M) or Bachelor (B) level.

There were three lectures in the past from which to learn:

- Intelligent Systems (a Bachelor course at 9.00, about Artificial Agents)
- Semantic Web (a Bachelor course at 9.00, about Logic)
- Automated Reasoning (a Master course at 11.00, about Logic)

The lectures of the first two are empty (E), for Automated Reasoning it is packed (P) until the final lecture.

- a) Show, using **Naive Bayesian Learning** (with Laplace Smoothing), how to predict whether the course Intelligent Web Applications (a Master course about Artificial Agents scheduled at 9.00) is going to be empty or packed. Please use the abbreviations given in brackets.
- b) Explain (very briefly) why this method is called naive.

Solution:

$$P(P|M,A,9) = P(P) * P(M|P) * P(A|P) * P(9|P) = 1/3 * 1 * 0.01 * 0.01 = 0.00003$$

$$P(E|M,A,9) = P(E) * P(M|E) * P(A|E) * P(9|E) = 2/3 * 0.01 * 1/2 * 1 = 0.003$$

So, it can be expected that IWA will have an empty lecture room.

The method is naive because it assumes independence of the features (time, topic, level).

5 a) 10 points, 2 for probabilities, 2 Bayes rule, 2 smoothing, 2 comparison, 2 for prediction

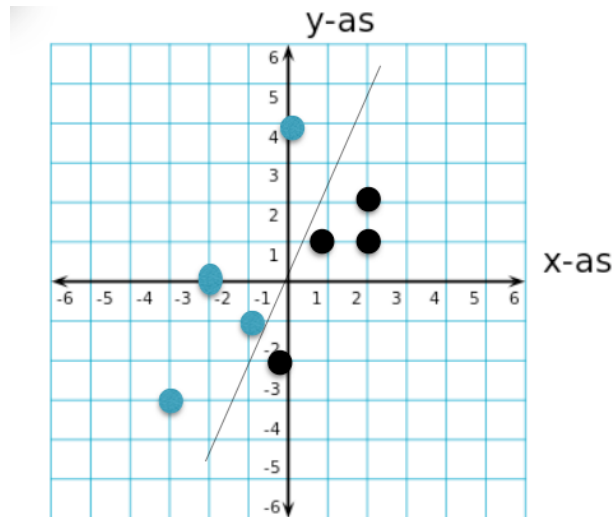
5 b) 5 points: correct answer is independence of features. Points for closeness to this answer.

Exercise 6: Neural Networks (10 Points)

Given the following training set for a classification problem of two concepts A (blue) and B (black).

Class A (-1): examples: (-2,0), (-1,-1), (-3,-3), (0,4)

Class B (1): examples: (1,1), (2,1), (2,2), (0,-2)



We use a simple perceptron learning algorithm for learning the two concepts.

Decision region for concept A : $w_0 + w_1.x_1 + w_2.x_2 < 0$

Decision region for concept B: $w_0 + w_1.x_1 + w_2.x_2 > 0$

The learning rate parameter is 0.2.

Start with all weights of 0.5

Desired value of A is -1, and the desired value of B is 1.

Questions:

- Consider point (0,-2). Show whether the output for (0,-2) is in correspondence with the training set.
- Update the weights if needed based on (0,-2) (from 7a)), and show whether the output for the next example point (1,1) in correspondence is with the training set.
- Adapt the training set in such a way that the perceptron learning algorithm cannot solve the classification problem. Give a short explanation.

Answer:

a. $0.5 + 0.5 \times 0 + 0.5 \times -2 = -0.5$ (is A volgens regel, maar in trainingenset B)

b) aanpassen gewichten:

$$w_0 = 0.5 + 0.2 \times 1 \times 1 = 0.7$$

$$w_1 = 0.5 + 0.2 \times 0 \times 1 = 0.5,$$

$$w_2 = 0.5 + 0.2 \times -2 \times 1 = 0.1$$

$$0.7 + 0.5 \times X_1 + 0.1 \times X_2$$

(X1,X2) nu (1,1) $0.7 + 0.5 + 0.1 = 1.3$ (is B volgens regel, in trainingset ook B).

c) punten zo toevoegen dat er geen rechte lijn meer doorgetrokken kan worden om de A's en de B's te classificeren. Een single-layer perceptron niet meer afdoende is voor het kunnen classificeren van de punten.

Punerverdeling:

a) 4 (verkeerde conclusie 3 punten)

b) 4 (alleen verkeerde d waarde, 3 punten)

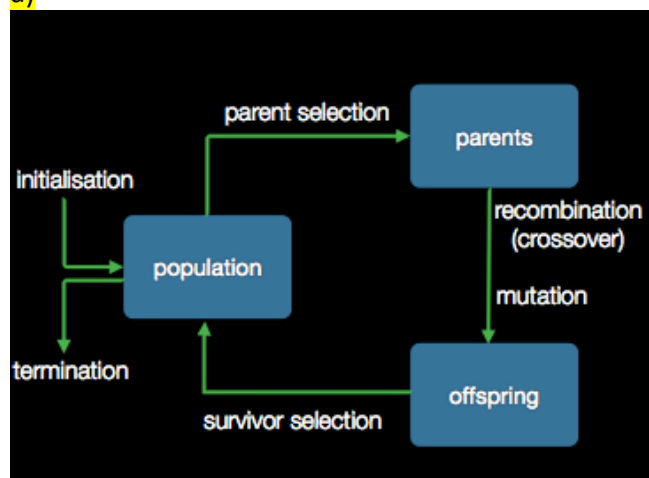
c) 2

Exercise 7: Evolutionary Methods (10 Points)

- a) Describe the main idea of evolutionary algorithms. Do this by describing the main steps in the algorithm.
- b) How can you increase the population diversity (Novelty) and how can you decrease population diversity (Quality) in evolutionary algorithms.

Answers:

a)



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BEGIN
  INITIALISE population with random candidate solutions;
  EVALUATE each candidate;
  REPEAT UNTIL ( TERMINATION CONDITION is satisfied ) DO
    1 SELECT parents;
    2 RECOMBINE pairs of parents;
    3 MUTATE the resulting offspring;
    4 EVALUATE new candidates;
    5 SELECT individuals for the next generation;
  OD
END
```

b)

Novelty: mutation & recombination,

Quality: parent selection, survivor selection

- a) 6 points

- b) 2 points for Novelty (increase), 2 points for Quality (decrease)

End of Exam