Technische Hochschule Rosenheim

Faculty of Computer Science
Prof. Dr. M. Tilly

Winter Term 2021/2022

Mock Exam - Applied Artificial Intelligence(AAI)
400 - Introduction to AI (Part 1)(IA1)

Date: tbd	Duration: 75 Minutes	Material: handwritten notes on DIN A4

Name: ....

Matrix number: ....

Good luck!

Notes:

1. The staples must not be loosened. The exam includes **11 pages incl. cover sheet and worksheets.**.
2. Work on the questions directly in the task. If necessary, use the worksheets at the end.
3. If, in your opinion, there are contradictions in the tasks or information is missing, make reasonable assumptions and document them..
4. The distribution of points is for orientation, but it is not binding.
5. Please do not write in pencil, red or green pens and if possible **legible**.

SOLUTION is available in the new year!

Name: Matrix number:

1. Task - General questions 4+9 Points

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a)

Mark the correct answer or statement; mark exactly one answer per question.

1. Intelligent Agents
   - ☐ PEAS stands for platform, estimation, allocation and services.
   - ✓ PEAS stands for performance, environment, actuators and sensors.
   - ☐ PEAS stands for power, evaluation, agents and science.
2. Uninformed Search
   - ☐ A heuristic is required for uninformed search.
   - ☐ A* and greedy best-first search ar uninformed search algorithms.
   - ✓ Depth first search (DSF) is an uninformed search algorithm.
3. Proportional Logic Translate the following Propositional Logic to English sentences. Let: E=Liron is eating and H=Liron is hungry than $E \implies \neg H$ means
   - ☐ If Liron is hungry, then Liron eats.
   - ☐ Liron is eating if and only if Liron is not hungry.
   - ✓ If Liron is eating, then Liron is not hungry.
4. First-Order Logic: $\forall n \in N . \exists m \in N . n < m$
   - ✓ This says for every natural number, there is a larger natural number.
   - ☐ This says there is a natural number that is smaller than all natural numbers.
   - ☐ This says there is a natural number between any two natural numbers.

b)

Can you fill?

Solution:

Task Environment	Observable	Agents	Deterministic	Episodic	Static	Discrete
Crossword puzzle	Fully	Single	Deterministic	Sequential	Static	Discrete
Chess with a clock	Fully	Multi	Deterministic	Sequential	Semi	Discrete
Poker	Partially	Multi	Stochastic	Sequential	Static	Discrete
Backgammon	Fully	Multi	Stochastic	Sequential	Static	Discrete
Taxi driving	Partially	Multi	Stochastic	Sequential	Dynamic	Continuous
Medical diagnosis	Partially	Single	Stochastic	Sequential	Dynamic	Continuous

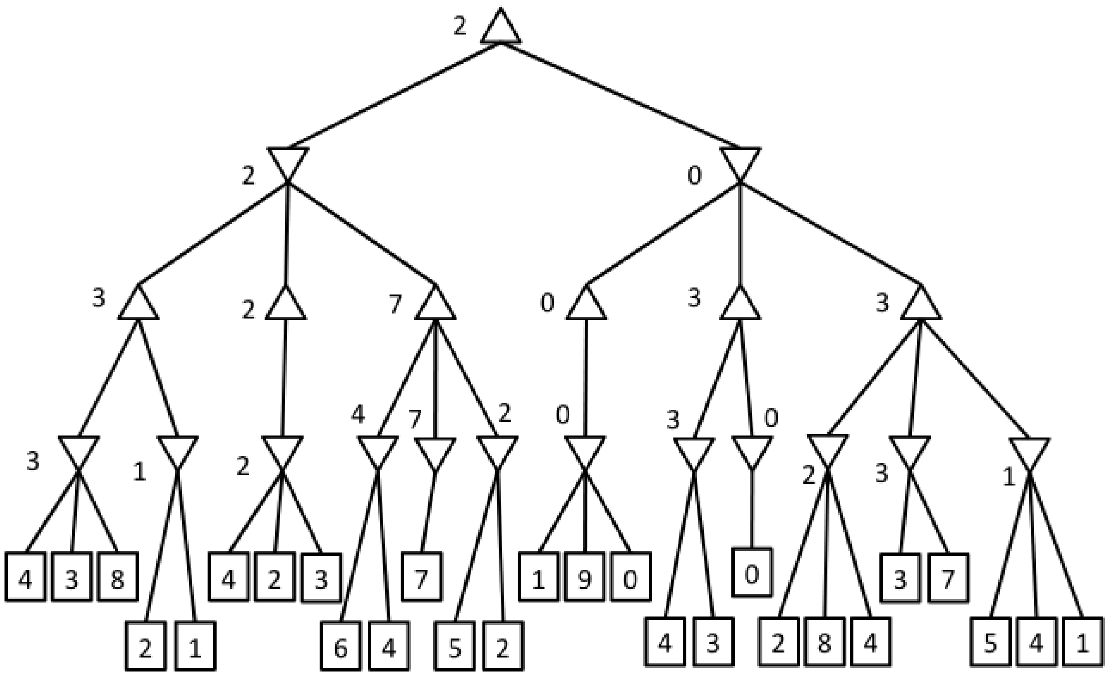
Name: Matrix number:

2. Task - Search 5+15 Points

a)

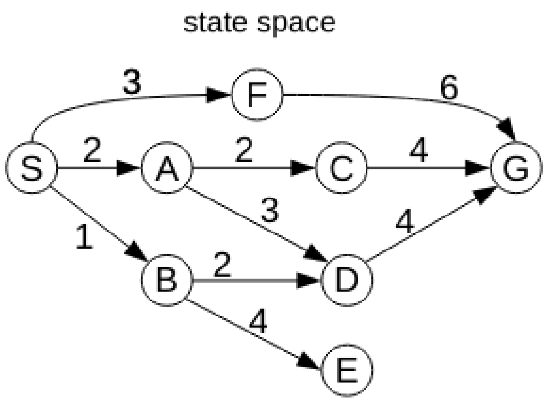
Give the values calculated by minimax for all states in the tree. You can note it directly in the figure!

Solution:



b)

The graph in the figure below shows the state space of a hypothetical search problem. States are denoted by letters, and the cost of each action is indicated on the corresponding edge. Note that actions are not reversible, since the graph is oriented.



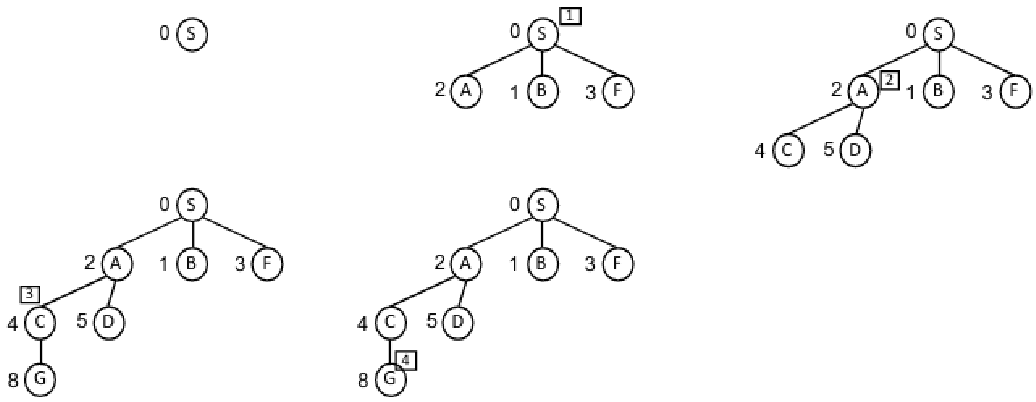
heuristic function (goal state: G)

S	A	B	C	D	E	F	G
6	4	5	2	2	8	4	0

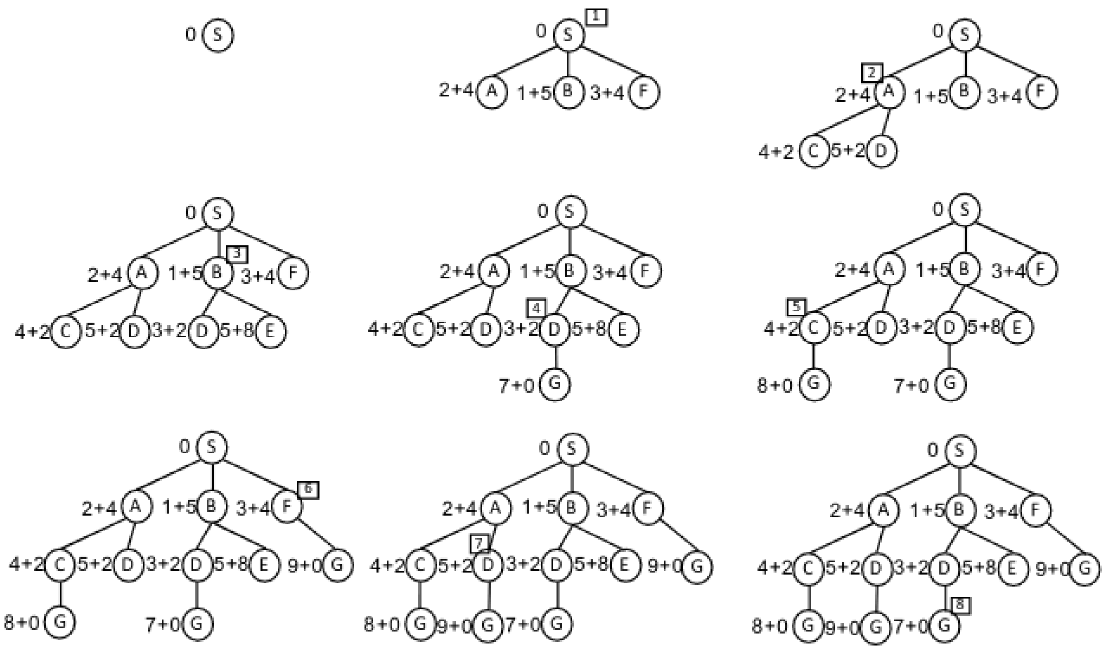
The table next to the state space shows the value of some admissible heuristic function, considering G as the goal state (it is easy to verify that such an heuristic never overestimates the true, minimum path cost from any given state to the goal state G).
Considering S as the initial state, solve the above search problem using:
a) depth-first search (DSF)
b) A* search with the heuristic above
When drawing the search tree you should clearly indicate: the order of expansion of each node (e.g., by numbering the expanded nodes according to the order of their expansion); the action corresponding to each edge of the tree; the state, the path cost and the value of the heuristic of each node. In the case of depth-first search you should also indicate which nodes of the search tree are simultaneously stored in frontier during the search process.

Solution:

a)
The search tree built by depth-first search is shown below. In this case a solution is found along the path which is explored first (when the node corresponding to state G is selected for expansion at step 4).



b)
The search tree built by A*-search is shown below. Next to each node the corresponding path cost g and heuristic h are shown as g + h. Remember that at each step the leaf node with the minimum value of g + h is chosen for expansion (ties are broken randomly, as in all search strategies). The solution found at step 8 is guaranteed to be the minimum-cost one, according to the fact that A* is optimal when an admissible heuristic is used.



3. Task - Knowledge and Knowledge Base 5+4+10 Points

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a)

Resolve to Conjunctive Normal Form (CNF) the formula

$$\neg(\neg p \lor q) \lor (r \implies \neg s)$$

For each step name the resolution rule you use.

Solution:

1.$\neg(\neg p \lor q) \lor (\neg r \lor \neg s)$
2.$(\neg\neg p \land \neg q) \lor (\neg r \lor \neg s)$
3.$(p \land \neg q) \lor (\neg r \lor \neg s)$
4.$(p \lor \neg r \lor \neg s) \land (\neg q \lor \neg r \lor \neg s)$

b)

Use the truth tables method (model checking) to determine whether the KB :

$$p \land \neg q \implies p \land q$$

entails the query $\phi : \neg p$.

Solution:

p	q	¬p	p ¬q	p q	p ¬q → p q
T	T	F	F	T	T
T	F	F	T	F	F
F	T	T	F	F	T
F	F	T	F	F	T

kb |= ¬p since each time ¬p is true , KB is true.

c)

Consider the following popular puzzle. When asked for the ages of her three children, Mrs. Baker says that Alice is her youngest child if Bill is not her youngest child, and that Alice is not her youngest child if Carl is not her youngest child.

Write down a knowledge base that describes this riddle and the necessary knowledge base that only one of the three children can be her youngest child.

Show with resolution that Bill is her youngest child.

Solution:

Let the propositions A, B and C denote that Mrs. Baker's youngest child is Alice, Bill and Carl, respectively.

We have the following clauses for the knowledge base:
1. $A \lor B \lor C$ (One child has to be the youngest.)
2. $\neg A \lor \neg B$ (Alice and Bill cannot both be the youngest.)
3. $\neg A \lor \neg C$
4. $\neg B \lor \neg C$

The following clauses represent the information from Mrs. Baker:

5. $B \lor A$ (Alice is her youngest child if Bill is not her youngest child. That is, $\neg B \implies A$.)
6. $C \lor \neg A$ (Alice is not her youngest child if Carl is not her youngest child. That is, $\neg C \implies \neg A$)

We want to show that Bill is the youngest child. Negating this, we get the following clause:

7. ¬B (Assume that Bill is not the youngest child.)

We use resolution to derive the empty clause as follows:

8. (from 5,7) A
9. (from 3,6) ¬A
10. (from 8,9) {}

4. Task - Propositional Logic 3+10 Points

a)

Let's consider a propositional language where

- p means "Paola is happy",
- q means "Paola paints a picture",
- r means "Renzo is happy".

Formalize the following sentences:

- "if Paola is happy and paints a picture then Renzo isn't happy"
- "if Paola is happy, then she paints a picture"
- "Paola is happy only if she paints a picture

Solution:

1.$p \land q \implies \neg r$
2.$p \implies q$
3.$\neg(p \land \neg q)$ ..which is equivalent to $p \implies q$

b)

Kyle, Neal, and Grant find themselves trapped in a dark and cold dungeon. After a quick search the boys find three doors: the first one red, the second one blue, and the third one green.
Behind one of the doors is a path to freedom. Behind the other two doors,however, is an evil fire-breathing dragon. Opening a door to the dragon means almost certain death.
On each door there is an inscription:

- RED DOOR: freedom is behind this door!
- BLUE DOOR: freedom is NOT behind this door!
- GREEN DOOR: freedom is NOT behind the blue door!

Given the fact that at LEAST ONE of the three statements on the three doors is true and at LEAST ONE of them is false, which door would lead the boys to safety?
Write down the axioms and the truth table.

Solution:

Language

- r: "freedom is behind the red door"
- b: "freedom is behind the blue door"
- g: "freedom is behind the green door"

Axioms

Assume Freedom is behind the red door. All three doors would then have true statements which we know is not possible since one of them must be false.
Assume Freedom is behind the blue door. All three doors would then have false statements which we know is not possible since one of them must be true.
Freedom is therefore behind the green door. The blue door and the green door have true statements and the red door has a false statement.

1. "behind one of the door is a path to freedom, behind the other two doors is an evil dragon"

$$(r \wedge \neg b \wedge \neg g) \vee (\neg r \wedge b \wedge \neg g) \vee (\neg r \wedge \neg b \wedge g)$$

2. "at least one of the three statements is true"

$$r \vee \neg b$$

3. "at least one of the three statements is false"

$$\neg r \vee b$$

Solution:

r	b	g	2	3	$2 \wedge 3$
T	F	F	T	F	F
F	T	F	F	T	F
F	F	T	T	T	T

Freedom is behind the green door!

5. Task - First Order Logic 5+10 Points

a)

Define an appropriate language and formalize the following sentences using FOL formulas.

1. Bill has at least one sister.
2. Bill has no sister.
3. Bill has at most one sister.
4. Bill has (exactly) one sister.
5. Bill has at least two sisters.

Solution:
1. $\exists x.SisterOf(x, Bill)$
2. $\neg\exists x.SisterOf(x, Bill)$
3. $\forall x\forall y.(SisterOf(x, Bill)\ SisterOf(y, Bill) \implies x = y)$
4. $\exists x.(SisterOf(x, Bill) \wedge \forall y.(SisterOf(y, Bill) \implies x = y))$
5. $\exists x\exists y.(SisterOf(x, Bill) \wedge SisterOf(y, Bill) \wedge \neg(x = y))$

b)

Formalize in first order logic the train connections in Italy. Provide a language that allows to express the fact that a town is directly connected (no intermediate train stops) with another town, by a type of train (e.g., intercity, regional,interregional).
Formalize the following facts by means of FOL. Therefore, define constants and predicates. Do not formulate axioms!

1. There is no direct connection from Rome to Trento.
2. There is an intercity from Rome to Trento that stops in Firenze, Bologna and Verona.
3. Regional trains connect towns in the same region.
4. Intercity trains don't stops in small towns.

Solution:

Constants: RM, FI, BO, VR, TN, . . . are identifiers of the **towns** of Roma, Firenze,Bologna, Verona, Trento,
InterCity, Regional, . . . are the identifiers of the **type of trains**

Predicates

1. **Train** with arity equal to 1, where Train(x) means x is a train
2. **Town** with arity equal to 1, where Town(x) means x is a town
3. **SmallTown** with arity equal to 1, where SmallTown(x) means x is a small town
4. **TrainType** with arity equal to 2, where TrainType(x, y) means that the train x is of type y.
5. **IsInRegion** with arity equal to 2, where IsInRegion(x, y) means that the town x is in region y.
6. **DirectConn** with arity equal to 3, where DirectConn(x, y, z) means that the train x directly connects (with no intermediated stops) the towns y and z.