

CS_M45 Foundations of Artificial Intelligence

(Attempt 2 questions out of 3)

Question 1

a) Describe the early AI system SIR. What were its limitations? **[5 marks]**

b) Outline Shank's theory of conceptual dependency and indicate how it may be implemented. Use a script for `going to a library` in your explanation. What do you consider are the limitations to this approach for understanding stories? **[7 marks]**

c) Construct a definite clause grammar (DCG) to recognise simple English sentences built from the following vocabulary:

nouns: horse, boy, dog, bear
adjectives: big, small, brown, white
determiners: the, a, all, many
transitive verbs (past tense): chased, raced, followed
modifiers for adjectives: very, moderately, somewhat

Only the past tense third person singular and plural are to be used and at most one adjective with a possible modifier can appear in a noun phrase. Examples of sentences are:

*All big dogs chased the very white horse; some very brown bears raced many boys;
a somewhat small dog raced the brown dog.*

You may use a predicate `add_s(X,Y)` which adds an 's' to the end of an identifier in order to create plural nouns. **[7 marks]**

Modify the grammar so that the passive form of the sentence is also constructed. For example

`phrase(sentence(S), [the, big, dog, chased, some, white, horses])`
will succeed in instantiating S to

`[some, white, horses, were, chased, by, the, big, dog].` **[6 marks]**

Question 2

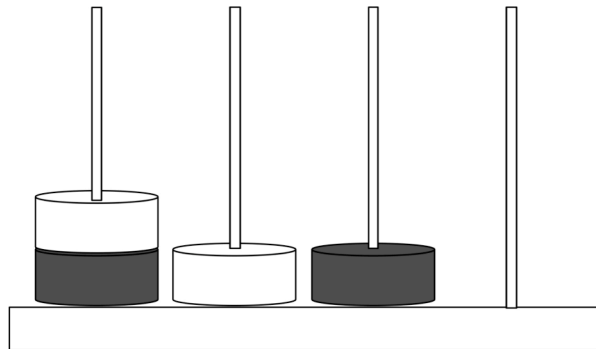
a) A very simple form of the game Sudoku can be played on a 4x4 grid, an illustrative example being given below:

a		d	
b		a	
		c	

The letters a to d are to be entered into the vacant squares so that each row, column and sub-square all have exactly the four distinct letters. Outline how the generate and filter technique can be used to solve this type of puzzle. You should give Prolog code for a possible generator and filter for the above puzzle. **[8 marks]**

Explain why this naïve algorithm would be inefficient to play the standard Sudoku puzzle on a 9x9 grid with digits 1 to 9. **[4 marks]**

b) A form of connect 3 is played as follows:



Players I and II alternatively drop black and white disks onto one of the four rods. The first player to obtain a row or column of three *adjacent* disks of their colour is the winner. The above is the position after four moves with player I (black) about to play. There can be at most four disks on any one rod. Describe the mini-max algorithm with a suitable heuristic for this game for determining a move for a player. **[6 marks]**

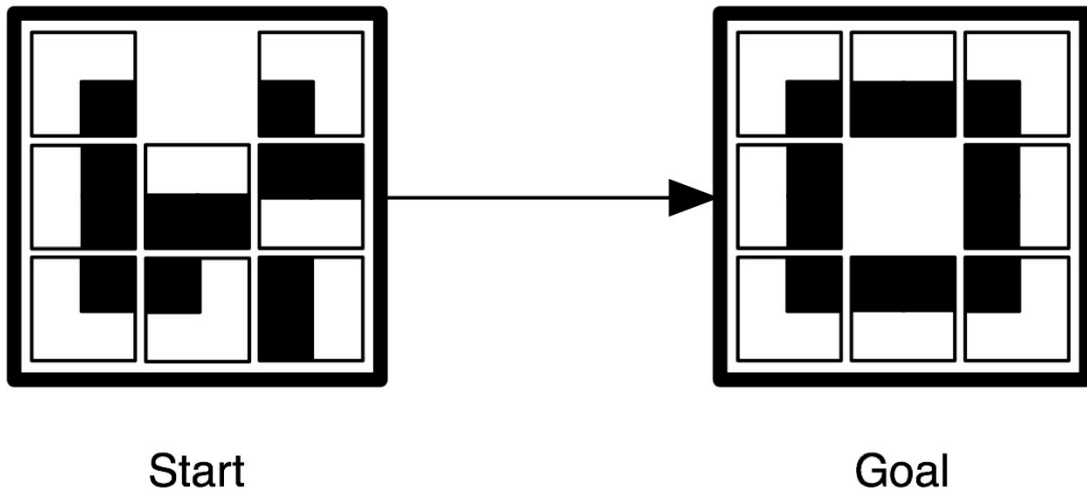
By taking a two move look-ahead in the mini-max algorithm, find the move suggested for player I using your heuristic starting from the above state. **[5 marks]**

Indicate which leaf nodes do not need to be evaluated if the alpha-beta pruning technique is adopted. **[2 marks]**

Question 3

a) Describe, using pseudo-code, the tree algorithm A^T and the best-first-search algorithm A^* . Prove if the heuristic used in A^* is *admissible*, then A^* will find an optimal solution if one exists? [6 marks]

b) A version of the 8-puzzle is illustrated below. The start state has to be transformed into the goal state by sliding tiles in the grid.



A heuristic function h is defined by taking the sum over all tiles of the Manhattan distance of a tile from its final position in the goal state plus an extra 1 if there is a tile in the centre square. Use this heuristic in A^* to find a sequence of moves to reach the goal state. [6 marks]

b) A logic puzzle is specified by a set of clues (simple facts) together with a set of queries. Show how a puzzle can be represented in Prolog as a fact `puzzle(Clues,Queries,Solution)` and describe and explain a general scheme `solve_puzzle(Puzz,Soln)` for solving such puzzles. [5 marks]

c) Four students live on different floors of a hall of residence building. They have different colour eyes, different first names and like different sports. The following clues are given:

- 1) The student with brown eyes plays golf and lives immediately below the student with blue eyes.
- 2) Bill, who plays cricket, lives on the top floor.
- 3) Alan lives below the student who likes soccer and immediately above the student with hazel eyes.
- 4) Colin plays rugby and lives below Denis.
- 5) The blue eyed student likes soccer.

The queries are:- Q1: What is the colour of Alan's eyes and what sport does he like? and Q2: Who is the grey eyed student?

Use a term `stdnt (Name, Eyes, Sport)` to represent each student and a list to indicate the four students in the order of their floor (the last element being the top floor). **Without** finding the solution, give the main Prolog procedures and facts for solving this problem. Your program should include code for `below`, `immediately_below`, `immediately_above` and `top`.

[7 marks]