

**PRIFYSGOL CYMRU; UNIVERSITY OF WALES**

**DEGREE EXAMINATIONS JANUARY 2002**

**SWANSEA**

**Computer Science**

**CS 335 Foundations of Artificial Intelligence**

**Attempt 2 questions out of 3**

**Time allowed: 2 hours**

**Students are permitted to use the dictionaries provided by the University through the invigilators**

# CS\_335 Foundations of Artificial Intelligence

(Attempt 2 questions out of 3)

## Question 1

a) Describe briefly the system STUDENT. What features of natural language understanding did it possess? [5 marks]

b) Outline the main properties of definite clause grammars (DCGs)? [3 marks]

The lexicon for a fragment of English consists of:

animate nouns: dog, cat, man, boy, girl

inanimate nouns: toy, ball, stick

transitive verbs: chases, throws, hits

determiners: the, a, every

Only the present tense third person *singular* is to be used — plural nouns do not need to be considered. Sentences containing the transitive verbs can be constructed using the *active* or *passive* voice yielding respectively two different forms, e.g.,

active: *the dog chases a cat* or passive: *a cat is chased by a dog*.

You should assume that only animate nouns can be the subject of the verbs. Construct a DCG to recognise such sentences. [10 marks]

Modify the grammar so that only the active voice is recognised (or generated), but the passive voice equivalent of the sentence is constructed by the grammar and assigned to the variable *S* in the nonterminal `sentence(S)`. So, for the goal `phrase(sentence(S), [the, boy, throws, a, ball])` the variable *S* is instantiated to the list `[a, ball, is, thrown, by, the, boy]`. [7 marks]

## Question 2

a) Describe the machine learning technique of explanation based generalisation (ebg) defining each of the following terms in your answer : *domain theory* , *training example* and *operational criterion* . [6 marks]

Give a definition, with explanation, for the Prolog procedure `ebg(TrainingGoal, GenGoal, BodyList)`

which will construct the generalised rule for the learned concept. [5 marks]

How can ebg be modified so that duplicate goals do not appear in `BodyList`? [2 marks]

b) The information to be used for ebg is described below:

Domain theory:

- A country will give aid to another country if it is needy and the countries are allies.
- A country is needy if the country has a famine.
- A country has a famine if the crops have failed in the country.
- A country has a famine if there is a locust swarm which has eaten the crops in the country.
- The crops have failed in a country if the country has a drought.

Describe this theory as a set of Prolog rules using the predicate symbols `country/1`, `allies/2`, `needy/1`, `famine_in/1`, `crops_failed_in/1`, `locust_swarm/1`, `ate_crops_in/2`.

A training example is given as

- USA is a country.
- Sudan is a country.
- UK is a country.
- India is a country.
- USA and Sudan are allies.
- UK and India are allies
- Swarm1 is a locust swarm
- Swarm1 ate the crop in Sudan
- There is a drought in India

Represent the training example as a set of Prolog facts and obtain the new rule for `gives_aid(Country1, Country2)` generated by ebg assuming the operational criterion (leaves) set is `{country, allies, locust_swarm, ate_crops_in}` and the training goal is `gives_aid(usa, sudan)`. [7 marks]

Determine the result for training goal `gives_aid(uk, india)` with `drought_in` added to the operational criterion. [3 marks]

How would this change if `crops_failed_in` is added instead? [2 marks]

### Question 3

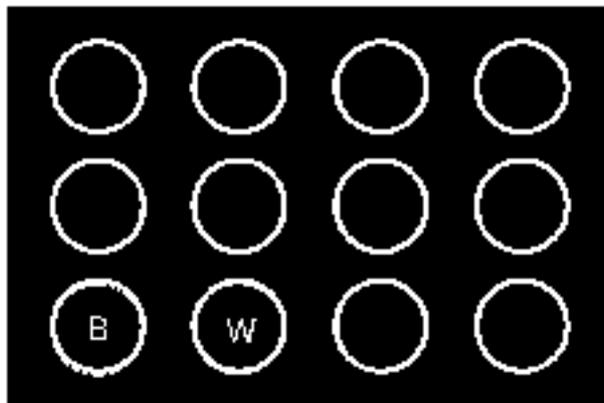
a) “The chess playing program *Deep Blue* only beat Kasparov by brute force and not intelligence”, discuss. Why was IBM interested in the *Deep Blue* project, after all chess is only a game? [5 marks]

b) Describe the mini-max method for determining a move in a two person game given a heuristic function  $h$ . [2 marks]

How can the method be improved using alpha-beta pruning? Illustrate your answer with suitable figures. [3 marks]

What is the expected improvement in the mini-max method resulting from the use of alpha-beta pruning? [1 mark]

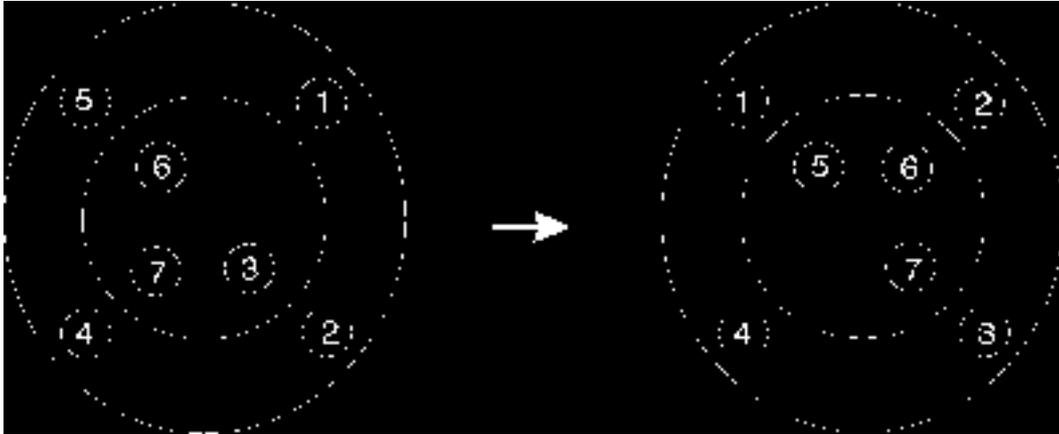
A version of connect3 is played on the board illustrated below.



Black and White disks are dropped into the top of one of the columns and play alternates between Black and White, with Black making the first move. The winner is the first player to obtain three *adjacent* disks of their colour in a horizontal, vertical or diagonal line. Give a suitable heuristic function for this game, and generate a mini-max tree of depth 2, to

determine Black's next move if the configuration of the board after the first two moves is as above. **[5 marks]**

c) Describe, using pseudo-code, the A\* (best-first-search) algorithm using a heuristic function  $h$ . What conditions on function  $h$  guarantee A\* will find an optimal solution if one exists? **[4 marks]**



The initial and final configurations for a board game are displayed in the figure above. The configuration on the left is to be converted to that on the right by a sequence of moves. A valid move consists of transferring a numbered disk into the empty region from one of the three regions having a common edge. For example, 1, 6 or 3 only could be moved to the empty region in the initial configuration. A heuristic function is defined as the sum of the shortest paths to the correct position, including the empty region. Use A\*, with heuristic  $h$ , to solve the puzzle illustrated in the figure above. **[5 marks]**