SOUTH EASTERN KENYA UNIVERSITY

UNIVERSITY EXAMINATIONS 2017/2018

UNIVERSITY EXAMINATION FOR THE BACHELOR OF SCIENCE IN COMPUTER SCIENCE AND BACHELOR OF INFORMATION TECHNOLOGY

SCI 205: INTRODUCTION TO ARTIFICIAL INTELLIGENCE

DATE: 13TH DECEMBER, 2017 **TIME: 10.30 -12.30 PM**

INSTRUCTIONS TO CANDIDATES

a) Answer ALL questions from section A(Compulsory)

b) Answer ANY TWO questions from section B

SECTION A (30 MARKS)
Compulsory

1.

a. Represent the following sentences in first-order logic, using a consistent vocabulary (which you must define):
   i. Some students took AI in spring 2017.
   ii. Every student who takes AI passes it.
   iii. Only one student took AI in spring 2016. [6 marks]

b. Write down logical representations for the following sentences, suitable for use with Generalized Modus Ponens:
   i. Horses, cows, and pigs are mammals.
   ii. An offspring of a horse is a horse.
   iii. Bluebeard is a horse. [6 marks]

c. Define what it means for a heuristic function to be admissible, and explain why it might be desirable for such a function to have this property. [3 marks]

d. Explain the difference between uninformed and informed search. List two examples of each type of algorithm. [2 marks]

e. In the context of planning:
   i. Explain the term‘heuristic’ [2 marks]
   ii. List two examples of typical heuristic functions [2 marks]

f. Explain what A* search is, including the advantages and disadvantages with respect to its theoretical properties. [3 marks]

g. From *Likes(Jerry,IceCream)* it seems reasonable to infer $\exists x$ *Likes(x,IceCream)*.
   i. Write down a general inference rule, that sanctions this inference. [3 marks]
   ii. State the conditions that must be satisfied by the variables and terms involved [3 marks]

SECTION B (40 MARKS)

Attempt ANY TWO questions from this section

2.

a. Describe the Iterative Deepening A* (IDA*) algorithm. Your answer should include a clear statement of the algorithm in pseudo-code, and a general description of how it works. [8 marks]

b. Explain how the ID A*algorithm searches the following search tree (Fig 1). Numbers between nodes denote the cost of the path between those nodes, and numbers on the nodes denote the value of the heuristic for that node.[8 marks]

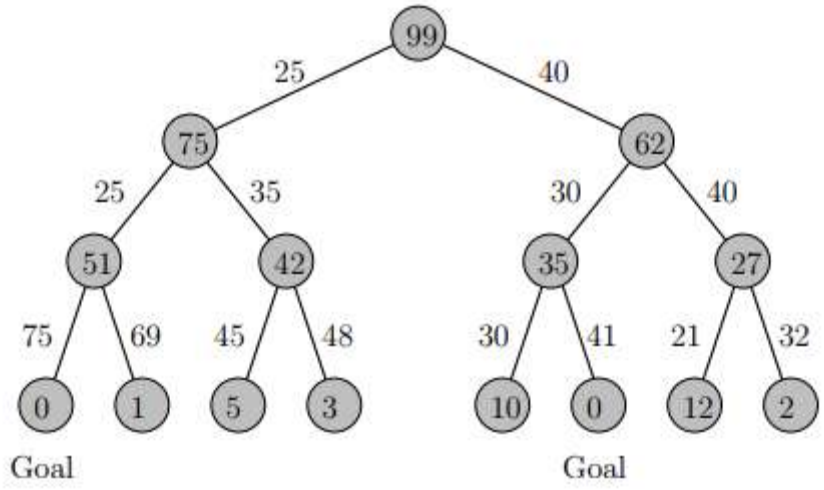

Fig 1

c. Give two reasons why the IDA* algorithm might prove unsuitable as a solution to a search problem, in each case giving a brief explanation of why this is the case, and suggesting a potential solution. [4 marks]

3. A perceptron takes input $x^5 = (x_1 x_2 \ldots x_n) \in$R and computes its output

$$h(x; w) = \sigma\left(w_0 + \sum_{i=1}^{n} w_i x_i\right)$$

where$w^T = (w_0 w_1 w_2 \ldots w_n)$ is a vector of weights and σ is an activation function. We have a set $s^T = ((x_1 y_1) \ldots (x_m y_m))$ of m labelled training examples and seek to minimize the error

$$E(w) = w_0 + \sum_{i=1}^{n} (y_i - h(x_{i,} w))^2$$

a. Derive the gradient descent training algorithm for this problem. [5 marks]
b. We now notice that for the particular problem of interest a solution will only make sense if a specific subset S of the weights is positive. Devise a modified version of the training algorithm that enforces this. [8 marks]
c. A colleague is attempting to solve a heuristic search problem using the A* algorithm, but is unable to decide which of a number of heuristics to use. Your colleague has a large collection of test problems, and believes that the best heuristic to use might depend on particular characteristics of the problem being solved. Explain in detail how you might apply machine learning to help your colleague. [7 marks]

4.

a. Suppose you are given the following axioms:
   1. $0 \leq 3$.
   2. $7 \leq 9$.
   3. $\forall x\, x \leq x$.
   4. $\forall x\, x \leq x + 0$.
   5. $\forall x \quad x + 0 \leq x$.
   6. $\forall x, y \quad x + y \leq y + x$.
   7. $\forall w, x, y, z \quad w \leq y \wedge x \leq z \Rightarrow w + x \leq y + z$.
   8. $\forall x, y, z \quad x \leq y \wedge y \leq z \Rightarrow x \leq z$ *a.*

   i. Give a backward-chaining proof of the sentence 7 ≤ 3+9. (Be sure, of course, to use only the axioms given here, not anything else you may know about arithmetic.) Show only the steps that lead to success. [5 marks]
   ii. Give a forward-chaining proof of the sentence 7 ≤ 3+9. Again, show only the steps that lead to success. [5 marks]

b. The following Prolog code defines a predicate P.

```
P(X,[X|Y]).
P(X,[Y|Z]) :- P(X,Z).
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   i. Show proof trees and solutions for the queries P(A,[2,1,3])and P(2,[1,A,3]). [5 marks]
   ii. What standard list operation does P represent? [5 marks]