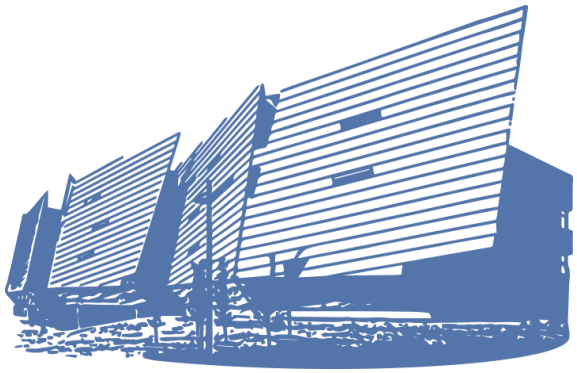

Galway Mayo Institute of Technology, Dublin
Rd Campus

Final Year Exam Solutions

Tomas O'Malley (G00361128)

COMP08016 Artificial intelligence
Bachelor of Science in Computing in Software Development
Department of Computer Science

June 7, 2020

Contents

Chapter 1

Semester 8 Year 4 Artificial intelligence

This is a LaTeX document holding The answers/questions from 2015 exam papers to 2019 for the module COMP08016 – Artificial Intelligence. This .pdf acts as a study aid for any student preparing for the 2hr written paper session during May or August(Repeat).Best of Luck

- Black is Examiners Question
- Blue is my sample question

1.0.1 Artificial Intelligence - Exam paper 2018-19 Semester 8

1. Question 1 (25 marks)
    - Describe, using examples where appropriate, how an Artificial Neural Network (ANN) can be trained to learn classification tasks that are linearly-separable. Include a fully labelled diagram in your answer, showing the structure of a perceptron and explain the key steps involved in the training process. (15 Marks)
        - my answer
    - Discuss the structure and function of a multilayer back-propagation neural network. Your answer should include a diagram that illustrates the direction of information flow through the network, how errors are back-propagated and address the techniques for choosing a network topology. (10 Marks)
        - my answer
2. Question 2 (25 marks)
    - Figure 1 below depicts a semantic network of eight nodes interconnected by edges. The starting node is node 'A" and "H" is the goal node. Each node is labelled with a letter in the upper compartment and a heuristic estimate of distance to the goal node in the lower compartment. The actual distance between two nodes is shown as a number along their connecting edge.

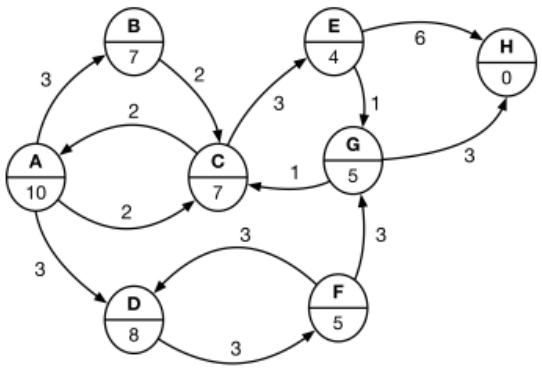

Fig. 1

- my answer

- (a) Show how the A* algorithm can find the optimal path from the initial node (A) to the goal node (H). Your answer should clearly show the state of the OPEN and CLOSED queues for each iteration of the algorithm and how the path evaluation function, f(n), is computed. (11 Marks)
  - my answer
- (b) Discuss the efficiency of the A* algorithm and the parts of the algorithm that contribute most to the computational complexity of the search of a semantic network. Your answer should also address how different types of graph topologies may impact the performance of A*. (6 Marks)
  - my answer
- (c) Using a diagram and code snippets where appropriate, discuss how iterative deepening can be applied to A* to reduce computational complexity without compromising algorithmic optimality and completeness. (8 Marks)
  - my answer

3. Question 3 (25 marks)
   - Figure 2 below depicts a 4-ply game tree having leaf nodes decorated with a score that represents the computation of a static evaluation function:

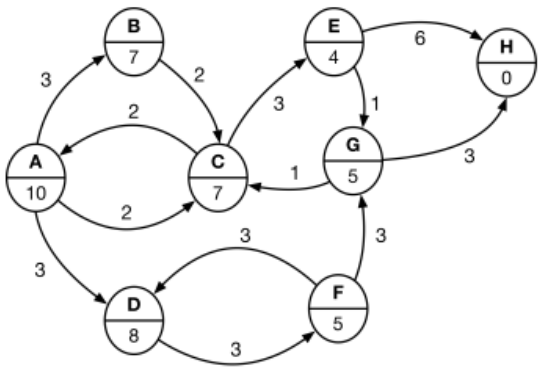

Fig. 1

   - my answer
   - (a) Show, using labelled diagrams, how the minimax algorithm can determine the best move to make from node 'A'. Your answer should clearly illustrate how MAX and MIN values are computed at each level. (10 Marks)

- my answer

- (b) Describe how alpha-beta pruning can be applied to the game tree in Figure 2 to reduce the number of nodes to be generated and examined. Your answer should show the pruned game tree, indicate the alpha and beta cut-off points and address the computational effectiveness of alpha-beta pruning. (15 Marks)
  - my answer

4. Question 4 (25 marks)

- (a) Explain, using examples, the following terms as they apply to heuristic search algorithms:
  - Admissibility
  - Monotonicity
  - Foothills and Plateaux
  - my answer
- (b) Discuss how steepest-ascent can overcome the limitations of the basic hill-climbing algorithm and contrast hill-climbing and best-first approaches. Use diagrams and pseudocode or Java snippets to illustrate your answer. (10 Marks)
  - my answer
- (c) Explain how simulated annealing can be used to overcome the limitations of hill-climbing algorithms when searching for an optimal solution to a search problem. (6 Marks)
  - my answer

5. Question 5 (25 marks)

- (a) Explain the fuzzy set operations that underpin fuzzy logic and explain how they relate to Boolean logic. Include diagrams with your answer where appropriate.(8 marks)
  - my answer
- (b) An autonomous car has a braking system implemented using fuzzy logic, that applies pressure to a brake in response to the distance of an object ahead of it and the amount of rain on a road surface. Figures 3, 4 and 5 below depict fuzzy sets that describe the linguistic variables distance, road and brake respectively that are used by the braking system. The universe of discourse ranges from 0 – 100 metres for the variable distance and from 0 – 5mm for the variable road. The linguistic variable brake is defined using singleton spikes and has a universe of discourse spanning the range 0-100 percent

  The following three rules describe the reasoning used by a fuzzy inference system:

  - IF distance IS very very short OR road IS extremely dry THEN brake IS more or less hard
  - IF distance IS not slightly long AND road IS somewhat moist THEN brake IS not soft
  - IF distance IS medium AND road IS not very wet THEN brake IS very normal

Compute, using the Sugeno inference method, the predicted braking pressure with input parameters of distance = 30 metres and road = 3mm of rain. Your answer should clearly show each step in the fuzzy inference process. (17 Marks)

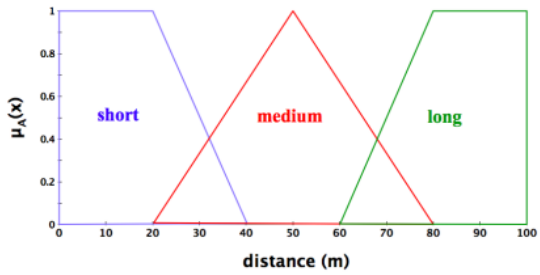

Fig. 3: *Fuzzy sets for the variable Distance*

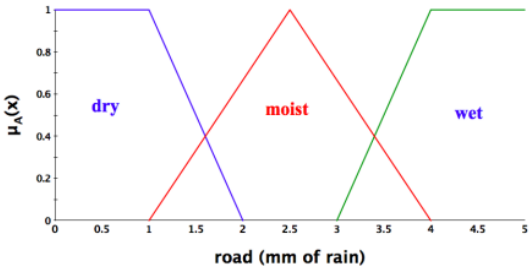

Fig. 4: *Fuzzy sets for the variable Road*

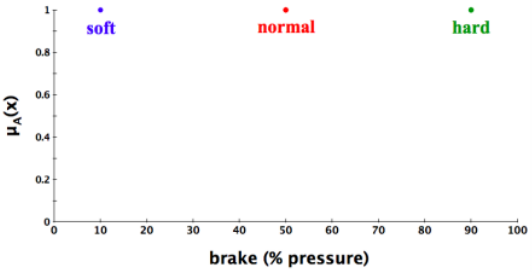

Fig. 5: *Singletons for the variable Brake*

- my answer

Formula

Hedge	Formula
Somewhat	$\sqrt[3]{\mu_a(x)}$
More or Less	$\sqrt{\mu_a(x)}^2$
Indeed	$2(\mu_a(x))^2$ if $0 \le \mu_a(x) \le 0.5$ $1 - 2(1 - \mu_a(x))^2$ if $0.5 < \mu_a(x) \le 1$
A Little	$\mu_a(x)^{1.3}$
Slightly	$\mu_a(x)^{1.7}$
Very	$\mu_a(x)^2$
Extremely	$\mu_a(x)^3$
Very Very	$\mu_a(x)^4$

Table 1: *Fuzzy Hedges*

Chapter 2

Semester 8 Year 4 Artificial intelligence

- Black is Examiners Question
- Blue is my sample question

2.0.1 Artificial Intelligence - Exam paper 2017-18 Semester 8

1. Question 1 (25 marks)
   - (a) Describe, using examples where appropriate, how an Artificial Neural Network (ANN) can be trained to learn classification tasks. Include a fully labelled diagram in your answer, showing the structure of both a neuron and a perceptron. (15 Marks)
     - my answer
   - Discuss the structure and function of a multilayer back-propagation neural network. Your answer should include a diagram that illustrates the direction of information flow through the network and address techniques for choosing the network topology. (10 Marks)
     - my answer
     - my answer
2. Question 2 (25 marks)
   - Figure 1 below depicts a 4-ply game tree having leaf nodes decorated with a score that represents the computation of a static evaluation function:

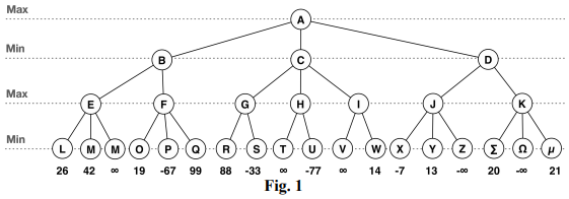

Fig. 1

   - (a) Show, using labelled diagrams, how the minimax algorithm can determine the best move to make from node 'A'. Your answer should clearly illustrate how MAX and MIN values are computed at each level. (10 Marks)
     - my answer

- (b) Describe how alpha-beta pruning can be applied to the game tree in Figure 1 to reduce the number of nodes to be generated and examined. Your answer should show the pruned game tree, indicate the alpha and beta cut-off points and address the computational effectiveness of alpha-beta pruning. (15 Marks)
  - my answer

3. Question 3 (25 marks)

- (a) "Branching factor is the one characteristic of an algorithm, more than any other, that will determine the effectiveness of a search strategy on a semantic network."

  Discuss this statement and evaluate implications of branching factor for the computational efficiency of a search strategy. (12 Marks)

  - my answer
- Discuss the limitations of the basic hill-climbing algorithm and how they may be mitigated by steepest-ascent and simulated annealing techniques. Use diagrams and pseudocode or Java snippets to illustrate your answer. (13 Marks)

  - my answer

4. Question 4 (25 marks)

- EFigure 2 below depicts a semantic network of ten nodes interconnected by edges. The starting node is node 'A" and "J" is the goal node. Each node is labelled with a letter in the upper compartment and a heuristic estimate of distance to the goal node in the lower compartment. The actual distance between two nodes is shown as a number along their connecting edge.

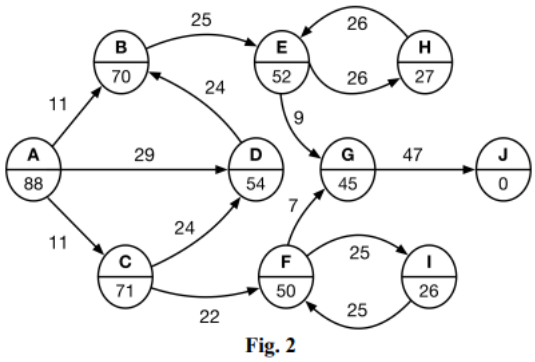

Fig. 2

- (a) Show how the A* algorithm can find the optimal path from the initial node (A) to the goal node (J). Your answer should clearly show the state of the OPEN and CLOSED queues for each iteration of the algorithm and how the path evaluation function, f(n), is computed. (11 Marks)
  - my answer
- (b) Discuss the efficiency of the A* algorithm and the parts of the algorithm that contribute most to the computational complexity of the search of a semantic network. Your answer should also address how different types of graph topologies may impact the performance of A*.(6 marks)

- my answer

- (c) Using a diagram and code snippets where appropriate, discuss how iterative deepening can be applied to A* to reduce computational complexity without compromising algorithmic optimality and completeness. (8 Marks)
  - my answer

5. Question 5 (25 marks)

- . (a) Explain the following terms as they apply to fuzzy logic:
  - Membership Functions (4 Marks)
  - Hedges (4 Marks)

  - my answer
- Compare the following partitioning strategies for distributed databases:(6 marks)

  Range Partitioning
  Hash Partitioning
  List Partitioning

  - my answer
- (b) A college has created a result forecasting system based on fuzzy logic that computes a percentage based on input values of course difficulty and CAO points. Figures 3, 4 and 5 below depict fuzzy sets that describe the linguistic variables course, points and result respectively that are used by the forecasting system. The universe of discourse ranges from 0 – 10 for the variable course and from 200 – 600 for the variable points. The linguistic variable result has a universe of discourse spanning the range 0-100 percent

  The following three rules describe the reasoning used by a fuzzy inference system for computing a percentage result for the inputs course and points:

  - If course is difficult and points is not high then result is poor
  - If course is easy then result is good
  - If course is normal and points is average then result is mediocre

  Compute, using the Mamdani inference method and a Right-Most-Max defuzzifier, the predicted result for a student with 450 points that has taken a course rated with a level of difficulty of 6.5. Your answer should clearly show each step in the fuzzy inference process. (17 Marks)

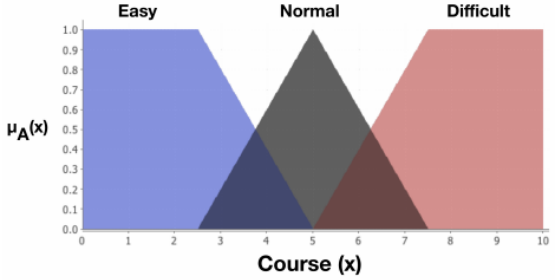

Fig. 3: *Fuzzy sets for the variable Course*

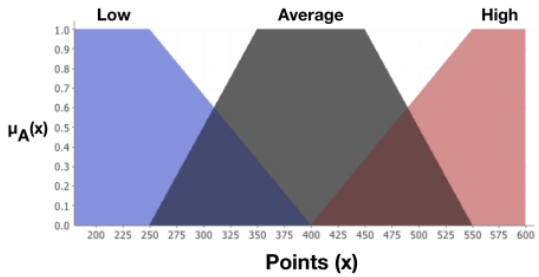

Fig. 4: *Fuzzy sets for the variable Points*

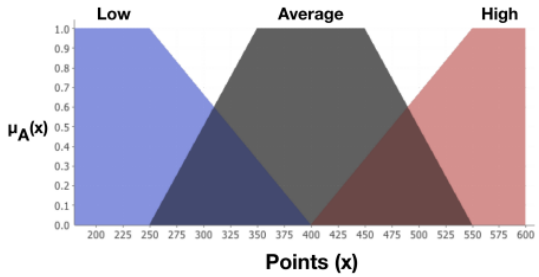

Fig. 4: *Fuzzy sets for the variable Points*

- my answer

Chapter 3

Semester 8 Year 4 Artificial intelligence

- Black is Examiners Question
- Blue is my sample question

3.0.1 Artificial Intelligence - Exam paper 2016-17 Semester 8

1. Question 1 (25 marks)
    - 1. (a) Using examples where appropriate, describe each of the following terms as they apply to artificial neural networks:
      - Activation Functions (5 Marks)
      - Perceptrons (5 Marks)
        - my answer
    - (b) Discuss how backpropagation can be used to train a multi-layered neural network. Your answer should include a diagram and explain each step in the process. (15 Marks)
        - my answer
2. Question 2 (25 marks)
    - Figure 1 below depicts a semantic network of nodes interconnected by edges. The starting node is node 'A" and "I" is the goal node. Each node is labelled with a letter in the upper compartment and a heuristic estimate of distance to the goal node in the lower compartment. The actual distance between two nodes is shown as a number along their connecting edge

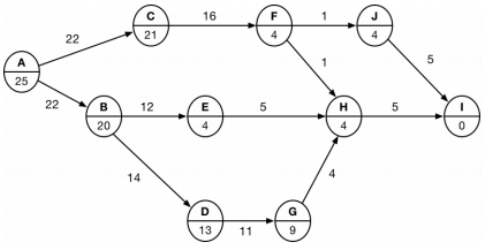

Fig. 1

- (a) Show how the A* algorithm can find the optimal path from the initial node (A) to the goal node (I). Your answer should show the state of the OPEN and CLOSED queues for each iteration of the algorithm and how the path evaluation function, f(n), is computed. (13 Marks)
  - my answer
- (b) Discuss the factors that impact on the space complexity of the A* algorithm and explain, using examples, how iterative deepening can reduce the memory overhead whilst preserving both optimality and completeness. (12 Marks)
  - my answer

3. Question 3 (25 marks)
   - (a) Discuss each of the following topics as they relate to semantic networks:
     • Branching Factor (6 Marks)
     • Brute Force Search (6 Marks)
     - my answer
   - (b) Describe the structure and function of a Radial Basis Function (RBF) neural network. Your answer should include a diagram explaining the role of each layer in the network topology. (13 Marks)
     - my answer
4. Question 4 (25 marks)
   - Figure 2 below depicts a 4-ply full game tree having leaf nodes decorated with a score that represents a goal state. You may assume that node 'A' is a MAX node.

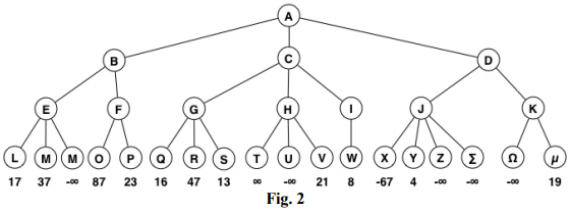

Fig. 2

   - (a) Show, using labelled diagrams, how the minimax algorithm can determine the best move to make from node 'A'. Your answer should also illustrate how MAX and MIN values are computed at each level. (10 Marks)
     - my answer
   - (b) Describe how alpha-beta pruning can be applied to the game tree in Figure 2 to reduce the number of nodes to be generated and examined. Your answer should show the pruned game tree, indicate the alpha and beta cut-off points and address the effectiveness of alpha-beta pruning. (15 Marks)
     - my answer
5. Question 5 (25 marks)
   - (a) Explain the fuzzy set operations that underpin fuzzy logic and explain how they relate to Boolean logic. Include diagrams with your answer where appropriate. (10 Marks)

- my answer

- (b) Figures 3, 4 and 5 below depict fuzzy sets that describe the variables growth, taxtake and spending respectively. The universe of discourse ranges from 0 - 10 percent for the variables growth and tax-take and from 0-25 percent for the variable spending. The following three rules describe the reasoning used by a fuzzy inference system to compute the increase in government spending for the inputs growth and taxtake:

  1. if growth is very strong and taxtake is not small then spending is high
  2. if growth is weak or taxtake is not normal then spending is low
  3. if growth is moderate and taxtake is somewhat normal then spending is balanced

  Compute, using the Sugeno inference method, the crisp value of spending for the inputs growth=7.5 and taxtake=3. Your answer should clearly show each step in the fuzzy inference process and how the output values are computed. (15 Marks)

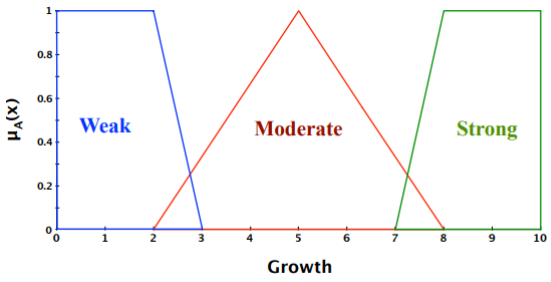

Fig. 3. Fuzzy Sets for Economic Growth

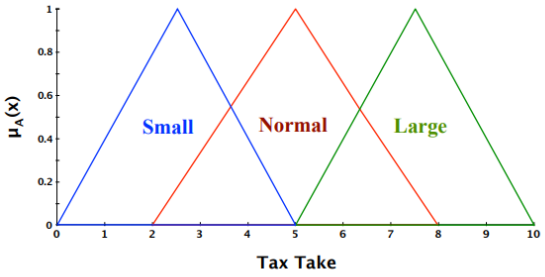

Fig. 4. Fuzzy Sets for Tax Take

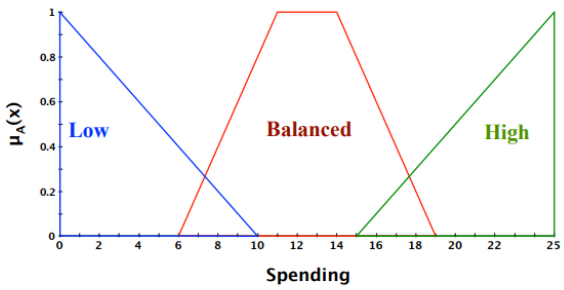

Fig. 5. Fuzzy Sets for Spending

- my answer

Chapter 4

Semester 8 Year 4 Artificial intelligence

- Black is Examiners Question
- Blue is my sample question

4.0.1 Artificial Intelligence - Exam paper 2015-16 Semester 8

1. Question 1 (25 marks)
    - "Brute force recursive search algorithms are the most versatile and adaptable mechanisms for traversing a semantic network or search tree."
      Provide a critique of this statement that addresses both the space and time complexity of the depth-first approach and show how the weaknesses of the algorithm can be overcome through depth limitation and iterative deepening. Use diagrams and code snippets to illustrate your answer. (25 Marks)
        - my answer
2. Question 2 (25 marks)
    - Figure 1 depicts a semantic network of nodes interconnected by edges. The starting node is node 'A" and "I" the goal node. Each node is labelled with a letter and a heuristic estimate of distance to the goal node. The actual distance between two nodes is shown as a number along their connecting edge.

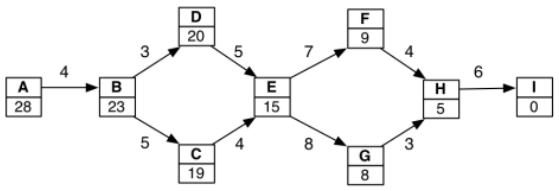

Figure 1

    - (a) Show how the A* algorithm can find the optimal path from the initial node (A) to the goal node (I). Your answer should show the state of the OPEN and CLOSED queues for each iteration of the algorithm and also show how the path evaluation function, f(n), is computed. (15 marks)
        - my answer

- (b) Using either pseudocode or Java to illustrate your answer, provide a critique of those parts of the A* algorithm that contribute to its optimality and completeness. (10 Marks)
    - my answer

3. Question 3 (25 marks)

- Figure 2 below depicts a 4-ply game tree, with leaf nodes labelled with a score that represents a goal state.

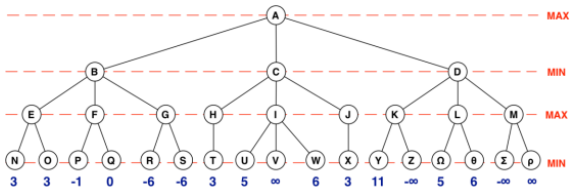

Figure 2

- (a) Show, using labelled diagrams, how the minimax algorithm can determine the best move to make from node 'A'. Your answer should also illustrate how MAX and MIN values are computed at each level. (10 Marks)
    - my answer
- (b) Describe how alpha-beta pruning can be applied to the game tree in Figure 2 to reduce the number of nodes to be generated and examined. Your answer should show the pruned game tree, indicate the alpha and beta cut-off points and address the effectiveness of alpha-beta pruning. (15 Marks)
    - my answer

4. Question 4 (25 marks)

- . (a) "Branching factor is the most salient characteristic that determines the effectiveness of a search algorithm on a semantic network."
  Discuss this statement and evaluate implications of branching factor for both the space and time complexity of a search strategy. (13 Marks)
    - my answer
-) Discuss the application of breadth-first search and its heuristically informed variants to semantic trees and networks. Your discussion should address the impact of each approach on search optimality, completeness and space complexity. Include diagrams and algorithms, in either pseudocode or Java, with your answer. (12 Marks)
    - my answer

5. Question 5 (25 marks)

- . (a) Explain the following terms as they apply to fuzzy logic:
  - Membership Functions (5 Marks)
  - Hedges (5 Marks)
  - Fuzzy Set Operations (5 Marks)
    - my answer

- (b) Discuss how fuzzy rules are evaluated and aggregated in the Mamdani inference model. Your answer should include sample rules and diagrams where appropriate. (10 Marks)
    - my answer

6. Question 6 (25 marks)
    - (a) Explain the following terms as they apply to artificial neural networks (ANNs):
      - Activation Functions (3 Marks)
      - Weight Training (3 Marks)
        - my answer
    - (b) Using a fully labelled diagram, describe the structure of a perceptron and show how a perceptron can learn classification tasks. (10 Marks)
        - my answer
    - (c) Describe the structure and function of a multilayer back-propagation neural network. Your answer should include a diagram that illustrates the direction of information flow through the network. (9 Marks)
        - my answer

Chapter 5

Semester 8 Year 4 Artificial intelligence

- Black is Examiners Question
- Blue is my sample answer

5.0.1 Artificial Intelligence - Exam paper 2014-15 Semester 8

1. Question 1 (25 marks)
    - "Brute force recursive search algorithms are the most versatile and adaptable mechanisms for traversing a semantic network or search tree."
      Provide a critique of this statement that addresses both the space and time complexity of the depth-first approach and show how the weaknesses of the algorithm can be overcome through depth limitation and iterative deepening. Use diagrams and code snippets to illustrate your answer. (25 Marks)
        - my answer
2. Question 2 (25 marks)
    - Figure 1 depicts a semantic network of nodes interconnected by edges. The starting node is node 'A" and "I" the goal node. Each node is labelled with a letter and a heuristic estimate of distance to the goal node. The actual distance between two nodes is shown as a number along their connecting edge.

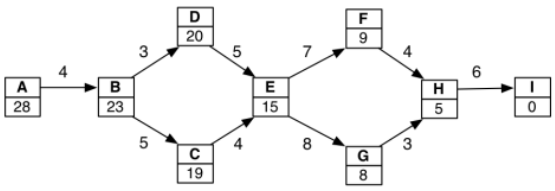

Figure 1

    - (a) Show how the A* algorithm can find the optimal path from the initial node (A) to the goal node (I). Your answer should show the state of the OPEN and CLOSED queues for each iteration of the algorithm and also show how the path evaluation function, f(n), is computed. (15 marks)
        - my answer

- (b) Using either pseudocode or Java to illustrate your answer, provide a critique of those parts of the A* algorithm that contribute to its optimality and completeness. (10 Marks)
    - my answer

3. Question 3 (25 marks)

- Figure 2 below depicts a 4-ply game tree, with leaf nodes labelled with a score that represents a goal state.

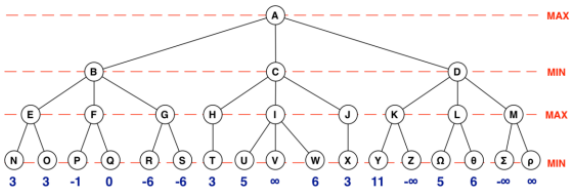

Figure 2

- (a) Show, using labelled diagrams, how the minimax algorithm can determine the best move to make from node 'A'. Your answer should also illustrate how MAX and MIN values are computed at each level. (10 Marks)
    - my answer
- (b) Describe how alpha-beta pruning can be applied to the game tree in Figure 2 to reduce the number of nodes to be generated and examined. Your answer should show the pruned game tree, indicate the alpha and beta cut-off points and address the effectiveness of alpha-beta pruning. (15 Marks)
    - my answer

4. Question 4 (25 marks)

- . (a) "Branching factor is the most salient characteristic that determines the effectiveness of a search algorithm on a semantic network."
  Discuss this statement and evaluate implications of branching factor for both the space and time complexity of a search strategy. (13 Marks)
    - my answer
-) Discuss the application of breadth-first search and its heuristically informed variants to semantic trees and networks. Your discussion should address the impact of each approach on search optimality, completeness and space complexity. Include diagrams and algorithms, in either pseudocode or Java, with your answer. (12 Marks)
    - my answer

5. Question 5 (25 marks)

- . (a) Explain the following terms as they apply to fuzzy logic:
  - Membership Functions (5 Marks)
  - Hedges (5 Marks)
  - Fuzzy Set Operations (5 Marks)
    - my answer

- (b) Discuss how fuzzy rules are evaluated and aggregated in the Mamdani inference model. Your answer should include sample rules and diagrams where appropriate. (10 Marks)
    - my answer

6. Question 6 (25 marks)

- (a) Explain the following terms as they apply to artificial neural networks (ANNs):
  - Activation Functions (3 Marks)
  - Weight Training (3 Marks)
    - my answer
- (b) Using a fully labelled diagram, describe the structure of a perceptron and show how a perceptron can learn classification tasks. (10 Marks)
    - my answer
- (c) Describe the structure and function of a multilayer back-propagation neural network. Your answer should include a diagram that illustrates the direction of information flow through the network. (9 Marks)
    - my answer

Chapter 6

References

6.0.1 References

All answers were sourced from notes via www.learnonline.gmit.ie