ROBERT GORDON UNIVERSITY ABERDEEN

CM2602

Academic Year	**2024-25**
Semester	**1**
Module Number	**CM2602**
Module Title	**Artificial Intelligence**
Assessment Method	**CourseWork**
Deadline (time and date)	**28th April 2025, 13:00 IST**
Submission	**Assessment Dropbox in the Module Study Area in CampusMoodle.** **The project report, complete source code has to be submitted by the deadline.** **Attending CW via is compulsory and failing to do so will set your CW grade to "Fail".**
Word Limit	**10000 words.**
Use of Generative Artificial Intelligence (AI) text	**IS authorised. Provide a detailed report on how it has been in your work, with respect to each question. It can be used to understand the concepts, but the implementation should be your own and you should be able to defend on viva.**
Module Co-ordinator	**Nipuna Senanayake**

What knowledge and/or skills will I develop by undertaking the assessment?

Develop an understanding of the principal theories, concepts and methods used in the development of artificial intelligence algorithms. Specifically:

- Using MS Excel Solver for solving constraint satisfaction problem (CSP)
- Ontology engineering and SPARQL queries with Twinkle

What knowledge and/or skills will I develop by undertaking the assessment?

- Implementation of searching algorithms from the scratch with any programming language and analysing of performance them
- Using available libraries to implement fuzzy logic based problem solving

On successful completion of the assessment students will be able to achieve the following Learning Outcomes:

LO1 Describe intelligent problem-solving methods and their applications underpinned by AI's philosophical and cognitive theory.

LO2 Compare and contrast reasoning and knowledge representation strategies used in Artificial Intelligence.

LO3 Identify, contrast and apply suitable search techniques related to AI problem solving.

LO4 Analyse legal, ethical, and professional issues in the context of intelligent systems solutions for real-world applications.

Please also refer to the Module Descriptor, available from the module Moodle study area.

What is expected of me in this assessment?

Task(s) – content

Question 1

Use MS-Excel Solver add-on to model the following situation as a CSP and find the optimum value of each variable.

A smart city is deploying a traffic management team to monitor and control traffic at key intersections. There are four traffic officers (O1, O2, O3, O4) who must be assigned shifts for the upcoming week. The objective is to optimize shift allocation while ensuring fairness, fulfilling preferences, and maintaining smooth traffic flow.

Workload Distribution:

- Each officer must work at least 2 shifts in a week.
- The total number of shifts assigned must be exactly 10 (not exceeding the limit).

Shift Preferences:

- O1 and O2 prefer morning shifts but can work evening shifts if necessary.
- O3 and O4 prefer evening shifts but can work morning shifts if necessary.

Shift Coverage:

- Each shift must have at least one officer assigned to it.
- There are 5 morning shifts and 5 evening shifts that need coverage.

Balanced Distribution (Soft Constraint):

- The difference in shift counts among officers should be minimized to ensure fairness in workload.

Question 2

Answer all sub sections associated with Ontology Engineering with illustrative evidence.

Cybersecurity is a rapidly evolving field that plays a critical role in protecting digital assets, networks, and systems against cyber threats. With the increasing complexity of cyberattacks, security professionals require a structured knowledge model to enhance threat detection, response, and mitigation strategies.

Developing a Cybersecurity Ontology provides a standardized and machine-readable way to represent knowledge in this domain. This ontology will serve as a knowledge repository that helps security professionals, researchers, educators, and organizations in various cybersecurity-related tasks, including:

Threat Intelligence: Categorizing and analyzing various types of cyber threats, vulnerabilities, and attack vectors.
Incident Response: Defining workflows for handling security breaches and mitigating risks.
Compliance & Regulations: Structuring knowledge about industry standards like ISO 27001, NIST, and GDPR.
Education & Awareness: Training cybersecurity professionals with best practices and security frameworks.
Security Controls & Policies: Defining best practices for securing IT infrastructure, including authentication, encryption, and network monitoring.

a) Define the scope you attempt to cover from your knowledge model/ontology and propose relevant competency questions (at least 05 aspects). List all the sources you referred for the information gathering in the references section.

b) Suggest an appropriate concept graph (i.e., taxonomy) to link the information fragments you identified above.

c) Design a suitable domain ontology (i.e. RDF / OWL) to make above proposed concept graph machine-readable. Introduce at least 05 individuals for each knowledge branch.

d) Write five SPARQL queries, to mine the created ontology, in response of deriving required answers for five competency questions of your choice. You may use Twinkle for SPARQL query execution. Support your answer with valid screen shots and summarized elaborations.

Question 3

The aim of this part of the coursework is to implement two search algorithms (Uniform Cost Search and A*) for finding the shortest path in a six-by-six maze. You can use Python or any other programming language of your choice to implement this requirement. Make sure to submit your complete source code along with proper code comments, and your coursework report.

The following figure shows the sample setup of the maze.

	0	**1**	**2**	**3**	**4**	**5**
0	0	6 Barrier	12	18	24	30
1	1	7	13	19 Barrier	25	31 Barrier
2	2	8 Start	14	20	26	32
3	3	9	15	21	27 Goal	33
4	4	10	16	22 Barrier	28	34
5	5	11	17	23	29	35

Task 1:

Using a suitable data structure, setup the above maze in your programming environment. Follow the below rules when you are setting up the maze:

a) The (x, y) coordinates of each node are defined by the column and the row shown at the top and left of the maze, respectively. For example, node 15 has (x, y) coordinates (2, 3).
b) Randomly select a node within the 0-11 nodes as the stating node. For example, node 8 is the starting node for the above maze.
c) Randomly select a node within the 24-35 nodes as the goal node. For example, node 27 is the goal node for the above maze.
d) Randomly select four barrier nodes from the remaining 34 nodes in the maze. For example, nodes 6, 19, 22 and 31 are the barrier node in the above maze.

Task 2:

Perform the Uniform Cost Search for the above randomly setup maze and output the visited nodes list, time to find the goal and the final path. Follow the following rules when you are performing the different search strategies.

a) Process neighbors in increasing order. For example, if processing the neighbors of node 8 , first process 2, then 7, then 9, then 14.
b) Only valid moves are going horizontal, vertical and diagonal.
c) No moves are allowed through the barrier nodes.
d) It takes 1 minute to explore a single node. The time to find the goal will be the sum of all nodes explored, not just the length of the final path.
e) Calculate the edge costs based on relative position of the nodes using a suitable distance measurement.

Task 3:

f) Develop a function to calculate the heuristic cost for each node using the Chebyshev Distance defined in the following equation:

$$d(N, G) = \max(|N_x - G_x|, |N_y - G_y|)$$

Where (Nx , Ny) denotes the current node of interest and (Gx , Gy) denotes the goal node.

Task 4:

Using the heuristic cost calculated in Task 3, perform A* search and output the visited nodes list, time to find the goal and the final path.

Task 5:

Repeat the above task 2,3, and 4 for three different random mazes (i.e. three times) and analyze the two search results in terms of completeness, optimality and time complexity. Also report the mean and variance of the solution time and path length.

Question 4

Fuzzy Logic-Based Anomaly Detection and Correction in Smart Grid Systems

You are working for a smart grid technology company that develops intelligent power distribution and fault-tolerant systems for electricity networks. Your task is to design a fuzzy logic-based anomaly detection and correction system to enhance the reliability of smart grid operations. The system should be able to detect and mitigate power anomalies such as voltage fluctuations, frequency instability, and phase mismatches, improving grid stability and minimizing power outages.

Requirements:

Anomaly Detection:
Implement a power anomaly detection mechanism that monitors electrical parameters in the grid. Use a fuzzy logic system to analyze real-time data and determine the likelihood of anomalies based on:

- Voltage Deviation
- Frequency Variation
- Line Load Imbalance

Fault Mitigation:
Create a fuzzy logic-based mechanism to correct anomalies when detected. Develop rules that determine how to mitigate faults based on their type and severity. Consider strategies such as:

- Load Balancing (Redirecting excess load to avoid overload conditions).
- Power Factor Correction (Adjusting capacitor banks to maintain efficiency).
- Frequency Regulation (Using energy storage to stabilize frequency).

Fuzzification:
Define linguistic variables and fuzzy sets for input variables related to grid stability, such as:

- "Voltage Deviation" → {Low, Medium, High}
- "Frequency Variation" → {Stable, Unstable}
- "Load Imbalance" → {Balanced, Unbalanced}

Fuzzy Rules:
Create a set of fuzzy rules to assess the likelihood and severity of anomalies based on input variables. Example fuzzy rule:

- If Voltage Deviation is "High" AND Frequency Variation is "Unstable" AND Load Imbalance is "Unbalanced," then the system should trigger a High Severity Fault Alert.

Defuzzification:
Implement a method for deciding on the appropriate mitigation action based on the fuzzy logic system's output. Example actions:

- If anomaly severity is high, isolate the faulty section.
- If anomaly severity is moderate, balance loads dynamically.

User Interface (Optional):
Design a dashboard to allow grid operators to:

- View real-time anomaly detection results.
- Choose fault correction strategies manually or automatically.

Testing:
Create test cases with simulated grid anomalies (voltage drops, frequency spikes, phase shifts) to evaluate the effectiveness of the detection and correction system. Measure the system's ability to accurately detect and correct anomalies.

Optimization:
Optimize the fuzzy logic system to:

- Minimize false positives (incorrect anomaly detections).

- Minimize false negatives (missed anomaly detections).
- Maximize grid stability improvement rates.

Documentation:
Provide documentation on how the system works, including:

- Fuzzy sets
- Fuzzy rules
- Decision-making process

Coding Task:
You are required to implement the core components of the fuzzy logic-based anomaly detection and correction system using any programming language of your choice. You may use existing libraries such as skfuzzy, but the core fuzzy logic processing must be implemented manually.

Key Components to Code:

- Fuzzification (Convert real-time power data into fuzzy linguistic variables).
- Fuzzy Rules Processing (Infer the severity of power anomalies using defined rules).
- Defuzzification (Decide on the appropriate response to correct power anomalies).
- Simulated Test Cases (Create a sample dataset with simulated anomalies to test the system's performance).

Question 5

The fifth component is a **quiz of 1.5 hours** that will be covering the whole syllabus of this module. It is planned to have during the last lecture session. Should there be any changes in the date/time of the quiz, it will be informed via CampusMoodle announcement. Attendance is mandatory for this quiz, non-attendance will lead to grade of F for this section.

Task(s) - format

Submit detailed illustrative report through with a word count not exceeding 10,000 to the CampusMoodle course page.

How will I be graded?	
A number of subgrades will be provided for each criterion on the feedback grid which is specific to the assessment. The overall grade for the assessment will be calculated using the algorithm below.	
A	At least 50% of the subgrades to be at Grade A, at least 75% of the subgrades to be at Grade B or better, and normally 100% of the subgrades to be at Grade C or better.
B	At least 50% of the subgrades to be at Grade B or better, at least 75% of the subgrades to be at Grade C or better, and normally 100% of the subgrades to be at Grade D or better.
C	At least 50% of the subgrades to be at Grade C or better, and at least 75% of the subgrades to be at Grade D or better.
D	At least 50% of the subgrades to be at Grade D or better, and at least 75% of the subgrades to be at Grade E or better.
E	At least 50% of the subgrades to be at Grade E or better.
How will I be graded?	
F	Failing to achieve at least 50% of the subgrades to be at Grade E or better.
NS	Non-submission.

*If the word count is above the specified word limit by more than 10% or the submission contains an excessive use of text within tables, the grade for the submission will be reduced to the next lowest grade.

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Feedback grid

GRADE	A	B	C	D	E	F
DEFINITION / CRITERIA (WEIGHTING)	**EXCELLENT** Outstanding Performance	**COMMENDABLE/VERY GOOD** Meritorious Performance	**GOOD** Highly Competent Performance	**SATISFACTORY** Competent Performance	**BORDERLINE FAIL**	**UNSATISFACTORY** Fail
Constraint Satisfaction Problem **(1 weight)**	Excellent understating of all the artifacts in the CSP problem, excellent implementation of such artifacts along with answers to the questions with an appropriate discussion.	Very good understand of CSP (problem) information along with very good implementation and answer to the question.	All the aspects relevant to the problem are identified, good implementation and well answered the questions without a discussion how the answers were reached.	Most of the CSP information covered, moderate level of implementation and most of the questions are answered.	At least half of the CSP aspects covered with minimum implementation and answered at least half of the questions.	Very few parts of CSP addressed, poor implementation and answers to the questions.
Ontology Engineering **(2 Weight)**	Excellent gathering of Cybersecurity aspects with proper citations, modelling them with OWL and querying with SPARQL	Very good attempt to gather Cybersecurity aspects with proper citations, modelling them with OWL and querying with SPARQL	Good attempt on Cybersecurity aspects, implementation and SPAQL queries with possible exceptions of citations.	Satisfactory attempt on Cybersecurity aspects, implementation and SPAQL queries with above average work on queries.	Poor attempt on Cybersecurity aspects, implementation and SPAQL queries. Possibly one part is very poor or omitted.	Very poor attempt on Cybersecurity aspects, implementation and SPAQL queries. Possibly two sub parts are very poor or omitted
Searching Algorithms **(3 weight)**	Excellent understating of two searching algorithms, their implementations based on the specified distance matrix, produce the correct outputs for randomly generated start points and generalization of results based on complexity analysis.	Very good understating of two searching algorithms, their implementations based on the specified distance matrix, produce the correct outputs for randomly generated start points and generalization of results based on complexity analysis.	Good understating of two searching algorithms, their implementations based on the specified distance matrix, produce the correct outputs for randomly generated start points and moderate level generalization of results based on complexity analysis.	Satisfactory understating of two searching algorithms, their implementations based on the specified distance matrix, produce the outputs (with minor errors in the code) for randomly generated start points and moderate level generalization of results based on complexity analysis.	Poor understanding on searching algorithms, their implementations with minor errors in the code) based on the specified distance matrix, produce the outputs (with minor errors in the code) for randomly generated start points and moderate level generalization of results based on complexity analysis.	Very poor understanding is demonstrated by the student on understating implementation and generalization.

GRADE	A	B	C	D	E	F
DEFINITION / CRITERIA (WEIGHTING)	**EXCELLENT** Outstanding Performance	**COMMENDABLE/VERY GOOD** Meritorious Performance	**GOOD** Highly Competent Performance	**SATISFACTORY** Competent Performance	**BORDERLINE FAIL**	**UNSATISFACTORY** Fail
Fuzzy Logic (1 weight)	Excellent understanding of fuzzy logic, its application to the specified domain problem and complete implementation.	Very good understanding fuzzy logic, its application to the specified domain problem and the implementation with minor coding/implementation mistakes.	Good understanding fuzzy logic, its application to the specified domain problem with minor issues in the modelling aspect and the implementation with minor coding/implementation mistakes.	Satisfactory work with fair understanding in fuzzy logic, modelling the problem and the implementation.	Poor work with below average understanding in fuzzy logic, modelling the problem and the implementation	Very poor work with significantly below average understanding in fuzzy logic, modelling the problem and the implementation.
In Class Quiz (3 weight)	Above 70% mark in the quiz.	60-70 % mark in the quiz.	50-60 % mark in the quiz.	40-50 % mark in the quiz.	30-40 % mark in the quiz.	Below 30 % mark in the quiz.

All the mark ranges <u>in the quiz</u> may be subjected to change based on the class performance as a whole.

Coursework received late, without valid reason, will be regarded as a non-submission (NS) and one of your assessment opportunities will be lost.

What else is important to my assessment?

What is the Assessment Word Limit Statement?

It is important that you adhere to the Word Limit specified above. The Assessment Word Limit Statement can be found in Appendix 2 of the RGU Assessment Policy. It provides detail on the purpose, setting and implementation of wordage limits; lists what is included and excluded from the word count; and the penalty for exceeding the word count.

What's included in the word count?

The table below lists the constituent parts which are included and excluded from the word limit of a Coursework; more detail can be found in the full Assessment Word Limit Statement. Images will not be allowed as a mechanism to circumvent the word count.

Excluded	Included
Cover or Title Page	Main Text e.g. Introduction, Literature Review, Methodology, Results, Discussion, Analysis, Conclusions, and Recommendations
Executive Summary (Reports) or Abstract	Headings and subheadings
Contents Page	In-text citations
List of Abbreviations and/or List of Acronyms	Footnotes (relating to in-text footnote numbers)
List of Tables and/or List of Figures	Quotes and quotations written within "…"
Tables – mainly numeric content	Tables – mainly text content
Figures	
Reference List and/or Bibliography	
Appendices	
Glossary	

What are the penalties?

The grade for the submission will be reduced to the next lowest grade if:

- The word count of submitted work is above the specified word limit by more than 10%.
- The submission contains an excessive use of text within Tables or Footnotes.

What else is important to my assessment?

What is plagiarism?

Plagiarism is "the practice of presenting the thoughts, writings or other output of another or others as original, without acknowledgement of their source(s) at the point of their use in the student's work. All materials including text, data, diagrams or other illustrations used to support a piece of work, whether from a printed publication or from electronic media, should be appropriately identified and referenced and should not normally be copied directly unless as an acknowledged quotation. Text, opinions or ideas translated into the words of the individual student should in all cases acknowledge the original source" (RGU 2022).

What is collusion?

"Collusion is defined as two or more people working together with the intention of deceiving another. Within the academic environment this can occur when students work with others on an assignment, or part of an assignment, that is intended to be completed separately" (RGU 2022).

For further information please see Academic Integrity.

What if I'm unable to submit?

- The University operates a Fit to Sit Policy which means that if you undertake an assessment then you are declaring yourself well enough to do so.
- If you require an extension, you should complete and submit a Coursework Extension Form. This form is available on the RGU Student and Applicant Forms page.
- Further support is available from your Course Leader.

What additional support is available?

- RGU Study Skills provide advice and guidance on academic writing, study skills, maths and statistics and basic IT.
- RGU Library guidance on referencing and citing.
- The Inclusion Centre: Disability & Dyslexia.
- Your Module Coordinator, Course Leader and designated Personal Tutor can also provide support.

What are the University rules on assessment?

The University Regulation 'A4: Assessment and Recommendations of Assessment Boards' sets out important information about assessment and how it is conducted across the University.