Bournemouth University

Faculty of Science and Technology

Department of Computing & Informatics

Unit Title: Machine Intelligence (COMP6068)		
Assessment Title: Tasks from selected topics of Machine Intelligence		
Unit Level: 6	**Assessment Number:** 1 **of** 1	
Credit Value of Unit: 20	**Date Issued:** 01/10/2021	
Unit Leader: Hamid Bouchachia	**Submission Due Date:** 14/01/2022	**Time:** 12:30 PM
Other Marker(s): N/A	**Submission Location:** Turnitin (+ large file submission box)	
Quality Assessor (QA): Vegard Engen	**Feedback Method:** Turnitin	

This is an individual assignment which carries 100% of the final unit mark.

ASSESSMENT TASK

- This assignment consists of **one problem with 3 parts**. You need to address all questions for full marks.
- This is an individual assignment.
- This assignment addresses all Intended Learning Outcomes (ILOs) for this unit (see below).

PROBLEM

Mr. Willy, a home printer, has acquired a programmable second-hand gravity printer (this term will be explained later) which allows him to print several coloured posters at the same time. This printer is programmable in the sense that it is provided with an ordered list of posters to print, and it interprets this list to decide the actual printing order. It has $N(2 \leq N \leq 32)$ ink cartridges, each of a different colour (the colours are numbered from 0 to N-1) and can print several posters simultaneously, provided that any two of these posters do not use a common colour.

The printing of a poster (or simultaneously of several posters as explained below) is done in a unit of time, and since Mr. Willy has just acquired this new printer, he prefers that one of his workers is near the machine at all times to check that everything is going well. He cannot run the printer for more than T units of time in the day.

Your job is as follows: every day around 3:30 pm, Mr. Willy provides you with the list of orders for the next day, and you must provide him with **the program for his printer** by 6:30 pm at the latest. In other terms, the job consists of transforming the list of customer orders into an optimised printing schedule (program).
Let's define what the list of orders (input of the problem = input to your algorithm) and program (expected output of your algorithm) are:

Input:
The list of orders is provided in the form of an ascii text file in the following format:

- On the first line, separated by spaces: the number N of ink cartridges of the printer, the number C of orders placed for that day, the time T of printing available;
- On each of the following C lines, separated by spaces: the number K of colours to use for the poster, followed by the list of K colours used.

Here is an example of a list of orders:

6 5 3	6 ink cartridges, 5 orders placed, 3 time units
4 0 1 3 5	order 0 uses 4 colours: 0, 1, 3 and 5
3 0 2 3	order 1 uses 3 colours: 0, 2 and 3
3 1 2 4	order 2 uses 3 colours: 1, 2 and 4
1 4	order 3 uses 1 colour: 4
2 1 5	order 4 uses 2 colours: 1 and 5

Output
The program you need to provide looks like this:

- on the first line: an integer giving the number A of posters to print;
- on each of the following A lines, the order number.

An example program supplied to the printer for the preceding list of orders is given in Figure 1.

5 1 4 0 3 2	5 posters to print

Figure 1: program supplied to the printer (left column)

It is not imperative that all orders be printed, but it is mandatory that the printing time does not exceed T because the printer cannot be stopped while a program is running. The first printing is made at time 0.

The program is interpreted by the printer as a part of Tetris where posters obey gravity. For instance, for the program on Figure 1, the posters are printed according to the following diagram shown in Figure 2. Here the x-axis indicates the colours (0 to 5) and the y-axis the order (time).

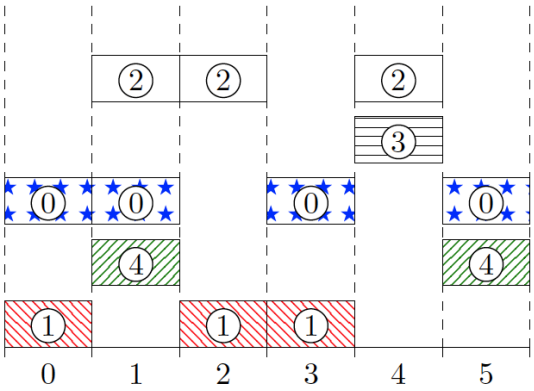

Figure 2: Translation to Tetris

The printing schedule resulting from Tetris in Figure 2 could read as follows:

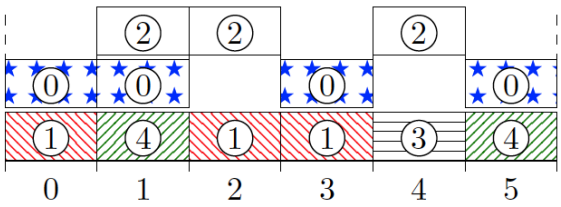

Figure 3: Scheduling after application of gravity: posters 1, 3 and 4 are printed at time 0, prints 0 at time 1 and prints 2 at time 2.

As can be seen from Figure 3, all colours of a poster are printed at the same time (due to the gravity notion).

The main objective is to print as many posters as possible in the allotted time T.

Unfortunately, the salesman has warned Mr. Willy that due to its age, the printer has a slight defect: you cannot use all the colours simultaneously, otherwise the pipes overheat and the colours bleed on the posters.

In terms of income, each poster printed earns Mr. Willy £10, while each sheet wasted (because of the ink smeared) costs him £5. A score is associated with each program is calculated according to this rule of income and loss. However, if the printing time exceeds T, the score is 0.

QUESTIONS
Part 1: Optimisation [*8 marks*]

- Why can this problem be considered an optimisation problem? [*8 marks*]

Part 2: Genetic Algorithms [*48 marks*]

2.1. Using genetic algorithms to solve this problem, theoretically design a technical solution (providing technical details) by describing the following [*24 marks*]:

a. the fitness function *(6 marks)*
b. the encoding of the chromosomes *(6 marks)*
c. the crossover operator *(6 marks)*
d. the mutation operator *(6 marks)*

2.2. Implement Python code with comments by using off-the-shelf (and provide the reference) or adapting the code given in the lab and run your simulation to find the optimal schedule that produces the best (final) score that should be indicated too. Please make sure to submit your code. (*20 marks*)

2.3. In your report, please critically discuss the outcome of your simulation and how the algorithm evolved the solutions to obtain that final score. (*4 marks*)

Part 3: Ant Colony Optimisation [*44 marks*]

Explain how Ant Colony Optimisation (ACO) can be applied to solve this problem by describing the main modelling steps. Please be systematic in your explanation, by providing:

3.1. How to model this problem to fit the ACO heuristic. The modelling task consists of providing the algorithm in the form of a pseudocode and describing its building blocks (steps) with full details. The answer should be as complete as if you were to implement the pseudocode. Please try to be general and not very specific about the example given above, meaning your reasoning should be about any possible list of orders (*20 marks*)

3.2. Implement in python your algorithm by using off-the-shelf (and provide the reference) or adapting the code given in the lab and run your simulation to find the outcome (*20 marks*)

3.3. Discuss the result in comparison to your GA outcome. (*4 marks*)

SUBMISSION FORMAT

Theoretical questions should be answered in written form except for the two code elements requested as part of Part 2 and Part 3 (Question 2.2 and Question 3.2).

Note that the limit on the number of words for the theoretical questions is **1500 words**.

You have two boxes, one for the written theoretical questions and one for the two code elements. The answers to the theoretical questions should be submitted through Turnitin. Please make sure to zip the code into one file and upload into the code submission box on Brightspace.

MARKING CRITERIA

The following criteria will be used to assess the assignment:

Criteria	**Mark**	**ILO(s)**
Part 1 as per the mark breakdown given above	8%	1,2,3
Part 2 as per the mark breakdown given above	48%	1,2,3,4
Part 3 as per the mark breakdown given above	44%	1,2,3,4

Breakdown of the marking is indicated as part of the questions. The answers will be evaluated based on the explanations and technical details to show a fair understanding of the core concepts of Genetic Algorithms and Ant Colony algorithms.

- In Part 1, you should provide well motivated answer with ample details against other possible alternative answers if any.
- In Part 2, the modelling as well as the description of the operators should be clear. The code should be well documented.
- In Part 3, your answers should be precise. Please avoid any ambiguity and be systematic in your description inspiring from the labs. The code should be well documented.

There is not necessarily one answer for questions 2 and/or 3. Therefore to obtain a higher mark, answers provided should evidence a detailed understanding of the algorithms and the results obtained are essentially correct. The answers should contain discussion that informs on different possible variations and arguments in favour of your adopted solution. To be precise, you may give examples and use graphics.

Note that the best guideline for helping obtain higher marks is to stick to the pattern of answering questions as demonstrated in the lab sessions.

INTENDED LEARNING OUTCOMES (ILOs)
This unit assesses your ability to:

1. Understand the essential elements of machine intelligence including machine learning, optimization and pattern recognition.
2. Develop a critical understanding of the “true predictive capability” concept of a learning machine, demonstrating awareness of pitfalls of the different approaches and the power of nature-inspired algorithms in solving problems.
3. Analyse decision making from both a computational and problem-solving perspective.
4. Critically evaluate different software that allow to solve-real world problems in different decision-making areas.

QUESTIONS ABOUT THE BRIEF
Support will be available via the assignment webpage (accessible via Brightspace) and in class. Additional support is available on request via email. Please note that the University guidelines state that emails should be responded to within 3 working days. Students are encouraged to work continuously on the assignment as the lectures progress.

Unit Leader Signature Hamid Bouchachia

Help and Support

Undergraduate Coursework Assessments

If a piece of coursework is not submitted by the required deadline, the following will apply:

1. If coursework is submitted within 72 hours after the deadline, the maximum mark that can be awarded is 40%. If the assessment achieves a pass mark and subject to the overall performance of the unit and the student's profile for the level, it will be accepted by the Assessment Board as the reassessment piece. The unit will count towards the reassessment allowance for the level; This ruling will apply to written coursework and artefacts only; This ruling will apply to the first attempt only (including any subsequent attempt taken as a first attempt due to exceptional circumstances).
2. If a first attempt coursework is submitted more than 72 hours after the deadline, a mark of zero (0%) will be awarded.
3. Failure to submit/complete any other types of coursework (which includes resubmission coursework without exceptional circumstances) by the required deadline will result in a mark of zero (0%) being awarded.

The Standard Assessment Regulations can be found on **Brightspace or via** https://www1.bournemouth.ac.uk/students/help-advice/important-information (under Assessment).

Exceptional Circumstances

If you have any valid **exceptional circumstances** which mean that you cannot meet an assignment submission deadline and you wish to request an extension, you will need to complete and submit the online Exceptional Circumstances Form together with appropriate supporting evidence (e.g. GP note) normally **before the coursework deadline**. Further details on the procedure and links to the exceptional circumstances forms can be found on **Brightspace or via** https://www1.bournemouth.ac.uk/students/help-advice/looking-support/exceptional-circumstances. Please make sure that you read these documents carefully before submitting anything for consideration. For further guidance on exceptional circumstances please contact your Programme Leader.

Referencing

You must acknowledge your source every time you refer to others' work, using the **BU Harvard Referencing** system (Author Date Method). Failure to do so amounts to plagiarism which is against University regulations. Please refer to https://libguides.bournemouth.ac.uk/bu-referencing-harvard-style for the University's guide to citation in the Harvard style. Also be aware of Self-plagiarism, this primarily occurs when a student submits a piece of work to fulfill the assessment requirement for a particular unit and all or part of the content has been previously submitted by that student for formal assessment on the same/a different unit. Further information on academic offences can be found on **Brightspace** and from https://www1.bournemouth.ac.uk/discover/library/using-library/how-guides/how-avoid-academic-offences

Additional Learning Support

Students with **Additional Learning Needs** may contact the Additional Learning Support Team. Details can be found here: https://www1.bournemouth.ac.uk/als

Primary Research (Undergraduate Levels)

You should not be conducting any primary research (i.e. carrying out an investigation to acquire data first-hand, for example, where it involves approaching participants to ask questions or to participate in surveys, questionnaires, interviews, observations, focus groups, etc.) unless otherwise specified in the brief. However, if there is a genuine requirement to collect primary research data you will require ethical approval before doing so. In the first instance, please discuss with the Unit Leader. The collection of primary data without appropriate ethical approval is a serious breach of Bournemouth University's Research Ethics Code of Practice and will be treated as Research Misconduct.

IT Support

If you have any problems submitting your assessment please contact the IT Service Desk - +44 (0)1202 965515 - immediately and before the deadline.

Disclaimer

The information provided in this assignment brief is correct at time of publication. In the unlikely event that any changes are deemed necessary, they will be communicated clearly via e-mail and Brightspace and a new version of this assignment brief will be circulated.