UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

HONOURS (Computer Science / IT)	APK CAMPUS
IT18X07 **OPTIMISATION** **EXAMINATION**	
2019–11-08	

EXAMINER **Prof. DA Coulter**
EXTERNAL MODERATOR **Dr GB O'Reilly (VAS-X / USC)**

TIME **2 HOURS** **MARKS** **100**

Please read the following instructions carefully

1. Write clearly and legibly on the answer sheet provided.
2. Fill in your details on both the question and answer book(s).
3. When submitting place your question paper inside your answer book(s).
4. This paper consists of 4 pages including the cover page

STUDENT # _____

SURNAME, INITIALS _____

Q1	
Q2	
Q3	
Q4	
Total	

Game images are from the Open Source Free Orion Project (https://www.freeorion.org)

Question 1 – Evolutionary Algorithms – 30 marks

Two-cent Interactive Entertainment and Social Profiling Incorporated (两分钱) has just announced "Utopia" its new space empire simulation game in the 4X (eXplore, eXpand, eXploit, and eXterminate) genre. The game is played online with many thousands of simultaneous users and features a procedurally generated AI controlled universe.

As one of Two-cent's newly employed consumer-workers it is up to you to create the automated ship design subsystem. Ships in the game have many slots into which various modules must be placed. Each module has a mass (which limits the maneuverability of the ship), a power usage, a resource cost, and an expected utility value (determined by another subsystem). The goal of your subsystem is to generate ship designs that maximize the total ship utility while minimizing resource costs. Certain additional requirements are imposed such as that each ship requiring sufficient power, containing certain key components such as engines and sensors etc.

a)	You are to use an evolutionary approach to solve this problem. • Name and discuss the components of such a solution in the context of this problem. (5 marks) • Restate the standard evolutionary algorithm pseudo-code in the context of this problem (5 marks)	[10]
b)	Some of the parameters that need to be evolved are continuous real values. In order to re-use previously developed evolutionary code you have opted to use a mapping approach. Your colleagues warned you that this may leave you vulnerable to Hamming cliffs. Describe the problem and how you plan to address it.	[5]
c)	With the release date growing ever nearer the company has switched to a 996 work-schedule (9 am to 9pm, 6 days a week). The resulting intensive beta-testing has revealed that the original single-core evolutionary implementation does not scale well. How will you address the problem and what issues will you need to consider?	[5]
d)	When ships from opposing empires encounter each other they may enter into combat. Combat is resolved by ships from the various fleets executing programs which control their orientation, engines, and weapon usage in response to values from their sensors. An evolutionary approach is to be used in order to find satisfactory instances of these programs. Your team has decided to use a Genetic	[10]

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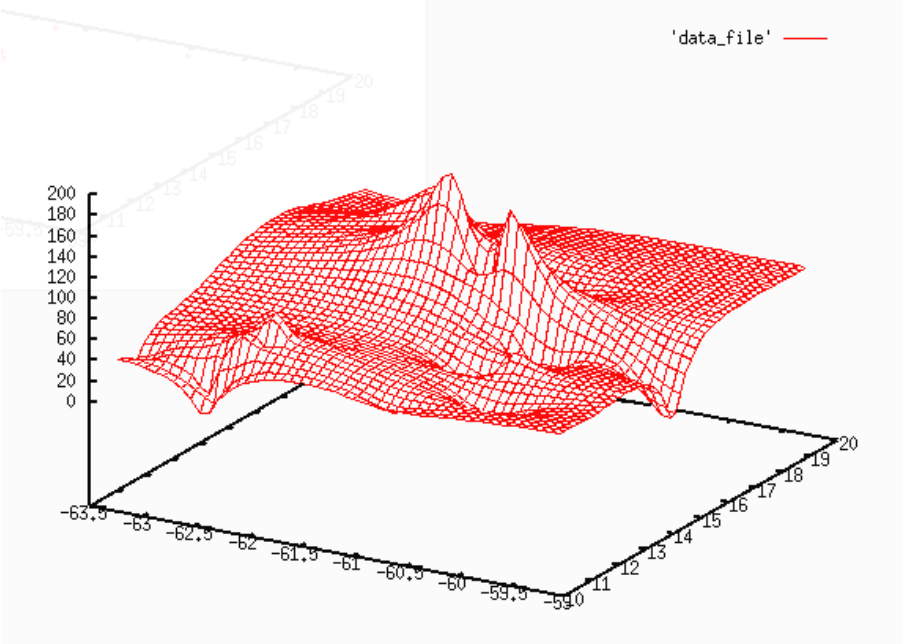
	Programming based approach in order to achieve this goal. Discuss the approach and the issues which will need to be considered for this in the context of the problem.	

Question 2 – Particle Swarm Optimisation

a)	One of the key selling points of the game is to be its accurate implementation of relatively realistic hard science-fiction based physics. Within the lore of the game faster than light (FTL) travel can only be achieved from volumes of space which are relatively high up in terms of the local solar system's gravity wells (i.e. high points in surfaces depicted in the diagram below)  However, the presence of dark matter makes it difficult to find these highpoints without sending ships to measure the volumes of space directly (a costly process). For this reason, the AI system is to build swarms of survey ships to cooperatively map the local volume of space and find suitable FTL access points. Your team has chosen to use a Global Best Particle Swarm based approach to control those ships. Provide pseudo-code for such an approach and relate it to the given problem.	[10]
b)	It turns out that while ships are finding acceptable FTL access points they are struggling to find the most desirable ones as they get stuck in local minima. It is thought that it may be possible to improve the exploration ability of the swarm by increasing the sophistication of their local information sharing via social networks. Discuss what changes you would need to make to the approach to achieve this.	[5]
c)	Early results have indicated a problem with survey ships gaining unacceptably high velocities causing them to skip over potentially good solutions and spend large amounts of time limping back into the solar system. Discuss some techniques you could use in order to address these issues in the context of the problem.	[5]
d)	The system is still failing to find a good balance between exploration and exploitation. Briefly describe five different techniques which could be used to control this balance.	[5]
e)	Feedback from beta testers regarding the ship design module you created in question 1 has highlighted issues with the system being too complicated. The whole ship	[5]

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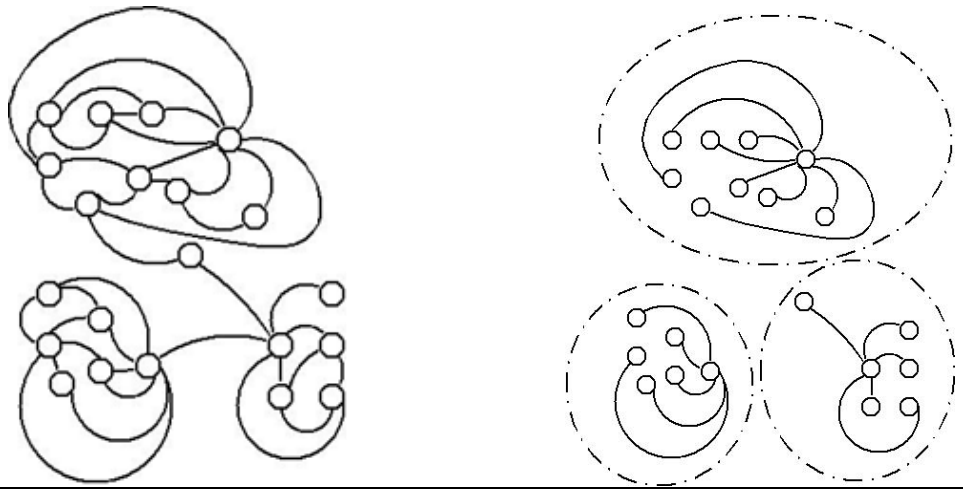
	design system has been simplified so that a module may either be included or not (multiple copies of a module are no longer possible). What impact does this have on the system and how do you address it?	

Question 3 – Ant Colony Optimisation

a)	The game's economy is also entirely AI-driven. All resources for producing ships and colonies need to be mined from the local solar systems and are unevenly distributed. As mining ships travel, they leave behind trails of ionised particles which other ships can detect but which only persist for a limited period of time. Give the pseudo code for the standard ant colony optimisation approach within the context of the given problem.	[10]
b)	Inspired by your team's solution to the problem in question 2 (b) Two-cent wants to begin mining the social interactions between human players in the game in order to identify potential social influencers for their upcoming marketing campaign. In order to do this, they have created a graph representation of all of the players who have ever communicated with each other. Your task is to come up with an ant-based approach for identifying the strongly connected components of these social graphs. 	[5]
c)	An important responsibility of the economy governance AI is the assignment of tasks to the various NPC (non-player controlled) ships. You feel very strongly that a response-threshold based approach should be taken but before making your case for it you go through some of the other task-allocation based approaches in the context of the given problem.	[5]
d)	You now present your approach to response-threshold based task allocation within the context of the given problem.	[10]

Question 4 – Hybrid / Connectionist / Additional approaches

a)	It turns out that maintaining a simulation of ionised particle decay across all points in space was a bad idea from a computational costs point of view. The latest update from the physics engine team has removed that feature from the game. Unfortunately, the conventional Ant Colony Optimisation based approach for resource extraction is no longer possible. You propose a system based on Stochastic Diffusion Search instead.	[10]

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