UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

HONOURS (Computer Science / IT)	APK CAMPUS
IT18X07 OPTIMISATION EXAMINATION SSA	
2020–12	

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. **You must complete this test yourself within the prescribed time limits.**
2. **You are bound by all university regulations please special note of those regarding assessment, plagiarism, and ethical conduct.**
3. **You must complete and submit the** "Honesty Declaration : Online Assessment" **document along with your submission to EVE. No submissions without an accompanying declaration will be marked.**
4. **You may submit scanned pages as per the instructions on EVE**
5. **Your answers to the question (in a single PDF format) together with the declaration must be submitted in a zip archive named in the following format.**
   STUDENTNUMBER_SURNAME_INITIALS_SUBJECTCODE_ASSESSMENT
   e.g. 202012345_COULTER_DA_IT18X07_EXAM_SSA.zip
6. **Additional time for submission is allowed for as per the posted deadlines on EVE.**
7. **No communication concerning this test is permissible during the assessment session except with Academy staff members.**

Question 1 – Evolutionary Algorithms – 30 marks

The US Robotics and Mechanical Arms corporation is in need of a motion planning software suit in order to control the movement of an industrial robotic arm. The arm is controlled by applying varying amounts of power for varying durations to a set of servomotors in sequence.

a)	You are to use a variation of the standard evolutionary approach to help plan the motion of the arm for an unchanging set of movements as part of an industrial process. The arm must avoid a set of immovable obstacles as part of its motion. The motion should be a short as possible and consume as little power as possible.
	• Discuss your approach in terms of the following (5 marks)
	    o Candidate solution representation
	    o Evolutionary operators and associated strategies
	    o System parameters
	    o Fitness evaluation.
	    o Stopping conditions
	• Provide a UML activity diagram for your customized algorithm (5 marks)
		[10]

b)	The company has just made a deal with the leading cloud service provider Valdivian Web Services (VWS). How would you adapt your approach to work well in a cloud context? What would the impact be in terms of balancing exploration versus exploitation?	[5]
c)	The robot arm is now equipped with rather poor-quality sensors. Due to ongoing internal reorganization of the factory floor the location of obstacles may change without warning. In addition, you are now required to avoid unnecessary wear and tear on the robot as well as limit the robots use of power. In addition, precise values for how much power a given movement will require are only roughly known. Provide a thorough description of the kind of problem domain you now face.	[5]
d)	The arm design is now on widely used and a great deal of telemetry is available for the arm's usage in real world environments. Management would like to write software which evolves functions describing the real-world usage of these arms. You may use either Genetic Programming or Gene Expression Programming to do so. Justify your selection of your chosen technique and detail what would need to be done in the context of this problem for your selected approach.	[10]

Question 2 – Particle Swarm Optimisation

a)	In addition to telemetry data regarding robotic arm operation a great deal of information is being collected about the details of the environment within which the arms operate and whether or not they experienced a failure. These details include information regarding humidity, temperature, water coolant mineral hardness, power stability, air quality, etc. One of the other teams in the company, The Connectionist Intelligence Group, have created a black box neural network model of robotic arm failure which provides a probability that the arm will fail within when operated under a given set of conditions.
	
	This is useful but management would rather know what the best operating conditions are. They would like you to use one of the basic variants of PSO in order to explore this space.
	    • Describe how you would implement such a system in detail in terms of:
	        o Problem representation
	        o Fitness evaluation
	        o Initialisation of the algorithm
	        o Termination criteria
	        o Social network structures
	    • Provide pseudocode for your version of the approach. Where you include mathematical expressions be sure to include a description of how this relates to your problem domain. (5 marks)
		[10]

b)	Describe the parameters of your PSO system.	[5]
c)	Discuss a couple of ways in which exploration vs exploitation can be controlled in your system and/or a few modifications to your system which will help do so.	[5]
d)	While the neural network based model of failure prediction works management isn't too pleased that no one can really explain **why** it works. It turns our that the problem of predicting failure is very highly dimensional. Researchers in the company have created simple, human understandable, models of product failure but these can only consider a few of the dimensions at a time. Describe how you can still explore the parameter space of these simple models collectively via a cooperative split particle swarm system. Pay special attention to the problem of fitness evaluation within this context.	[10]

Question 3 – Ant Colony Optimisation

a)	The robotic arm factory is itself being automated. As part of the process management would like you to design a way for small repair robots to be able to find their way to supply depots and broken machines as needed in a dynamically changing factory floor environment. They would like you to base this approach on the foraging behaviour of ants. Describe in detail how you would do so including details about environmental representation and inter-ant communication.	[10]
b)	Describe the parameters for your system in detail.	[5]
c)	Productivity has dropped amongst the remaining human work force. HR believes the issues may be the formation of silos / cliques (groups of employees who communicate more with each other than with members outside their group). HR would like you to identify these groups by analysing the email communication patterns of employees via an ant-based system.	[10]
d)	Having identified the workers who were most involved in the loss of productivity HR has given you access to their Personnel Database which contains information	[5]

	about each employee such as their psychological and physical profiles. They would like to see if there are any patterns in those employee profiles. That is, things that make them more similar to each other than to normal productive staff members. You have been asked to construct an ant based clustering approach to mining this data.	

Question 4 – Hybrid / Connectionist / Additional approaches

a)	The head of the Connectionist Intelligence Group has resigned in a rage and deleted both the trained neural network weights for the product failure prediction model as well as the source code for the system they developed. Due to the version control system being little more than an FTP server and a sense of optimism there is no hope of reconstructing that which was lost. Management has tasked you with retraining the neural network using your choice of either an evolutionary or neural network-based approach. Describe in detail how you would do so in terms of the following (2 marks each): - How a neuron in your network works - How the neural network works (a multi-layer perceptron network) - How you map the network onto your chosen approach - How you evaluate fitness - Any complexities which may arise as a result of your chosen approach	[10]