NEURAL AND EVOLUTIONARY COMPUTATION EXAM

CREDIT GIVEN FOR THE BEST 4 ANSWERS

TIME ALLOWED 2.5 HOURS

1(a) Using appropriate examples distinguish clearly between biologically motivated computing and computational biology. Suggest why a considerable overlap between these two fields of research is developing.

[6 marks]

1(b) Consider the following statement:

"The differences between the functional organisation of biological neurones and the neurons found in Artificial Neural Networks are ***much*** *greater than their similarities".*

Discuss this statement in the light of your understanding of these two types of 'device'. Credit will be given for reference to specific issues. Illustrate your answer with appropriate figures and examples and reference to particular research sources.

[12 marks]

1(c) Explain the variety of ways that Evolutionary Algorithms could be applied to the design of Artificial Neural Networks.

[7 marks]

2(a) Sketch the shape of the curve that satisfies Equation 1 and discuss its nature and occurrence in a selection of natural examples.

$$A = 1/1+e^{-N}$$ Equation 1

[4 marks]

2(b) State an ANN training algorithm which uses Equation 1 and explain very clearly and precisely why this equation must be differentiable for the algorithm in which it is used to work. Credit will be given for showing a thorough appreciation of the nature and workings of the algorithm.

[10 marks]

2(c) Given that the ANN considered in this system exhibits dynamical behaviour, explain why the initial weights in the ANN should be small, randomly assigned real values.

[6 marks]

2(d) Explain why Hebbian learning is an example of associationism and account for the Hebbian learning process in the ANN training algorithm.

[5 marks]

3(a) With reference to the general structure of a Genetic Algorithm explain what effect

(i) increasing the mutation rate

(ii) increasing crossover

could have on the likelihood that the G.A. would converge to a "good" solution.

[6 marks]

3(b) Explain what a schema is and how an understanding of schemata can help us appreciate the changes in the frequency of bit substrings within an evolving population. Illustrate your answer with an appropriate example.

[7 marks]

3(c) With reference to the structure of a G.A., explain what is meant by saying that the mutation rate is usually set as a "global external parameter".

[6 marks]

3(d) It is also possible to introduce operators into a G.A. that modulate the mutation rate so that it ceases to be a global external parameter. Explain some ways **in which** this could be achieved.

[6 marks]

QUESTION 4

4(a) The Iris Data Set, as originally analysed by R A Fisher, is a valuable resource for testing the power of new methods of data analysis.

(i) Describe the nature of the data set and explain why it is of value in testing and comparing adaptive computational methods.

[4 marks]

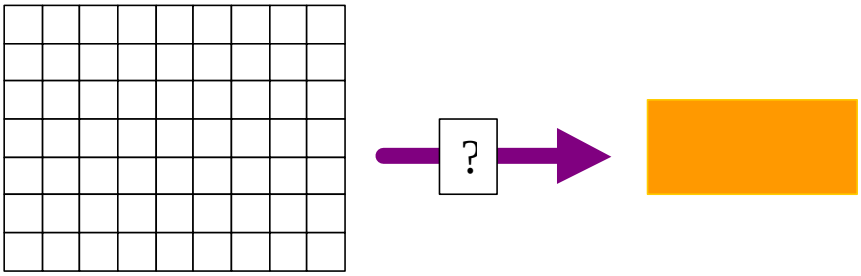
(ii) What are the limitations of reaching general conclusions about a data analysis strategy or technique when based solely on results produced from analysis of the Iris data set?

[4 marks]

(iii) Explain why a Kohonen Self-Organising Map (SOM) method would be more appropraite as a learning system than a MLP in the case of the Iris Data Set.

[4 marks]

4(b) One of the major problems for a designer of a computer system that exhibits some type of learning or adaptation concerns the representation of data with which the system has to deal. Consider the sensor array of 63 units arranged as shown in Figure XX. The box with the question mark is intended to convey the message that some preprocessing may or could take place at this stage.



(i) Discuss some of the ways information from this array could be presented to a Neural Network system that classifies the patterns on the grid into known types.

[8 marks]

(ii) Explain the reasons why a Kohonen SOM could be a better choice of ANN than MLP in this particular case.

[5 marks]

QUESTION 5

Below you will find some short extracts from a research paper. Read the material and then answer the questions at the end.

"The anatomy of a Evolutionary Algorithm is quite simple and yet the genes, chromosomes and genomes which are the biological source structures are highly organised biological systems ... Simple mutations can have complex origins and quite a few 'spontaneous' mutations arise from the juxtaposition (in time) of a number of discrete events ... Some genes remain stable over many generations because if they get damaged there are cellular (enzyme) processes available to it which can correct the dysfunctional changes.

... Baeck discusses results from experiments with genetic algorithms in which mutation rate was changed from a global external parameter into an internal item which changed during the search process (as in an Evolution Strategy). He shows how preliminary findings confirm the value of appropriate settings of environment-dependent self-adaptation in genetic algorithms and Davidor makes use of a Lamarckian operator to improve machine learning strategies based on genetic algorithms. This suggests an addition to a basic selectionist scheme in which the environment tests but does not set a genome. If there was a sufficiently robust model of the environment and adaptor-environment interaction it would be possible to specify adaptive strategies. It would then be possible to go further and consider contexts for the occurrence of such interactions and mechanisms which could bring it about ...

Hall noted that some mutations in bacteria occur more frequently when they are advantageous to the cell for example, if the cell is in some way subject to environmentally stressful conditions ... Various mechanisms can account for this. In this sense the environment can be said to "talkback" to the genome. An example of an EA implementation of such a system would be to include operations on bit- or trit- or real number strings which execute the analogue of an enzyme repair system to fix mutated genes. At a simple level certain repairs cannot be made because the chemical materials that are used as building blocks are not available."

Adapted from R. Paton, "Evolutionary Computing at the 'Soggy' End", paper presented to the AISB Workshop on Evolutionary Computation, 1994

QUESTION 5

5(a) Explain why an Evolutionary Algorithm is an example of a selectionist system.

[5 marks]

5(b) Why is mutation not quite so simple as often portrayed? (certainly in many EA designs)

[4 marks]

5(c) Explain what is meant by mutation rate in a GA being a "global external parameter".

[4 marks]

5(d) What is Lamarckism and explain why a Lamarckian operator in a GA would be non-selectionist ?

[4 marks]

5(e) What would be the effect of 'the analogue of a repair mechanism' on the mutation rate in a GA and suggest how it might be implemented.

[4 marks]

5(f) Explain how 'talk-back' would contravene a wholly selectionist viewpoint**.**

[4 marks]