UNIVERSITY OF KENT AT CANTERBURY

MODULE SPECIFICATION

1. The title of the module
CO637 Natural Computation

2. The Department which will be responsible for management of the module
Computing Laboratory

3. The start date of the module
September 2006

4. The number of students expected to take the module
50

5. Modules to be withdrawn
None

6. The level of the module:
H

7. The number of credits which the module represents
15

8. Which term(s) the module is to be taught in (or other teaching pattern)
Spring

9. Prerequisite and co-requisite modules
Prerequisite modules are CO322, CO325 and either CO520 or CO523.

10. The programmes of study to which the module contributes
BSc (Hons.) Computer Science, Computer Science with Management Science, Computer Science with Artificial Intelligence, and Business Computing, Web Computing plus Year in Industry variants.

11. The intended subject specific learning outcomes and, as appropriate, their relationship to programme learning outcomes
On successful completion of this module, students will:

A) To be able to describe what is meant by a natural computation paradigm, list a number of natural computing paradigms and give a brief description of each together with some examples of their (actual or potential) applications.

B) To be able to select the appropriate technique for a particular problem from a set of problem-solving heuristics based on these natural computing paradigms, and to be able to justify this choice based on a knowledge of the properties and potential of these methods. To be able to compare the general capabilities of a number of such methods and give an overview of their comparative strengths and weaknesses.

C) To be able to analyse phenomena from the natural world from the point of view of their being computational systems. To be able to take these phenomena and distinguish between the features which are important for computational problem solving and those that are merely a fact of their realization in the natural world.

D) To be able to implement a basic genetic algorithm on the computer, and apply this program to the solution of problems. To be able to take problems and encode them in representations which are appropriate for genetic algorithms, in such a way that demonstrates an understanding of some principles for creating a good encoding.

E) To be able to describe some examples of how physical devices other than traditional electronics can be used to form the basis of computing systems, and to be able to discuss in an informed way reasons why these devices might be better than traditional devices for some applications. To be able to apply similar reasoning to the analysis of related systems not directly studied on the course.

12. The intended generic learning outcomes and, as appropriate, their relationship to programme learning outcomes

F) To be able to exploit library and online resources to support investigations into these areas.

G) To be able to write coherently and critically about the topics studied in the course, based on readings from the scientific literature and demonstrating an awareness of how to write in a scientific manner.

H) To be able to apply mathematical techniques where appropriate.

I) To be able to apply appropriate computer programming techniques.

J) To be able to apply appropriate scientific principles and methodology.

Relationship to programme level learning outcomes:

A2: delivered through module learning outcomes D and I.

A4: delivered through module learning outcomes A, B and C.

A5: delivered through module learning outcomes B,D and H.

B1: delivered through module learning outcomes B,C, D and E.

C1: delivered through module learning outcomes D and I.

C2: delivered through module learning outcomes B,C, E, G and J.

D3: delivered through module learning outcomes D, F and G.

D5: delivered through the diligent completion of coursework assignments.

13. A synopsis of the curriculum
Motivation

There is an increasing use of nature-inspired computational techniques in computer science. These include the use of biology as a source of inspiration for solving computational problems, the application of artificial intelligence techniques to various problems, and the use of physical, chemical and biological and systems to construct computers. It is therefore proposed to allow students the opportunity to become exposed to these ideas for use in their late careers.

Syllabus

Introductory material. Is computer science the study of computers as products of human ingenuity or the study of natural processes? Is computing actually a property of the natural world? Is it possible to interpret natural phenomena using computational concepts? The use of metaphor, model and inspiration in computer science. Issues concerning scientific method and methodology. What sort of scientific questions can we answer using computational and informational concepts? Examples of biological problems that can be tackled using computational concepts (not computer simulation of biosystems). Using computational properties of the world directly for problem solving.

Evolutionary computing. General context via the idea of biologically-inspired computing techniques. Genetic algorithms: basic ideas, details of selection, crossover, mutation algorithms, how to choose between various types of algorithms. Genetic programming.

Artificial immune systems. Background to the biological immune system, how these ideas are abstracted to create AISs. Framework for AIS design. Applications.

Swarm intelligence. Basic ideas. Ant colony optimization. Particle swarm optimization. Applications.

Computation based on chemistry. Exploiting properties of chemicals to do computing. DNA computing and applications. Wavefront computing and applications.

Artificial life and simulated biology. The distinction between using computers to study existing biological systems and using them to investigate what life in general could be like. Reasons for using computers in biology. Applications of artificial life and biological simulation in a number of biological and medical areas; e.g. ecology, evolution, molecular biology, and/or cancer research. Theoretical notions such as emergence and the complex systems stance towards the natural world.

14. Indicative reading list:

P. Bentley, *Digital Biology*, Hodder-Headline, 2001.

L.N. DeCastro and J. Timmis, *Artificial Immune Systems*, Springer, 2002.

L.N. DeCastro and F. von Zuben, *Recent Developments in Biologically Inspired Computing,* Idea Group, 2004.

M. Mitchell, *An Introduction to Genetic Algorithms,* 1998.

M. Dorigo and T. Stutzle, *Ant Colony Optimization,* MIT Press, 2004.

15. Learning and Teaching Methods, including the nature and number of contact hours and the total study hours which will be expected of students, and how these relate to achievement of the intended learning outcomes

The total expected study hours for this module is 150. Thirty-two of these are contact hours (22 lectures and 10 seminars). The remaining time consists of private study, coursework preparation and revision for the examination.

16. Assessment methods and how these relate to testing achievement of the intended learning outcomes

Two pieces of coursework (40%) and an examination (60%).

Coursework 1. Implementation and testing of a genetic algorithm on the computer. Assesses learning outcomes D, G, J, K.

Coursework 2. An essay on a topic chosen from a list proposed. Assesses learning outcomes C-F, G, H.

Examination. A range of questions drawn from the whole syllabus. Assesses learning outcomes A-F, H, I, K.

17. Implications for learning resources, including staff, library, IT and space

Nothing special

18. Disability statement

As far as can be reasonably anticipated, the curriculum, learning and teaching methods and forms of assessment do not present and non-justifiable disadvantage to students with disabilities.

Statement by the Director of Learning and Teaching: "I confirm I have been consulted on the above module proposal and have given advice on the correct procedures and required content of module proposals"

....

Director of Learning and Teaching Date

Statement by the Head of Department: "I confirm that the Department has approved the introduction of the module and will be responsible for its resourcing"

....

Head of Department Date

Revised 16 November 2006