UNIVERSITY OF KENT AT CANTERBURY – CODE OF PRACTICE FOR QUALITY ASSURANCE

MODULE SPECIFICATION

1. **Title** **CO636** Cognitive Neural Networks
2. **Department** Computer Science
3. **Start Date** September 2006
4. **No. of Students** 60-100
5. **Module to be Withdrawn** This is a revision of CO621 Cognitive Neural Networks
6. **Level** H
7. **Credits** 15
8. **Teaching Term** Autumn

9(a). Prerequisites CO322 or A-level Maths or Equivalent

9(b). Corequisites None

10. Programmes Computer Science, Mathematics and Computer Science, Computer Science with Management Science, Computer Science with Artificial Intelligence, Business Computing, BSc Computing and Business Administration, BEng Computer Systems Engineering, BA/BSc Joint Honours Programmes in Applied Computing, BA/BSc Programmes 'with Computing', include Year-in-Industry versions.

11. Subject Specific Learning Outcomes: Students who successfully complete this module will be able to:

1. Describe what is meant by neural networks, list a number of types of network and give a brief description of each together with some examples of their (actual or potential) applications.
2. Select the appropriate neural network paradigm for a particular problem and be able to justify this choice based on knowledge of the properties and potential of this paradigm. To be able to compare the general capabilities of a number of such paradigms and give an overview of their comparative strengths and weaknesses.
3. Explain the mathematical equations that underlie neural networks, both the equations that define activation transfer and those that define learning.
4. Analyse cognitive and neurobiological phenomena from the point of view of their being computational systems. To be able to take these phenomena and identify the features which are important for computational problem solving.
5. Build neural networks using state of the art simulation technology and apply these networks to the solution of problems. In particular, to select from the canon of learning algorithms which is appropriate for a particular problem domain.
6. Discuss examples of computation applied to neurobiology and cognitive psychology, both in the instrumental sense of the application of computers in modelling and in the sense of using computational concepts as a way of understanding how biological and cognitive systems function. To be able to analyse related systems not directly studied in the course in a similar fashion.
7. Discuss examples of neural networks as applied to neurobiology.

Outcomes (1)- (5) are related to the following Computer Science programme outcomes:
Knowledge and Understanding of: A.2 (Software) and A.4 (Practice); Intellectual Skills: B.1 (Modelling); Subject-Specific Skills: C.1 (Design and Implementation); D.1 (Teamwork) and D.3 (Information Technology).
Outcomes (6)- (7) are related to the following Computer Science programme outcomes: Intellectual Skills: B.2 (Reflection and Communication); Subject-Specific Skills: D.2 (Communication) and D.5 (Self-Management).

12. Generic Learning Outcomes:

1 Utilize the library, exploit online resources and internet sites to support investigations into these areas.

2 Improve their analytical skills in respect of subsymbolic systems.

3 enhance their experience of working with others through group work.

Outcome (1) relates to the following Computer Science programme outcomes:
Subject-Specific Skills: C.1 (Design and Implementation) and D.3 (Information Technology); Subject-Specific Skills: D.2 (Communication) and D.5 (Self-Management).
Outcome (2) relates to the following Computer Science programme outcomes:
Intellectual Skills: B.1 (Modelling); Subject-Specific Skills: C.1 (Design and Implementation).
Outcome (3) relates to the following Computer Science programme outcomes:
Subject-Specific Skills: D.1 (Teamwork); D.2 (Communication) and D.5 (Self-Management).

13. Synopsis of Curriculum

The course is taught using a mixture of lectures and practical classes. Basic material will be taught in 1-hour lectures and 1-hour practicals. An indicative list of lectures and practicals follows.

Proposed Lectures:

Lecture 1: Introduction to cognitive neural networks.
The focus of the lecture will be the basic motivation for cognitive neural networks. Neural networks will be placed into a historical perspective related to symbolic approaches and in the context of the artificial intelligence hypothesis.
An overview of the general approach to be taken throughout the course will be given. The course text O'Reilly and Munakata "Computational Explorations in Cognitive Neuroscience" will be introduced. Work assessments and submission dates will be provided.
Practical 1. Students will familiarise themselves with the Leabra environment.

Lectures 2, 3 & 4: The individual neuron.
The focus of the lecture will be on developing the idea of the components of a neuron as a 'detector'. This lecture will explain neural networks in terms of the biology of the brain at a cellular electro-transmission level. This will be followed by abstracting the neurobiology into an initial neural network framework, i.e. a set of mathematical equations.
Practicals 2, 3 & 4: Students will run single neuron simulations and appraise their level of understanding. Students will work through the exercises/ explorations in Chapter 2.

Lecture 5, 6, 7 & 8: Networks of Neurons.
The focus of these lectures will be to provide a general framework for neural network architectures both at an abstract level and in terms of networks in the cortex. Unidirectional (feedforward) and bi-directional (recurrent) interactions will be explained together with inhibitory mechanisms.
Practicals 5, 6, 7 & 8. Students will work through the explorations in Chapter 3.

Lecture 9, 10, 11 & 12: Model Learning.
These lectures will provide the theoretical outline of a simple Hebbian model of learning, pertaining to neurobiology and neural networks. It will also introduce other models of unsupervised learning.
Practicals 9, 10, 11 & 12: Students will work through the explorations in Chapter 4.

Lecture 13, 14, 15 & 16: Task Learning
These lectures will provide the outline for error-driven task learning; the delta rule and back propagation will be presented. A discussion of the biological implausibility of backpropagation networks will follow.
Practicals 13, 14, 15 & 16: Students will work through the explorations in Chapter 5.

Lecture 17, 19 & 19: Combined model, task learning and other mechanisms.
These lectures will address the advantages and disadvantages of Hebbian and Error driven learning and how these different methods of learning may be combined.
Individual explorations: Students will work through the explorations in Chapter 6.

Lecture 20: The brain and implications for biologically plausible neural networks.

This lecture will consider a broad framework of biologically plausible neural networks and how this framework relates to brain architecture and function.

Lectures 21 & 22: Perception, Vision, Object Recognition and Attention.
The focus of these lectures will be from the lower level representations of vision to the higher level of object recognition. The neural networks considered will be placed within the context of the human dual route (what-where) visual system.
Individual explorations: Explorations will be based on the ability of the 'what-where' pathway to influence the network's allocation of attention to spatial locations (Chapter 8).

14. Indicative Reading List

R.C. O'Reilly and Y. Munakata
"Computational Explorations in Cognitive Neuroscience, Understanding the Mind by Simulating the Brain"
A Bradford Book, MIT Press
2000

D.E. Rumelhart, J.L. McClelland and the PDP Research Group
"Parallel Distributed Processing, Volume 1: Foundations"
MIT Press
1986

D.E. Rumelhart, J.L. McClelland and the PDP Research Group
"Parallel Distributed Processing, Volume 2: Psychological and Biological Models"
MIT Press
1986

W. Bechtel and A. Abrahamson
"Connectionism and the Mind, Parallel Processing Dynamics and Evolution of Networks"
Blackwell Publishers
2002

S. Haykin
"Neural Networks, A Comprehensive Foundation"
Prentice Hall International Edition
1999

C.M. Bishop
"Neural Networks for Pattern Recognition"
Oxford University Press
1995

R. Ellis and G. Humphreys
"Connectionist Psychology, A Text with Readings"
Psyhology Press Publishers
1999

15. Teaching and Learning Methods

The module will comprise 150 hours of study over one teaching term and the exam term. There will be approximately 22 hours of lectures and 16 hours of practicals. In addition, students will need to spend 32 hours on private study and materials, 40 hours on exercises and assessments, and 40 hours on pre-examination revision. 16 one-hour lab sessions will be dispersed between the lectures, supervised by a lecturer. Here students will obtain in-depth hands-on experience with neural network models.

The lectures initially serve to introduce the relevant issues and terminology, often on the basis of interactive discussion of illustrative examples. Lectures and practicals will follow the course text, with some topics supplemented by directed reading and exercise sheets. The students will acquire the listed skills by participating in exercises and assessments. Feedback on their work and further lectures will then concentrate on directing the students' reflection on their own practical work, leading to insights and skills at a more abstract level.

16. Assessment, examination methods and requirements

Coursework (20%)
A number of simulation exercises will be undertaken using the Leabra system following those described in the course book.

Examination (80%)
Learning outcomes not assessed by coursework will be assessed in a written examination.

The coursework will assess specific learning outcomes (1)-(7) and generic learning outcomes (1)-(3). The exam will assess specific learning outcomes (1)-(4) and (6)-(7) and generic learning outcome (2).

17. Resource requirements

The major requirement will be the teaching time, hardware and software. The software to be used is free for teaching purposes and would be run on PCs. It is proposed that this will be installed in appropriate computing rooms during the summer vacation. There are no library resource requirements over and above purchasing a small number of core texts, as the students will require their own copy to use as a work book.

18. Disabilities Statement

The department recognises and has embedded the expectations of SENDA, and supports students with a declared disability or special (educational) need in its teaching, through the establishment of Inclusive Learning Plans agreed between student, department and the Disability Support Unit. We will liaise with the Disability Support Unit in order to provide specialist support where needed.

Where a particular disability adversely affects a student's ability to attain one of the module learning outcomes, the corresponding programme learning outcome will be adversely affected to the same degree.

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 13 November 2006