Neural Network Models Exam Coursework 2001-2002 Deadline April 22th 2002 at 10.00 am *

Download the research paper *Modeling Distributed Concept Representation in Hopfield Neural Networks* , L. Carvalho, Mathematical and Computer Modelling, Vol. 30, 1999, p. 225–242 via the library's electronic journal portal http://www.lib.ic.ac.uk/ejournals/ejnls_titl.htm

This paper gives a new description of attractors in Hopfield networks, and a new learning algorithm for Hopfield networks. Read the introduction. What does it mean for neurons to be excited/inhibited in a pattern v? (Questions without a mark attached are to help you understand the paper.) Why is independence denoted by an orthogonality sign $\perp$? What is the meaning of the sign $+$ in $p_i = v_i + r_i$?

Read Theorem 1 and its proof, and give the definition of stability of a pattern (2/20). Read Theorem 2 and Corollary 3 without the proof. Show graphically how different stable patterns of activation can be reached as a result of the same initial excitation (1/20). You can draw the figure by hand if you want. Give you own definition of a probabilistic inference rule. You do not have to look up any references, and certainly not 26 and 27, they are not helpful. Explain how the decay process can be viewed as a probabilistic inference rule (3/20). Skip Theorem 4, and the rest of the introduction section.

Read the section on the synthesis problem, but only for the definitions of the minimum topology and maximum fault-tolerance criteria. Does the weight matrix have to be symmetric or zero-diagonal? Skip the section from syntactic criteria onwards. What is missing in both the author's synthesis criteria (1/20)?

The final section on the synthesis method introduces a non-linearity, called T in the paper, for the first time. Read up to and including example 1, but skipping the formula below formula (8).

*Hand it in at the General Office, Level 6

This is the main part of your exam coursework. Program an algorithm that does the minimization in (8). Your algorithm does not have to be sophisticated, but it needs to have a feature similar to simulated annealing. Describe it (2/20). Give your own definition of the XOR function for four variables, based on the XOR function of two variables. Show how your algorithm finds a neural network that calculates the XOR function of four variables (3/20). Try to minimize the topology, and show what trade-off that entails (3/20).

Choose w_{12} to be equal to the CID number on your college security card, multiplied by a power of 10 of your own choice, but so that your simulation uses all significant digits of your CID number. If your security card bears no number, use your date of birth.

The Challenge. If you want to get top marks, you have to do this challenge. However, you will get better marks for a good report without the challenge than for a mediocre report with the challenge solved.

Explain how the choice of T on page 238 can affect the stability criterion. Investigate several possibilities for T, linear and non-linear, and justify your choice of stability criteria. You may have to deviate from the choice of stability criterium in the paper. Also explain how a stability criterium does not automatically rule out local minima. (5/20)

You could organize your work as follows.

day 1 Read the paper, looking up anything you don't understand in your lecture notes. Plan what you are going to program.

day 2 Do the programming, and debug your program.

day 3 Run the simulations, and collect the results in a form that you can present in your report. Simulations can be in any programming language, on any machine. You can use Matlab or other software packages, but make sure that you have control over the parameters that you want to vary. What is called a Hopfield network in Matlab is not necessarily the same as what is called a Hopfield network in this exam paper.

day 4 Write the report. It should be maximum six pages (single sided) a4, in a font not smaller than 10 point. You will not get marks for anything exceeding six pages, even if it is appendices. Font size in tables and figures should be at least 10 point, or the tables and figure will not be marked. Describe the problem, and how you have solved it. Describe your simulations, but do not give programme listings. Do not give references to the literature. Make sure you do and answer everything

that is asked for in the coursework. If you have problems with formulas in text processing, do them by hand. Do not bind the report, but staple the pages together. Mention your name, and indicate for what degree (e.g. MEng Elec. Eng., MEng ISE, etc.) you are studying.

day 5 Check the consistency and quality of your work. Make last minute changes if necessary. If you feel confident and have the time, tackle the challenge. Resist the temptation to spend more than five 8-hour days of intensive effort on your coursework. You will not be compensated for it in marks. Just as an exam paper requires a concentrated effort over a few hours, this coursework requires a concentrated effort over a few days.

Do not forget to attend on the "exam" day. Bring a copy of your report with you, and your college security card. I will ask you one or two questions based on what you have written in your report, to make sure that you have written it yourself. No preparation is necessary.

Good luck.

Dr. P. De Wilde