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Artificial Intelligence (CMC143)

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CMC 143 Artificial Intelligence
Delivery Schedule and Topic Guide semester B 2004

eek ommencing) umber	Lecture Title	Indicative Texts
Feb 2	**An Introduction to the Nature of Intelligent Systems**: Introduction: The strengths and weaknesses of the conventional *numerical* model of computation (the Von Neumann Model). Defining Intelligence and its significance to modern corporate activities. A brief overview of connectionist, and symbolic approaches to delivering intelligent solutions. Some examples of applications incorporating these ideas.	S Greenfield, ***The Human Brain***, Harper Collins, 1997, S Greenfield(ed), ***The Human Mind Explained***, Cassell, 1996,
Feb 9	**The Connectionist Approach**: How the model came into being by reference to the history and development of an understanding of biological computation centred on the brain 's neurons. The neurons basic biological structure dendrites axons and synapses. Hebb's law. Mathematical model of a single two input artificial neuron based upon summation and thresholds (McCulloch and Pitts). The logical functions that can and cannot be implemented using such a model. Briefly mention Rosenblatt's practical implementation of a neuron. Introduction of the notion of training by error detection to achieve learning. Parity and connectedness flaws of the Perceptron stall neural development.	M. M. Nelson & W. T. Illingworth, ***A practical Guide to Neural Nets***, Addison Wesley, 1992. [P Quinlan, ***Connectionism & Psychology***, Harvester Wheatsheaf 1991 D.M. Skapura, **Building Neural Networks**, Addison Wesley, 1995. Steven Rose, **The Making of Memory**, Bantam Books, 1993.
Feb 16	**Learning in Neural Nets** Realistic problems need to consider multiple artificial neurons but how are they to be trained? This requires an unde rstanding of topology, node characteristics, training and learning. The back propagation algorithm is the dominant approach . The session concentrates on showing how the mechanism of back propagation operates using an example taken from Nelson.	Nelson Ch 9. **Understanding Neural Networks Vol 1: Basic Networks,** M. Caudill and C. Butler. Each student uses a copy of the basic data for the example to aid their following of the lecture worked example. Each student is given a copy of the : **DTI neural nets guidance notes**

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Assessment

- **Time Constrained Assignment**
  - Open Book
  - Three Hours
  - Two sections
- **Exam**
  - Closed Book
  - Pre-release

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Overview

- **Visit dc.lincoln.ac.uk**

For

- **Delivery schedule**
- **Seminar material**
- **Lectures**

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From Glass Box to Black Box and back again

A gentle introduction to Artificial Intelligence
Terry Spencer

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Objective

- **To give some insights into new methods for solving problems**
-
- ***To a person with a hammer everything looks like a nail!!!***

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Microsoft

- In Excel Tipwizard observes the users actions
- Analyses the processes and improves them

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D&B

- Sits at the client end
- Picks up messages
- Actions defined by a rules
- Used for email filtering routing report distribution

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TIVO and Orange

- Profiles

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Why Bother!

- **Forward thinking enterprises need to remain competitive and alert to opportunities**
- **Often Involves taking risks**
- **Judging the Risks is based upon sound information**
- **Imagination and vision must guide the decisions about technology**

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The Knowledge Economy

- **Using and leveraging Knowledge will be the dominant economic force**
- **Why?**
- **Most of today's work is about adding value this involves reasoning and problem solving**
- **NOT calculation and data processing**

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Work Smarter not Harder

- **Effectiveness is achieved not by working harder but by working smarter**

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Meeting the need AI

- **Neural Nets**
- **Knowledge based systems**
- **Fuzzy Logic**
- **Natural language processing**
- **(Agents)**

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Setting the Context to meet the need

Numeric/Algorithmic Problems	Symbolic/Heuristic Problems
Calculating Rapidly and with High Accuracy	Assessing Situations
Storing Vast amounts of Numeric and Alphanumeric data	Coping with Uncertainty
Manipulating data with great speed	Dealing with Abstraction
Operating reliability and Predictability	Adapting to change
	Learning from experience
	Perceiving Patterns
	Understanding Images
Traditional Techniques	AI Techniques

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What is the A in AI

- **Artificial**
- ***N*ot manifest in the normal manner perhaps under lab conditions but indistinguishable from the real thing**
- **A simulation lacks essential features (simulated death)**

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What is the I in AI

- Intelligence
- The ability to detect similarities in situation that are dissimilar
- The ability to detect differences in situation which are similar
- To respond flexibly to partial ambiguous and conflicting events

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Key themes

- To recognize patterns
- To deal with uncertainty
- To handle symbols

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What sort of patterns

- Sound
- Vision
- Data

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The impact of uncertainty

- **Pervasive**
- **Reduces the opportunity to**
- ***pre-plan in advance of events***

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The AI domain

- **Pattern Recognition**
- **Learning**
- **Reasoning**
- **Problem Solving**

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Neural Nets

- **Von Neumann Eat your Heart out!!!**
- **Sequential and Complex to**
- **Parallel and Simple**

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Intelligent Knowledge Based Systems - IKBS

- **They capture an enterprises intellectual capital expertise and experience and**
- **distribute such a resource throughout the company**

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IKBS

- **Data Processing**
  - **Captures Magnifies and distributes access to**
  Arithmetic
- **Decision Support Systems**
  - **Captures Magnifies and distributes access to**
  Information
- **Knowledge based Systems**
  - **Captures Magnifies and distributes access to**
  Judgment

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Case Based Reasoning

- **Programming by example in which knowledge is stored in the form of experiences, or cases.**
- **Product Support Help Desks**

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Constraint programming

- **Used to tackle hard planning problems such as work-force management routing and resource allocation.**
- **Arithmetic constraints: $X>0$ or $Y+Z < 15$**

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Example 2

- **Roster scheduling**
- **The Problem of assigning M jobs to N machines. Job I incurs a cost C. The objective is to assign the jobs to the machines(one job per machine) at the minimum total cost.**

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Genetic Algorithms.(John Holland)

- **The smarts of evolution and self preservation to solve problems by sorting out the right answers from the wrong.**
- **A technique based on natural selection. Generations of bit strings are created, combined and evaluated using genetic-like operations to find near optimal solutions.**

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Fuzzy AI

- **Can express linguistic terms such as maybe false sort of true**
- **Permits quantification of imprecise information. Make decisions based on vague and incomplete data yet by applying a defuzzification process arrive at definite conclusions**
- **(DOD 1991)**

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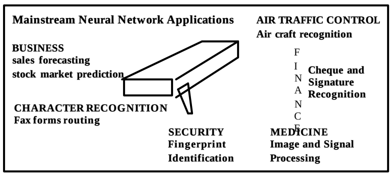
*From **Carbon** to Silicon: A biological metaphor for computation*

- **Neural Nets**



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NN and Pattern recognition

- **Why are we so good at it?**
- **Seems to depend upon knowledge stored as a network of interconnected brain cells**

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How

- The brain
- 10 - 100 billion neurons
- Fire at 1000 pulses per second
- Accepts inputs and generates responses to them

- What if a computer were constructed to, behave in a similar fashion ?

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The neuron

- Three parts
- Dendrite
  - Carry signals in
- Cell body
- Axon
  - Carries signals out

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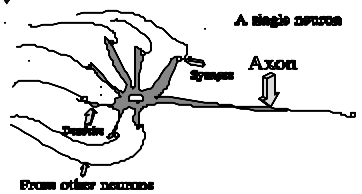
The Neuron



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Interneuron behaviour

- **Synapse**
  - the point at which a nervous impulse passes from one neuron to another
  - Two types
    - Excitatory
      - Their firing promotes the firing of the neuron
    - Inhibitory
      - Their firing discourages the firing of the neuron
  - The neurons behaviour is adaptable

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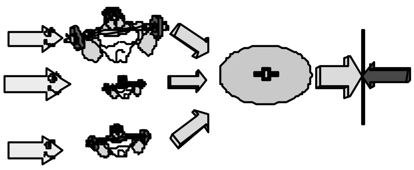
The behaviour of a single neuron



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Interneuron behaviour

- **Synapse**
  - the point at which a nervous impulse passes from one neuron to another
  - Two types
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      - Their firing discourages the firing of the neuron
  - The neurons behaviour is **adaptable**

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• Adaptable ---- Ability to learn

- **Hebb's Law**
- **Training**
- **Learning Laws**
- **The most popular -- Backpropagation**

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A Learning Law

- **Hebb's Rule (Donald 1949 The Organization of Behaviour)**
  - Describes the changes that occur on a cellular level when an animal learns.
- **Biologically**
  - When a neuron stimulates another neuron at a time when the receiving neuron is actively firing, the connection from the first neuron to the second is strengthened.

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History

- **1936 Turing uses the brain a computing paradigm**
- **1943 Warren McCulloch and Walter Pitts paper on Neurons**
- **1949 Hebb's learning Law In *The organisation of behaviour***
- **1962 Rosenblatt's Perceptron**
- **1969 Minsky & Papert critique**

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McCulloch and Pitts Ref

- University of Illinois
- ‘A logical Calculus of the ideas Immanent in Nervous Activity’
- Bulletin of Mathematical Biophysics 1943, 5, pp 115-133

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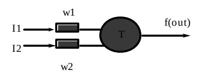
Mc & Ps mathematical model

- SINGLE neuron model
- 2 inputs
- Variable input strengths
- Aggregate inputs
- Threshold
- Response on or off



If (I1 * w1) + (I2 * w2) => T Then f(out) = 1

If (I1 * w1) + (I2 * w2) < T Then f(out) = 0

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Success and failure!

- logical operations successful AND OR
- logical operations unsuccessful EXOR

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Rosenblatts Perceptron - Category learning

- **The first trainable *single* neuron**
- **I = Sum i=1 to n of wi*xi**
- **y = +1 if I >= T**
  = -1 if I < T
- **wnew = wold + Beta*y* x**
- **Beta = +1 if the perceptrons answer is yes**
  = -1 if the perceptrons answer is wrong

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Perceptron's Failings

- **Parity**
- **Connectedness**

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Synthetic Artificial neuron

- **Take their *multiple* inputs**
- **Multiply by their respective weights**
- **Add all the individual products together**
- **Forward the result to a transfer function to generate an output**
- **Link the output to *other* synthetic inputs**

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Multiple Neurons and topology

- **Layers**
- **Input Output Hidden**
- **Multiple Neurons --- A neural *NET***

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Topology

- **Example**
- **Feed Forward**
- **Fully Connected**

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Transfer Function(1)

- **The transfer of input stimulus pattern to output response is called the *Transfer Function* of the artificial neuron**
- **Its a three stage process**
- **Stage 1 Sum**
- **Stage 2 Activation**
- **Stage 3 Threshold**

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Transfer Function(2)

- **Stage 2 converts the net input to a neuron to an activation level for that neuron**
- **Activation level is equivalent to the degree of excitement of a natural neuron**
- **The network processes an input stimulus pattern by the flow of activity from the input layer to the output layer**

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Output

- **input level I**
- **I = sum from i to n wi*xi**
- **Output level yi**
- **(f(I), if f(I) > T)**
- **(0, otherwise)**

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A Typical Activation Function

- **A sigmoid function –**
- **f(I) = 1/ 1 + e (-I)**
- **a useful derivative**
- **df(I)/dI = f(I)(1 - f(I)**

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Neural Nets are specified by

- **The net topology**
- **Node characteristics and**
- **Training or learning rules**

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Factors then are

- **Number of processing elements**
- **Number of interconnections**
- **Number of layers**
- **Possible weighting schemes**
- **Possible transfer functions**
- **Possible training methods**

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How do neural networks learn?

- **Neural networks learn to solve a program they are not programmed to do so**
- **Learning in neural nets consists of *making systematic changes to weights* in order to improve the networks response performance to acceptable levels**
- **A learning law *is the procedure which specifies the weight change***

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Training

- **Training is *the procedure by which the network learns***
- **Learning is the end result of the procedure**

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Two training modes

- **Supervised**
- **Unsupervised**

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Supervised

- **Requires a teacher**
- **Presentation of training data or training set**
- **I.e. for each input presented the corresponding desired output is also presented**

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Learning Law

- **Is associated with error measurement and its reduction.**
  - error being the difference between the desired output and the actual output
- **Can be very time consuming**

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Graded training

- **Similar to supervised but the exact desired output is not given - only a 'grade' on how well the network is doing**
- **E.g.. success fail too high too low**

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Unsupervised(self supervised, self organization)

- **Input patterns only**
- **No feedback on performance**
- **Adjustment of weights is by an internal monitoring of performance**
- **Kohonen networks**

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Back Propagation Learning and network

- **A training algorithm developed in the late 70's and early 80's**
- **80% of all current neural network projects use this approach**
- **Uses a generalisation of the delta rule**

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Useful URL

- http://www.shef.ac.uk/psychology/gurney/notes/contents.html

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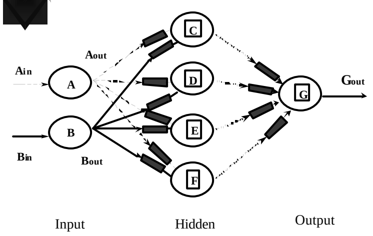
Back propagation



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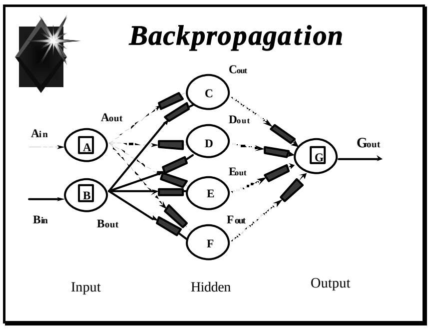

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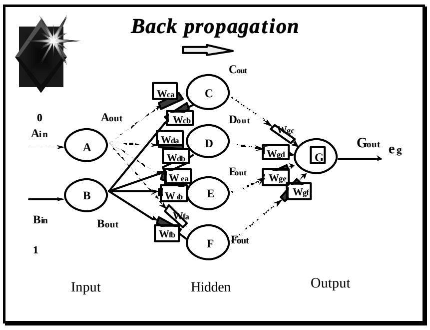

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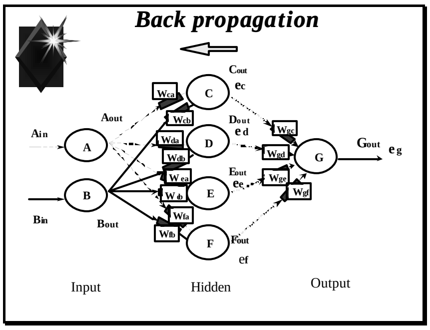

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Two phase training

- **Forward phase**
- **Input presented**
- **Resulting activity flows through the network from layer to layer to give the output response**

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Backward phase

- ***Errors* are propagated backwards through the network**
- **from the output layer back to the input layer**
- **with the weights of the intervening layers being modified as the error propagates**

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For the middle layer

- **The error in the output layer is passed back to the middle layer processing elements**
- **It is weighted by the same connection weights that modified the forward activation flow**
- **For reasons of mathematical stability, this net weighted error is multiplied by the derivative of the activation function of the middle-layer processing element.**

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For the middle layer

- **i.e.**
- **For each processing element, all current outputs are compared with the desired output and the difference, or error is computed.**

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Comments

- **Typically a backpropagation network consists of 3 or 4 fully interconnected layers**
- **Backpropagation AN uses a transfer function that is sigmoidal**

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Back Propagation

- **The learning law is delta wij = B*E*F(i) (wnew=wold)**
- **E is the error for the chosen AN**
- **B is the learning constant and F(I) is the input to the AN**
- **For the output layer**

E is the desired minus the actual output.

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Gradient Descent Rule

- **The backpropagation generalised delta rule is a gradient descent system**
- **A mathematical approach to minimising the error between the actual and desired outputs**
- **the weights are modified by an amount proportional to the first derivative of the error with respect to the weight**
- **converges to stability very slowly**

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Knowledge in a Neural Net

- **Is not stored in specific memory locations**
- **Is related to network structure**
- **Consists of the overall state of the network at some equilibrium condition**
- **A black box!!!**

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Not algorithms

- **The task is to specify**
- **Number of processing elements**
- **Number of interconnections**
- **Number of layers**
- **Transfer functions**
- **Weighting scheme**
- **Learning laws**

The power is in the collective computational ability

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Key characteristics

- **Adaptable**
- **Fault Tolerant**