19ECS 773: Deep Learning

Topic: Feed Forward Neural Networks

Unit I

April 16 2021, 2.00-3.00PM

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Outline

- What are Neural Networks?
- Biological Neural Networks
- ANN – The basics
- Feed forward net
- Training
- Example – Voice recognition
- Applications – Feed forward nets

What are Neural Networks?

- Models of the brain and nervous system
- Highly parallel
  - Process information much more like the brain than a serial computer
- Learning

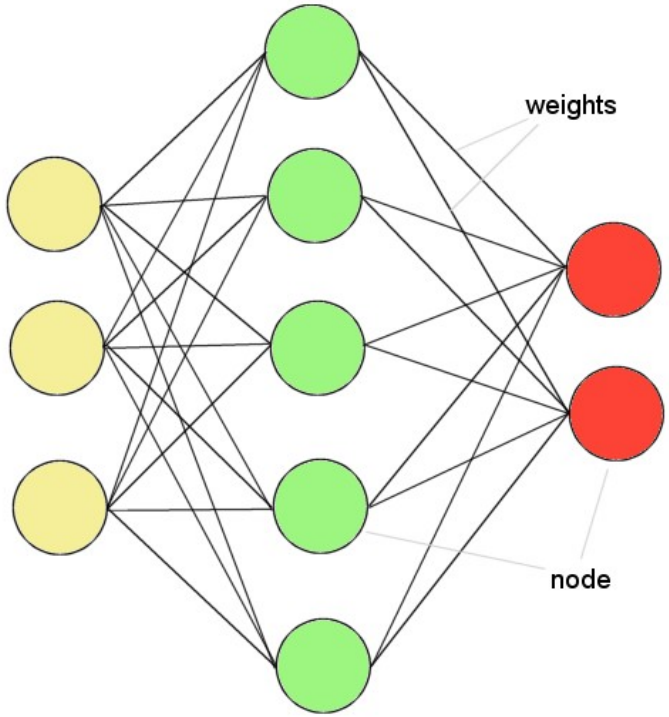
- Very simple principles
- Very complex behaviours

- Applications
  - As powerful problem solvers
  - As biological models

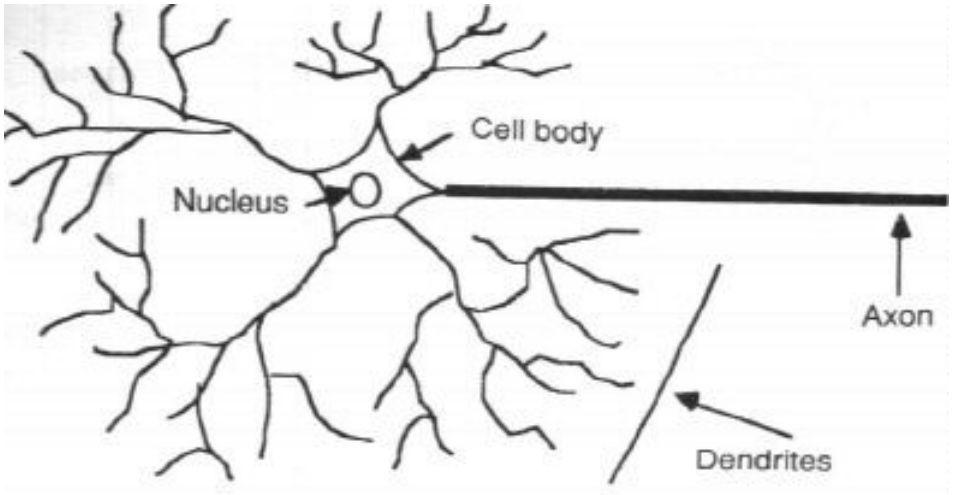
ANNs – The basics

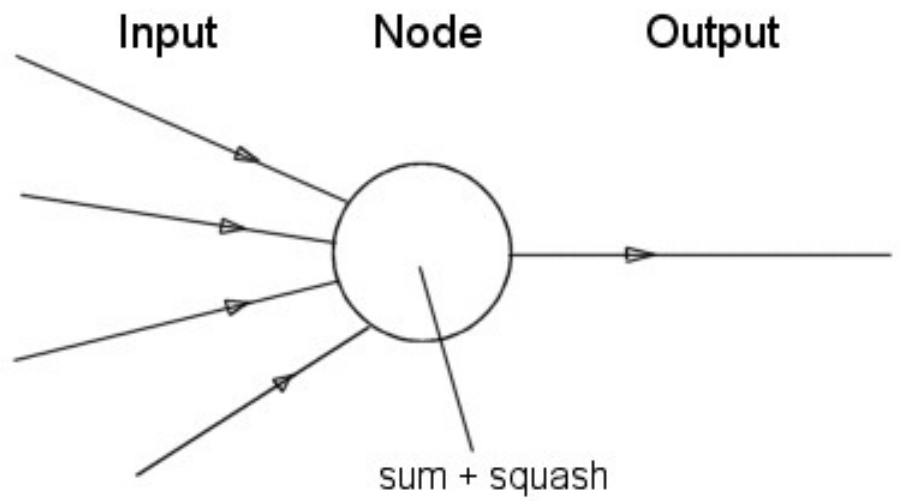
- ANNs incorporate the two fundamental components of biological neural nets:

1. Neurons (nodes)
2. Synapses (weights)

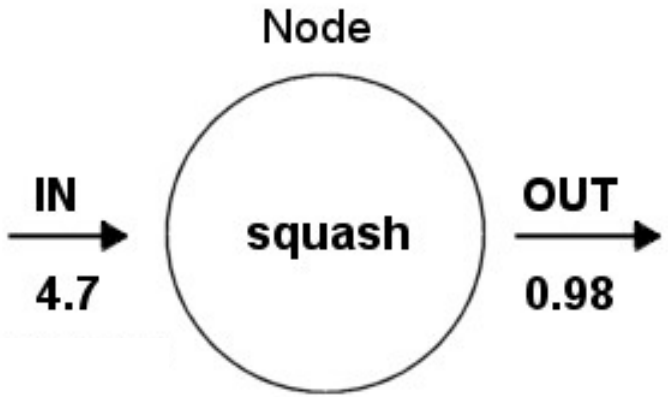


- Neurone vs. Node

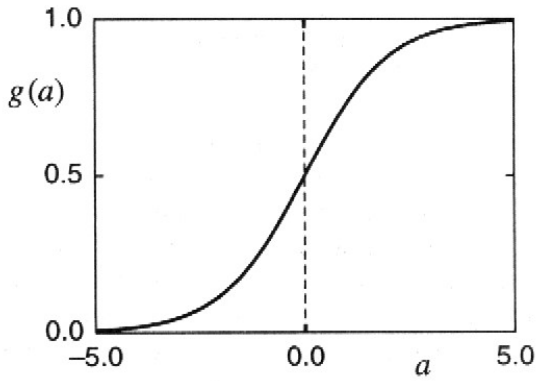




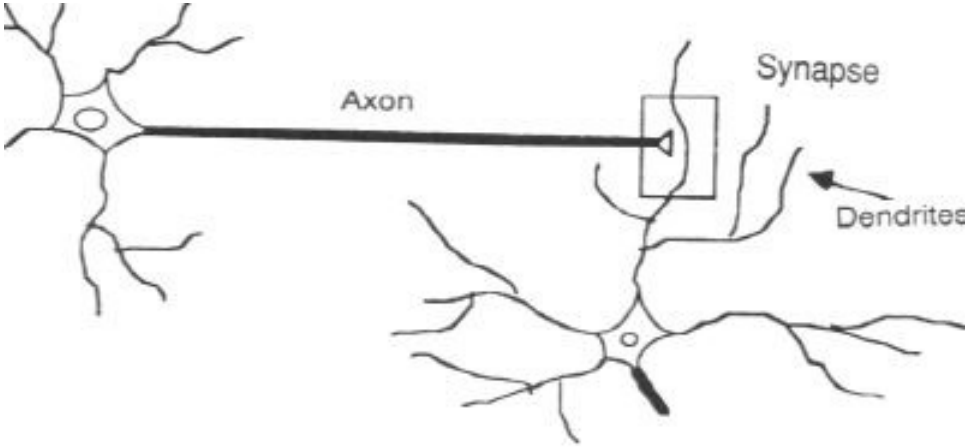
- Structure of a node:

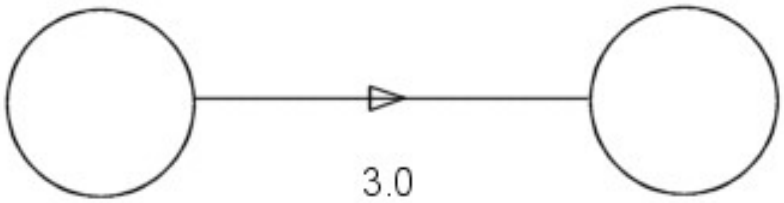


- Squashing function limits node output:



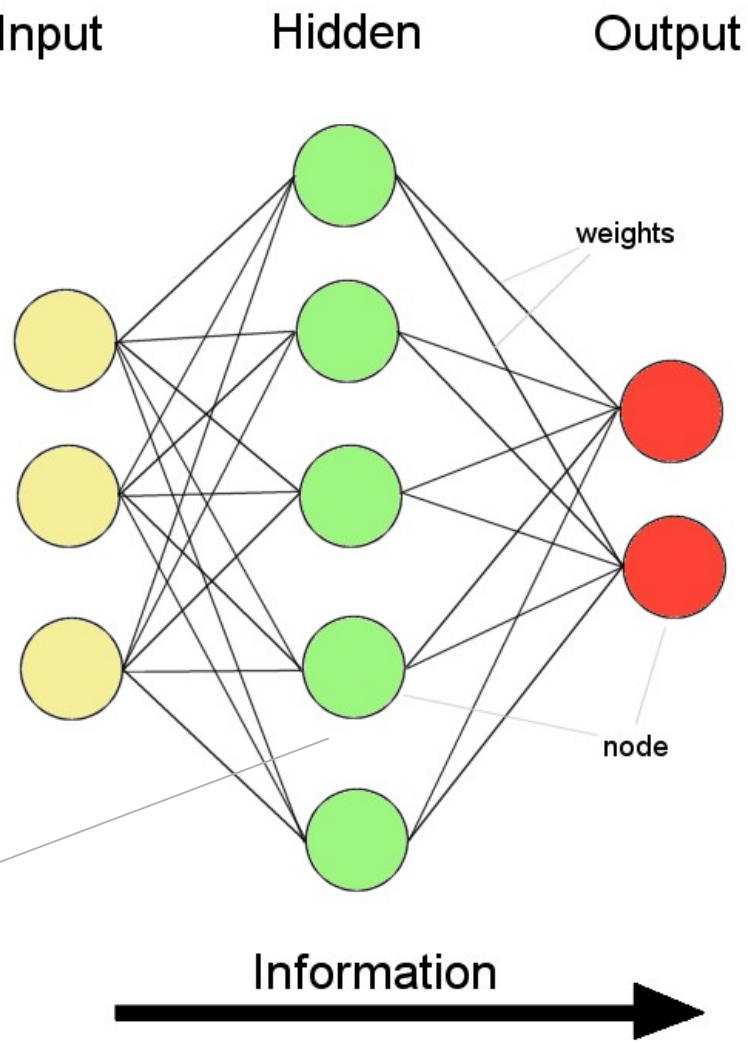
- Synapse vs. weight



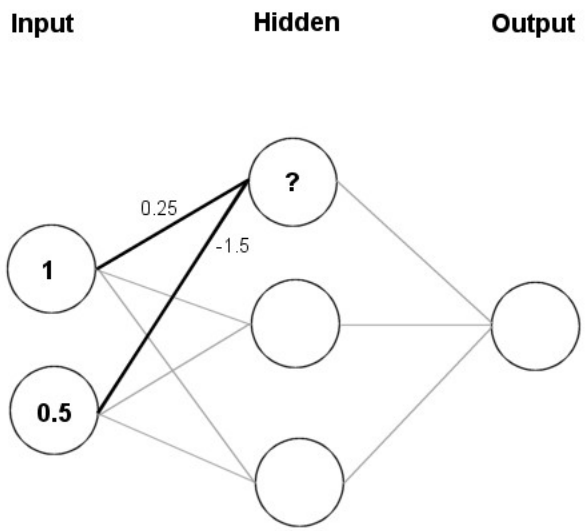


Feed-forward nets

- Information flow is unidirectional
  - Data is presented to *Input layer*
  - Passed on to *Hidden Layer*
  - Passed on to *Output layer*
- Information is distributed
- Information processing is parallel



- Feeding data through the net:



$(1 \times 0.25) + (0.5 \times (-1.5)) = 0.25 + (-0.75) = -\mathbf{0.5}$

Squashing: $\frac{1}{1+e^{0.5}} = 0.3775$

- Data is presented to the network in the form of activations in the input layer

- Examples
  - Pixel intensity (for pictures)
  - Molecule concentrations (for artificial nose)
  - Share prices (for stock market prediction)

- Data usually requires preprocessing
  - Analogous to senses in biology

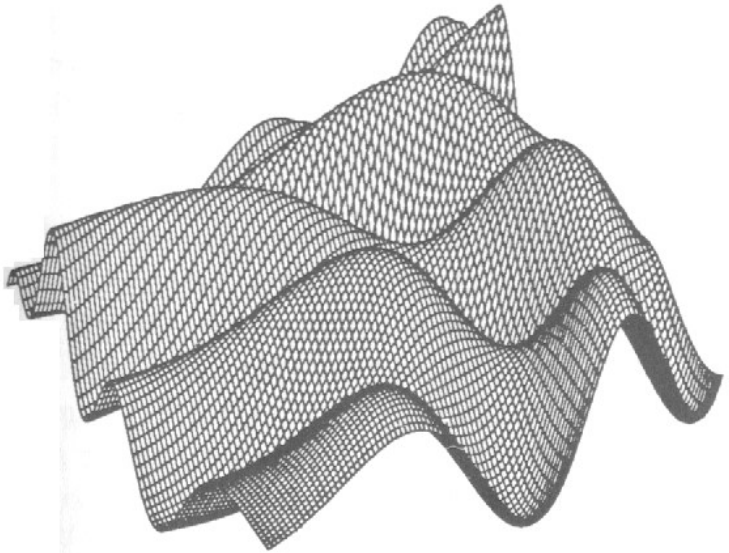
- How to represent more abstract data, e.g. a name?
  - Choose a pattern, e.g.
    - 0-0-1 for “Chris”
    - 0-1-0 for “Becky”

- Weight settings determine the behaviour of a network

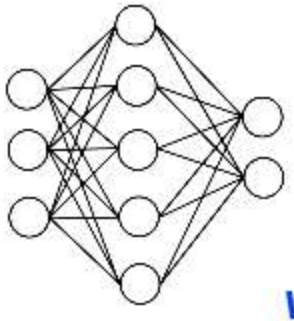
  → How can we find the right weights?

Training the Network - Learning

- Backpropagation
  - Requires training set (input / output pairs)
  - Starts with small random weights
  - Error is used to adjust weights (supervised learning)
  - → Gradient descent on error landscape



1.

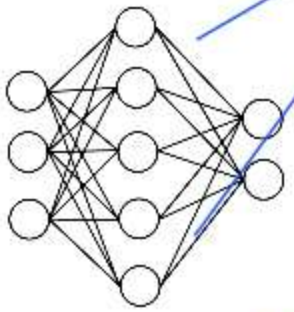


Wallace

Wallace - Darwin (calculate error)

adjust weights

2.

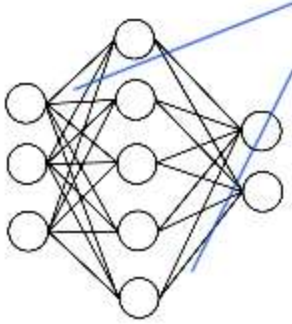


Wallace

Wallace - Darwin (calculate error)

adjust weights

3.



Darwin

- **Advantages**
  - It works!
  - Relatively fast

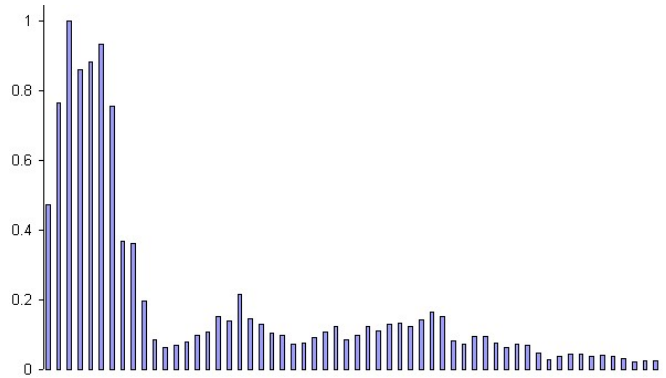
- **Downsides**
  - Requires a training set
  - Can be slow
  - Probably not biologically realistic

- **Alternatives to Backpropagation**
  - Hebbian learning
    - Not successful in feed-forward nets
  - Reinforcement learning
    - Only limited success
  - Artificial evolution
    - More general, but can be even slower than backprop

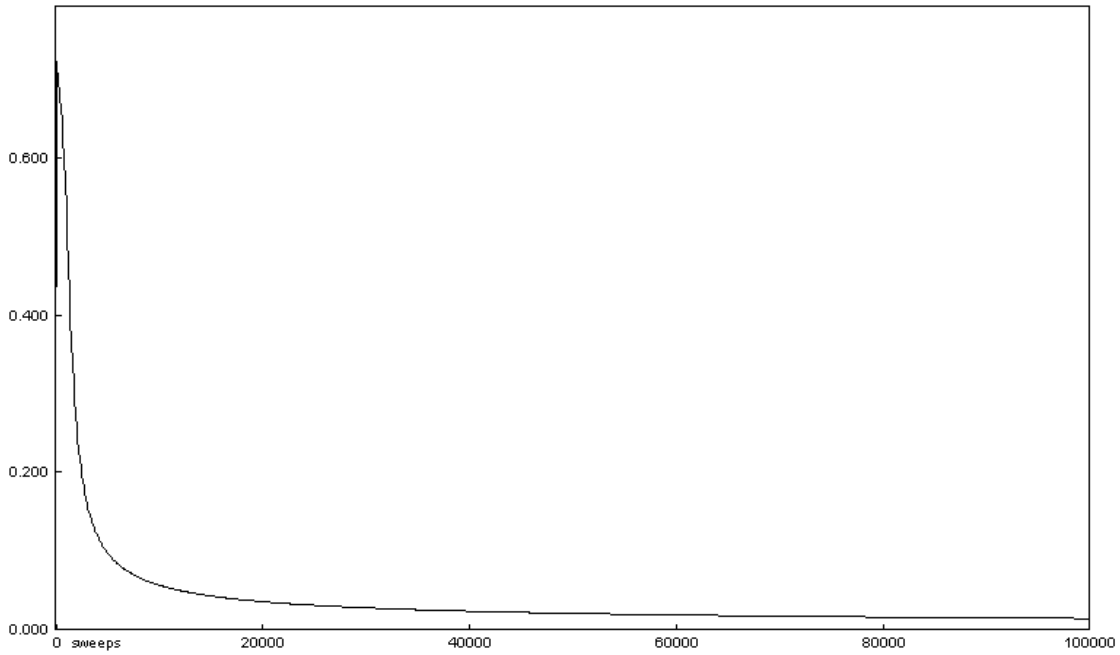
Example: Voice Recognition

- Task: Learn to discriminate between two different voices saying “Hello”

- Data
  - Sources
    - Steve Simpson
    - David Raubenheimer
  - Format
    - Frequency distribution (60 bins)
    - Analogy: cochlea

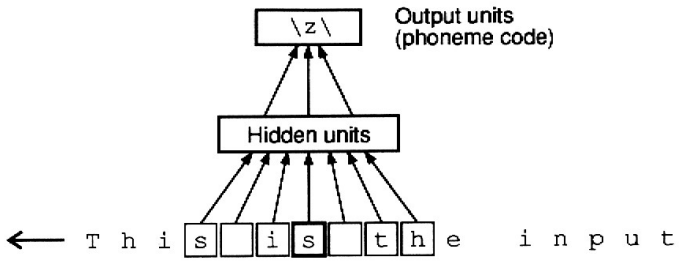


- Repeat process (sweep) for all training pairs
  - Present data
  - Calculate error
  - Backpropagate error
  - Adjust weights
- Repeat process multiple times



Applications of Feed-forward nets

- Pattern recognition
  - Character recognition
  - Face Recognition
- Sonar mine/rock recognition (Gorman & Sejnowksi, 1988)
- Navigation of a car (Pomerleau, 1989)
- Stock-market prediction
- Pronunciation (NETtalk)
  (Sejnowksi & Rosenberg, 1987)



Thank You!