BRSU

Neural Networks - Assignment 1

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1 Outline Chapter I

- What is a neural network?
  - Motivated by human brain
  - complex, nonlinear, parallel
  - Benefits of neural networks
    - Nonlinearity
    - Input-output mapping
    - Adaptivity
    - Evidential Response
    - Contextual information
    - Fault tolerance
    - VLSI implementability
    - Uniformity of analysis and design
    - Neurobiological analogy
- Human brain
  - about 10 billion neurons
  - about 60 trillion synapses/connections
  - energetic efficient

  - chemical synapses: electrical signal $- >$ chemical signal $- >$ electrical signal
  - plasticity via new connections and modification of existing ones
  - structural level of organization
- Models of a neuron
  - Neuron: Information-processing unit
  - Three basic elements:
    - Set of synapses
    - Adder
    - Activation function/squashing function
  - Types of activation function
    - Threshold function (McCulloch-Pitts model)
    - Piecewise-linear function
    - Sigmoid function
  - Stochastic model of a neuron
- Neural Networks viewed as directed graphs
  - Block diagram: functional description
  - Signal-flow graph: signal flow
    - Rule1: Signal flows in direction defined by arrow
    - Rule2: Node signal equals sum of entering signals
    - Rule3: Signal of node is transmitted to each outgoing link
  - Architectural graph: network layout
- Feedback
  - Feedback: Output influences input
  - Recurrent networks
  - closed-loop operator: $\frac{A}{1-AB}$
  - open-loop operator: AB
- Network architectures
  - Single-layer feedforward networks
    - No hidden layer
  - Multi-layer feedforward networks
    - Contains hidden layer
  - Recurrent Networks

        - ∗ At least one feedback loop

- Knowledge representation
    - Training via input-output pairs
    - Learning: applying algorithm on a training set
    - Generalization: test learned model on test set
    - Rule1: Similar input from similar classes should be classified into the same category
    - Rule2: Items of different classes should be given different representations in the network.
    - Rule3: The more important a feature, the more neurons to represent it
    - Rule4: Prior information should be built into the network beforehand
    - How to build prior information into neural network design
        - ∗ No well-defined rules
        - ∗ receptive fields
        - ∗ weight-sharing
    - How to build invariances into neural network design
        - ∗ Invariance by structure
        - ∗ Invariance by training
        - ∗ Invariant feature space
- Artificial intelligence and neural networks
    - Representation
    - Reasoning
    - Learning
    - Level of explanation
    - Processing style
    - Representational structure
- Historical notes

2 From Haykin's book, Chapter 1 problems - "Models of a neuron", solve any 2 out of 11 (1.1 to 1.11).

2.1 Exercise 1.6

Consider the pseudolinear activation function $\phi(v)$ shown in figure P1.6.
(a) Formulate $\phi(v)$ as a function of v.

(b) What happens to $\phi(v)$ if α is allowed to approach zero?

(a)

$$\phi(v) = \begin{cases} 0 & \text{if } v < -0.5\alpha \\ b & \text{if } v > 0.5\alpha \\ \frac{b}{\alpha}v + 0.5b & \text{else} \end{cases}$$

(b)
The function will not be defined for $\alpha = 0$. The function becomes more and more similar to a step function with value 0 for $v < 0$ and value b for $v > 0$.

2.2 Exercise 1.7

Repeat Problem 1.6 for the pseudolinear activation function $\phi(v)$ shown in Fig. P1.7.

(a)

$$\phi(v) = \begin{cases} -b & \text{if } v < -\alpha \\ b & \text{if } v > \alpha \\ \frac{b}{\alpha}v & \text{else} \end{cases}$$

(b)
The function will not be defined for $\alpha = 0$. The function becomes more and more similar to a step function with value -b for $v < 0$ and value b for $v > 0$.

3 From Haykin's book, Chapter 1 problems - "Network architectures", solve any 2 out of 7 (1.12 to 1.19) including 1.13.

3.1 Exercise 1.12

3.2 Exercise 1.16

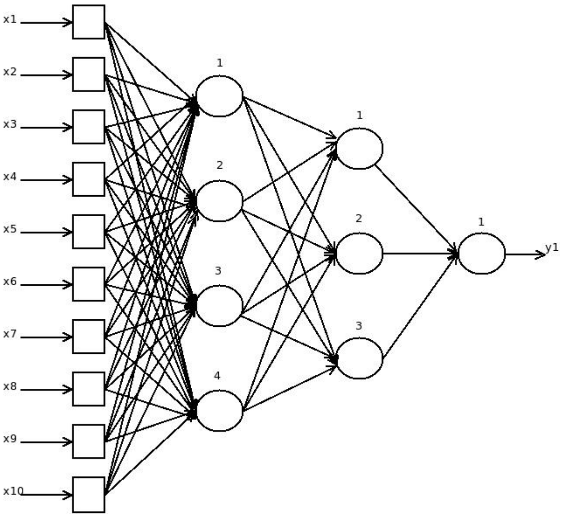

Figure 3.1: Fully recurrent network with five neurons, no self-feedback

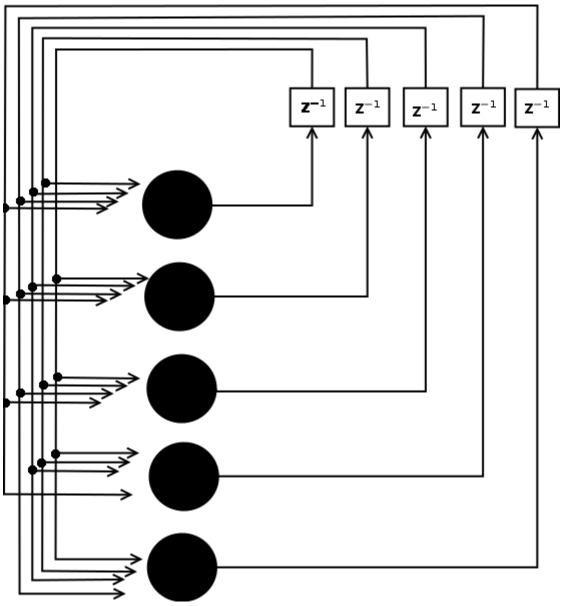

Figure 3.2: Fully connected 10-4-3-1 feedforward network