Artificial Neural Networks

- An artificial neural network (ANN) is a massively parallel distributed processor that has a natural propensity for storing experimental knowledge and making it available for use. It means that:

✓ *Knowledge is acquired by the network through a learning (training) process;*

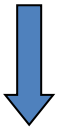
✓ *The strength of the interconnections between neurons is implemented by means of the synaptic weights used to store the knowledge.*

✓ The **learning process** is a procedure of the adapting the weights with a learning algorithm in order to capture the knowledge. On more mathematically, the aim of the learning process is to map a given relation between inputs and output (outputs) of the network.

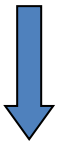
✓ A neural network is a parallel system, capable of resolving paradigms that linear computing can not.

How?

$f(x_1,\ldots,x_n)$ Unknown multi-factor decision rule



Learning process using a representative learning set



$(w_0, w_1,\ldots,w_n)$ A set of weighting vectors is the result of the learning process

$\hat{f}(x_1,\ldots,x_n) =$
$= P(w_0 + w_1x_1 + \ldots + w_nx_n)$

A partially defined function, which is an approximation of the decision rule function

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- The perceptron
- Multilayer neural networks
- The Hopfield network
- Bidirectional associative memories (BAM)
- Kohonen network

???????

- Perceptron's training algorithm
- The back-propagation training algorithm

???????

- Hebbian learning algorithm
- Competitive Learning Al**gorithm**

Exercise1

We have data on a number of students in last year's class. We want to build an intelligent system will allow us to determine whether current students are likely to get an A mark

The data consists of exam performance of a group of last year's students

Student	GPA>=80?	Male ?	Works hard?	Smoke	A?
S1	yes	yes	No	Yes	No
S2	yes	Yes	Yes	No	Yes
S3	No	No	Yes	No	No
S4	No	Yes	No	Yes	No
S5	Yes	No	Yes	Yes	Yes
S6	No	Yes	Yes	Yes	No

We propose to build a neural network system to solve this problem.

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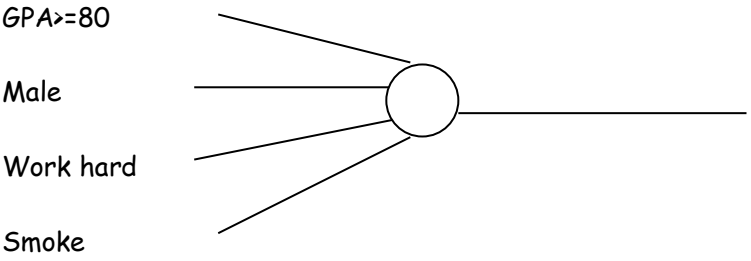
1-assume you NN system is composed of a single cell, how many inputs this system will have, and how many outputs ?, Draw the structure of such system

Answer:



2- Perform the training of the NN system, for one run assuming all the weighs are initialized to 0.2, the threshold set to 0.5 and use the step activation function.

2.1 what are value of the weight after the first run ?
Answer:

2.3 Repeat step 2 until the system satisfies all the training examples (gives the correct output for all the training example)

2.4 What are the values of the final weights

2.5 Using the above system, predict the performance of the following students

S7 : GPA>=80: No
Male: yes
Work Hard: Yes
Smoke: No

S8:
GPA>=80: yes
Male: No
Work Hard: Yes
Smoke: No

Exercise 2

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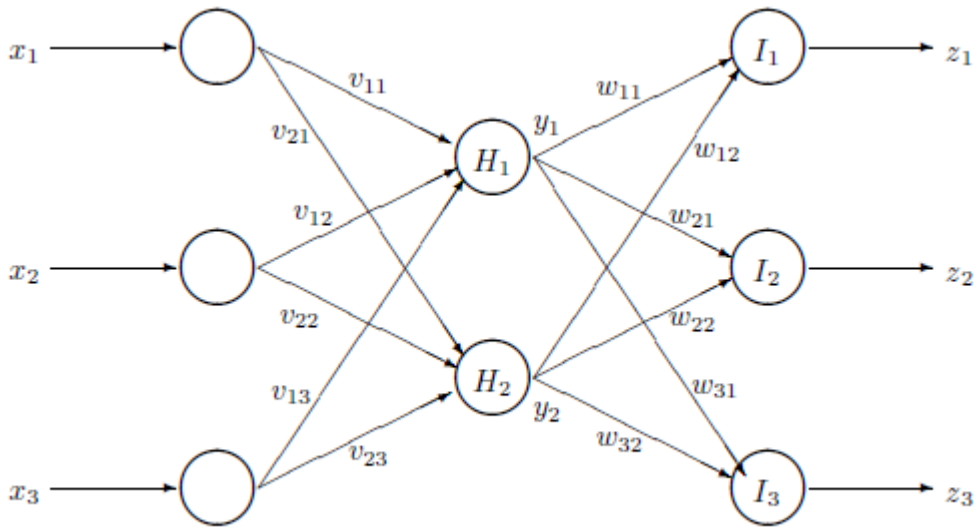
a. A neuron with 4 inputs has the weight vector w = [1, 2, 3, 4] ^{T} and a threshold value ɵ = 0 (zero). The activation function is linear, the activation function is given by f(net) = 2 × net. If the input vector is x = [4, 8, 5, 6] ^{T} give the output of the neuron (2points).

b. A training pattern, consisting of an input vector x = [x1, x2, x3] ^{T} and desired outputs t = [t1, t2, t3] ^{T}, is presented to the following neural network. What is the usual sequence of events for training the network using the backpropagation algorithm?(1 point)



A. (1) calculate $y_j = f(H_j)$, (2) calculate $z_k = f(I_k)$, (3) update v_{ji}, (4) update w_{kj} .
B. (1) calculate $y_j = f(H_j)$, (2) calculate $z_k = f(I_k)$, (3) update w_{kj} , (4) update v_{ji}.

C. (1) calculate $y_j = f(H_j)$, (2) update v_{ji}, (3) calculate $zk = f(I_k)$, (4) update w_{kj} .
D. (1) calculate $z_k = f(I_k)$, (2) update w_{kj} , (3) calculate $yj = f(H_j)$, (4) update v_{ji}.

c. For the same neural network given , the input vector to the network is x = [x1, x2, x3]^T the vector of hidden layer outputs is y = [y1, y2]T , the vector of actual outputs is z = [z1, z2, z3]^T and the vector of desired outputs is t = [t1, t2, t3]^T. The network has the following weight vectors(2points):

$$\mathbf{v}_1 = \begin{bmatrix} 0.4 \\ -0.6 \\ 1.9 \end{bmatrix}, \quad \mathbf{v}_2 = \begin{bmatrix} -1.2 \\ 0.5 \\ -0.7 \end{bmatrix}, \quad \mathbf{w}_1 = \begin{bmatrix} 1.0 \\ -3.5 \end{bmatrix}, \quad \mathbf{w}_2 = \begin{bmatrix} 0.5 \\ -1.2 \end{bmatrix} \quad \text{and} \quad \mathbf{w}_3 = \begin{bmatrix} 0.3 \\ 0.6 \end{bmatrix}.$$

Assume that all units have sigmoid activation functions given by

$$f(x) = \frac{1}{1 + \exp(-x)}$$

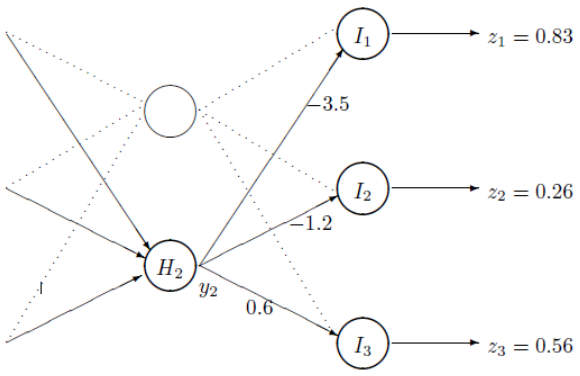
And that each unit has a threshold value ɵ = 0 (zero). If the network is tested with an input vector

x = [1.0, 2.0, 3.0] ^{T} then the output y1 of the first hidden neuron will be: ……

(Hint: on some calculators, exp(x) = e^x where e = 2.7182818)

Exercise 3

The following figure shows part of the neural network. The actual outputs of the network are given by z = [0:83; 0:26; 0:56]$_T$ and the corresponding target outputs are given by t = [0:58; 0:70; 0:20]$_T$. The weights w_{12}, w_{22} and w_{32} are also shown below.



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For the sigmoid activation function given in the previous exercise , the derivative can be rewritten as $f`(Ik) = f(Ik)[1 - f(Ik)]$:

a)What is the error gradient for each of the output units?

b) Suppose that the output y2 = N, calculate the updates in the weights w_{12}, w_{22} and w_{32}

a)What is the error gradient for the neuron H2?

b) Suppose that the input vector [1,2,3] , calculate the updates in the weights w_{21}, w_{22} and w_{23} between the input layer and the output layer.

Exercise 4

- Calculate the weight matrix for a Hopfield network to store the pattern [1 -1 1 -1]

.

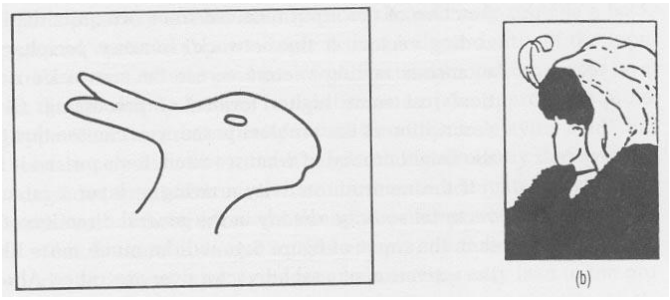
- Which of the following statements is NOT true for a Hopfield network?
  A. The output of the units is often specified by a bipolar step function.
  B. The weight matrix is symmetric — that is, $w_{ij} = w_{ji}$ for all units i and j.

  C. A unit can be connected to itself — that is, w_{ii} *not* = 0 for all units i.

Hopfield Nets in the Brain??

- The cerebral cortex is full of recurrent connections, and there is solid evidence for Hebbian synapse modification there. Hence, the cerebrum is believed to function as an associative memory.

- Flip-flop figures indicate distributed hopfield-type coding, since we cannot hold both perceptions simultaneously (binding problem)



Exercise 5:

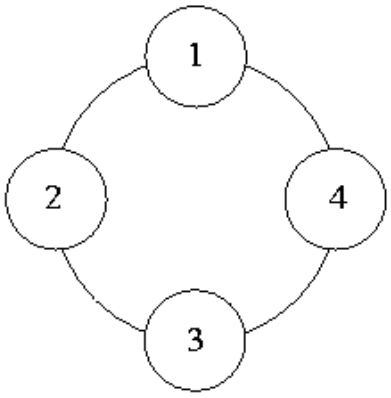
a)Explain by your own words the Hebbian learning algorithm ?

b)What is the topological mapping in a self-organizing feature map (SOFM)?

A. A map which organizes the robots and tells them where to go.

B. A mapping where similar inputs produce similar outputs, which preserves the probability distribution of the training data.
C. An approximation of a continuous function, which maps the input vectors onto their posterior probabilities.
D. A mapping where similar inputs produce different outputs, which preserves the possibility distribution of the training data.

d. A self-organizing feature map has four cluster units arranged in a one-dimensional ring, as shown in the following diagram:



The weight vectors of the four units are given as follows:
$w_1 = [-1.00, -1.50, 0.50]^T$
$w_2 = [2.00, -2.00, 5.20]^T$
$w_3 = [1.50, 6.00, 4.30]^T$
$w_4 = [-4.00, 7.00, 0.60]^T$

An input vector $x = [-1.40, 2.30, 0.20]^T$ is presented to the network. Which unit is nearest to x in terms of Euclidean distance? Or who is the winner who will takes all? And what is the all?!!!!

I hope after all these lectures and example the Artificial neural networks are clear for you .

When to use neural network? advantages and disadvantages?

Useful Resources:

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http://archive.ics.uci.edu/ml/index.html

http://fbim.fh-regensburg.de/~saj39122/jfroehl/diplom/e-index.html

http://www.alyuda.com/products/forecaster/neural-network-applications.htm

http://tralvex.com/pub/nap/

Projects ideas?

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