

# Intelligent Systems: Reasoning and Recognition

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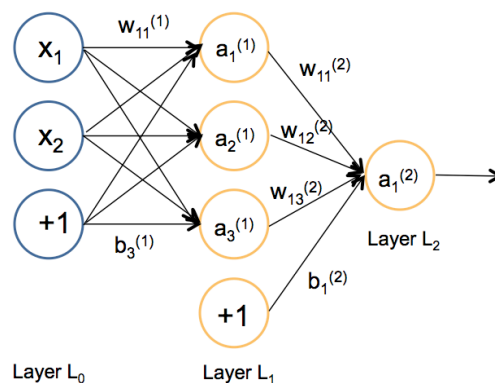
MoSIG M2  
Exercise 4v2

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## Artificial Neural Networks.

The following by may be performed by computer program or by hand. The recommended method is to write an interactive Python program.

Assume that you have a 2-layer network with 3 hidden units, and one output, using a sigmoid activation function.



The weights for the first layer have been initialized to the following (random) parameters:

$$W_{ji}^{(1)} = \begin{pmatrix} 1 & 0 \\ -1 & 0 \\ 0 & 1 \end{pmatrix}, b_j^1 = \begin{pmatrix} -1 \\ 1 \\ 0 \end{pmatrix}, W_{ji}^{(2)} = (1 \quad -1 \quad 0) \text{ and } b_j^2 = (0)$$

You have the following 4 samples of training data.

$$\{\bar{X}_m\} = \left\{ \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ 0 \end{pmatrix} \right\} \text{ with } \{y_m\} = \{1, 0, 1, 0\}$$

- Calculate the output of each unit  $a_{ji}^{(l)}$  for the first training sample  $\bar{X}_1$ .
- Calculate the error term  $\delta_{j,l}^{(l)}$  for each unit by back-propagation for the first training sample  $\bar{X}_1$ .
- Calculate the corrections  $\Delta w_{ji}^{(l)}$  and  $\Delta b_{j,l}^{(l)}$  for the first training sample  $\bar{X}_1$ .
- Apply the correction to the network parameters for layer 2 using a learning rate of  $\eta=0.5$ .
- (optional) Write a python code to evaluate  $\Delta w_{ji}^{(l)} = a_i^{(l-1)} \delta_{j,m}^{(l)}$  and  $\Delta b_{j,m}^{(l)} = \delta_{j,m}^{(l)}$  for all 4 training sample  $\{\bar{X}_m\}$  and  $\{y_m\}$  without applying the correction to the weights. Compute the average of the correction factors and then update the weights with a learning rate of  $\eta=0.5$  using the average. What are the resulting network parameters?