Examination of 'Neural Nets and Fuzzy Computing in Automation' (AS-74.3115)

Spring 2009

1. Consider the following Adaline with four inputs: $\mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix}$. The weight vector is represented by $\mathbf{w} = (w_1 \quad w_2 \quad w_3 \quad w_4)$. The Adaline output is calculated as

$$y = \mathbf{wx}.$$

There are three training input patterns for our Adaline, as shown below:

$$\mathbf{x}_1 = \begin{pmatrix} 1 \\ 0 \\ 0.5 \\ -1 \end{pmatrix}, \ \mathbf{x}_2 = \begin{pmatrix} -0.5 \\ 1 \\ 0.5 \\ 0 \end{pmatrix}, \text{ and } \mathbf{x}_3 = \begin{pmatrix} -1 \\ 0 \\ 1 \\ -0.5 \end{pmatrix}.$$

The desired outputs for these inputs $\mathbf{x}_1$, $\mathbf{x}_2$, and $\mathbf{x}_3$ are $y_1^d = -1$, $y_2^d = 0$, and $y_3^d = 1$, respectively. The initial weight vector is selected as:

$$\mathbf{w}^{(0)} = \begin{pmatrix} 1 \\ -0.5 \\ -1 \\ 0.5 \end{pmatrix}^T.$$

The learning rate is chosen to be $\lambda = 0.5$.

Calculate the training procedure of this Adaline with the above training data and parameters. Run only *one* complete training cycle with all the three training data pairs used. Note, there is no bias in our Adaline.

Hints: The Adaline learning algorithm is described as follows:

(1) Calculate the actual output of the Adaline y, given a training input pattern.

(2) Compare its actual output with the desired output. The connection weights are modified:

$$\mathbf{w}^{(k+1)} = \mathbf{w}^{(k)} + \lambda (y^d - y)\mathbf{x}^T,$$

where y^d is the corresponding desired output, and k is the iteration step.

(3) Repeat Steps 1 and 2 for all the training data pairs, and finish this training cycle.

2. Consider the following single-input and single-output Mamdani fuzzy logic system with three inference rules:

if x is SMALL then y is SMALL,

if x is MEDIUM then y is MEDIUM,

if x is LARGE then y is LARGE,

where x is the system input, and y is the output. The trapezoid-typed input and output membership functions for SMALL, MEDIUM, and LARGE are illustrated in Figs. 1 and 2, respectively.

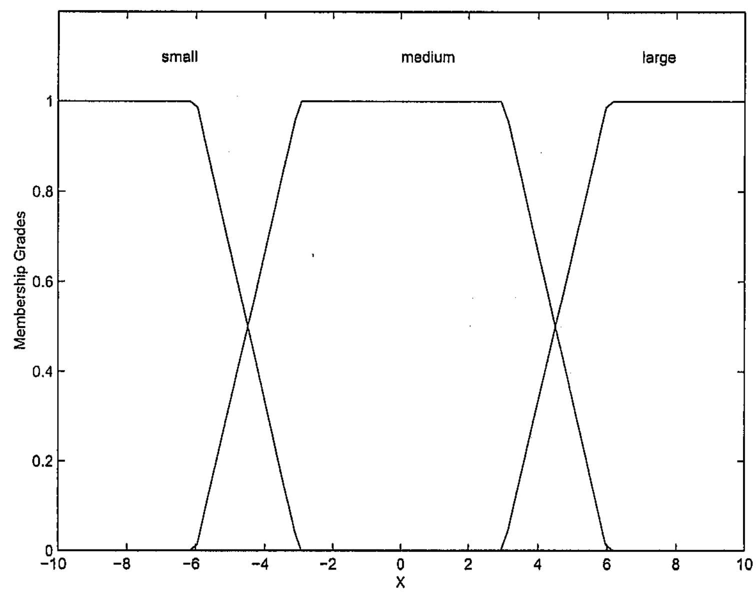

Fig. 1. Input membership functions for SMALL, MEDIUM, and LARGE.

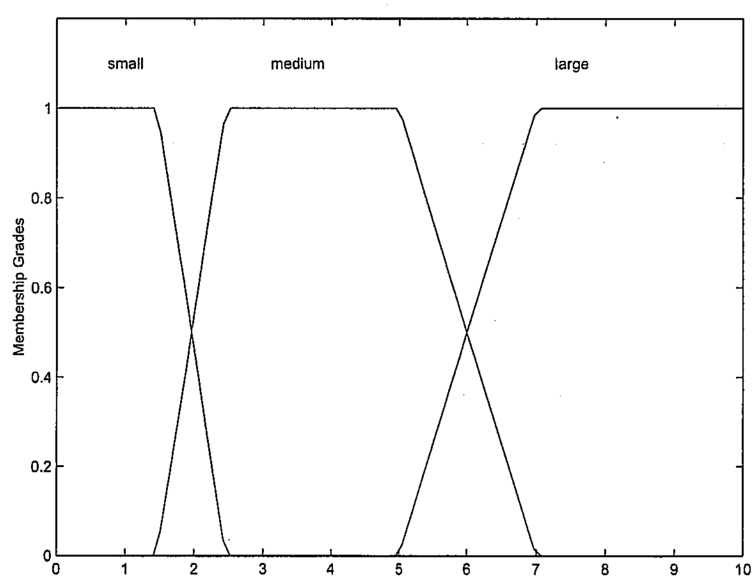

Fig. 2. Output membership functions for SMALL, MEDIUM, and LARGE.

Suppose we have inputs $x = -5$ and $x = 5$, what are the corresponding outputs of this fuzzy system? The Max-Min composition and Mean of Maximum defuzzification operators are used here. Please detail your calculation procedure with necessary *figures*.

3. Describe the hybrid learning algorithm of the ANFIS and its advantages, particularly, explain why the least squares method can be applied to update the consequent parameters of the ANFIS.

4. Explain how a basic *binary* genetic algorithm works. Explain *graphically* what the mutation and crossover operators are. Describe how the genetic algorithms can be applied in the optimization of the neural networks and fuzzy systems.

5. Discuss the basic principles and typical applications of neural networks and fuzzy logic. Present a few possibilities of using them to solve the problems in your own major subject.