ES 615 Nature Inspired Computing
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Instructor Prof. Nithin George

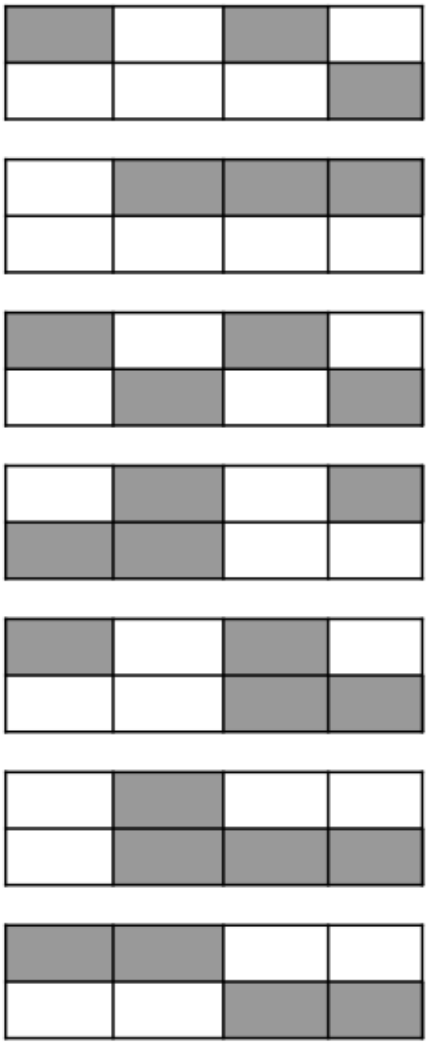
Assignment -4 Pattern Identification using RBF

Name - Devanshu Thakar

Roll no. – 18110174

Problem Stat

The Figure below shows the 7 possible patterns which will be used to unlock a bank vault. The first three cards are with Person A, the next two cards are with Person B and the last two cards are with Person C. Person A needs to select any two cards from the available three cards, Person B needs to select any one card from the available two cards and Person C needs to select any one card from the available two cards. The cards will be inserted one after the other into a neural network-based lock system. The lock must unlock if Person A inserts the two cards, followed by card by Person B and then Person C. If Person A inserts only one card in the beginning and the second card is inserted after Person B/C inserts their card, the sequence will be invalid and the lock will not unlock. If Person B/C inserts the card first and Person A inserts later, the sequence will be invalid and the lock must not unlock. Any pattern other than the available patterns (7 patterns) must also create an error and the lock must not unlock. Use a radial basis function (RBF) network with four Gaussian functions to implement this logic for the lock/unlock system.



Solution :

The give pattern can be encoded as a binary number with dark box indicating 1 and the light box indicating 0. The binary encoding can be converted to decimal. Therefore the input to the network can be a vector of size 4 with values in range of 0 to 255 (8 bits).

The general form of **Gaussian function** is:

$$g(x) = ae^{-\frac{||(x-c)^2||}{2\sigma^2}}$$

- The centres for the Gaussian function is found by clustering the training data. Here hierarchical clustering algorithm was used.
- The standard deviation for the Gaussian is computed from the standard deviation of a particular cluster.
- The scaling factor for all Gaussian was set at 1.

After determining the centres and standard deviations, weight needs to be computed. The computation of weight can be performed directly using **Least square estimate** as

$$W = (\phi^T \phi)^{-1} \phi_T \, \mathbf{t}$$

Where ϕ is the matrix of values from all four gaussians in columns and the number of rows equal to the training data. **t** is the output vector for the training data.

- A bias term can also be included with weight vector W.
- The output from weight vector can be feed to an activation function. Here, ReLU activation function was used.

References :

1. https://towardsdatascience.com/most-effective-way-to-implement-radial-basis-function-neural-network-for-classification-problem-33c467803319

2. http://www.personal.rdg.ac.uk/~sis01xh/teaching/CY2D2/Pattern8.pdf