Chapter 6

DELPHI ADAPTED (WEIGHTED) BIDIRECTIONAL ASSOCIATIVE MEMORIES (DABAM)

6.1 Introduction

A new fuzzy technique Delphi Adapted BAM (DABAM) is proposed in this chapter. DABAM is proposed to function as a multiple expert system, in that it can be used to combine any number of expert’s views into one relational matrix. To create a balance between views of experts, who might have different experiences in the problem under analysis, each expert is given a weight as in Delphi method.

The Delphi method (Dalkey and Helmer, 1963) is a proven tool for collective decision making (Linstone and Turoff, 2002) for a situation in which decision needs to be made by a group of experts who might have divergent views on the topic. This method can also be called a prediction method based on expert judgment. The Delphi method is characterized by the properties like anonymity, feedback, statistical and convergence. It tries to achieve a consensus among the experts. In order to account for the amount of fuzziness in group decision making Murray et al.(1985) proposed Fuzzy Delphi method. Since then the method has found many applications.

An important field where Fuzzy Delphi method has found numerous applications is in forecasting of stock prices. Kuo et al. (1996) used integration Artificial Neural Networks and Fuzzy Delphi for stock market forecasting. Chang and Wang (2006) proposed Fuzzy
Delphi and back-propagation model for sales forecasting in Printed Circuit Board (PCB) industry in which fuzzy logic and artificial neural network are integrated into the fuzzy back-propagation network. In their study the sales managers and production control experts are requested to express their opinions about the importance of each input parameter in predicting the sales with linguistic terms, which are then converted into pre-specified fuzzy numbers and the results indicate that this model predicts sales much better than all the existing models.

Jafari et al. (2008) used Fuzzy Delphi Method in Maintenance Strategy Selection Problem. They applied Fuzzy Delphi method for the assessment of the importance of each goal and capability of each maintenance strategy, considering the expert’s opinion. Hsu et al. (2010) applied Fuzzy Delphi Method in lubricant regenerative technology selection in which they proposed two phase procedure. In the first phase they utilized Fuzzy Delphi Method to obtain the critical factors of the regenerative technologies by interviewing the foregoing experts. In the second phase, Fuzzy Analytic Hierarchy Process is applied to find the importance degree of each criterion as the measurable indices of the regenerative technologies. Roy and Garai (2012) developed Intuitionistic Fuzzy Delphi method as a more realistic and interactive forecasting tool.

6.2 Bidirectional Associative Memories (BAM)

Bi-directional associative memories (BAM) was introduced by Kosko (1988) to produce two-way associative search for stored associations and as a model BAM has been applied to analyze problems by passing information through $M$ (forward recall) and $M^t$ (backward recall) in which the factors that attribute to the problem can be classified into
antecedent and consequent sets. Tryon (1999) used Bidirectional Associative Memories to explain post-traumatic stress disorder. Salih et al. (2000) developed a new synthesis approach for BAM using feedback neural networks which could solve problems using the perceptron training algorithm. Wu and Pados (2000) proposed a Feedforward BAM in contrast to conventional feedback BAM and they showed that this newly proposed Feedforward BAM guaranteed perfect bidirectional recall for arbitrarily correlated patterns. Chartier et al. (2007) proposed a new model called Feature-Extracting Bidirectional Associative Memory (FEBAM) which could create its own set of perceptual features. They used BAM-inspired architecture to create FEBAM and tested the model with simulation of image reconstruction and blind source separation tasks. They argued that the model possessed more cognitive explanatory power than any other nonlinear/linear PCA and ICA algorithm.

Singh et al (2009) used Bi directional Associative memory Neural Network method in character recognition for the English alphabets. They found the near optimal network architecture that could classify and store patterns. Srivastava and Pathak (2010) applied the technique of Bidirectional associative memory for human recognition in passive environment. This is done by combining the two biometric face and ear recognition through bidirectional associative memory. They propose this BAM based approach for automatic passive human recognition system in which camera captures the ear and the face of the human in surveillance and proved to be more effective.
In this chapter, the novelty of Fuzzy Delphi Method in bringing a consensus among experts is combined with Bidirectional associative memories so that the new technique thus obtained can function as a multiple expert system.

The fundamental definitions and ideas of BAM are listed below.

6.2.1. Neuron Fields

A group of neurons forms a field. Neural networks contain many fields of neurons. $F_x$ denotes a neuron field which contains $n$ neurons and $F_y$ denotes a neuron field which contains $p$ neurons.

6.2.2. Neuronal Dynamical Systems

The neuronal dynamical system is described by a system of first order differential equations that govern the time evaluation of the neuronal activations or membrane potentials.

$$\dot{x}_i = g_i \left( X, Y, \ldots \right), \quad \dot{y}_j = h_j \left( X, Y, \ldots \right)$$

where $x_i$ and $y_j$ denote respectively the activation time function of the $i^{th}$ neuron in $F_x$ and the $j^{th}$ neuron in $F_y$. The over dot denotes time differentiation, $g_i$ and $h_j$ are functions of $X$, $Y$ etc. and

$$X(t) = (x_1(t), \ldots, x_n(t)), \quad Y(t) = (y_1(t), \ldots, y_p(t))$$

Define the state of the neuronal dynamical system at time $t$. Additive bivalent Models describe asynchronous and stochastic behavior. At each moment each neuron can randomly decide whether to change state, or whether to omit a new signal given its current activation.

The BAM is a non-adaptive, additive, bivalent neural network.
6.2.3 Bivalent Additive BAM

In neural literature, the discrete version of the earlier equations is often referred to as the Bidirectional Associative Memories or BAMs. A discrete additive BAM with threshold signal functions, arbitrary thresholds and inputs, an arbitrary but a constant synaptic connection matrix $M$ and discrete time steps $K$ are defined by the equations

$$x_i^{k+1} = \sum_{j} S_j(y_j^k) m_{ij} + I_i$$

$$y_j^{k+1} = \sum_{i} S_i(x_i^k) m_{ij} + I_j$$

where $m_{ij} \in M$. $S_i$ and $S_j$ are the signal functions. They represent binary or bipolar threshold functions.

6.2.3 Synaptic connection Matrices

Let us suppose that the field $F_x$ with $n$ neurons is synaptically connected to the field $F_y$ with $p$ neurons. Let $m_{ij}$ be a synapse where the axon from the $i^{th}$ neuron in $F$ terminates, $m_{ij}$ can be positive, negative or zero. The synaptic matrix $M$ is a $n \times p$ matrix of real numbers whose entries are the synaptic efficacies $m_{ij}$. The matrix $M$ describes the forward projections from the neuronal field $F_x$ to the neuronal field $F_y$. Similarly, $M^T$, a $p \times n$ synaptic matrix and describes the backward projections $F_y$ to $F_x$.

6.2.5 Unidirectional Networks

These kinds of networks occur when a neuron synoptically interconnects to itself. The matrix $N$ is $n \times n$ square matrix.
6.2.6. Bidirectional Networks

A network is said to be a bidirectional network if $M = N^T$ and $N = M^T$.

6.2.7. Bidirectional Associative Memories

When the activation dynamics of the neuronal fields $F_x$ and $F_y$ lead to the overall stable behavior, the bi-directional networks are called as Bi-directional Associative Memories or BAM. A unidirectional network also defines a BAM if $M$ is symmetric, that is, $M = M^T$. In the next section, we proceed on to give more details about this BAM.

6.2.8. Additive Activation Models

An additive activation model is defined by a system of $n + p$ coupled first-order differential equations that interconnects the fields $F_x$ and $F_y$ through the constant synaptic matrices $M$ and $N$ described earlier.

$$\dot{x}_i = -A_i x_i + \sum_j^n S_j(y_j^k) m_{ij} + I_i$$

$$\dot{y}_j = -A_j y_j + \sum_i^n S_i(y_i^k) m_{ij} + I_j$$

$S_i(x_i)$ and $S_j(y_j)$ denote respectively the signal function of the $i^{th}$ neuron in the field $F_x$ and the signal function of the $j^{th}$ neuron in the field $F_y$. Discrete additive activation models correspond to neurons with threshold signal functions. The neurons can assume only two values ON and OFF. ON represents the signal value +1 and OFF represents 0 or -1 (-1 when the representation is bipolar). At each moment each neuron define a random variable that can assume the value ON ( +1 ) or OFF ( 0 or -1). The network is often assumed to be deterministic and state changes are synchronous ie an entire field of neurons is updated at a time. In case of simple asynchrony only one neuron makes a state
change decision at a time. When the subsets represent the entire fields $F_x$ and $F_y$ synchronous state change results.

In a real life problem the entries of the constant synaptic matrix $M$ depends upon the investigator's feelings. The synaptic matrix is given a weightage according to their feelings.

6.3 Methodology

6.3.1 Delphi Adapted (weighted) BAM

Form synaptic connection matrices $N_1 = (b_{ij}^{(1)})$, $N_2 = (b_{ij}^{(2)})$, $\ldots$, $N_k = (b_{ij}^{(k)})$, where $i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, p$, which represent opinions of $k$ experts about causal relationship between the neuron field $F_x$ with $n$ neurons and the neuron field $F_y$ with $p$ neurons.

a. Assign each expert a weight $\alpha_n$ ranging from 1 to 5 according to his/her expertise in the problem under analysis.

b. Multiply the weight with the corresponding synaptic connection matrix

$$M_n = \alpha_n N_n = \alpha_n (b_{ij}^{(n)}) = (\alpha_n b_{ij}^{(n)}) = (a_{ij}^{(n)})$$ where $\alpha_n$ is a constant, $n = 1, 2, \ldots, k$.

c. Form fuzzy triangular number $(P_{ij}, M_{ij}, O_{ij})$. Here $P_{ij} = \min \{a_{ij}^{(n)}\}$, $M_{ij} = \frac{1}{k} \sum_{n=1}^{k} a_{ij}^{(n)}$, and $O_{ij} = \max \{a_{ij}^{(n)}\}$ where $i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, p$ and $a_{ij}^{(n)} \in M_n \forall n = 1, 2, \ldots, k$

d. Obtain the combined synaptic connection matrix $M = (a_{ij})$ where $a_{ij} = \frac{P_{ij} + M_{ij} + O_{ij}}{3}$ for all $i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, p$. 

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e. Choose different input vectors keeping different nodes in ON state to obtain the dynamical system.

As traditional methods of analyzing the empowerment of women have not adequately enlightened the researchers, an attempt here is made in the next chapter to adopt Sen’s capability approach using Delphi Adapted Bidirectional Associative Memories (DABAM).