Chapter 4

The Concept of

Parallel Learning Processing Neuron

4-1 PLP Definition and Psychological Argument

The main reason behind the suggestion of the present concept is its tidy relation with the psychological and phenomenological aspects of the human memory. Physiological basis of the memory still is something of mystery and the only neuro-physiological evidence is the occurrence of changes in synaptic connectivity [1]. Therefore, to analyse the human memory, psychological and biological methods are almost the only means to understand the memory behaviour and suggest models imitating its mechanisms and performances [2]. Post [3] showed the association mechanism of the human memory in his study of the biological associative memory and proposed a bi-directional architecture model. His distributed memory memorises triplets of entities (images) and recalls one of these entities from the two other entities in the specific triplet. This process suggests of association to happen in two phases: memorising phase and recalling phase. In our strategy model, the memory is based on the integration of the two phases of the human memory a parallel fashion. There will be no separation between the two phases like the classical model of associative memory where ANN has to be learned first and then input distorted signals is presented to the network for recalling its closest associated memory.

It has been shown that the brain uses certainly an *association* mechanism to store related information [2]. Suppose that you were invited to a birthday party and in that party, you have seen a friend whom you haven't seen for a long time. Therefore, you will remember your old friend later if someone tries to remind you about that enjoyable party with its music, decoration or events. Moreover, you will remember the party with its music and events when you see or remember the image of your old friend. Therefore, you must have associated during the storage phase two information, if not more and for that multi-directional associative memory [4] is proposed, and for remembering an event or information you must have recall the information associated to it. The founding scientist of the neural networks associative memory M. Minsky agreed totally with the idea and stated the following. "I see no reason to believe that intelligence can exist apart from a highly organised body of knowledge, models, and processes. The habit of our culture has always been to suppose that intelligence resides in some separated crystalline element. Call it consciousness, apprehension, insight, gestalt, or what you will, but this is merely to confound naming the problem with solving it" [5].

The psychological proof of the recalling process of human memory can formulated in the following. During the remembering process, especially when you fail recalling your old friend, you use descriptions of your friend and different associations with it from that party to recall him. However, you did many trials before you get the closest image of your old friend while you keep at the same time the few details about your friend to recall him. Therefore, we suppose that the brain does that by sending a flow of information that represents the stored static associated memories to a decision (processing) network. This decision network is a neural network where the image of the requested information is recalled based on the processing of the flow of information it receives. It means that the neural network is on the phase of learning and processing simultaneously. Therefore, it is trying to process the distorted input image to get the closest stored one while it is storing (learning) the suggested memories. This is so called parallel learning processing property of the associative memory.

4-2 PLP Biological Argumen ts

The biology of the human memory storage and its recalling process remains still a mystery because of the morphological and functional complexity of its system of neural network. Almost all the present models of the memory processing (storage and recalling) are based on the psychological observation based on the revealed results of the physiological experiments [6] or not ([7]).

In an interesting article of R. Galambos [8], one can find some physiological explanation of the memory processing (storing, recalling) in which he investigated a new approach of the memory activity. Electron microscope studies of the so-called central nervous systems suggest that the central glia-nervous system might be a descriptive term for the anatomical structure in which the events related to memories take place. If one pursues this suggestion logically, one can conceive and theorise about a brain that operates not because of its neuron alone but because its neurons and glia cells collaborate intimately with one another [9]. The nature of this collaboration and in particular the question of whether memories are a function of interactions between the neurons and the glia cells is obviously legitimate subjects for scientific investigation. However, in that way, the parallel learning processing strategy could be suggested as a possible co-operation method between glia cells and neuron cells although without any biological proof of the nature of this processing, except for the above psychological argument. Therefore, in reality the collaboration of the glia cells with the neurons could be expected as that the first send continuously the different memories (associations) which could be also changed during the process, to the network of the second cells. Therefore, as mentioned earlier in the definition of our PLP strategy model [10] of the above memories, the sending process will continue until the image of your friend will be totally recalled at the neural network. The flux of memories of changing associated memories (sent by the glia cells to the neuron cells) or the same group of associations will be sent periodically.

Currently, biologists visualise information storage memories as achieved through actions and interactions of brain neurons alone. While this concept may well be correct, there is no-irrefutable proof for it. Experiments that clearly define the function of the brain glia cells will support either the concept or lead to its modification.

4-3 PLP Training Argument

For this argument, the PLP power is shown through the implicit use of a learning (training) rule suggested by Wang et al. [11] for the enhancement of the recalling capability of the BAM. The mentioned learning rule is called *multiple training.* It consists of learning many times, a given association of two memories, which does not initially minimise the energy surface in the configuration space. Therefore, the above rule is proposed to deepen the energy surface at the association location in the configuration space and thus stabilise it. However, the PLP could be very useful, in the above sense as it sends continually the associated memories, which themselves could be changed during their sending or not to enforce the stability of the association.

4-4 PLP Hardware Arguments

One of the most important features, which characterise the implementations of artificial neural networks, is the ability of the implementation for supporting the dynamical changes of the surrounding area. This ability does not only reflect the error correction capability, even more it means also the ability of reconfiguring the hardware function to realise some suggested tasks. However, the first point is realised by the intrinsic property of artificial neural networks, although the second was not taken considered in the current and previous implementations of the ANN, as far as we know. It is for satisfying the above second feature that the PLP strategy was suggested in which the classical distinction between the learning phase and the processing phase of the ANN is discarded. This dynamic of learning-processing seems to be convenient especially for some kind of asynchronous ANN namely the Bidirectional Associative Memory (BAM) which could be one of the best tools to correct some communication conflicts between two digital systems. It is thought also that some applications, based on their processing algorithm, need some kind of dynamicity like the PLP strategy for testing and recalling. As an application of the PLP strategy using the BAM network, the classification of power spectral density of the industrial spectral signatures [12] could be without doubt an interesting application area. In this application, however, the experimentalist has to use many associations of spectral density signatures with different scales in order to check the closest signature to a given distorted one. However, the experimentalist has to change the scale of the associations many times and consequently relearn the BAM at each time, until he/she gets the best closest signature to the inquired input. Therefore, we suggest to apply the present strategy in such way that the experimenter narrow his choice of the scale as limited as possible. Then, after initialising the BAM first time, send these associations to the network continuously and periodically until a stable configuration of the network is achieved.

4-5 Similar Concept to the PLP Strategy

Let us observe first, the state equation of the BAM again using the synaptic matrix based on the Hebbian rule to store M associations (pairs) of X and Y:

$$W = \sum_{i=1}^{M} X^{(i)T} Y^{(i)} \qquad (1)$$

Upon presentation of an input pattern (or probe vector), X (respectively, Y), the BAM begins to evolve from the initial state X (respectively, Y) according to the state equations

$$Y' = \operatorname{sgn}(XW) = \operatorname{sgn}\left(\sum_{i=1}^{M}\left(X^{(i)T}X\right)Y^{(i)}\right) \text{ and } X' = \operatorname{sgn}(YW) = \operatorname{sgn}\left(\sum_{i=1}^{M}\left(Y^{(i)T}Y\right)X^{(i)}\right) \quad (2)$$

X' and Y' denote the next state of the current state. In the work of B. Zhang et al [13] where they looked at the BAM from Matched-Filtering viewpoint they take $\operatorname{sgn}(x) = 1$ if $x > 0$ and $\operatorname{sgn}(x) = -1$ otherwise. In reality, they inspire their idea from the work of R. J. Marks II, et al [14]. Functionally speaking, the above equation can be equally realised by matched-filtering because the later also performs correlation between an input noise and the known signal. When this correlation signal is maximal, the matched filter yields the known signal closest to the input in mean square sense or with maximum output signal-to-noise ratio. The BAM with Hebbian correlation encoding scheme (1) is in fact identical to a closed loop feedback system composed of two matched-filter banks as shown in the Figure (1). It is clear that the above architecture and processing strategy look mainly like the bi-directional associative memory based on the (PLPN).

However, it is believed that biological neural networks mainly those concerning memory, are highly organised, not on their wet-ware apparition only, but also on their functionality too. Therefore, the power of the biological intelligence resides in its combination of the concept of parallelism in its two apparition, the functional algorithm and the processional application. In this chapter, the perception of the first apparition have been presented and suggested it later to be a new hardware implementation strategy of the artificial neural network. In the next chapter, the attempt to implement bidirectional associative memory based on the PLP neuron, on a digital circuit using the simple IC gates will be presented to simulate its different functions under the present strategy.

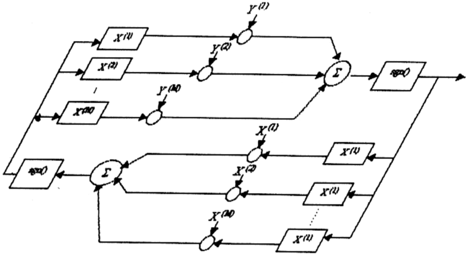

Figure (1). Matching filter memory architecture