Chapter 9

General Conclusion & Perspectives

*"In the same sense that theoretical chemistry is really physics, much of the study of theoretical computer science (such as neural networks), is also physics. This will become increasingly apparent as we continue to refine the "**Computronium**" that we find in nature. As models of computation are made closer to physics in order to make them deal more efficiently with fundamental physical constraints, the computations themselves begin to take on a more physics-like character. We have found that computations exhibit conservation laws, and that reversibility guarantees that you have exactly the same constraint as the second law of thermodynamics inside your models. That is, no process of a fixed size that takes place within a system continue indefinitely output less information than comes into it".*

***Norman Margolus*[1].**

[1] N. Margolus, Fundamental Physical Constraints on the Computational Process, from *Nanotechnology*, ed. Crandell and Lewis, MIT Press, pp. 209-201, 1989.

9-1 General Conclusion

A new strategy for the ANN processing has been suggested replacing the classical model in which the neuron *functionalities* (learning and processing) are sequential although the network itself reflects the neurons parallel processing. The new so-called Parallel Learning Processing PLP strategy has been suggested to improve the network parallelism by a new dimension concerning the functionality of its basic units. In our point of view, this suggestion is proposed to *'fractalise'* the classical neural network model in which parallelism is reflected only at the network level while the basic unit is sequentially processing. The strategy has been used in a Hopfield derived network namely BAM because of the simplicity of the Hebbian learning rule which can support such dynamical processing.

Two methods have been used for the digital implementation of the PLP based BAM namely the PCB implementation technique and the VHDL hardware description technique. The later method has been approved rather than the earlier because of its methodological simplicity and its hardware construction low effective cost.

9-2 Perspectives

New perspectives for the ANN implementation, mainly those based on nanotechnology such as quantum dots ([1], [2]) are increasingly promising. This new growing technique could certainly overcome most of current ANN implementation techniques (VLSI, FPGA...etc) restrictions, such as the area and power consumption.

Furthermore, the *universality* of the physical laws as well as the *'fractality'* of the natural creations and processes, imply in our point of view the existence of a physical

equivalence to the biological 'intelligence'. The first insight (as far as we know) was the Hopfield 'Computational Energy' which despite its restrictions perform an 'intelligent' memory recalling based on a relaxation process of a spin network (Ising Model). Therefore and in order to develop futuristic super computational engines, the physical systems in their theoretical formulation as well as in their material existence will certainly play a crucial role.

Physical systems such as the Nanostructures could be the best application field of the above mentioned capabilities eventually by exploiting their apparent mesoscopic phenomena. These systems however could solve the present computer (processor) integration technology requirements, such as the real-time processing, the scalability and the expandability.

9-3 Open problems

The major work worth of realisation is concerning the converging process of the PLP dynamics. However, the PLP strategy dynamics has not been fully simulated in the converging sense in the present theses, and some understanding of its dynamic's parameters are needed. Precisely, how should the energy surface topology (concerning Glia cells network) be modified based on some information about the object configuration, in order to recall it. Besides, one can also suggest similar model but with other neural network architectures such as feed-forward network. An eventual study of the influence of the stability of two interconnected networks on each other could yield promising results in this direction.