ABSTRACT.

It is our personal belief that we need a more reflexive attitude reconsidering where the problems are, what are the proper questions, what formal tools we need and how to use these tools to solve the questions in the way to attain a more thorough understanding of neural computation in the brain. In this paper we comment on some points that could be of interest in the biological perspective of neural computation. First some methodological remarks as well as a theoretical frame of reference is mentioned. Then, some of the anatomical and physiological basis are reported and finally, a frame for cooperative computation is introduced. Here neural nets are considered as "source of inspiration" to formulate inference networks, where in addition to analogical and logical calculus, a more general concurrent computation is permitted. In this way, classical connectionism (with the pass of numerical values) and symbolic computation (with the pass of messages and instructions) are integrated, and we can focus on the study of organizational principles more genuine of the neural tissue.

1. INTRODUCTION AND SUBJECTIVE HISTORICAL PERSPECTIVE.

Warren S. Mc Culloch, in LEKTON (the belated introduction to The Logical Structure of Mind, by Eilhard von Domarus) said that "Sam Wortis accused me of always trying to write an equation for the brain'. Now this purpose still remain true for us when we try to define the scope and goal of neural computation. The key point in not to know what a neuron could be but to discover what kinds of processors and processes could be able to reproduce the logical organization and emergent behavior observable in biology. This organizational principles has to be independent of the physical implementation (nervous tissue or semiconductors). Learning, memory, perception, self-organization, self-repair and fault-tolerant, evolutive design, morphogenesis and self-reproduction, to name but a few, are some of the properties observed in the real neural nets.

Historically we can consider that neural computation was born around 1943 with the work of Mc Culloch-Pitts (A Logical Calculus of the Ideas Immanent in Nervous Activity) and the complementary papers of Rosenblueth, Wiener and Bigelow (Behavior, Purpose and Teleology) and Kenneth Craik (The Nature of Explanation). Since then (Mira and Fonseca, 1970) the initial physiological and psychological motivations were progressively lost in a large measure, while the mathematics of analogic and logic models was being built.

In the analogical side, the Rosenblatt's "perceptron", the "adalines" of Widrow, the Minsky and Papert developments on perceptron computations and the discrete and continous formulations of spatio-temporal filters defines the scenario in the 60th. The "equation for the brain" at this level is a modular, multilayer, non linear, distributed net of processors where the plasticity is embodied by means of adaptive values in thresholds and weighting coefficients. Algorithmic programming in the usual sense of computer science is substituted by training with stimulus-response desired crosscorrelations (programming by examples). This perspective is dominant in the fiorello of interest in neural nets (Runelhart and Mc Clelland, 1986; Edelman, 1981; Fahlman and Hinton, 1978; Feldman et al, 1988; Hecht-Nielsen, 1988; Anderson; 1981, Kohonen, 1988). The two books of reprinted papers on
Neurocomputing edited by Anderson and Rosenfeld (1989) and by Anderson, Pellionisz and Rosenfeld (1990), gives a good feeling of the field.

From the logical point of view, neural computation projects on the field of finite state modular automata with deterministic, probabilistic or fuzzy transition matrices. Formal neurons are considered as local processors with a high degree of connectivity and capable of computing any logical function of its inputs, including feedback and synaptic delay. Proper questions on analysis and synthesis, reliability, oscillations and adaptive change of function were stated and solved in the past among others by McCulloch and Pitts, Kleene, J. von Neuman, Arbib, da Fonseca, Moreno-Díaz, Winograd and Cowan, Golomb and Hartmanis. The "equations for the brain" at this level can always be written if we can univocally specify the input and output spaces of each neuron as well as the transition matrices between the $2^N$ macrostates with $N \geq 10^{11}$. Clearly, without specific reference to the value and novelty of formal research at this level, it is clear to us that the more genuine properties of neural computation still remain open and stand out to those questions on cellular automata.

It is our personal belief that we need a more reflexive attitude reconsidering where the problems are, what are the proper questions, what formal tools we need and how to use these tools to solve the questions in the way to attain a more thorough understanding of neural computation in the brain. In this paper we comment on some points that could be of interest in the biological perspective of neural computation. First some methodological remarks as well a theoretical frame of reference is mentioned. Then, some of the anatomical and physiological basis are reported and finally, a frame for cooperative computation is introduced. Here neural nets are considered as a "source of inspiration" to formulate inference networks, where in addition to analogical and logical calculus, a more general concurrent computation is permitted. In this way, classical connectionism (with the pass of numerical values) and symbolic computation (with the pass of messages and instructions) are integrated, and we can focus on the study of organizational principles more genuine of the neural tissue such as co-operativity with fault tolerance, self-organization, self-reproduction, learning, evolution algorithms and dynamic crosscorrelations between neural "software" and neural "hardware" with the possible emergence of a new concept of biological computability where structure and function are meshed together in an irreducible manner. The possible results of this perspective are of potential interest not only for the understanding of the brain but for the synthesis of artificial "neural nets".

2. A THEORETICAL FRAME OF REFERENCE.

We have claimed in several occasions (Mira and Moreno-Díaz, 1982; Mira et al., 1983, 1989, 1990) the need of some methodological distinctions between the proper domain of neural nets (with evolutive programming and emergent codes) and the descriptive domains with representation spaces and imposed codes. At the same time, a clear duality between neural processors and neural processes (Mira and Delgado, 1988) is necessary. A processor is a physiological machine while a process is an abstract formulation of a computation completely independent of potential physical implementations. The way in which neural processes are implemented using neuronal processors, von Neumann machines or networks of microcomputers is a problem of programming. Nevertheless it is clear that some architectures (special purpose hardware) are more efficient than others for specific processes.

The theoretical frame suggested here (Mira and Moreno-Díaz, 1982) was developed from generalization of previous proposals on cooperative processes and layered computation. The net is considered as a layered tridimensional array of processors (or processes) with physical (or functional) connectivity specified by means of sampling volumes in the input and output spaces. These spaces are symbolic representation spaces. The sampling volume in the output space cope with feedback, connectivity, and dialogue area in cooperative computation.

Each element, $N^k_{i,j}$, in the "position" $(i,j)$ of the layer $k$ samples information from an area $R^k_{i,j}$ of the input space corresponding to this layer (that coincides with the output space of the previous one) and from an area $R^k_{i,j}$ from the output space of this layer. In this frame the input (output) spaces coincide with the external space of signals or messages only when the layers are situated at the beginning (receptors) or at the end (effectors) of the