IC/72/83

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

INFORMAL MEETING ON NEURAL NETWORKS

24 - 26 July 1972

(SUMMARIES)

INTERNATIONAL ATOMIC ENERGY AGENCY

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

1972 MIRAMARE-TRIESTE

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DETERMINISTIC MODELS, COMPUTER SIMULATION AND A KINETIC APPROACH TO NEURAL SYSTEMS

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Part I: DETERMINISTIC MODELS

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The understanding of a certain natural process and the possibility of giving an explanation for it imply the knowledge of a scientific theory, that is, a mathematical model, which is able to justify every already-known aspect of the process. In general, we trust our knowledge of the natural processes according to the successes obtained by the models we adopt to describe them.

For what concerns the nervous system as a processor of information, although mathematics would seem hopelessly inadequate when we think of the great complexity of the cerebral cortex, theoretical models assume a greater importance and have become so increasingly numerous, the more the scientist feels the importance of giving a satisfactory description of thought-processes.

Models of neural function can be categorized into many broad classes. We consider here only three of them; deterministic, computer simulated and statistical.

Our main guiding principle since the beginning of our work has been, though, the conviction that the human brain, tremendous in its complexity, yet obeys, if one looks at the operation of individual neuron, dynamical laws that are not complicated, and that these laws are such as to engender in large neuronal assemblies collective modes of behaviour, to which thought-processes are correlated.

The relevant feature of the deterministic approach was the use of matrix algebra, rather than boolean logic[1), 2), 3)]; this permitted us to give, among other things, explicit methods for the design of networks whose reverberations cannot exceed prefixed periods no matter how coefficients are changed, as well as to investigate the rôle of coupling strengths in determining cyclic behaviours [4),5)].

The deterministic mathematical model of neural networks with which we are concerned has been introduced by E. R. Caianiello [2)]. In this model the evolution of a network is described by means of "Neuronic Equations" which describe the instantaneous activity of the net, and "Mnemonic Equations" describing the learning processes. The "Adiabatic Learning Hypothesis" which asserts that learning processes take place more slowly than the processes described by the neuronic equations, allows us to study independently the neuronic equations and the mnemonic equations, within a time interval, whose width is discussed in Ref. 2.

The "individual" and the "global" problems of synthesis were investigated under "self-duality" conditions which characterize the so-called "normal systems" [6)]. The results obtained are employed to solve some global problem of synthesis without the use of the theory of linear inequalities.

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6) Accardi L. and Aiello A. (1971) Kybernetik 10, 115-119.