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ON

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24 - 26 July 1972

(SUMMARIES)

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I N F O R M A L   M E E T I N G

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Part II: COMPUTER SIMULATION

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To acquire a theory of the functional organization of the nervous system is a most difficult problem. At the present time, there exists no theory meeting experimental tests on any level above that of the individual cell.

Ideally, in order to construct a theory, we should have in our possession well-established experimental results, and a well-developed body of appropriate mathematical models.

A typical example of network modeling (simulations which explore the behavior of explicitly constructed single units connected into large regular assemblies) is that of Farley and Clark [16)-19)]. Simplified-parameter (formal) neurons are simulated in a digital computer. A network of 1296 units occupies a planar array whose connections are well defined. (Other similar studies, e. g., Smith and Davidson [22),23)], use random connections.) Experiments are run to examine oscillation and stability characteristics, the net exhibiting such physiologically noted activity as irregular firing, rhythmic patterns, and "driven" firing. These aspects of the network's behavior are functions of controlled variables such as stimulus, connection pattern, and threshold.

Although there has been a considerable amount of work done on mathematical and simulated models [1),7)-10),20),21)] oriented toward neural organization, the relationship of such models to experimental neurophysiology, if any, remains unclear.

The question is open, of course, whether the mass action studied in these models reflects a significant aspect of nervous system behavior. In the absence of such knowledge the physiological pertinence of this kind of modeling is not easily established; it is interesting, however, that some of the results bear a strong qualitative resemblance to cortical activity.

Although the "neurons" used in these models are exceedingly simplified representations of biological neurons, it is entirely conceivable that the gross behavior in both model and prototype is essentially independent of finer unit specification. In our research we shall describe the behaviour of a neural network model with a new method of analysis[11].

Taking into account Caianiello's work of 1961 [15] a model of a neuron quite similar to his is proposed and studied. For this model, where a temporal summation and a period of refractoriness are assumed, a mathematical approach and a simulation on computer were realized. Particular types of nets were used, namely, nets with topological structures and fully random nets. The difference between the two types is that the first type has a two-dimensional square structure and depends on the rules of the formation of connection between the neurons, while the second type is realized by means of the probability distribution function governing the formation of the structure of the net.

These types of neural nets are analysed by means of a method which permits us to obtain various parameters which characterize their behaviour in time and space in terms of the trajectory of the system. Many experiments are also reported; the statistical analyses made on them show the great importance and influence of refractoriness on the behaviour of neural networks.

In the last part of the work an interesting case is reported in which the reaction of the net to a disturbance shows that a kind of adaptation takes place, although the structure of the net stays unchanged. Some hypotheses for this behaviour are also made.

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