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INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

INFORMAL MEETING

ON

NEURAL NETWORKS

24 - 26 July 1972

(SUMMARIES)

INTERNATIONAL ATOMIC ENERGY AGENCY

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International Atomic Energy Agency
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INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

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Please note that copies of papers referred to may be obtained direct from the authors and not from the ICTP.

THE BEHAVIOUR OF NOISY NEURAL NETWORKS

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A noisy neuron is one which is capable of spontaneous firing due to the random release of transmitter substance at its synapses. The description of such neurons is in terms of their probability of firing at a certain time. Using quantized time and a label for each individual neuron, a network of N such neurons can be described by an N-vector $\underset{\sim}{P}_k = (P_{1,k},\ldots, P_{N,k})$. The theory of Taylor[1] results in a set of equations which determine the time-evolution of any network of such neurons. Symbolically the equations are of the form

$$P_{i,k+1} = f_i(\underset{\sim}{P}_k) \quad , \quad i = 1, 2, \ldots, N \quad . \qquad (1)$$

The exact form of the functions f_i depends upon the connectivity of the network.

As an initial investigation we have restricted ourselves to the simplest connectivities, namely to:

i) a ring of neurons

and

ii) a toroid of neurons.

In the first case Eq.(1) reduces to a set of linear equations capable of exact solutions. In the second case Eq.(1) gives a set of quadratic difference equations.

Computer-based iterative solutions of these equations together with some analysis on quadratic difference equations[2] has established the following results[3]:

i) The set of equations (1) possess steady-state solutions

$$P_{i,k} = f_i(\underset{\sim}{P}_k) \qquad \text{for all } i \ . \qquad (2)$$

The number of such solutions for a general network is not at present known but is related to the connectivity of the network. However, at least one steady-state solution exists.

ii) From an arbitrary initial state the network will evolve until

either a) it settles into a final state which is one of the steady-state solutions

or b) it oscillates indefinitely, which for some special cases of interest involves a cycle with a certain reverberation period.

Special cases of Eq.(1) can be found which possess degenerate steady-state solutions. The final state achieved by the network will then depend upon its initial state.

REFERENCES

1) J.G. Taylor, Spontaneous Behaviour in Neural Networks, J. Theoret. Biol. (to appear).

2) T.W. Chaundy and E. Phillips, Quart. J. Maths. (Oxford series) 7, pp. 74-80 (1936).

3) T.P. Martin and J.G. Taylor, "Solutions of probabilistic equations for neural networks", King's College, London, preprint.