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Introduction

(1984)
Francis Crick

Function of the thalamic reticular complex: the searchlight hypothesis

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This paper by Francis Crick brings together ideas from many of the areas that a modern neural modeler should know about. One of the entertaining aspects of research in neural networks, from the point of view of participants, is the necessity to be at least aware of results in a large number of fields. It is not the research area for narrow specialists.

In this paper, we see a good deal of detailed neuroanatomy and physiology used to propose a functional brain model using a novel short term synaptic modification suggested by von der Malsburg to explain some suggestive results in cognitive psychology found by Anne Triesman. This eclectic combination is typical of what has become known as Cognitive Science, and neural network modeling is one important facet of contemporary Cognitive Science.

This paper concerns itself with a number of issues that are becoming more important in network research. Up to this point, we have had models for learning that have been implicitly or explicitly concerned with long term memory effects, that is, permanent synaptic changes resulting from events more than a few hours or days old. However, in the actual operation of cognition, many short term effects, some associated with short term memory and some linked to what is usually called attention, occur. Crick discusses in this paper some short term learning effects that have time scales of seconds or less. These can be interpreted as a model for attention, but they also have some short term memory-like effects as well.

These effects are made to occur by a particular neuroanatomical arrangement of cells, discussed at considerable length, and by a particular form of very short term Hebbian synaptic modification proposed by Christoph von der Malsburg. A more detailed and mathematical discussion of the implications of short term modifiability is contained in a recent paper by von der Malsburg and Bienenstock (1986). They describe the modification rules as follows (p. 250):

> Rule A: successful synaptic events enhance the transmission efficacy of the synapse.
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> Rule B: transmission failures such as presynaptic firing without postsynaptic firing, and possibly also 'failures' of the inverse type, i.e., postsynaptic without presynaptic firing, depress synaptic activity.
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> Both types of plastic change become effective within a few milliseconds....
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> Short-term plasticity is restricted to a small range of strengths: the absolute value of the strength saturates after a small number of similar events. In case of successful transmission, it reaches a maximal level. In case of failures, it settles at a minimum....
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> Short-term plasticity lets connectivity and activity evolve on the same time scale, leading to the notion of a joint activity-and-connectivity state. It is proposed that the events which underlie brain function are best described by such compound states....

Traditional Hebbian synaptic modifications are assumed to give rise to slow, long term temporal integration of correlations over very long times. The short term effects

operate using very short term correlations. Von der Malsburg and Bienenstock go on to show that activity-and-connectivity states give rise to attractor dynamics, similar in spirit to those we have seen in other contexts in this collection.

Crick draws on the prediction that these short term synaptic effects allow for the formation of flexible, somewhat transient representations of information determined by both the sensory inputs and the structure of long term memory. This notion is embedded in a number of specific suggestions about how the brain might realize such a system and how it might be used psychologically. The general implication for the field is that effects occurring at short time scales may be very important and perhaps can be analyzed by some of the same techniques used in learning models that assume much longer time scales. There is the hope that all these ideas can be brought together (as the brain does it!) in one neatly fitting package.

Reference

C. von der Malsburg and E. Bienenstock (1986), "Statistical coding and short term synaptic plasticity: a scheme for knowledge representation in the brain," *Disordered Systems and Biological Organization*, E. Bienenstock, F. Fogelman Soulié, and G. Weisbuch (Eds.), Berlin: Springer.