separating boundaries between classes gives error rates on optical character recognition lower than neural nets (Boser, Guyon and Vapnik, 1992).

Often the analogies and language used in the NN community obscure the data analytic reality. There is a lack of reflective introspection into how their methods work, and under what data circumstances. But these lapses are more than offset by the complexity, interest, size and importance of the problems they are tackling; by the sheer creativity and excitement in their research; and by their openness to anything that works.

Comment: Neural Networks and Cognitive Science: Motivations and Applications

James L. McClelland

Artificial neural networks have come and gone and come again—and there are several good reasons to think that this time they will be around for quite a while. Cheng and Titterington have done an excellent job describing that nature of neural network models and their relations to statistical methods, and they have overviewed several applications. They have also suggested why neuroscientists interested in modeling the human brain are interested in such models. In this note, I will point out some additional motivations for the investigation of neural networks. These are motivations arising from the effort to capture key aspects of human cognition and learning that have thus far eluded cognitive science.

A central goal of congnitive science is to understand the full range of human cognitive function. During the 1960s and 1970s, when symbolic approaches to human cognition dominated the field, great progress was made in characterizing mental representations and in capturing the sequential thought processes needed, for example, to solve arithmetic problems, to carry out deductive reasoning tasks, even to prove theorems of logic from given axioms. Indeed, by 1980 a general computer program for solving integro-differential equations had been written. These accomplishments are certainly very valuable, yet they still leave many scholars of cognition with the very strong feeling that something very important is missing. Efforts in machine recognition of spoken and visual input, machine understanding of language, machine comprehension and analysis of text, not to mention machine implementation of creative or insightful thought, all continue to fall short. A huge gap remains between the capabilities of human and machine intelligence.

The interest in the use of neural networks among cognitive scientists springs largely from the hope that they will help us overcome these limitations. Although it is true that there is much to be done before this hope can be fully realized, there are nevertheless good reasons for thinking that artificial neural networks, or at least computationally explicit models that capture key properties of such networks, will play an important role in the effort to capture some of the aspects of human cognitive function that have eluded symbolic approaches. In what follows I mention two reasons for this view.

The first reason arises in the context of a broad class of topics that can be grouped under the rubric of "interpretation." A problem of interpretation arise whenever an input is presented to the senses, be it a printed digit, a footprint, a scientific argument or a work of creative expression such as a poem or a painting. The problem is to determine what the thing is or what it is intended to signify. The problem is difficult because the direct data is generally insufficient so that the ability to determine the correct interpretation depends on context.

Let us consider two examples. The first, shown in Figure 1, is from Massaro (1975) and illustrates the role of context in letter recognition. The same input gives rise to two very different interpretations depending on the context in which it occurs. The second comes from very simple stories of a kind studied by Rumelhart (1977):

> Margie was playing in front of her house when she heard the bell on the ice

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