A NEURAL NETWORK MODEL USING INTER-PATTERN ASSOCIATION (IPA)

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Abstract This paper investigates a neural network model — IPA model, in which a basic logical operation is used to determine the inter-pattern association (i.e., association between the reference patterns), and a simple rule is applied to construct the tri-state interconnections in the network. Computer simulations of the reconstruction of similar English letters in the random noise have shown a better performance by the IPA neural network over the Hopfield model. A 2-D hybrid optical neural network is used to show the usefulness of this new model. Since there are only three gray levels in the Interconnection Weight Matrix (IWM) , the requirement for the dynamic range of the Spatial Light Modulators (SLMs) is easily satisfied, and the interconnections in the proposed network are much simpler than those in other models.

Outline of a Theory of Massively Parallel Analog Computation

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1. Field Transformation Computers

1.1 Truly Massive Parallelism

AI is moving into a new phase characterized by a broadened understanding of the nature of knowledge, and by the use of new computational paradigms. A sign of this transition is the growing interest in neurocomputers, optical computers, molecular computers and other massively parallel analog computers. We have argued elsewhere [1, 2, 3, 4] that the new AI will augment the traditional deep, narrow computation with shallow, wide computation. That is, the new AI will exploit *massive parallelism*. Now, massive parallelism means different things to different people; massive parallelism may begin with a hundred, a thousand, or a million processors. On the other hand, biological evidence suggests that skillful behavior requires a very large number of processors, so many in fact that it is infeasible to treat them individually; they must be treated *en masse*. This has motivated us to propose [1] the following definition of massive parallelism: *A computational system is* **massively parallel** *if the number of processing elements is so large that it may conveniently be considered a continuous quantity.* That is, a system is *massively* parallel if the processing elements can be considered a *continuous mass* rather than a *discrete ensemble.*

How large a number is large enough to be considered a continuous quantity? That depends on the purpose at hand. A hundred is probably never large enough; a million is probably always large enough; a thousand or ten thousand may be enough. One of the determining factors will be whether the number is large enough to permit the application of continuous mathematics, which is generally more tractable than discrete mathematics.

We propose this definition of massive parallelism for a number of reasons. First, skillful behavior seems to require significant neural *mass.* Second, we are interested in computers, such as optical computers and molecular computers, for which the number of processing elements *is* effectively continuous. Third, continuous mathematics is generally easier than discrete mathematics. And fourth, we want to encourage a new style of thinking about parallelism. Currently, we try to apply to parallel machines the thought habits we have acquired from thinking about sequential machines. This strategy works fairly well when the degree of parallelism is low, but it will not scale up. One cannot think individually about the 10^{20} processors of a molecular computer. Rather than postpone the inevitable, we think that it's time to develop a theoretical framework for understanding massively parallel analog computers. The principal goal of this paper is to outline such a theory.