CISD 830

Assignment 2 Research Paper

Idea Submission

by

Jerry A. Smith

smithjer@scis.nova.edu

April 1999
Table of Contents

1  GOALS ................................................................................................................................. 3
2  PRIOR RESEARCH ............................................................................................................. 3
3  RELEVANCE AND SIGNIFICANCE .................................................................................. 5
4  APPROACH ....................................................................................................................... 6
5  RESOURCES ..................................................................................................................... 7
6  REFERENCES ...................................................................................................................... 8
APPENDICES .......................................................................................................................... 9

APPENDIX A – ACRONYMS ............................................................................................... 9
1 Goals

The author proposes the study of digital, software programmable, massively parallel computing architectures, because there is a need to determine which types of architectures are best suited for their application to neural dynamic networks, in order to better understand how to implement real-time artificial neural networks that can emulate nature’s best computing machine, the human brain.

The results of this research will be summarized in a report, and utilized in follow-on course and dissertation research related activities by the author. In this report, the author will identify a suitable definition for what constitutes a massively parallel computing machine. Then, a survey of current massively parallel machines that are suitable for deploying artificial neural networks will be conducted, analyzed, and presented. The author will also present insights as to when such architectures will be suitable for emulating highly complex neural systems, such as the human brain.

2 Prior Research

An important field in computer science is the development of high-performance computing machines that are based on large numbers of processors, which collectively are capable of performing collaborate tasks that are computationally intensive. These massively parallel machines have the advantage of being able to reduce the completion time of distributed algorithms while also retaining the structural semantics of the underlying environment that is under investigation.
Artificial neural dynamics is one such type of distributed algorithm that lends itself to implementation using massively parallel architectures. Artificial neural networks (ANNs) are a computer science discipline that draws its computational inspiration from the human brain’s ability to perform complex tasks. ANNs consist of a large number of massively parallel nonlinear process elements (neurons) that are highly interconnected. Each neuron receives inputs from other neurons, performs a series of computations, and outputs the results to other connected neurons. Due to this similarity in structure, massively parallel systems have been proposed as neural network implementation solutions.

While research abounds on massively parallel systems, only a disproportionate amount of the current work is devoted to mapping artificial neural networks onto massively parallel architectures. Sundararajan and Saratchandran (1998) have synthesized a set of summary information for some of the most common ANN structures and parallel architectures. This summary, however, does not address the implementation of hybrid ANN (i.e., neural dynamic systems composed of multiple topologies) nor issues associated with the fusion of data gathered through diverse preceptors. Tomas Nordstrom (1995) has also contributed to the field of highly parallel computing for artificial neural networks. His main contribution being the development of a new system architecture that incorporates highly parallel communicating process modules based on a single instruction, multiple data stream (SIMD) format.
3 Relevance and Significance

The human brain is an amazing massively parallel, highly distributed, computing machine. It is composed of between $10^{11}$ and $10^{12}$ neuron (the same order of magnitude as the number of stars in a galaxy), with each neuron having as many as $10^4$ connections to other neurons. There is also about $10^9$ meters of axons, axon branches, and dendrites (25 times the circumference of the earth). The average synaptic processing rate, or number of times a neuron fires per second, is only 50 Hz, with a maximum rate of 500 to 1000 Hz. Yet, even with this detailed level of understanding there still has been no man-made machine that has come close to emulating this organically based system. Why?

While it is not the intention of the author to answer this question during the conduct of this research topic, the author does believe such an answer will come either by pure accident or through the application of one of Sherlock Holmes’s greatest fact finding principles. Sherlock once said, “When you have eliminated the impossible, whatever remains, however improbable, must be the truth.” As scientists, we cannot accept the happenstance of discovery by pure accident. So instead, we are left with the methodical searches that lead to the elimination of the impossible, which enables us to then see only the truth that remains.

For the author, this search for truth will be conducted over a multi-year trip composed of three phases: Charlie, Felix, and Schuyler. The goal of the first phase is to emulate the neurological constructs of the Blattodea, the common cockroach. Hence, the first phase name of Charlie (as in Charlie the Cockroach). The goal of the second phase is to further
the neurological construct mapping research by extending the emulation to that of the Felis Catus, the common house cat. As one can see, the second phase is has been named Felix, for Felix the Cat. The last phase’s goal is to build on the previous two phases and yet further extend the neurological construct mapping research to that of a Homo sapiens child of approximately two years of age. The name for this phase is Schuyler; take from author’s eldest son.

So, this research is vital part of an ongoing effort to emulate the human brain through Neurological Construct Mapping (NCM), thus answering the first question through the delivery of just such a system. This research will help the author focus on the improbable by first understanding the possible and eliminating the impossible.

## 4 Approach

The principle methodology to be used during the execution of the project is based on traditional research protocols(Booth et al., 1995; McKenzie, 1995). As such, the author will use the following steps as guidelines during the execution of this project:

### Step 1 – Task Definition: The research topic and question will be further explored and narrowed in order to better understand the problems being addressed.

### Step 2 – Information Seeking: Resources will be identified that are relevant to the topic.

### Step 3 – Information Location and Access: All relevant information will be gathered and examined. An initial bibliography, with keyword cross-referencing, will be created.
Step 4 – Select Approach: An approach/ theme/ strategy is selected for the research topic and question.

Step 5 – Synthesis: Relevant information will be integrated in order to demonstrate original insight to the area under investigation. The structure of the report will be created.

Step 6 – Evaluation: All results will be re-examined and the report will be refined.

As part of step 2 and step 3 (information identification and gather), the author foresees the need to interview several primary resources currently conducting research in the field of massively parallel systems. The following two sources are currently being considered: Intel’s Supercomputing Systems Division (Intel Paragon) and the Massachusetts Institute of Technology (MIT J-Machine).

5 Resources

Libraries and electronic databases that support computer sciences and information technologies will be the principle resources needed to perform the research. The following initial, albeit incomplete, set of references has been or will be reviewed, and may be used in part of the research effort:


Anonymous. p1-jc-93.3,


6 References


Appendices

Appendix A – Acronyms

ANN – Artificial Neural Networks

SIMD – Single Instruction, multiple data stream