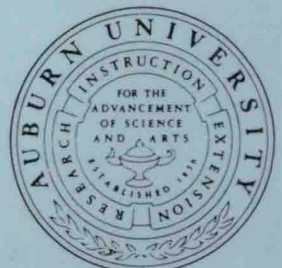
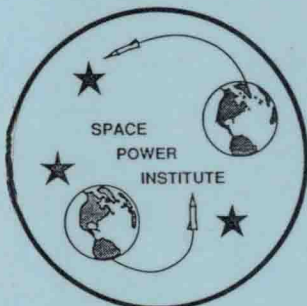


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OF THE

FIRST WORKSHOP ON
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ACADEMIC/INDUSTRIAL/NASA/DEFENSE
WNN-AIND 90

February 5-6, 1990
Auburn University Hotel and Conference Center, Auburn, Alabama

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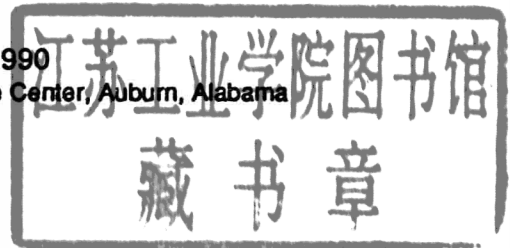


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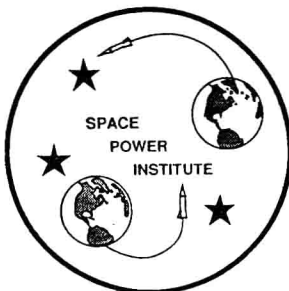
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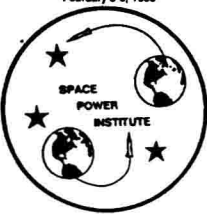
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PREFACE

Neural Networks: Academic/Industrial/NASA/Defense

During the past two decades, the profile of applications oriented systems modeling has evolved tremendously. Tasks and capabilities have expanded to utilize computers and to realize techniques originally confined to the paper and pencil speculative realm. Insights into why these expansions were needed and directions for future efforts may be gleaned from a review of the literature and conversations with experienced researchers. Examples of future directions with potential commercial applications are found in this proceedings.

First, the Neural Network Possibilities and Challenges section covers some background material and potential. Next, some applications examples are presented in the section on Pattern Recognition - Trends and Predictions. Engine diagnosis is covered in the Health Monitoring - Space Shuttle Main Engine (SSME) section. The Power Systems section covers fundamentals and goals. Next, Manufacturing and Robotics sections look further into commercial applications. Composite Systems and Environments sections cover the integration of neural networks into a research environment and blending them with supportive techniques. The Implementations section papers cover the physical environment and computer implementation aspects of obtaining a working neural network system. Finally, the Perspectives section contains panel discussion material and more food for thought.

Next year's workshop plans are underway. Extensions of work presented here and comments on it are welcome for WNN-AIND 91!

MARY LOU PADGETT
WNN-AIND 90 Program Chairman

First Workshop on
NEURAL NETWORKS:
ACADEMIC/INDUSTRIAL/NASA/DEFENSE
WNN-AIND 90

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TECHNICAL CHAIR, NEURAL NETWORKS: *Dr. C.-H. John Wu*, Electrical Engineering, Auburn University

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Robotics support was provided by Dr. John Hung and Dr. Steve Hung. Power systems support came from Dr. Gerald Sheble, Electrical Engineering, Auburn University. Manufacturing support was provided by Dr. J. T. Black and Dr. B. C. Jiang, Advanced Manufacturing Technical Center, Auburn University and Aerospace Engineering was represented by Dr. J. E. Cochran.

Hard work by many individuals has enhanced the quality of this proceedings. Names of attendees are included to further encourage technical interchange among WNN participants, all of whom have ideas and solutions contributing to the value of the workshops - this year and next!

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NEURAL NETWORK POSSIBILITIES AND CHALLENGES

**Overview
of
Advanced Architectures Research and Development Activities
in the
Software Technology Branch**

**Robert Savely, Branch Chief, Robert Lea, Robert Shelton, James Villarreal,
and Lui Wang**

**Software Technology Branch/PT4
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058**

Introduction

The purpose of this Research and Development activity is to evaluate and develop state-of-the-art software architectures or techniques which might be used to solve NASA's engineering problems. Development of these technologies may be in the form of building and providing tools to facilitate the general use of the technology, construct demonstrations which illustrate the potential uses of the technology, or enhancing of an existing technology to better suit the needs of NASA's advanced programs. Activity in this area includes investigations into such technologies as artificial neural systems, fuzzy logic, parallel processing, genetic algorithms, man-machine interfaces, and approaches to machine vision.

Artificial Neural Systems (ANS)

The STB has maintained several research initiatives in the field of artificial neural systems. Our preliminary efforts began with the publication of a Neural Network Survey in 1987. Two major software products for simulation and a number of applications have evolved since its inception.

Neural Network Simulation Tools

The Transputer-based Work Station

Due to the extreme computational demands which arise in training of ANS, a neural network work station was designed and built to be hosted by a network of Transputers. This work station software is currently in the process of being released to Cosmic Computing. The work station was designed to allow for the simulation of a wide range of neural network architectures. There is a sophisticated graphics interface to allow the user to visualize the progress of the network toward convergence. The network of 40 Transputers yields the performance of a super-computer at a fraction of the cost.

NETS

NETS (Network Execution and Training System) is a portable C-based simulation of the popular back-propagation neural network which can run on most computers. NETS is intended as a tool for anyone interested in exploring the use of neural networks. It is easy to use, but sufficiently rich in features that it has been used extensively in support of our in-house research. NETS is also available through Cosmic. NETS is currently in use at 288 government sites.

New Tools for ANS Research

Space-Time Neural Networks(STNN)

A spin-off of a project to monitor space shuttle main engine performance with neural networks resulted in the development of an innovative neural network architecture especially useful at sequence discovery and nonlinear filtering. This neural network borrows concepts from associative memory and filtering techniques. In its present form, the STNN dynamics adapt and learn sequences of finite lengths. Currently, efforts are underway to extend the STNN to sequences of arbitrary lengths. It is anticipated that this network will result in the issuance of a patent .

Faster Training Algorithms

A major barrier to the use of artificial neural systems is the potentially large amount of processing power required to accomplish the training process. Therefore much research is directed toward the improvement of training methods. This research has resulted in some break-through results which are now described.

The Difference Optimized Training Scheme for the Neocognitron Neural Network (DOTS)

The neocognitron is an artificial neural model which was intended to simulate some of the functions of the optic nerve and visual cortex. As originally conceived, the network would "learn" to recognize objects by repeated exposure, a process which often required hundreds of passes to achieve satisfactory results. The DOTS algorithm partitions the training images into a large number of possible templates, and intelligently selects a small collection of templates which describe the training data. From these templates, the synaptic connection strengths may be easily constructed. The time requirements for DOTS are much less than those for the iterative algorithm.

Accelerated Training Method for the Back-Propagation Neural Network

The back-propagation network has become an extremely popular tool for modeling complex functions and pattern recognition. For large networks, the standard training

algorithm may be extremely time-consuming if for no other reason, because the network may have thousands of weights to be determined. The accelerated training algorithm exploits the fact that the input weights for the network (often the vast majority) can be represented as a linear combination of the input vectors. This representation of the input weights can result in a big reduction in the number of optimization variables which must be considered, and thus in a significant savings of time. The degree of effectiveness of the algorithm is strongly dependent on the particular problem under consideration.

Pre-Processing Tool

Often the data which would be natural to present to a neural network is highly redundant. In such a case, an orthogonal basis is extracted from the vectors which comprise the input space. Vectors having the greatest information content are extracted first, and it is possible to determine when there is no benefit in extracting more vectors. The input vectors are projected along the orthogonal basis vectors and the projection coefficients are given to the network instead of the original input. For the problem which suggested the development of this tool, it was able to replace a network with over 15,000 weights with a network having 19 weights. The savings in training and execution times is apparent.

Applications

Our anticipated applications for neural networks will be as pattern classifiers, content addressable memories and general non-linear adaptive models. The use of neural networks as part of computer vision systems for inspection, retrieval and rescue is contemplated. Prototype networks have been built, trained and tested on several hard problems including finding concentration from reading IR spectrograms, prediction of solar activity, speech synthesis from text, and computer vision applications.

A joint STB and Life Sciences Directorate project is currently underway to investigate the uses of neural network technology to discover specific sites in the central nervous system which are key for the maintenance of posture. The network will be used to analyze posture platform data collected from patients with lesions in the central nervous system and post and pre flight data from astronauts. It is hoped that neural networks will be able to formulate the appropriate correlations in the data. The STB recently acquired a commercial neural network simulator from SAIC to support this project.

A part of the Advanced Software Development Workstation (ASDW)* project team is currently investigating the use of simple artificial neural networks for indexing and retrieving extremely large numbers of information objects, especially reusable software parts. An object's name and attributes, i.e., its characteristics, are stored in an associative memory, which is a content-addressable memory that functions as a simple two-layer neural network. Specifically, the associative memory is very similar to a Kohonen self-organizing feature map. Currently, the associations between all of the names and attributes are loaded directly into the associative memory, and the resulting topology of associations is identical to that of a trained neural network. However, work is underway to develop a weight-adjusting algorithm for the associations that will give more weight to those attributes and names that are retrieved most frequently by each user. In this way, the associative memory (neural network) can be

trained to be more responsive to each individual user. Results thus far are very encouraging and indicate that the use of an associative memory for information indexing and retrieval is very efficient and fast.

[*The ASDW is researching and developing the technologies required to support CASE (Computer Aided Software Engineering) with the emphasis on those advanced methods, tools, and processes that will be of benefit to support all of NASA and DOD. Immediate goals are to provide research and prototype tools that will provide near term productivity increases in projects such as the SSE (Software Support Environment), the SSCC (Space Station Control Center), and FADS (Flight Analysis and Design System) which is used to support the STS. Goals also include providing technology for future SSE and operational systems by adding knowledge based system support to all phases of information systems development, evolution, maintenance, and operation.]

Funding

Other than two Director's Discretionary Funding projects, funding for neural network technology has been difficult to acquire. However, STB has been successful with the use of the SBIR program to fund two neural network related projects:

- 1) Netrologic (San Diego, CA) is investigating the use of neural network technology for the monitoring of the space shuttle main engine (SSME) for failures. This is a full-scale example of a data fusion problem in that data from many different kinds of sensors must be reduced to obtain an estimate of the system's health. During launch, several SSME sensor readings are monitored by Booster Officers in the MCC. Applying data fusion to this system would, in a sense, "fuse" all sensor readings into a smaller, manageable number and allow the utilization of all the sensor readings in place of the 5 currently monitored. Classification into nominal and faulty engine behaviors would be determined from actual SSME test and launch data.
- 2) Martingale Research Corporation (Allen, TX) is developing a new neural network architecture called the Parametric Avalanche which is designed to implement a solution to the general stochastic filtering problem for non-linear systems in arbitrary noise. This neural network should see applications in the: 1) Tracking and control of nonlinear dynamical systems, such as spacecraft docking maneuvers, 2) Multi-sensor integration for monitoring of complex power systems, 3) and the control of large articulated space structures.

Measuring Effectiveness and Reliability

Our method for evaluating the performance of a neural network model is inherited from traditional validation procedures used for other modeling techniques (i.e. least squares, polynomial fitting, trigonometric series expansions). Where sufficient data exists, it is split into a training set and a test set. The training set is used to adapt the coefficients in the network.