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Sparse Distributed Memory Overview

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One of NASA's grand challenges is to build autonomous machines and systems that are capable of learning to perform tasks too tedious, or in places too remote and too hostile, for humans. The goal of the Learning Systems Division of RIACS is to find new approaches to autonomous systems based upon sound mathematical and engineering principles and the need to know how information processing is organized in animals, and to test the applicability of these new approaches to the grand challenge. The program includes the development of theory, implementations in software and hardware, and explorations of potential areas for applications.

There are two projects in the Learning Systems Division—Sparse Distributed Memory (SDM) and Bayesian Learning. My talk gave an overview of the research in the SDM project.

Now in its third year, the Sparse Distributed Memory (SDM) project is investigating the theory and applications of massively parallel computing architecture, called sparse distributed memory, that will support the storage and retrieval of sensory and motor patterns characteristic of autonomous systems. The immediate objectives of the project are centered in studies of the memory itself and in the use of the memory to solve problems in speech, vision, and robotics. Investigation of methods for encoding sensory data is an important part of the research. Examples of NASA missions that may benefit from this work are Space Station, planetary rovers, and solar exploration. Sparse distributed memory offers promising technology for systems that must learn through experience and be capable of adapting to new circumstances, and for operating any large complex system requiring automatic monitoring and control. This work, which is conducted primarily within RIACS, includes collaborations with NASA codes FL and RI, Apple Computer Corporation, Hewlett-Packard Corporation, MCC, Stanford University, and other research groups to be determined.

Sparse distributed memory is a massively parallel architecture motivated by efforts to understand how the human brain works, given that the brain comprises billions of sparsely interconnected neurons, and by the desire to build machines capable of similar behavior. Sparse distributed memory is an associative memory, able to retrieve information from cues that only partially match patterns stored in the memory. It is able to store long temporal sequences derived from the behavior of a complex system, such as progressive records of the system's sensory data and correlated records of the system's motor controls. Using its records of successful behavior in the past, sparse distributed memory can be used to recognize a similar circumstance in the present and to "predict" appropriate responses. Unlike numerical and symbolic computers, sparse distributed memory is a pattern computer, designed to process very large patterns formulated as bit strings that may be thousands of bits long. Each such bit string can serve as both content and address within the memory. Our project is concerned with research into aspects of sparse distributed memory that will enable us to evaluate and someday build autonomous systems based upon sparse distributed memory.

For the coming three years we have proposed research in four general areas: theory and design of SDM architectures, representation of sensory and motor data as bit patterns suitable for SDM, organization of SDM-based autonomous systems, and exploration of important domains of application. A major objective of our research is to explore the feasibility of SDM-based systems in applications such as vision processing, language processing, robotics and motor systems, and information retrieval. Each of the named areas will involve development of theory, simulations on appropriate computers such as the CM-2, and implementations on a digital prototype of SDM.