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PASM: A RECONFIGURABLE MULTIMICROCOMPUTER SYSTEM FOR IMAGE PROC--ETC(U)
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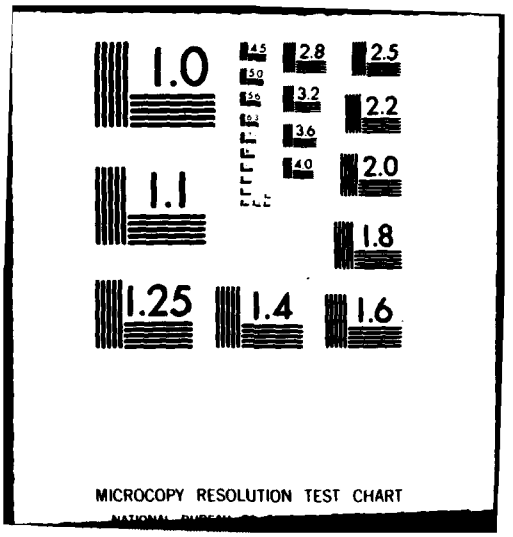
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As a result of the microprocessor revolution, it is now feasible to build multimicroprocessor systems capable of performing image processing tasks more rapidly than previously possible. There are several types of parallel processing systems. An SIMD (single instruction stream/multiple date stream) machine typically consists of a set of N processors, N memories, an interconnection network, and a control unit (e.g. Illiac IV). The control unit broadcasts instructions to the processors and all active ("turned on") processors execute the same instruction at the same time. Each processor executes instructions using data teken from a

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PASM: A RECONFIGURABLE MULTIMICROCOMPUTER SYSTEM FOR IMAGE PROCESSING

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April 1980

To be presented at the
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As a result of the microprocessor revolution, it is now feasible to build multimicroprocessor systems capable of performing image processing tasks more rapidly than previously possible. There are several types of parallel processing systems. An SIMD (single instruction stream - multiple data stream) machine typically consists of a set of N processors, N memories, an interconnection network, and a control unit (e.g. Illiac IV). The control unit broadcasts instructions to the processors and all active ("turned on") processors execute the same instruction at the same time. Each processor executes instructions using data taken from a memory with which only it is associated. The interconnection network allows interprocessor communication. An MSIMD (multiple-SIMD) system is a parallel processing system which can be structured as two or more independent SIMD machines (e.g. MAP). An MIMD (multiple instruction stream - multiple data stream) machine typically consists of N processors and N memories, where each processor can follow an independent instruction stream (e.g. C.mmp). As with SIMD architectures, there is a multiple data stream and an interconnection network. A partitionable SIMD/MIMD system is a parallel processing system which can be structured as two or more independent SIMD and/or MIMD machines. In this presentation, PASM, a partitionable SIMD/MIMD system being designed at Purdue University for image processing and pattern recognition, is described.

SIMD machines can be used for "local" processing of segments of images in parallel. For example, the image can be segmented, and each processor assigned a segment. Then, following the same set of instructions, such tasks as line thinning, threshold dependent operations, and gap filling can be done in parallel for all segments of the image simultaneously. Also in SIMD mode, matrix arithmetic used for such tasks as statistical pattern recognition can be done efficiently. MIMD machines can be used to perform

different "global" pattern recognition tasks in parallel, using multiple copies of the image or one or more shared copies. For example, in cases where the goal is to locate two or more distinct objects in an image, each object can be assigned a processor or set of processors to search for it. An SIMD/MIMD application might involve using the same set of microprocessors for preprocessing an image in SIMD mode and then doing a pattern recognition task in MIMD mode.

PASM is a large-scale dynamically reconfigurable multimicroprocessor system. It is a special purpose system being designed to exploit the parallelism of image processing and pattern recognition tasks.

Due to the low cost of microprocessors, computer system designers have been considering various multimicrocomputer architectures. PASM combines the following features:

(1) it can be partitioned to operate as many independent SIMD and/or MIMD machines of varying sizes, and

(2) a variety of problems in image processing and pattern recognition will be used to guide the design choices.

Figure 1 is a block diagram of the basic components of PASM. The Parallel Computation Unit (PCU) contains $N = 2^n$ processors, N memory modules, and an interconnection network. The PCU processors are microprogrammable microprocessors that perform the actual SIMD and MIMD computations. The PCU memory modules are used by the PCU processors for data storage in SIMD mode and both data and instruction storage in MIMD mode. The interconnection network provides a means of communication among the PCU processors and memory modules.

The Micro Controllers (MCs) are a set of microprogrammable microprocessors which act as the control units for the PCU processors in SIMD mode and

orchestrate the activities of the PCU processors in MIMD mode. There are Q = 2^q MCs. Each MC controls N/Q PCU processors. A virtual SIMD machine (partition) of size RN/Q where R = 2^r and $1 \leq r \leq q$, is obtained by loading R MC memory modules with the same instructions simultaneously. Similarly, a virtual MIMD machine of size RN/Q is obtained by combining the efforts of the PCU processors of R MCs. Q is therefore the maximum number of partitions allowable, and N/Q is the size of the smallest partition. Possible values for N and Q are 1024 and 16, respectively. Control Storage contains the programs for the MCs.

The Memory Management System controls the loading and unloading of the PCU memory modules. It employs a set of cooperating dedicated microprocessors. The Memory Storage System stores these files. Multiple devices are used to allow parallel data transfers.

The System Control Unit is a conventional machine, such as a PDP-11, and is responsible for the overall coordination of the activities of the other components of PASM. By carefully choosing which tasks should be assigned to the System Control Unit and which should be assigned to other system components (such as the Memory Management System), the System Control Unit can work effectively and not become a bottleneck.

In a companion presentation, examples of image processing on PASM type systems are discussed. The improvement in execution time, over that on a uniprocessor system, is examined for various tasks.

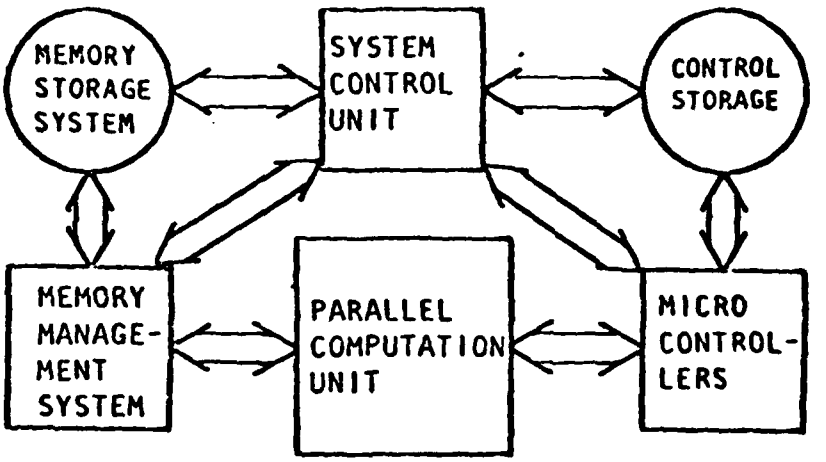

Fig. 1. Block diagram overview of PASM.