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N90-22219

Parallel Asynchronous Hardware Implementation of Image Processing Algorithms

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Research is being carried out on hardware for a new approach to focal plane processing. The hardware involves silicon injection mode devices. These devices provide a natural basis for parallel asynchronous focal plane image preprocessing. The simplicity and novel properties of the devices would permit an independent analog processing channel to be dedicated to every pixel. A laminar architecture built from arrays of the devices would form a two-dimensional (2-D) array processor with a 2-D array of inputs located directly behind a focal plane detector array. A 2-D image data stream would propagate in neuron-like asynchronous pulse-coded form through the laminar processor. No multiplexing, digitization, or serial processing would occur in the preprocessing stage. High performance is expected, based on pulse coding of input currents down to one picoampere with noise referred to input of about 10 femtoamperes. Approximately linear pulse coding has been observed for input currents ranging up to seven orders of magnitude. Low power requirements suggest utility in space and in conjunction with very large arrays. Very low dark current and multispectral capability are possible because of hardware compatibility with the cryogenic environment of high performance detector arrays.

The aforementioned hardware development effort is aimed at systems which would integrate image acquisition and image processing. Acquisition and processing would be performed concurrently as in natural vision systems. A key goal of the research will be hardware implementation of algorithms, such as the intensity dependent summation algorithm and pyramid processing structures, which are motivated by the operation of natural vision systems. Implementation of natural vision algorithms could benefit from the use of neuronlike information coding and the laminar, 2-D parallel, vision system type architecture. Besides providing a neural network framework for implementation of natural vision algorithms, a 2-D parallel approach could eliminate the serial bottleneck of conventional processing systems. Conversion to serial format would occur only after raw intensity data has been substantially processed. An interesting challenge arises from the fact that mathematical formulation of natural vision algorithms does not specify the means of implementation, so that hardware implementation poses additional questions involving vision science.

Acknowledgment

This work was supported in part by NASA under contract #NAS1-186 45.