Electronics/Computers

Spaceborne Processor Array

NASA's Jet Propulsion Laboratory, Pasadena, California

A Spaceborne Processor Array in Multifunctional Structure (SPAMS) can lower the total mass of the electronic and structural overhead of spacecraft, resulting in reduced launch costs, while increasing the science return through dynamic onboard computing. SPAMS integrates the multifunctional structure (MFS) and the Gilgamesh Memory, Intelligence, and Network Device (MIND) multi-core in-memory computer architecture into a single-system super-architecture. This transforms every inch of a spacecraft into a sharable, interconnected, smart computing element to increase computing performance while simultaneously reducing mass.

The MIND in-memory architecture provides a foundation for high-performance, low-power, and fault-tolerant computing. The MIND chip has an internal structure that includes memory, processing, and communication functionality. The Gilgamesh is a scalable system comprising multiple MIND chips interconnected to operate as a single, tightly coupled, parallel computer. The array of MIND components shares a global, virtual name space for program variables and tasks that are allocated at run time to the distributed physical memory and processing resources. Individual processor-memory nodes can be activated or powered down at run time to provide active power management and to configure around faults.

A SPAMS system is comprised of a distributed Gilgamesh array built into MFS, interfaces into instrument and communication subsystems, a mass storage interface, and a radiation-hardened flight computer.

This work was done by Edward T. Chow, Donald V. Schatzel, and William D. Whitaker of Caltech and Thomas Sterling of Louisiana State University for NASA's Jet Propulsion Laboratory.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-44023, volume and number of this NASA Tech Briefs *issue, and the page number.*

Instrumentation System Diagnoses a Thermocouple

This system can detect an open or short circuit or a debond.

John F. Kennedy Space Center, Florida

An improved self-validating thermocouple (SVT) instrumentation system not only acquires readings from a thermocouple but is also capable of detecting deterioration and a variety of discrete faults in the thermocouple and its lead wires. Prime examples of detectable discrete faults and deterioration include open- and short-circuit conditions and debonding of the thermocouple junction from the object, the temperature of which one seeks to measure. Debonding is the most common cause of errors in thermocouple measurements, but most prior SVT instrumentation systems have not been capable of detecting debonding.

The improved SVT instrumentation system includes power circuitry, a cold-junction compensator, signal-conditioning circuitry, pulse-width-modulation (PWM) thermocouple-excitation circuitry, an analog-to-digital converter (ADC), a digital data processor, and a universal serial bus (USB) interface. The system can operate in any of the following three modes:

- *Temperature Measurement*

In this mode, the ADC samples the output voltages of the thermocouple and the cold-junction compensator. Because the output voltage of the thermocouple is very small (typically of the order of microvolts or millivolts), it is necessary to utilize the gain of the ADC. The processor uses the cold-junction-compensator reading to obtain a compensated thermocouple output voltage, V_{out}, then calculates the temperature at the thermocouple tip by use of the equation of the form

$$T_{tip} = \sum_{k=0}^{n} A_k V_{out}^k$$

where the A_ks are calibration parameters, V_{out} is a the compensated thermocouple output voltage, and k and n are integers.

- *Thermocouple Validation*

For the purpose of determining whether there is a short or open circuit, the two thermocouple leads are subjected to a common-mode DC excitation or, via capacitors, to a differential-mode PWM excitation. From the response to the DC excitation, the processor can determine whether or not there is a short circuit. From response to the PWM excitation, the processor can determine whether there is an open circuit.

- *Bonding/Debonding Detection*

The processor commands the application of a PWM excitation, via a capacitor, to the thermocouple for a certain amount of time to heat the thermocouple. (Inductors in the thermocouple leads prevent the PWM excitation from reaching the thermocouple cold junction.) The characteristic time or rate of increase in temperature during the excitation is analyzed by the processor as an indication of the integrity of the thermocouple. The characteristic time or rate of decay of the temperature after the excitation is analyzed by the processor as an indication of the thermal resistance (and, hence, of bonding or debonding) between the thermocouple and the object, the temperature of which one seeks to measure.

The software running in the processor includes components that implement statistical algorithms to evaluate the state of the thermocouple and the instrumentation system. When power is first turned on, the user can elect to start a diagnosis/monitoring sequence, in which the PWM is used to estimate the characteristic times corresponding to the correct configuration. The user also has the option of using previous diagnostic values, which are stored in an electrically erasable, programmable read-only memory so that they are available every time the power is turned on.

This work was done by Jose Perotti and Josephine Santiago of Kennedy Space Center and Carlos Mata, Peter Vokrot, Carlos Zavala, and Bradley Burns of ASRC Aerospace Corp.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Kennedy Innovative Partnerships Office at (321) 861-7158. Refer to KSC-12875.

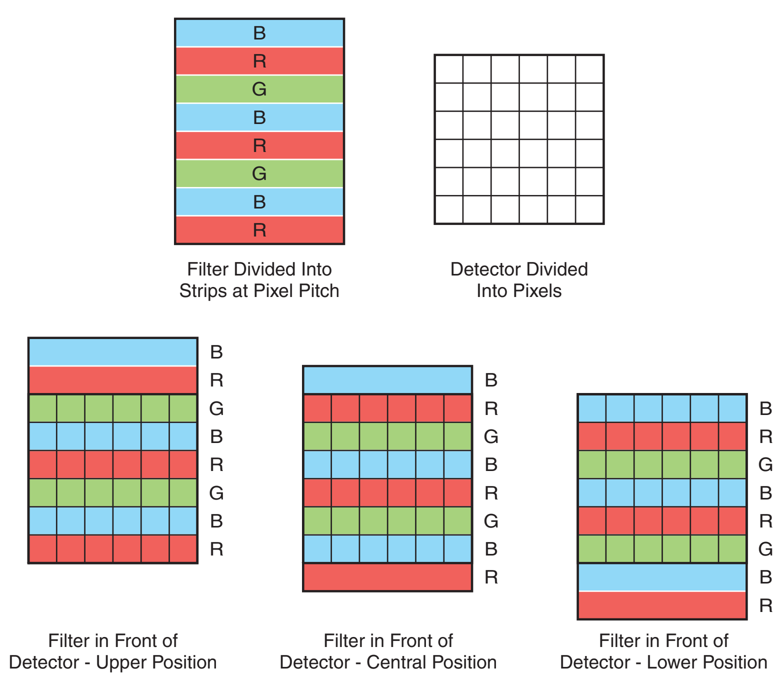
Chromatic Modulator for a High-Resolution CCD or APS

Color images would be detected without loss of spatial resolution.

NASA's Jet Propulsion Laboratory, Pasadena, California

A chromatic modulator has been proposed to enable the separate detection of the red, green, and blue (RGB) color components of the same scene by a single charge-coupled device (CCD), active-pixel sensor (APS), or similar electronic image detector. Traditionally, the RGB color-separation problem in an electronic camera has been solved by use of either (1) fixed color filters over three separate image detectors; (2) a filter wheel that repeatedly imposes a red, then a green, then a blue filter over a single image detector; or (3) different fixed color filters over adjacent pixels. The use of separate image detectors necessitates precise registration of the detectors and the use of complicated optics; filter wheels are expensive and add considerably to the bulk of the camera; and fixed pixelated color filters reduce spatial resolution and introduce color-aliasing effects. The proposed chromatic modulator would not exhibit any of these shortcomings.

The proposed chromatic modulator would be an electromechanical device fabricated by micromachining. It would include a filter having a spatially periodic pattern of RGB strips at a pitch equal to that of the pixels of the image detector (see figure). The filter would be placed in front of the image detector, supported at its periphery by a spring suspension and electrostatic comb drive. The spring suspension would bias the filter toward a middle position in which each filter strip would be registered with a row of pixels of the image detector. Hard stops would limit the excursion of the spring suspension to precisely one pixel row above and one pixel row below the middle position.



Red, Green, and Blue Filter Strips would be registered with pixel rows in a repeating pattern. The filter would be repeatedly placed in the upper, middle, and lower positions to repeatedly expose each pixel to each color.

In operation, the electrostatic comb drive would be actuated to repeatedly snap the filter to the upper extreme, middle, and lower extreme positions. This action would repeatedly place a succession of the differently colored filter strips in front of each pixel of the image detector. At each filter position, each detector pixel would thus acquire information on the local brightness in the momentarily selected color. The frequency of actuation of the comb drive would be three times the frame rate of the camera, so that over one frame period, each pixel would acquire full color information. Hence, the camera would acquire full color information at full pixel resolution.

Of course, it would be necessary to time-multiplex the outputs of the pixels for processing in a manner consistent with the spatial and temporal periodicity of the color information acquired by each detector pixel. To simplify the processing, it would be desirable to encode information on the color of the filter strip over each row (or at least over some representative rows) of pixels at a given instant of time in synchronism with the pixel output at that instant. This could be accom-