Wearable Environmental and Physiological Sensing Unit

Safety of operations in hazardous environments could be enhanced.

Ames Research Center, Moffett Field, California

The wearable environmental and physiological sensing unit (WEPS) is a prototype of systems to be worn by emergency workers (e.g., firefighters and members of hazardous-material response teams) to increase their level of safety. The WEPS includes sensors that measure a few key physiological and environmental parameters, a microcontroller unit that processes the digitized outputs of the sensors, and a radio transmitter that sends the processed sensor signals to a computer in a mobile command center for monitoring by a supervisor. The monitored parameters serve as real-time indications of the wearer's physical condition and level of activity, and of the degree and type of danger posed by the wearer's environment. The supervisor could use these indications to determine, for example, whether the wearer should withdraw in the face of an increasing hazard or whether the wearer should be rescued.

The sensed parameters are the temperatures inside and outside the wearer's protective suit, the wearer's pulse rate and level of oxygen saturation of hemoglobin, acceleration, and concentration of combustible gas in the air. The wearer's pulse rate and level of oxygen are sensed by a commercially available pulse/oximeter that is clipped to the wearer's ear. The pulse/oximeter sends red and infrared light of several wavelengths into the wearer's tissues and measures the pattern and intensity of the light as scattered by the wearer's tissues. A companion signal-processing electronic circuit processes the analog output of the pulse/oximeter into a digital stream that is sent to the microcontroller unit.

The temperatures inside and outside the protective suit are measured by thermocouples. The analog outputs of the thermocouple circuits are fed to analog-to-digital converters (ADCs) within the microcontroller unit. The temperature readings are obviously of value in sensing overheating of the wearer and assessing the level of external hazard during firefighting.

The pulse reading can be used to determine the wearer's panic level and estimate the rate of consumption of air if the wearer is breathing from a tank. The presence or absence of a pulse can be used to determine whether the wearer is still alive when the wearer is unconscious or otherwise unable to respond by radio. The oxygen level is a good indicator of the wearer's overall health and can aid in identifying a respiratory deficiency that could lead to unconsciousness.

The wearer's acceleration is sensed by a commercially available two-axis accelerometer, the analog outputs of which are sent via buffer amplifiers to ADCs in the microcontroller unit. The accelerometer readings are taken as indications of the wearer's motion and, hence, level of physical activity.

The combustible-gas sensor is a commercially available unit that contains a catalytic bead heated to a temperature (≈500 °C) at which it can oxidize combustible gases. The role of this sensor is to provide a warning when the concentration of combustible gas in the wearer's vicinity approaches the lower explosive limit. The temperature of the bead, which varies with the atmospheric concentration of combustible gas, is transduced to a voltage that is buffered and sent to the microcontroller unit.

The microcontroller unit combines all the digitized sensor readings into a single digital stream at a maximum data rate of 10 kb/s. The stream is used to modulate the carrier signal in the radio transmitter, which operates at a frequency of 433.92 MHz. A receiver in the mobile command station recovers the data stream and sends it to the serial port of a laptop computer equipped with software that recognizes the data streams of the individual sensors in the combined stream and generates a visual display of the data coming from each sensor.

This work was done by Stevan Spremo of Ames Research Center and Jim Ahlman, Ed Stricker, and Elmer Santos of San Jose State University.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-14770-1.

Broadband Phase Retrieval for Image-Based Wavefront Sensing

Broadband light can be approximated as monochromatic in phase-retrieval computations.

Goddard Space Flight Center, Greenbelt, Maryland

A focus-diverse phase-retrieval algorithm has been shown to perform adequately for the purpose of image-based wavefront sensing when (1) broadband light (typically spanning the visible spectrum) is used in forming the images by use of an optical system under test and (2) the assumption of monochromatic- ity is applied to the broadband image data. Heretofore, it had been assumed that in order to obtain adequate performance, it is necessary to use narrow- band or monochromatic light.

Some background information, including definitions of terms and a brief description of pertinent aspects of image-based phase retrieval, is prerequisite to a meaningful summary of the present development. "Phase retrieval" is a general term used in optics to denote estimation of optical imperfections or "aberrations" of an optical system under test. The term "image-based wavefront sensing" refers to a general class of algo-