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REAL TIME BIOMECHANICAL

Position Sensing Based on a Lateral Effect Photodiode

In research leading to an ocular communication system at Tufta-new England Medical Center, a technique has been sought to provide the position and orientation of the head of a potential user. This information along with the orientation of the eye is used to compute the line of gaze, which can then be used for visual selection of targets (e.g., the letters of the alphabet). Currently the project obtains this information via a 3-dimensional ultrasonic ranging device manufactured by the Science Accessories Corporation (1). While this device offers sufficient accuracy, it does not easily lend itself to a clinically usable system.

LATERAL EFFECT PHOTODIODE

An alternative has been explored in the form of a lateral effect photodiode manufactured by United Detector Technology Inc. (2) The photodiode is a 1cm x 1cm device that is capable of sensing light imaged on its surface. The diode has four electrodes on its edges. The photocurrent is divided among the electrodes in proportion to the relative distances from the image to the edges.

The photodiode has been purchased from United Detector Technology in a very usable form. The diode is mounted in a housing to which is attached a 28mm, f2.8 Pentax camera lens. A data acquisition circuit has also been provided which converts the values of current to voltage, and performs an analog to digital conversion. The resolution of this is 12 bits. The particular data collection circuit is compatible with the bus structure of the Apple II microcomputer.

PERFORMANCE

In laboratory calibration, the UDT device exhibited a 10-degree viewing cone with a sampling rate of 4HZ (with Apple soft Basic) and 2kHZ (with machine language code). The focus of the image is noncritical since the UDT photodiode senses the centroid of the image.

Although the A/D converter has a high resolution (16 bits), the stability of the signal is such that the working resolution is closer to 7 bits.

DEVICE IMPLEMENTATION

The sensitivity of the UDT photodiode is insufficient to detect a continuously illuminated infrared LED beyond 18 inches. A multiplexing circuit has been added that pulses a Telefunken (V194P) IR LED for 1 msec at 400 mA. The pulse duration is sufficiently long to be detected by at least one full sample (at 2 kHZ sampling rate). This allows the distance between the UDT detector and the IR LED to be approximately 5 feet. Multiple LED's can be pulled in sequence, with the results plotted on the high-resolution graphics screen of the Apple II. The data collection circuitry has the capability of supporting up to four photodiodes at one time. Using two diodes with appropriate optics, it is possible to compute the three dimensional coordinates of each IR LED.

The coordinating of three IR LED's mounted on the head (eyeglasses) are then used to compute the position and orientation of the head.

OTHER POSSIBILITIES

While the UDT sensor has been primarily considered for identifying head position and orientation, there are a number of other possible uses, which can be speculated upon. Within the line of gaze project, the ocular orientation is sensed by means of a CCD photosensitive array. The UDT device is considerably less sensitive (by at least 2 orders of magnitude) than the CCD camera. A safety consideration with infrared illumination of the eye mandates that the illumination must be less than 10 microwatts per cm² for continuous data (3). The fast response time of the UDT can be exploited by pulsing the IR source at higher power for short duration's. This maintains the average power output at an acceptable level. The technique is being explored as a possible replacement for the more expensive and delicate CCD device.

Other potentially exciting uses of this device include the sensing of hand and limb position. This introduces the possibility of developing a portable (transportable) system for monitoring manual tasks, or measuring range of motion. It will also be conceivable to locate multiplexed light emitting diodes on both hands for the sensing of American Sign Language, thus opening the potential for telephone transmission of ASL.