DESIGN OF A PROTOTYPE VIDEO-BASED FIRE DETECTION SYSTEM

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ABSTRACT

A video-based fire detection system currently under development at Washington State University is presented. The prototype system is intended to be a practical solution to the need for fire protection in industrial settings, such as in warehouses and on factory floors, or in situations in which a black and white video camera is already in use (e.g. for surveillance).

The system utilizes a video camera to monitor temperature and species sensitive sensors that change color at a prescribed temperature or carbon monoxide concentration. When the sensors change color in response to an accidental fire, the color change is detected by the video camera and the digitized image passed on to a personal computer via a frame grabber. The personal computer subsequently determines the location of the sensor and the time of the color change. The times and locations of sensors changing color are used as data for an inverse problem solution algorithm, based on LAVENT [1], which signals the detection of a fire, and then determines the location and size of the fire.

Previous work reported by Munk et al. [2] dealt with the development of FORTRAN code to implement the inverse problem solution algorithm used for the determination of the fire location and size. Limits on the accuracy with which the inversion algorithm could locate and size fires were assessed using computer synthesized data from simulated compartment fires. The present work involves the design, fabrication, and testing of a working prototype of the video-based fire detection system. Development of both hardware and software are addressed.

The prototype system consists of a 486 personal computer, a PULNEX TM-7CN black and white video camera, a SCENTECH IV-P24 frame grabber, and an array of color-changing sensors. Both temperature-sensitive sensors such as reversible thermochromic liquid crystal sensors, and irreversible polyamide sensors, and carbon monoxide-sensitive sensors (commercially available) have been tested in conjunction with the video-detection system.

Particular attention has been paid to issues concerned with sensor design, since the ability of the video camera to detect a change in the color sensitive sensors is critical for the system operation. Basic design considerations related to the sensor geometry (size, shape, and layout), are of interest. For example, practical design considerations related to realistic operating conditions such as the number of sensors required, sensor array distribution, sensor color change characteristics, and the effect of lighting and camera-to-sensor distances on sensor visibility have been considered.

Figure 1 shows the number of pixels counted in the images of 10 x 10 cm square, white and black targets. The number of pixels, plotted versus target-to-camera distance shows the expected r^{-2} dependence. Of interest here is the relatively large number of pixels in the images of targets which are representative of the sizes planned for the color-changing sensors. Even at fairly large distances, ~20 feet, the number of pixels, ~100 pixels, is sufficient to average out electronic noise and sensor edge effects.

The magnitude of color change produced by triggering a TLC sensor which is visible to a black-and-white video camera can be seen in Fig. 2. The figure shows pixel values averaged over the entire images of unactivated TLC sensors (black), activated TLC sensors (gray), and white targets where the sensors and targets were 10 x 10 cm, and located 12 feet from the video camera. Pixel values have been normalized to vary between 0 (pure black) and 10 (pure white) and plotted versus intensity of illumination in units of lux. The increase in pixel value in the image of the TLC sensor upon activation is

not great, about one-sixth of the change visible if the sensor changed from black to white. However, for spaces where the sensors would receive illumination greater than 80 lux the increase in pixel value is sufficient to clearly distinguish activated from unactivated sensors. Marks' Mechanical Engineers' Handbook gives 60 lux as the minimum level of illumination recommended for corridors and stairways [3].

Recent work has focused on developing software to gather the time-versus-temperature information required by the inversion algorithm, from the distributed color-changing sensor array. Specifically, PC-based software able to reliably determine the activation of any sensor in an array, and then to relay the room location of the sensor and the time of activation to the inversion algorithm is being coded.

In the presentation, the operation of the prototype fire detection system, including color-changing sensors, will be demonstrated. An overall evaluation of the system will be presented, based on the criteria of quick fire detection, accurate fire location, accurate fire sizing, simplicity of set up, simplicity of operation, system versatility and cost.

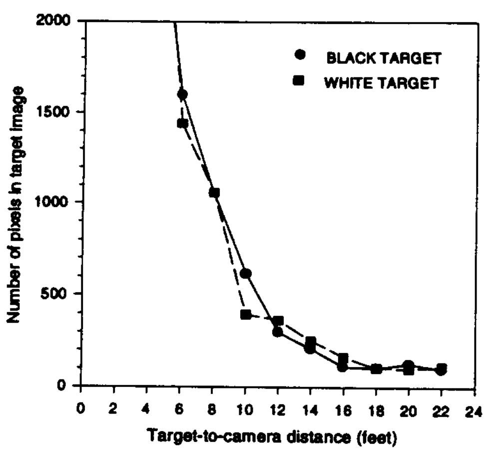

Fig. 1 Number of pixels in image of 10 x 10 cm target versus target-to-camera distance.

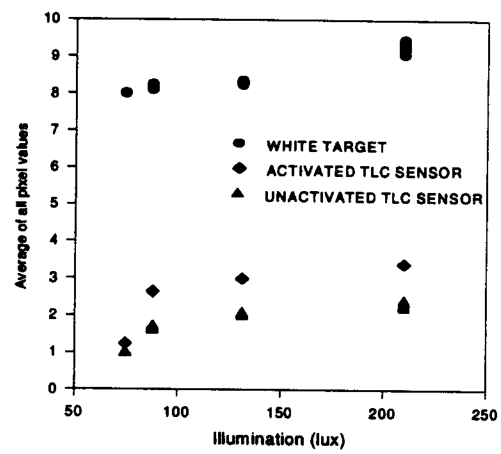

Fig. 2 Average pixel values of unactivated TLC sensors, activated TLC sensors, and white targets under varying illumination.

References

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