Fiber-based digital surveillance networks

M.A. Matin and Easwar Sankar

Visual surveillance systems are widely used, but are often inflexible and demand a great deal of human attention to be effective. This paper describes a flexible, automated visual surveillance system that offers high performance and easy customization. The system uses a central digital signal processor, based on reprogrammable electronics, to analyze video data from a network of cameras linked by an optical fiber network.

Fifteen years ago, governments were the main users of visual surveillance systems. Today, banks, shopping malls, office buildings, apartment complexes, and event centers use such systems routinely. Many visual surveillance systems are inflexible and expensive. In addition, changing security needs make regular system upgrades and modifications essential. However, each installation is unique, so there is no solution that serves all applications. Conventional visual surveillance systems also demand that a lot of operator time is spent viewing insignificant activities, compared with the very small fraction of their time that is spent viewing those of real importance.

Our research proposes a flexible visual surveillance network system that offers high performance and that can be easily customized to each application. The system uses a digital signal processor, based on field-programmable gate arrays (FPGAs), at the central processing unit to analyze video data from a network of cameras whose signals are transmitted via optical fiber. The equipment to be reused. The reprogrammable FPGA provides the flexibility and performance, as well as enabling easy upgrades.

Most surveillance video streams have a still background with little or no motion. Some form of automation would greatly reduce the wastage of manual labor, as well as making it possible...
to identify objects of interest and track them. One of the most common ways of achieving such automation is by using motion detection.

This paper proposes a video surveillance system capable of collecting video data from several physically-separated surveillance cameras connected with fiber. The data would be processed at a central location, as shown in Figure 1. The system requires minimal human intervention, since it is capable of substantial automation. Further, the architecture of the proposed system is customizable for minimal cost. The system has a video capture subsystem that can handle a variety of cameras, so it is compatible with most legacy systems. It can also be easily customized.

The system consists of a video capture subsystem, a transmission network and a video processing subsystem. Figures 2 and 3 show the video capture subsystem in detail. In a stereoscopic imaging system, the video capture module would consist of two cameras with similar optics, positioned so that the imaging planes are parallel. The cameras transmit video at a rate of 15 frames per second (fps). The frame size is 120×160 pixels, and color images are commonly transmitted using 24 bit per sample. The system can also support analog cameras, although this requires the use of an analog to digital converter that can support the required data rates.

An optical fiber transmission link consists of: the transmitter, consisting of the drive circuit and the light source; the fiber channel, consisting of fiber, regenerators, amplifiers and splices; and the receiver, consisting of a photo detector, amplifiers and the signal regeneration circuit. The fiber channel has a high bandwidth, which can be further enhanced using wavelength-division multiplexing (WDM). In this scheme, multiple sources use slightly different wavelengths to transmit several independent information streams over one fiber. WDM improves a fiber’s capacity, and enables signal routing and switching based on wavelength. The system’s use of an FPGA, rather than a dedicated DSP chip, adds further flexibility to this system as well as enabling higher clock rates than most commercially available DSPs.

A three-dimensional positioning algorithm situates an object in three dimensions, using images from a stereo pair of cameras and triangulation techniques. A video storage algorithm ensures that only those video frames that include scene changes are stored.

Figure 2. Schematic of the preprocessor subsystem.

Figure 3. Schematic of the FPGA subsystem.

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At SPIE’s Photonic Devices and Algorithms for Computing VI meeting last year, we described a proof of concept of the functions of this system, include the tracking of objects in three-dimensional space using a stereo pair of cameras. The algorithms described have been tested using MATLAB Simulink simulations.

Author Information

M.A. Matin and Easwar Sankar
School of Engineering and Computer Science
University of Denver
Denver, Colorado, USA

References