DEVELOPMENT OF AN IMAGE COMPRESSION AND AUTHENTICATION MODULE FOR VIDEO SURVEILLANCE SYSTEMS

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Abstract

An Image Compression and Authentication Module (ICAM) has been designed to perform the digitization, compression, and authentication of video images in a camera enclosure. The ICAM makes it possible to build video surveillance systems that protect the transmission and storage of video images. The ICAM functions with both NTSC 525 line and PAL 625 line cameras and contains a neuron chip (integrated circuit) permitting it to be interfaced with a local operating network which is part of the Modular Integrated Monitor System (MIMS). The MIMS can be used to send commands to the ICAM from a central controller or any sensor on the network.

The ICAM is capable of working as a stand alone unit or it can be integrated into a network of other cameras. As a stand alone unit it sends its video images directly over a high speed serial digital link to a central controller for storage. A number of ICAMs can be multiplexed on a single coaxial cable. In this case, images are captured by each ICAM and held until the MIMS delivers commands for an individual image to be transmitted for review or storage. The ICAM can capture images on a time interval basis or upon receipt of a trigger signal from another sensor on the network. An ICAM which collects images based on other sensor signals, forms the basis of an intelligent "front end" image collection system. The burden of image review associated with present video systems is reduced by only recording the images with significant action. The cards used in the ICAM can also be used to decompress and display the compressed images on a NTSC/PAL monitor.

Introduction

A major problem that has faced unattended surveillance systems used for safeguards applications is finding a way to verify that the image coming from a video surveillance camera is authenticated and has not been altered or delayed in time. Numerous attempts have been made since 1977 to develop ways to protect the images coming from a video camera. Several systems based

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on authenticating an analog video signal worked to provide a measure of protection, but all had some weaknesses that made them less than satisfactory. The emerging digital video technology has at last made it possible to design a full digital authenticated video system for use in unattended surveillance systems.

Sandia National Laboratories (SNL) is involved in a project to develop an Image Compression and Authentication Module (ICAM) for use by the international safeguards organizations and various US Government agencies in cooperative monitoring activities. The module (shown in figure 1) is built using a set of video compression cards (Recon 11 board set) and a controller board, jointly developed by SNL and Fast Forward Video (FFV) and manufactured by FFV. The boards are designed to operate with other computer boards using the PC-104 bus. The ICAM contains a neuron chip that interfaces it to a Local Operating Network (LON), developed by Echelon Corporation.
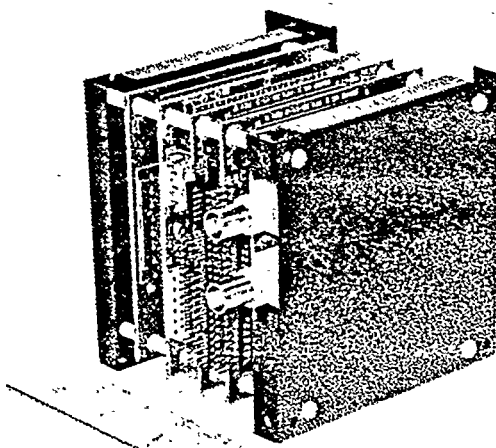
Figure 1. Image Compression and Authentication Module.

General Description of Module

The ICAM is a necessary component to complete an all digital remote monitoring system under development by SNL. The ICAM is designed to function with both 525 line and 625 line cameras. It will digitize video frames, compress them, authenticate the resulting digital file, and store the image file until it can be transmitted to a Digital Acquisition Unit (DAU). The ICAM uses small PC/104 cards that can fit into camera housings.

The controller card contains a neuron chip (integrated circuit) to permit it to interface with the LON, which is part of the MIMS. The MIMS is used to send commands to the ICAM from the DAU or any sensor on the network. The controller card also contains a four to one video multiplexer that allows it to select the video signal from any one of four video cameras or sources.

The ICAM is capable of working as a single unit, or it can be integrated into a network of other cameras. As a single unit it will send its video images directly to a digital acquisition system for immediate storage. Figure 2 shows the ICAM installed into a camera housing like the camera housings used by the International Atomic Energy Agency. Figure 3 shows the camera housings with the cover installed.

When a network of cameras are required, a large number of cameras with ICAMs can be attached to a single coaxial cable. Images are captured by each ICAM and stored until the images are transmitted to one or more DAU's which can be connected to the same cable. The ICAMs can capture images on a time

interval basis or upon receiving a trigger from another type of sensor on the integrated network. A network of
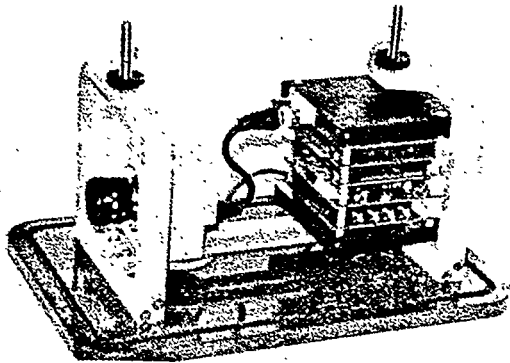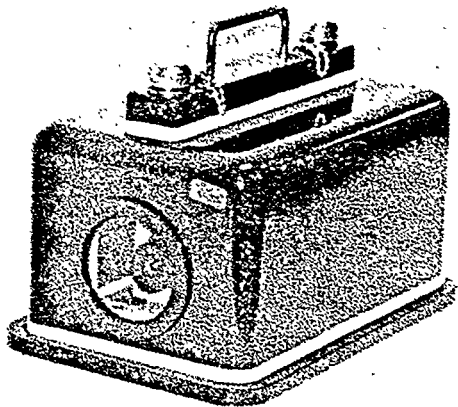

Figure 2. ICAM in Camera Housing.

Figure 3. Camera Housing

ICAMs, collecting selective images that are based on other sensor signals, can form the basis of an intelligent "front end" image collection system which reduces the review burden of present time lapse video systems.

Technical Details

The PC/104 form factor (under four inches square) of the Recon 11 makes it possible to integrate it into many different types of portable digital video applications. Adding the Recon

controller card even increases the capability of the combination to perform many tasks associated with the collection of video images for safeguards purposes. The functional block diagram in figure 4 shows a complete ICAM which consists of the Recon 11 cards and the controller card. The Recon controller card adds a number of special features that makes the ICAM a very flexible piece of surveillance hardware. The special features include an embedded 386 microprocessor, a local area network integrated circuit, RS-485 network interface, an ISA bus interface, and a high speed serial digital interface that can be multiplexed at rates up to one megabits per second. The Recon 11 cards can be power managed to reduce power consumption through a set of three power strobe control lines.

The Recon 11 cards have their own SCSI-2 interface that allows them to store and retrieve digital images from hard drives or any other SCSI device. The cards connected to fast hard drives have the capability of handling broadcast quality video up to realtime video rates (25/30 frames per second). The Recon 11 also has a number of other interfaces in addition to the SCSI interface. The interfaces are ISA bus, Ethernet, and RS-422/485 serial. The Recon 11 has an embedded 386 microprocessor with 256 KB of flash memory and 256 KB of SRAM (Static Random Access Memory) to handle the video compression parameters and the authentication algorithm.
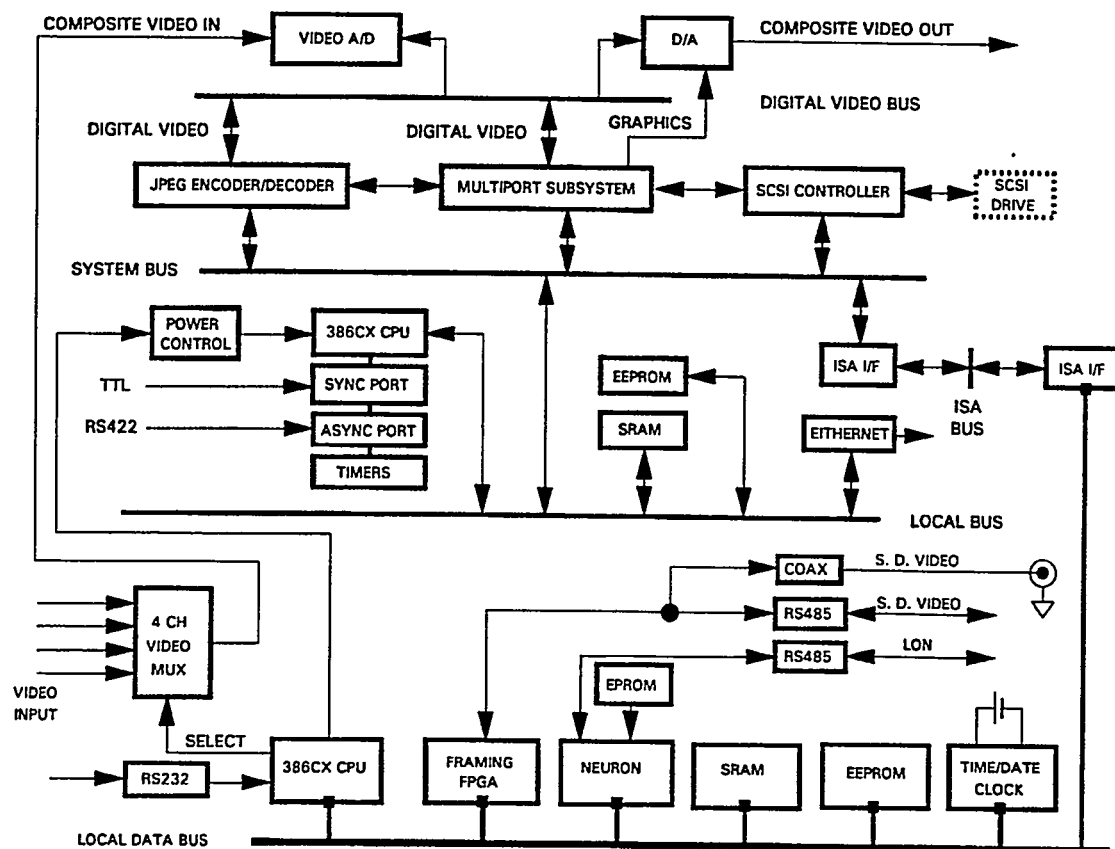
Figure 4. Functional Block Diagram of the ICAM

The Recon 11 boards can compress and decompress either NTSC (National Television Standards Committee) or PAL (Phase Alternating Lines) standard composite video signals. Video compression is based on the JPEG (Joint Photographic Experts Group) algorithm which performs compression on an intraframe basis. Every frame stands alone and does not depend on the video information in any previous or succeeding frame. Video compression ratios from 4 to 1 to over 100 to 1 can be performed in realtime. Most safeguards applications can use 20 to 1 compression ratios without any visible artifacts. At 8 to 1 compression ratios the horizontal resolution of the system is greater than

550 TV lines and the signal to noise ratio is about 60 db.

Authentication

The ICAM uses the Digital Authentication Signature (DAS) algorithm to protect the image when it is transmitted from a camera housing to a data storage location. Since the digital authentication signature is attached to the image file, it will continue to provide protection against substitution all the way through the image review process. The DAS generation process involves accepting an arbitrary length image file and computing its digital signature, which will then accompany the image file. A header, containing information such as a date/time stamp, a frame count,

a camera identifier, an alarm status, and other video format information, is appended to the image file prior to authentication. The contents of the header serve as a certificate of information necessary to validate the message. An important aspect of the signature generation function in the ICAM is the ability to destroy all secret information, such as the private key, upon activation of a tamper signal. If the private key is destroyed, data will continue to be authenticated by employing a backup key. Thus, the adversary cannot use tampering to achieve denial of information.

The DAS validation process during image review involves three important tasks: 1) Verifying that the received public key, camera identifier, and other parameters to be used in the validation process are valid, 2) verifying that previously received frames are not substituted for the current frame, and 3) validating the digital signature of the message.

Summary

The ICAM provides a wide range of capabilities to form the basis of many digital video surveillance systems. Not only can it be installed into camera housings, but it can be used as the central module for portable digital recorders and portable digital cameras. The module is capable of realtime operation at 25 or 30 frames per second, making it possible to transmit, authenticate, receive, and display live video images from remote cameras. The flexibility of the Recon 11 and controller card makes it possible to both capture and display video images. The controller card contains both the neuron IC and a 386 microprocessor which allows it to be a powerful standalone card. The controller also has a high speed serial digital capability of up to one megabits per second. Through various software programs the ICAM will offer many options for future international safeguards applications.