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Title: REMOTE INTELLIGENT NUCLEAR FACILITY MONITORING IN LABVIEW

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Remote Intelligent Nuclear Facility Monitoring in LabVIEW

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Abstract

A prototype system implemented in LabVIEW for the intelligent monitoring of the movement of radioactive material within a nuclear facility is presented. The system collects and analyzes radiation sensor and video data to identify suspicious movement of material within the facility. The facility system also transmits wavelet-compressed data to a remote system for concurrent monitoring.

Background

Fifty years after the detonation of the first atomic bomb, the limiting factor in the development of nuclear weapons is not the basic knowledge required to build weapons, but the procurement of weapons-grade nuclear material for their fabrication. Preventing the proliferation of nuclear weapons requires the rigid control of weapons-grade material. Although nuclear material handling facilities are protected against overt assault, the biggest threat to the safety of nuclear material is believed to come from facility workers [1].

The Problem

At Los Alamos National Laboratory (LANL), we have developed a prototype system in LabVIEW to monitor intelligently the movement of nuclear material within a nuclear material storage facility. Our requirements are that the system communicate with monitoring instruments such as radiation sensors and video cameras, process sensor and video data to determine how material is being moved, discriminate between routine and non-routine material movement, and alert others remotely of suspicious activity.

Our system monitors activity in a single room with two exits. At each exit we placed a neutron sensor. One of the sensors is connected to a Gamma Ray And Neutron Detector (GRAND), and the other is connected to a Portable Shift Register (PSR). Both of these were custom built by LANL. The PSR is also connected to a second neutron detector and neutron coincidence counter positioned away from either of the exits. The PSR and the GRAND collect data from the radiation sensors and store the data until it is requested by our main computer, a 133 MHz Pentium running Windows NT connected to the instruments over serial (RS232) cables. A portion of the room near one of the exits is also monitored by a charge coupled device (CCD) camera connected to a Data Translation DT3155 PCI frame grabber. A hardware overview is shown in figure 1.

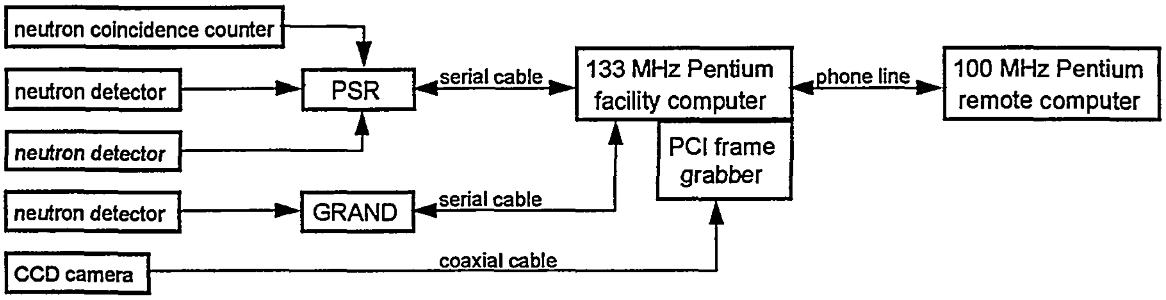

figure 1 nuclear facility monitoring system hardware overview

The Solution

The program development occurred in several stages which were incorporated into a single LabVIEW application. Figure 2 shows the main application LabVIEW user interface. The first stage was to interface the host computer with the GRAND and PSR. A LabVIEW virtual instrument (VI) was built for each instrument which sends text commands to the instruments over the serial bus using LabVIEW's built-in serial communication routines. The VIs configure the two instruments, periodically query the instruments for new data, and parse the neutron counts out of the returned data.

The second stage was to interface the computer with the CCD camera. The frame grabber for the camera is controlled with 'C' routines written by Data Translation which we modified and incorporated into our application using LabVIEW 'C' interface nodes (CINs). Because the video is to be sent to a remote computer over phone lines, we compressed the video images with a wavelet compression algorithm based on the FBI standard for fingerprint image compression [2]. We also count the number of pixels differing between a reference image and the current image to give an absolute measure of the amount of activity occurring in the camera's field of view.

The third stage in the development was to integrate the sensor and video data to monitor the room for suspicious activity. Suspicious activity can be difficult to categorize, but in a nuclear facility, we can expect most activities to be generally regimented, i.e. material is typically handled by the same group of people in relatively constant quantities in a fairly routine pattern. An intelligent system should be able to identity these patterns and recognize unusual patterns of movement. For testing our prototype system, we considered all activities normal except when a radioactive source is carried in one door and out the other without placing the source in the neutron coincidence counter. To integrate and analyze the data we used a traditional feed-forward, back-propagating neural network. For our relatively constrained application, a neural network is unnecessary, but our goal was to build an extensible system capable of incorporating many more sensors and recognizing subtle patterns of activity.

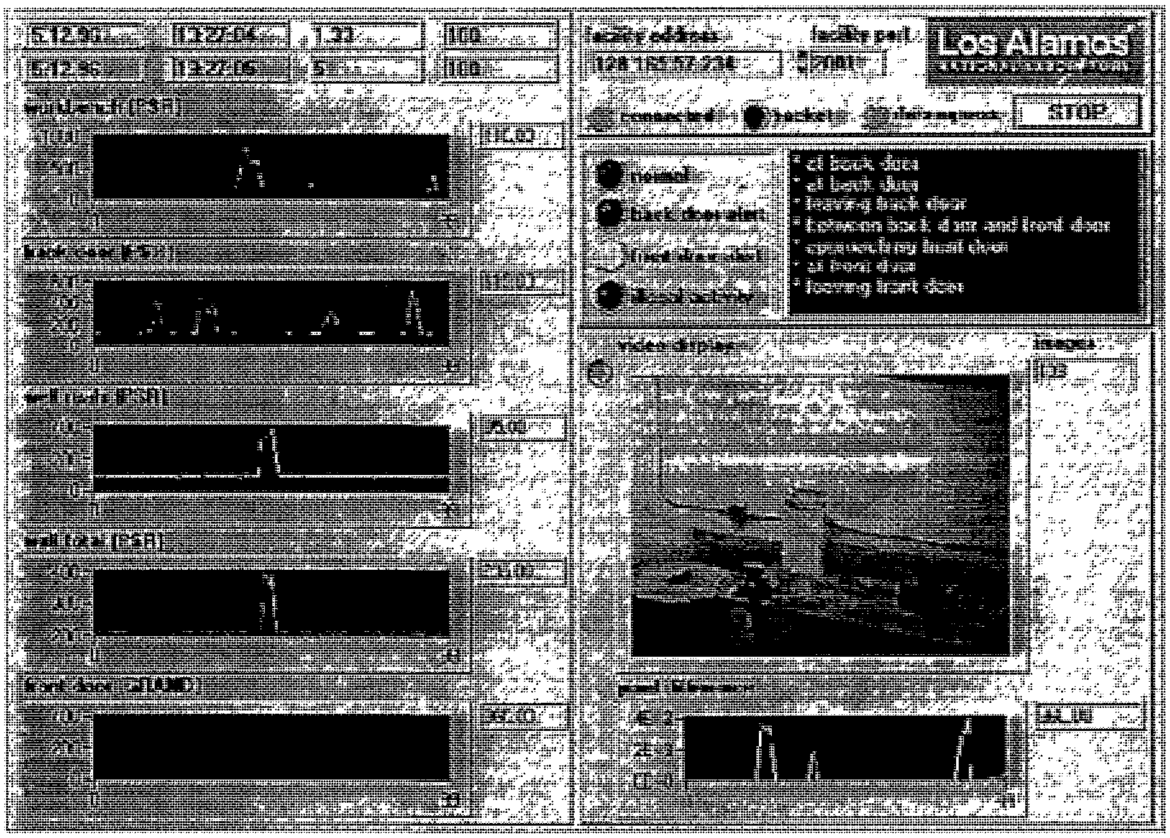

figure 2 LabVIEW user interface

The final stage in the development was to network the host system with a remote system, a 100 MHz Pentium notebook computer running Windows NT, for concurrent monitoring of sensor data, video and neural network results. We networked the system with standard phone line because we believed we could guarantee access to a phone line or both the local and remote computers which might not be possible if we networked the system using the internet. In our prototype system we connected the facility computer directly to the internet, and we connected the remote system to the phone line using a Megahertz XJ2288 28,800bps PCMCIA modem and Point to Point Protocol (PPP) which sends TCP/IP and other network-level protocols over serial lines. After connecting to a PPP server, the remote system was treated as if it were connected directly to the internet and allowed us to use LabVIEW's TCP/IP routines to communicate with the facility computer.

Conclusions

We have been encouraged by the results of our prototype system. Our finished system collected and analyzed the sensor and camera data, identified suspicious activity, compressed the video image, transmitted the compressed image and data over a standard phone line, and decompressed the image approximately once every second. The networking and the display of video and sensor data were trivial with LabVIEW. The communication with the serial instruments was also simple although we did have a problem with the serial ports occasionally freezing up which we traced to a problem with the low-level Windows NT serial port driver. We felt, however, that the communication with the camera, and the implementation of the compression/decompression algorithm and the development of the neural network were complicated by LabVIEW primarily due to the inability to debug CINs during run-time. In retrospect, these would have been easier with dynamic link libraries.

We believe our system performed quite effectively and could easily be extended to incorporate additional sensors and cameras installed in multiple rooms with little modification due largely to the object-oriented nature of LabVIEW. By adapting the core monitoring program, other applications could be developed including monitors for equipment malfunction in automated production or security monitors in the private sector as in banks or the home.

References

[1] P. Williams, P. Woessner. "The Real Threat of Nuclear Smuggling". *Scientific American*. pp 40-44. January 1996.

[2] J. Bradley, C. Brislawn, J. Brown, C. Rodriguez, L. Stoltz. "Video Imaging for Nuclear Safeguards". *Proceedings of the 1994 IEEE Data Compression Conference and Industry Workshop*. Snowbird, Utah, March 1994.

Author Biography

John Kucewicz received his BS in computer engineering from Texas A&M University in May, 1995 and plans to begin pursuit of his MS in bioengineering in August, 1997. He currently works for Los Alamos National Laboratory in the Nonproliferation and International Security Division. He can be reached by electronic mail at "kucewicz@lanl.gov".