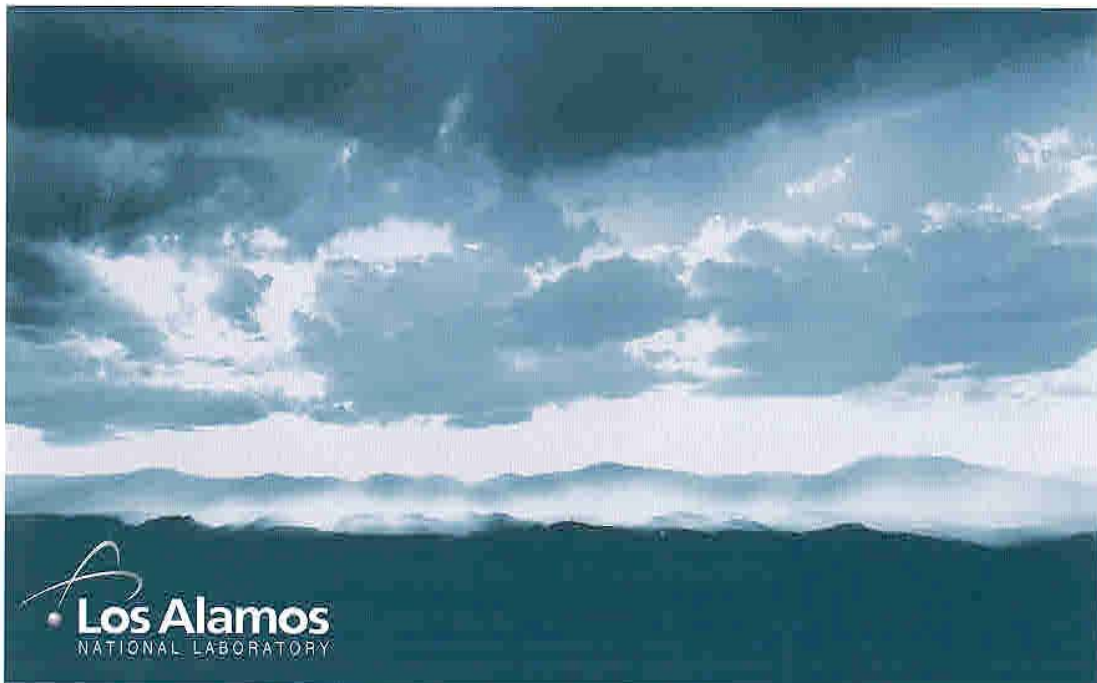


**Integrating IPix Immersive Video Surveillance with Unattended and Remote Monitoring
(UNARM) Systems**

Kelly Michel, Shirley Klosterbuer, and Diana Langner
Los Alamos National Laboratory
Los Alamos, NM 87545

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Kelly Michel, Shirley Klosterbuer, and Diana Langner
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Los Alamos, NM 87545

Abstract

Commercially available IPix cameras and software are being researched as a means by which an inspector can be virtually immersed into a nuclear facility. A single IPix camera can provide 360- by 180-degree views with full pan-tilt-zoom capability, and with no moving parts on the camera mount.

Immersive video technology can be merged into the current Unattended and Remote Monitoring (UNARM) system, thereby providing an integrated system of monitoring capabilities that tie together radiation, video, isotopic analysis, Global Positioning System (GPS), etc. The integration of the immersive video capability with other monitoring methods already in place provides a significantly enhanced situational awareness to the International Atomic Energy Agency (IAEA) inspectors.

Introduction

The Unattended and Remote Monitoring (UNARM) system developed by Los Alamos National Laboratory (LANL) Safeguards Science and Technology Group was originally developed in the 1980s. It is a comprehensive system that contains functional elements for the detection, collection, and review of safeguards data.¹ The system is principally used by the International Atomic Energy Agency (IAEA), but has begun being used in areas of homeland defense initiatives. UNARM is an integrated system of varying instrument types that sense an environment on different levels. One type of instrument used in the UNARM system, for purposes of surveillance, is the digital camera.

The camera that is currently certified and used by the IAEA in their UNARM systems is the DCM-14 camera, manufactured and produced by Aquila Corporation. The DCM-14 camera produces 640 by 480 resolution black and white images. The image files produced by the DCM-14 camera are a nonstandard, proprietary, JPG format. The IAEA is currently in the process of planning for the replacement of existing camera systems with the next-generation surveillance system (NGSS); requirements for the NGSS are under development.

As proof of principle, and for purposes of testing the new modular and component-based architecture developed by LANL for the UNARM system, LANL engaged in an exercise of testing whether generic cameras could be supported by the UNARM software and easily integrated.² The evaluation that was performed called for the use of commercially available surveillance cameras. The only requirement for the camera(s) that would be evaluated is that the cameras produce nonproprietary, standard image formatted files and be accessible through a computer network. Image file types generated by the camera could include any of the following VIFF, TIFF, BMP, or JPEG.

Evaluation Effort

Within the last two years, LANL has taken a new modular approach to the design and architecture of their UNARM systems for both hardware and software.² The goal in redesigning the UNARM architecture was to create a more flexible system that could leverage the power of commercially available products, but leverage those capabilities in a manner that was innovative and perhaps not anticipated by the original manufacturers. After the terrorist attacks of September 11, 2001, the commercial market demand for surveillance products grew dramatically. As a result, the functional capabilities of commercially available surveillance products have been enhanced significantly, making them attractive candidates for inclusion in the UNARM system. LANL began looking for ways to modify the existing UNARM architecture to support the integration of these commercially available surveillance products wherever possible and feasible.

After a technology briefing given to an NGSS forum in October, 2003, LANL decided to perform an evaluation to determine the feasibility of integrating an immersive imaging sensor into the UNARM system. Internet Pictures Corporation (IPix) offers a camera that produces fisheye images in a standard JPEG format. IPix also produced software that had the unique functional capability to view those fisheye images in an immersive manner—namely with a virtual pan, tilt, zoom (P-T-Z) within a still image. The camera selected and used for the evaluation was the IQEye-3 camera, produced by IQInvision, but configured with an IPix fisheye lens. For the remainder of this paper, the camera will be referred to as an IPix camera.

The IPix camera, configured with a fisheye lens, will image a 360-degree by 180-degree area. With this fisheye lens configuration, two cameras configured in this manner and placed back to back, could image a complete 360-degree by 360-degree area with no dead band. Raw images produced by a single camera are circular and have a warped look (Figure 1). The images are color, high resolution (1,280 by 968 maximum resolution, 1.3 megapixel) and may be viewed in an immersive manner, giving a user the sense of being inserted into the image and providing the ability to pan, tilt, and zoom within the image to see more or less detail, as required. Note that the camera has no physically moving parts. The camera itself does not pan, tilt, or zoom. The P-T-Z effects are purely virtual (Figure 2).

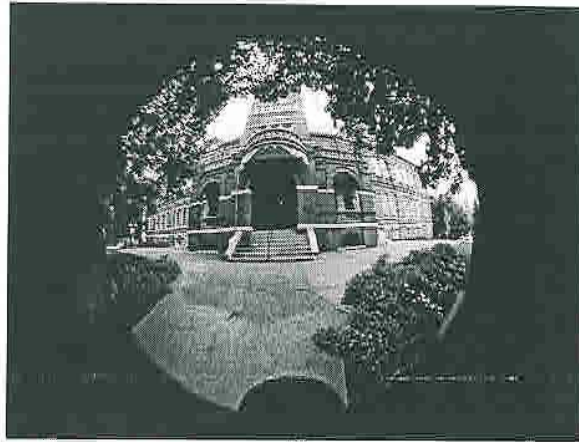


Figure 1: Sample of a raw image taken with an IQInvision IQEye3 camera configured with an IPix fisheye lens. The image area is 360 degrees by 180 degrees in scope. The image is 1.3 megapixels in resolution. (Note: the image used is from the IPix Software Development Kit software sample package).

IPix produces a software development kit (SDK) package that can be used to convert fisheye images into immersive, viewable items. Through the use of the IPix proprietary algorithms, accessed through the IPix SDK, the warped fisheye image can be flattened or dewarped, and the immersive P-T-Z controls accessed in a viewer.

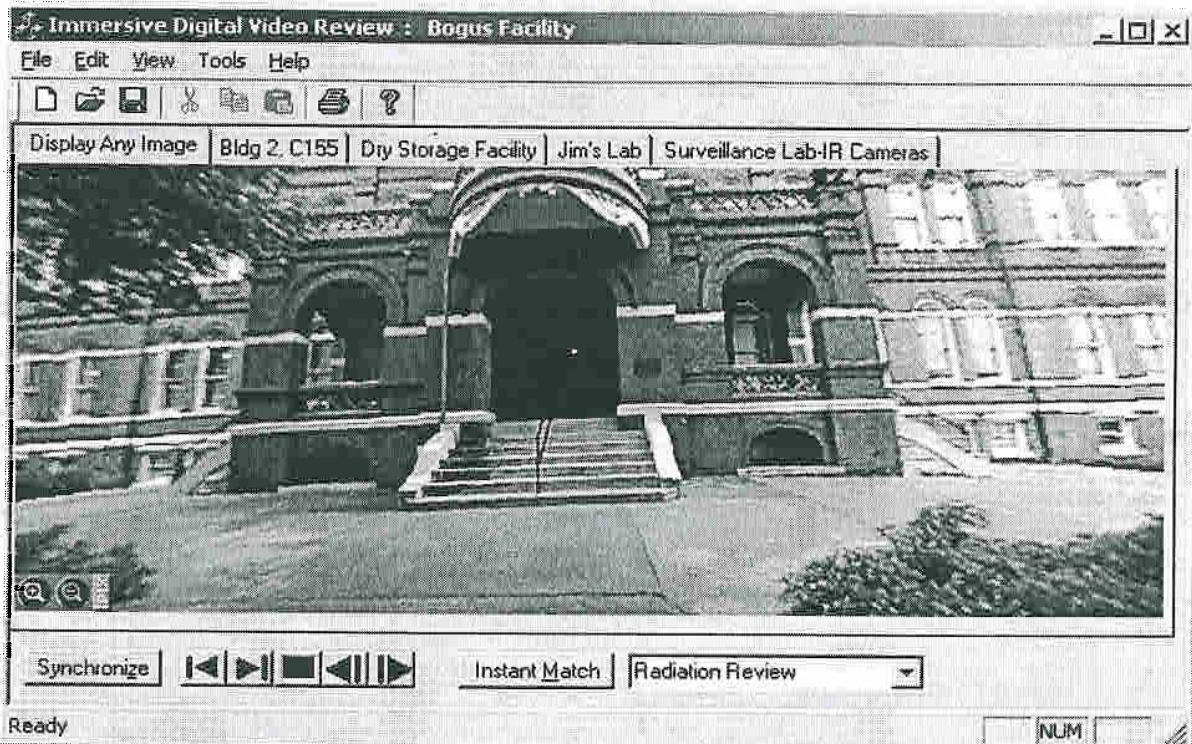


Figure 2. Fisheye image displayed in an immersive viewer developed by Los Alamos National Laboratory, using the IPix software development kit to obtain the immersive viewing capability. The image is dewarped and the viewer software provides the ability to virtually pan, tilt, and zoom within the context of the image. The image is 1.3 megapixels in resolution.

LANL developed a viewer application that will display immersive images, as well as any other standard image format type image file (i.e., BMP, JPEG, VIFF, TIFF, etc.). The application uses the IPix Corporation SDK library to dewarp IPix images and provide virtual P-T-Z functionality, and is fully integrated into the UNARM Integrated Review Software (IRS) suite of tools. As such, any image displayed can be correlated to any of the other data types that are collected and analyzed by the UNARM IRS tools (i.e., radiation data, isotopic data, GPS data, operator declarations, mass analysis, etc.) Using the integrated features of the UNARM IRS in concert with very powerful imaging equipment, a comprehensive and more complete understanding of the surveilled area is achieved.

The Immersive Digital Video Review (iDVR) software developed by LANL, and shown in Figure 2, allows the user to configure and monitor images for up to 20 distinct areas, with up to four cameras per area. A generic viewer page is also provided to allow a user to view selected image files that may be outside the set of UNARM collected and managed images. A user may configure each area being monitored at a given facility and name the area with a meaningful caption. An area tab page can then be configured to view images from cameras separately, or in a synchronized manner by designating one of the camera selections as prime (Figure 3). Images from cameras can be played forward or backward independently by using CD player-type controls aligned with each image, or in concert by using the controls in the master control region at the bottom of the application.

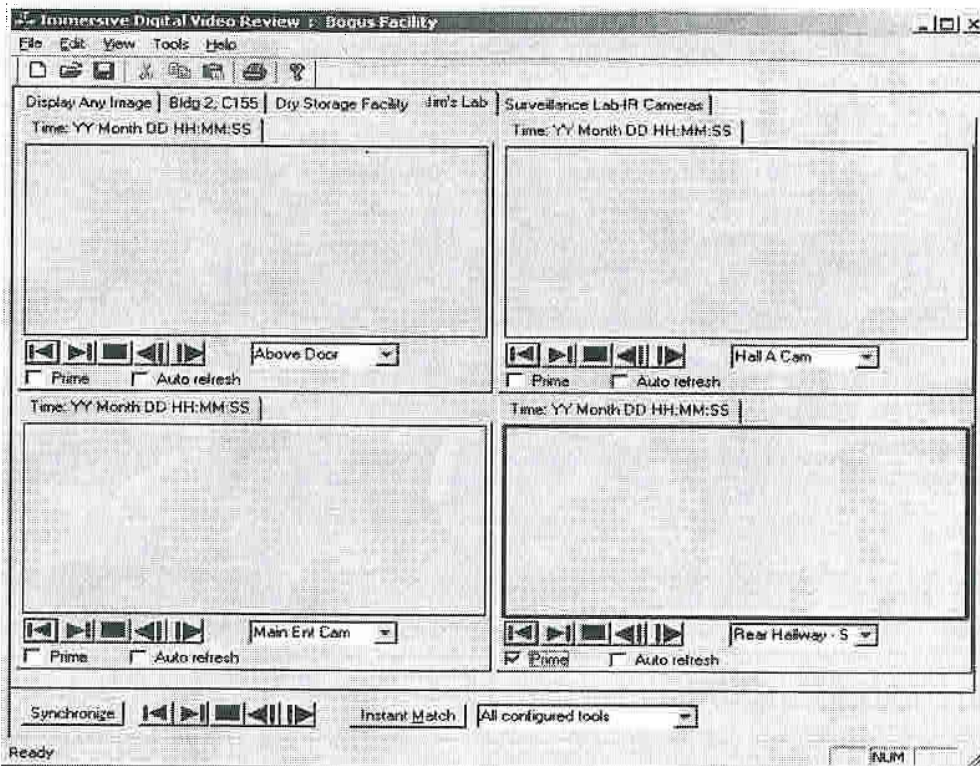


Figure 3. LANL-developed iDVR viewer application. The software can display images from up to four cameras simultaneously for a single area. The camera selected in the lower right corner is designated as “prime”. All other images may be synchronized to the time of the image designated as prime. The iDVR application software is fully integrated with the UNARM IRS suite of tools.

It is important to note that the iDVR application was developed as a prototype to verify that generic, commercially available cameras, meeting minimum requirements, could be used and integrated into the UNARM system and the supporting IRS suite of tools. The iDVR application is not camera dependent. The IPix camera was selected for the proof-of-principle exercise because of the immersive features, but any camera producing standard image file formats could have been used in this evaluation. LANL has considered an approach to camera surveillance that would use multiple imaging sensor types to photograph a single area and sense the environment on multiple levels (i.e., infrared, thermal, digital color, etc). The ability to view the varying image types in an integrated, side-by-side manner would likely be very beneficial. The iDVR application would support such an approach and would give a user the ability to view images for various camera types in a single application.

Off the shelf, the IPix camera can be triggered in one of three ways. The camera can be triggered based on time, motion, or through receipt of a trigger from an external instrument. Through the use of a physical interface to the camera with an external instrument, the camera can be triggered to begin taking and storing images. The IPix camera has been found to be compatible with the Independent Local Operational Network (ILON) nodes that are present in an UNARM system. As such, the IPix camera can be triggered by an ILOn when radiation is detected that is above a settable, configurable threshold. Once the camera receives a trigger, it will begin taking and/or storing images. The rate at which images are taken both pretrigger and post trigger is settable through a software interface to the camera. The camera can be configured to take images at a rate of several frames per second once a time, motion, or radiation trigger is received.

The trigger type for each IPix image is stored in the image file header. The trigger type can be extracted and stored in a database as each image is processed by the collection and review software. Each trigger type can be plotted against, and assessed for, radiation presence or motion presence. The duration of the presence of each may then be reviewed by an inspector and evaluated for relative significance.

The IPix camera that was used for the evaluation discussed in this paper is a low power consumption device. Using a special power supply converter produced by IQInvision, the camera may be powered by an Ethernet cable alone. The power converter device, called an IQPoet, will power the camera over a standard run of Ethernet cable (maximum is 100 meters) before requiring additional equipment to handle signal or power issues that can arise over extended distances of wiring runs.

LANL also evaluated the feasibility of using images from the IPix cameras to determine scene change occurrences, and the possibility of extracting objects from the scene as it changed. The objects that are extracted from an image, that constitute the "change" in the imaged scene, can be turned into a colored overlay that can then be inserted into a designated baseline image for the area. In this way, the software can assist in clearly identifying or extracting the changed objects in the scene. The prototype that was developed to perform this task was simple and was dependent on a consistent lighting environment in order to correctly identify and extract changes in the scene. To fully implement this capability and to ensure that it is maximally efficient for

inspectors, a slightly more sophisticated algorithm would likely need to be employed—this is especially true if the area being surveilled has changing lighting conditions.

Lastly, LANL investigated the feasibility of using third-party vendor viewer software with the IPix cameras. Specifically, the Milestone software has been evaluated and found to be a viable stand-alone option for reviewing and managing images from IPix cameras that do not require integration with the UNARM system. The Milestone XProtect Business viewing software will support live viewing of up to 64 cameras simultaneously, as well as provide the capability to view archived images. The Milestone software will also provide an interface for easily managing the on/off scheduling of each camera and for managing the image archiving task. However, the Milestone XProtect software cannot be integrated into the UNARM IRS suite.

Summary

Los Alamos National Laboratory has verified that the modular-design approach to both software and hardware has many benefits. With an increasing requirement to provide more functionality with smaller amounts of available funding, the ability to leverage the innovation and increasing functionality provided by commercial industry is critical.

LANL will continue investigating the use of immersive imaging camera options for broader applications that extend beyond IAEA uses. The cameras are cost efficient, with a single camera being capable of imaging a significantly large area. With a recent increase in the resolution capabilities of commercially available surveillance cameras to 2.0 megapixel, the ability to obtain more detail at greater distances is significant.

Keeping in mind that the design approach for our UNARM systems is now modular, and with a stated goal of having a foundation system that is flexible enough to support plug and play instruments sets, LANL has found that the UNARM system is capable of supporting commercially available surveillance camera types and integrating them with the UNARM IRS suite of review tools.

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