A DISTRIBUTED SURVEILLANCE SYSTEM TO IMPROVE PERSONAL SECURITY IN PUBLIC TRANSPORT

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This paper presents a distributed surveillance system to improve safety and security in public transport environments such as metropolitan railways, airports etc. The system is constructed by a set of modules that provide additional intelligence to detect potentially dangerous situations and provide more timely prevention and management of events. These modules include CCTV video processing, audio detection, mobile smart cards, a range of other possible sensors and a supervisory front-end. The system design uses ideas from control engineering and distributed network communication resulting in a CORBA based architecture and XML messaging. The system components have been implemented and integrated in two major successful trials in metropolitan railway stations (London and Paris) and at Newcastle International Airport, as part of a major EU-funded project PRISMATICA ("PRo-active Integrated systems for Security Management by Technological, Institutional and Communication Assistance").

1. Introduction and context

One of the major concerns to the stakeholders (i.e. passengers, staff, operating companies, regulators, local authorities, governments) of public transport systems is security and safety. Many researchers and practitioners have been working on analysing the contextual circumstances and determining how security-threatening events could be detected by computer systems and be better managed from an operational point of view. For example, projects such as PERSEC (EPSRC), PRISMATICA (EC) and ADVISOR (EC) [1, 2, 3], recognise that technical advances are necessary but not sufficient to address personal security issues. In an effort to understand the current status of security management in public transport systems and to make the systems safer and more attractive, the European Commission awarded a jointly funded research and development grant to a consortium of sixteen partners for a project known as PRISMATICA. The consortium involved public transport operators, research institutions and universities, manufacturers and consultancy companies. The technical aspects of this project included CCTV (Closed Circuit Television) intelligent video processing, audio detection, mobile smart cards, wireless data transmission, network communications, system supervision module and user interfaces.

This paper outlines the work that has been done as part of this project focusing on the local camera network and the system supervision module.

2. The PRISMATICA system

The PRISMATICA system is constructed by connecting together a set of intelligent detection devices [4]. Each of these devices monitors different surveillance aspects and handles different security issues individually and independently, in a manner inspired by human-based management. A CORBA (Common Object Request Broker Architecture) based distributed network approach and XML messaging is adopted as the communication infrastructure. A system supervision module (MIPSA) with a friendly user interface is provided to manage and coordinate all these devices on the network and present all the information to the front end users. All the interaction between devices and the MIPSA is done through text messages, encapsulated in a well defined generic XML protocol [5]. Figure 1 shows the organisation diagram of the trial PRISMATICA system. It consists of six major components, outlined in the following sections.

2.1. *Wireless data/video/audio transmission system (CEA, France)*

The core of this subsystem is a transmitter/receiver using spread-spectrum techniques to send multiple video/audio/data channels on a single radio link operating in a license-free band. The motivation is to provide mobility of sensors in a cluttered environment such as underground etc. Tests and evaluation were conducted in Gare de Lyon station, Paris.

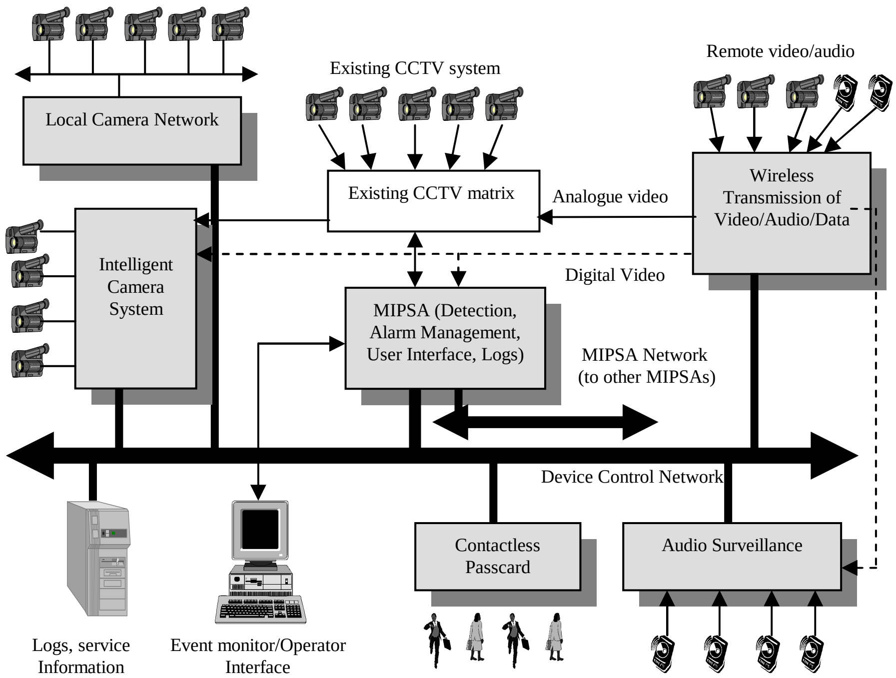

Figure 1 Overall organisation of the PRISMATICA trial system

2.2. *Audio Surveillance System (Thales, France)*

Consists of a PC with dedicated DSP boards that can detect abnormal sound signatures typically originating from passengers shouting for assistance, then sending messages to the MIPSA. Demonstrated in Gare de Lyon station.

2.3. *Contactless passcard system (RATP, France)*

It expands the concept of a smartcard ticket to using the same device as a “panic button” or “mobile help point”, whereby a passenger that requires assistance can press the button upon which radio beacons distributed in the area pick up the signal, localise its position and identify the caller (the card). A signal is then sent to the MIPSA where it is combined with video information to allow operators to deal with the event. Demonstrated in Gare de Lyon station.

2.4. *Local camera network (INRETS, France)*

This is a multi-camera vision system specified to meet key requirements of security and monitoring tasks in a transport network, such as detection of intrusion into forbidden areas, counting of passengers and occupation rate in key areas. These requirements are best met by a modular architecture based on localised image processing (at or near the camera), normally referred as an "Intelligent Camera" and distributed processing whereby cameras are connected on a local network sending event information or video only upon the detection of an event of interest. This system was integrated with the MIPSA in demonstrators in Paris and London and also tested with data obtained in Newcastle International Airport. The following different detection algorithms were developed and tested:

Intrusion detection in forbidden areas: A processor detects the moving edges in the image and takes into account the size of the moving objects, in order to avoid detection of small objects being thrown away by passengers or displaced by air flow (Figure 2 and Figure 3).

Abnormal stationary detection: This process averages the motion in the passenger flows and detects whether foreground parts of the image remain motionless for more than a user-defined time threshold value (Figure 4).

Queue length measurement (e.g. at check-in desks): Eight hours of video were recorded and an assessment was made by comparing the output of the queue detection algorithm (solid lines on Figure 5) to the queues as seen by a human observer.

Crowd density measurement (e.g. at main halls): Figure 6 gives an illustration of a density map, where the brighter the image the more occupied that space has been.

Counter-flow detection: This can be used as a clue to detect panic situations that could potentially affect the safety of many people. Figure 7 shows how a person going in an opposite way in one-way corridor is detected.

2.5. *Intelligent camera system (INRETS, France)*

The system integrates in a single PC simultaneous processing of up to four video sources. Whenever an event is detected, the respective information is sent to the MIPSA via the CORBA network. Demonstrated in Liverpool St. station (London) and Gare de Lyon (Paris).

2.6. *MIPSA (Kingston University, UK)*

The Modular Integrated Pedestrian Surveillance Architecture is designed to work as a system supervision module to cope with all the above devices on the network and to provide a single user interface to the front-end users (typically control room operators). Its main functions are:

Figure 2: An intruder standing in a forbidden area, as seen by the intrusion detection camera.

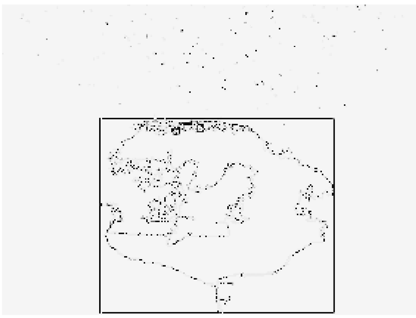

Figure 3: Result of the detection algorithm. The large black rectangle measures the size of the intruder.

Figure 4: Detection of abnormal stationary of a passenger standing still.

Figure 5: Measurement of the length of a queue.

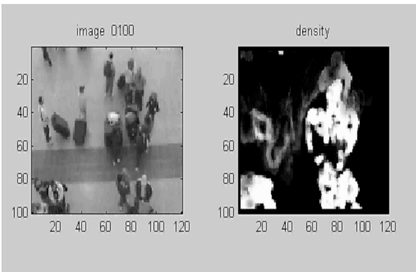

Figure 6: Density Map of people in a hall at Newcastle Airport.

Figure 7: Detection of a person going in an opposite way (Newcastle Airport)

- Configuration and supervision of system devices
- Video displaying, recording and reviewing
- Communication and visualisation of messages, especially of alarms
- Database storage and retrieval of historic data (video and event descriptors)

All the devices in the system communicate with the MIPSA through a CORBA based communication infrastructure, by sending message encapsulated in XML string. When the MIPSA receives any message through the network, it decodes the XML string, visualizes the information in the graphic user interface and logs it into a central database. SQL functions are integrated in the MIPSA so that the user can query, review and modify (part of) the logged data. In a surveillance environment, an operator needs to be provided with information on the location of detected events. This is catered for in the system by providing a mapping interface on which all the sensors are located. Thus, it is possible to activate the viewing of camera signals not only for the camera where an event has been detected, but also those of the neighbouring area (a “geographical link”). Moreover, it is possible for the user to set-up “logical” links between sensors to activate combined views. For example, if overcrowding is detected on a train platform, the operator might wish to have an overview of the situation at the station entrance points. This mapping facility, as illustrated in Figure 8, has been implemented into MIPSA as an important factor of PRISMATICA system.

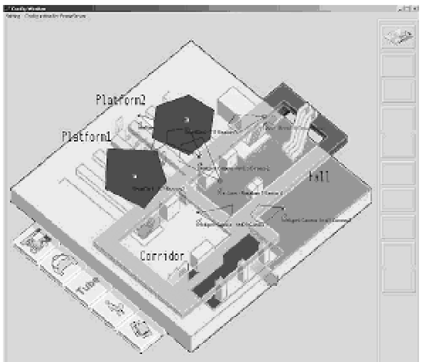

Figure 8 Map window of the MIPSA

Figure 9 Video display window of the MIPSA

The MIPSA also includes an analogue video matrix (called a Frame Server) to connect to existing CCTV systems. With the Frame Server, the MIPSA can capture and display images from up to 16 cameras simultaneously using signal multiplexing. Live video is both routed to intelligent devices for analysis and also displayed on the MIPSA for operators to monitor the station (Figure 9). In case of events, a single camera view function is provided so that the operator can focus his or her attention on the relevant area (with simultaneous smaller displays of geographically or logically related cameras), as shown in Figure 10.

A list of the event messages that have been sent by devices is logged (stored in the database for later search and retrieval) and displayed on the operator’s console below the video displays. When something unusual happens for one of the cameras and is detected by a particular device, its video display border is highlighted to alert the operator. By clicking on this highlighted video image, the event window (Figure 10) is activated. In addition to logging the event messages, the MIPSA also records the relevant video images into the database. This is done using a pre- and post- event video buffer so that an operator can quickly asses the nature of an alarm (how threatening to security it might be) by quickly playing back video (e.g. to decide if a person walking counter-flow is a member of staff or if an abandoned package is one of the trolleys left by an air passenger).

Figure 10 Event window of the MIPSA

3. Conclusions

In this paper we have outlined a distributed surveillance system developed to improve personal safety and security in public transport applications. The system design closely reproduces what public transport operators are familiar with, i.e. the concepts of distributed sensors, distributed monitoring and event visualization and operational responses usually found in a control room environment. Variability and scalability has been dealt by designing and implementing a generic XML-messaging system operating on a CORBA based network infrastructure which allows the integration of a variety of detecting systems including video processing, audio processing and smart card subsystem. All these work was done as part of the EU project PRISMATICA. The system has been tested in three major pilot sites: London Underground, Paris Metro and Newcastle International Airport.

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