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ADVANCED SECURITY TECHNOLOGIES FOR REMOTE SURVEILLANCE IN DISTRIBUTED SYSTEMS

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Abstract: *This paper presents the achievements of UTI in security technology research, focused on remote security monitoring technology in distributed systems. Particularly, the results of two security research projects on advanced security topics are presented: advanced automatic video surveillance and remote people tracking and monitoring. The first project explores advanced video processing techniques used for automatic unattended baggage detection in distributed environment, while the second combines people tracking techniques with real time reading of the vital signs in order to achieve real time people monitoring for safety and security. Both projects were developed under the Romanian National Research, Development and Innovation Plan, the Security Research Program and Aerospace Research Program, respectively.*

Key words: *remote, surveillance, tracking, monitoring, distributed.*

1. INTRODUCTION

A Surveillance system of CCTV cameras and Digital Video Recorders (DVRs) gives a user the ability to review footage that has been recorded, but how practical is a surveillance system if it is only of use after the event? Studies have shown that surveillance systems are limited without added intelligence. Watching only 2 monitors an operator misses 45% of action after 10 minutes and after 22 minutes misses 95% of action. This data is for a relatively empty scene: In a busy scene they see can see even less action and can virtually never detect a stationary or missing object.

Intelligent surveillance analysis is the future of security. Advanced software makes a surveillance system more than a recording device: it becomes an active tool for improving the quality and effectiveness of surveillance operations. The primary purpose of any surveillance system should be preventative. By alerting the user to events as they happen, operators are able to take immediate action.

The two projects, presented into this paper, cover two important (but not the only!) segments of an effective complex distributed surveillance system: automatic scene surveillance and remote people monitoring for safety and security. Thus, this "package" enables security officers as well as safety and health care personnel, to react to events in real time and in fact, often to pre-empt disasters.

A security system is only as good as the intelligence it provides.

2. SICIS – ADVANCED AUTOMATIC VIDEO CONTENT ANALYSIS FOR SECURITY SYSTEMS

The SICIS project was developed under the Security Research Program.

SICIS is a scalable automatic suspicious object detection system, based on advanced the video scene analysis; it also alerts the security intervention team and store the rough video and the security incidents into a database for further offline analysis [SICIS User Manual]. The system may be used for the automatic unattended packages /baggage detection in airports, bus or railway stations, as well as for the traffic and parking enforcement.

The application is based on the "Background change detection" technology: the analysis of the changes occurred into the observed scene, against a reference background; any change that triggers an alarm is that reported to the monitoring centre.

2.1 SICIS system architecture

The system has two video channels as inputs, connected to the video acquisition module [SICIS Technical Specification]. The core of the system is the object detection and identification engine, connected to the remote centre through the networking module. In order to reduce the required communication bandwidth, the system has a local storage unit; thus, it is possible to select, upon configuration, full video remote transmission, or, more convenient, to have a full local storage, and send to the remote centre only the alarm frames.

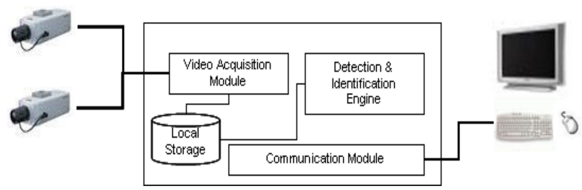

Fig. 1. SICIS Architecture

2.2 SICIS system functions

The SICIS system has the following major functionalities:

- CCTV cameras video flow acquisition (NTSC / PAL / SECAM).
- Signal processing for object detection.
- Signal processing for object identification. This function follows the detection; thus, the object detected in successive scenes is matched, using an advanced mathematical algorithm, with models stored into the database.
- Transmission of the information to a remote command and control centre. The video data is MPEG2/MPEG4 encoded.
- Acoustic and visual warning.

2.3 SICIS operation and user interface brief description

The SICIS graphic user interface is presented into the next figure. The system can work as a stand alone detection unit; therefore, the interface presents all the commands for system operation and setup. When is connected to a remote monitoring centre, the SICIS interface is still available for local operation.

The sensibility threshold sets the limit of the object occurrence into the scene, by comparing successive scene with the reference background. For each frame will be calculated the differences with the previous one; difference will be considered only those changes above the sensibility threshold, in order to avoid false alarms.

The initial step is set by the operator, by choosing a reference frame; therefore any object present into the initial frame will not be signaled as suspicious one. Starting with this point, an automatic counting of all changes into the scene is started, at pixel level.

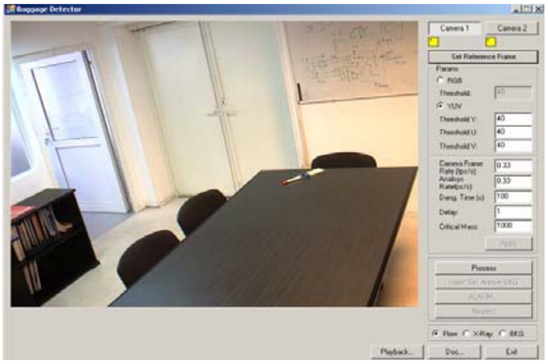

Fig. 2. SICIS Main Window

At any moment, all the adjacent areas to the changed zones are monitored, in accordance with the "critical mass" and "dangerous time" parameters. If the list of those areas isn't void, the suspicious objects are marked on the current image with red polygons and the event is signaled with an acoustic warning.

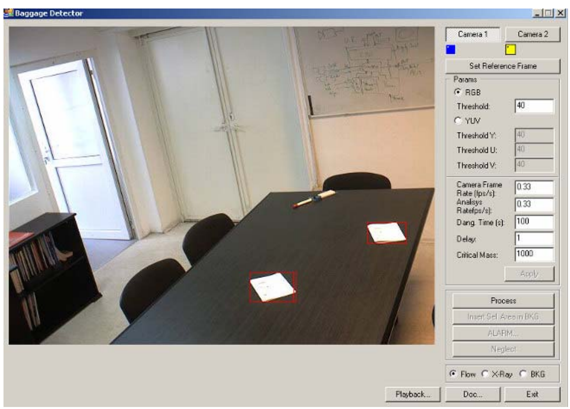

Fig. 3. Suspicious objects display on the current scene

Upon a new object detection, the camera symbol for the appropriate channel is changing to yellow color (see the above picture).

Once a suspicious object is detected, there are three possibilities to continue:

- Insert the selected area into the background; thus, those areas will be assimilated to the reference background.
- Issue an alarm; a warning message will be displayed and sent to the monitoring centre, as well.
- Neglect the areas.

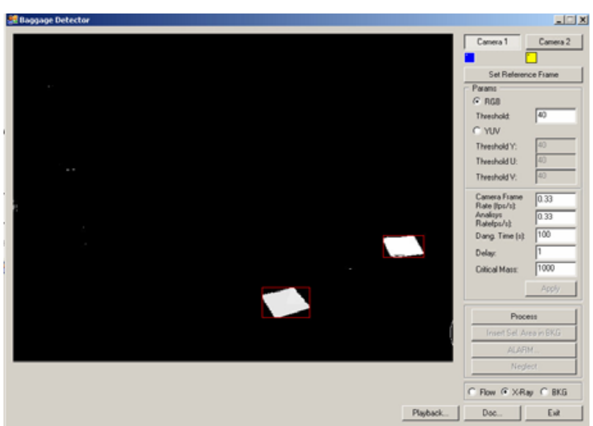

Fig. 4. Detection areas on an X-ray like visualization

The application develops a log of the events and operator's actions; it is possible to replay an event in order to check the scene developments.

2.4 Suspicious objects detection engine description

The engine inputs are two color video data flows. The frame rate can be set according to the location, traffic and environmental conditions; usually the frame rate was equal or less than 1 fps.

The engine setting parameters are:

- Critical mass: the number of pixels for the presumably dangerous objects. This parameter must be set upon location since it is influenced by the camera performance and field of view.
- The minimum time interval for an object to appear / disappear in/from a scene in order to trigger an event. This parameter is affected by the traffic and other operational constraints.
- Size of the "contextual" data: the size of the area around the suspicious object, area to be sent to the operator in order to understand the context of the event (applicable only for remote monitoring over a low bandwidth network).
- The sensibility threshold; it is used in order to avoid false alarms for slow moving shadows or sun spots.
- The decision threshold; the number of consecutive frames required in order to decide if a object appear / disappear from a scene.

The engine detection steps are depicted into the following figure.

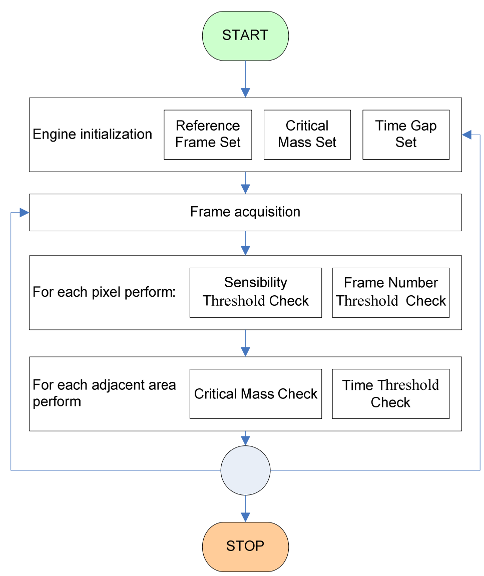

Fig. 5 SICIS Detection engine steps

2.5 Background modeling

The algorithm allows small/slow changes of the illumination to be incorporated into the reference background, in order to avoid false alarms.

Moving objects can be identified by the difference between the background and the current image. The simplest way is by using an image without any motion, but this method is not easy to be achieved when many people are present in a scene with illumination changes causing false positive alarms. The method using Gaussian distribution computes the mean value over predefined number of seconds, and the standard deviation of the median value is used to generate a background model. If the distance between an incoming pixel and the computed mean is larger than the standard deviation, the incoming pixel can be considered as a moving pixel or background pixel when the distance is smaller than the standard deviation. This algorithm provided considerably improved results for extracting moving parts, but the long training time (15-30 seconds) for initialization is a disadvantage.

SICIS uses a simple background generation method that requires a shorter training time. Next figure depicts this algorithm; in this method, a pixel that does not change for N consecutive frames is used to update the background image.

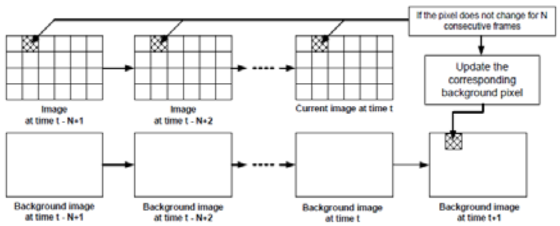

Fig. 6 SICIS Background generation algorithm

After a background image is generated, moving pixels can be extracted by comparing the background to the current images. Figure 3 shows an input image current frame and Figure 2 the corresponding background image. The threshold image is shown in Figure 4.

2.6 Results

A real-time tracking system using an adaptive background generation was implemented and tested in different situations; although most of the tests were conducted in indoor areas, some were performed outdoor, in car parking spaces. The system showed very good performances in spaces with controlled illumination conditions, having a low rate of false alarms as well a good incident detection rate. Yet the system showed good performances in outdoor areas with controlled illumination conditions and low traffic rate.

3. KTRACKP PORTABLE TRACKING AND MONITORING SYSTEM

The KTrackP project was developed under the Aerospace Research Program, by UTI with the scientific support of the Romanian Institute for Space Sciences.

The KTrackP system can be used for patient and personnel involved in special activities monitoring:

- Medical surveillance: collection of patient's the blood pulse and temperature information, together with the position (distance to, or estimated time to arrival at the care unit).
- Sportsman training: effort monitoring, position (for endurance sports).
- Expedition monitoring: position, vital parameters, SOS.
- Military and special forces training: real time positioning, operational tracking and simulations, blues force tracking.
- Border police and special transports security personnel tracking.

3.1 KTrackP main functionalities

The KTrackP system performs real time monitoring of several important security and safety personnel information: the geographical position, blood pulse, body temperature and emergency call [KTrackP User Manual].

The KTrackP standard system is composed by one monitoring station and a number of portable units installed on the monitored personnel. The K Track P portable unit has a set of sensors used in order to collect the pulse and temperature information.

The communication between the monitoring station and the portable unit is performed over commercial GPRS lines. The personnel localization data is acquired from a GPS module; additionally, support for Differential GPS service is available.

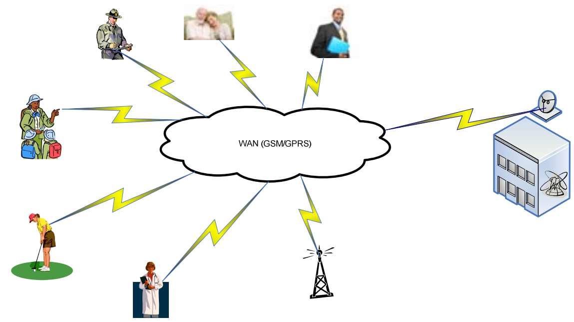

Fig. 7. KTrackP Architecture

The portable unit has the following modules [KTrackP Technical Specification]:

- 12 channels GPS receiver.
- Class 10 GSM/GPRS tri-band modem (900 / 1800 / 1900 Mhz).
- Dual GPS/GSM antenna.
- Sensors interface.
- Data processing and management core.
- Body sensors (temperature and blood pulse).
- Li-Polimer power pack.

Fig. 8. KTrackP Portable Unit

The technical features of the portable unit are summarize into the next table.

Inputs	Digital	4
	Analogic	2
Outputs	Digital	4
Power	External	10..31 V
	Back-up	12V
Consumption	Maximum	400 mA
	Minimum	60 mA
Serial ports available	RS 232	1

Tab. 1. KTrackP technical summary

The monitoring station has the following features [KTrackP Technical Specification]:

- Class 10 GSM/GPRS tri-band modem (900/1800/1900Mhz)
- GSM Antenna
- PC based workstation
- GIS based application software
- UPS protected power supply

The application software runs on MS Windows XP Professional OS.

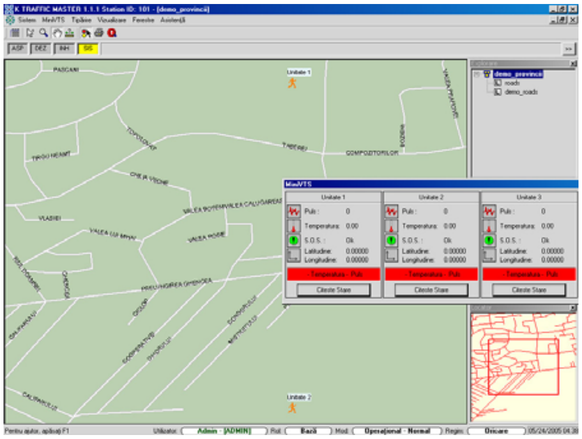

Fig. 9. KTrackP Monitoring station user interface

3.3 KTrackP extended version

The KTrackP system was upgraded to a new version suitable for military, police, firefighters, first responders training and operation needs for the localization, identification, geographical orientation and situation tracking in the tactical field. This upgraded version has several additional capabilities [Blue Force Tracker Technical Specification]:

- Using additional sensors the system computes the position in the GPS uncovered areas (urban areas, rifts, inside buildings).
- The system transmits its own position to the others members of the unit using ZigBee technology wireless communications.
- All the unit members positions are displayed on a digital map background set on a PC Pocket or PC Tablet.

The system ensures a high level of data security by using encrypted algorithms on 128 bytes.

For long range communications, this extended version uses the same GPRS channels as the standard version, while for ad-hoc communications into the operational theatre it uses ZigBee mesh networking.

ZigBee is optimized for timing-critical applications and power management:

- Time to Join Network: <30ms
- Sleeping to active: <15ms
- Channel access time: <15ms

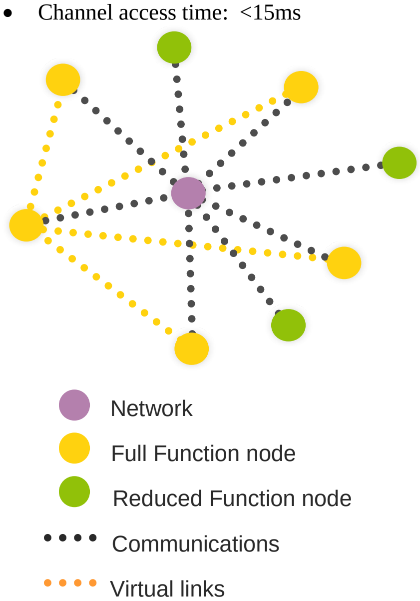

Fig. 10. ZigBee Mesh Networking

3.2 Results

The KTrackP system was tested on special forces in different environments and it showed very good results in both localization/tracking and vital signs monitoring tests.

A summary of the main functional parameters and the operational of the KTrackP revealed by the operational and functional tests are presented into the following table.

GPS localization accuracy	Position:	<3m CEP / 10m 2dRMS
GPS position acquisition time	Stand alone (outside)	Cold: <38s Warm: <32s Hot: <8s
Dead reckoning position accuracy, 2D		More than 5% of made distance (DT), 1σ for normal straight walking
Dead reckoning course accuracy		1.0° (1σ) in calibrate domain of declension/rotation -45° to +45°. Functional domain: -80° to +80°. Automatic detection of standing or laying
Dead reckoning measuring rate		1Hz or after every step
ZigBee output power	dBm	Minimum: -27 Maximum: 20
Temperature	Operational Storage	-30°C to +55°C -55°C to +85°C

Tab. 2. KTrackP functional summary

3.3 Future developments

Based on the results presented into this paper and on the latest developments in remote surveillance technologies, a new platform development is planed to be started. This new platform will respond to most actual requirements of the telemedicine and will serve as a technological enabler to help elderly people to stay independent and to allow those suffering from chronic diseases to be helped into their own houses.

4. ACKNOWLEDGEMENTS

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