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A Review SmartMonitor - An Intelligent Security System

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Abstract

SmartMonitor is an intelligent security system based on image analysis that combines the advantages of alarm, video surveillance and home automation systems. The system is a complete solution that automatically reacts to every learned situation in a pre-specified way and has various applications, e.g., home and surrounding protection against unauthorized intrusion, crime detection or supervision over ill persons. The software is based on well-known and proven methods and algorithms for visual content analysis (VCA) that were appropriately modified and adopted to fit specific needs and create a video processing model which consists of foreground region detection and localization, candidate object extraction, object classification and tracking. In this paper, the "SmartMonitor" system is presented along with its architecture, employed methods and algorithms, and object analysis approach. Some experimental results on system operation are also provided. In the paper, focus is put on one of the aforementioned functionalities of the system, namely supervision over ill persons.
Keyword- SmartMonitor, Visual Content Analysis (VCA), Intelligent Security

I. INTRODUCTION

"SmartMonitor" is an intelligent security system combining the advantages of an alarm system, video surveillance, visual content analysis (VCA) algorithms and home automation. The central unit of the system is built on the basis of electronic components specific to the personal computers (PCs) and supports cameras, sensors and controlled devices. The system is a complete solution and has various applications, e.g., protection against unauthorized intrusion, crime detection or supervision over ill persons. It can be utilized both inside and outside the building to increase security in houses, private apartments, nursing homes, small businesses or shops, as well as in backyards, gardens, parking spaces, building surroundings, especially near entrances or windows. "SmartMonitor" has already been described in literature [1].

The main tasks addressed by VCA are object detection, recognition and tracking. Many systems of such capabilities have been recently described in the literature, e.g., a system using dynamic saliency map for object detection and boosted Gaussian Mixture Model with Adboosting algorithm for object classification [2], an automated surveillance system using omnidirectional camera and multiple object tracking [3], a smart alarm surveillance system using improved multiple frame motion detection and layered quantization compression technology for real-time surveillance with possibility of remote viewing or a real-time surveillance system using integrated local texture patterns . There are also some recent solutions combining both sensors and VCA.

II. SYSTEM CHARACTERISTICS

"SmartMonitor" has properties that are typical for traditional security solutions and monitoring systems, but expands them with the capabilities of intelligent video processing based on the identification of objects and events. This extends the functionality of the product by enabling moving object discrimination before the alarm activation, which is impossible when simple motion detectors are used. The system enables the design of individualized alarm responses which depend on the type of detected object or event. An alarm can be triggered by both the result of image analysis and a specified type of sensor, e.g., carbon monoxide detector, or a combination of various factors.

A system response can be a single action or a set of actions, including a phone call, a siren, an email, a text message, a message played through a loudspeaker, a signal sent to the controlled device. The system offers remote access to several functionalities, such as activation or deactivation of the protection status, live preview of images from cameras or sending control signals to controlled devices to, for example, cut off the flow of current in a given socket. It should be highlighted that the system reacts automatically to every learned situation in a way that has been previously specified by the user.[4]

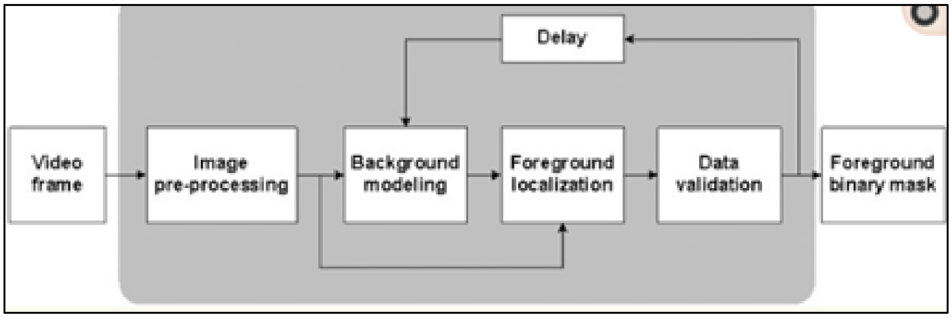

Fig. 1: A flowchart of the background subtraction process

III. LOGICAL AND PHYSICAL ARCHITECTURE

The multi-interface module is responsible for two-way communication with peripheral devices. For example, it manages the sequence of messages to provide parameters required for each of the connected devices and ensure appropriate times of delivery and reliable delivery. The graphical user interface (GUI) module is responsible for generating images in the user interface. The interface can be operated via a web browser or mobile browser and offers multilingual features. Signal receivers include driver modules that support receiver streams, such as WiFi or Bluetooth, and other dedicated devices that receive analog signals. Control modules/converters support devices physically connected to the system, such as wired cameras or wired sensors. Encryption devices are used in analog or digital direct transmissions to protect transmitted data which are decoded in the multi-interface module.

A crucial part in video processing stage is the identifying algorithm—it analyses images and reports detected parameters (e.g., an object's size or velocity) and event features (e.g., a fall). Moreover, it enables parallel processing of several video streams, while maintaining a relatively low use of computational resources and high reliability. The repository is responsible for combining parameters and features detected by the identifying algorithm into a definition of an object or event. The recording module is responsible for registration and appropriate storage of video streams and data related to the identified objects and events. The system for the connection to the environment is a secure interface, enabling communication between the system and Internet or mobile network.[5]

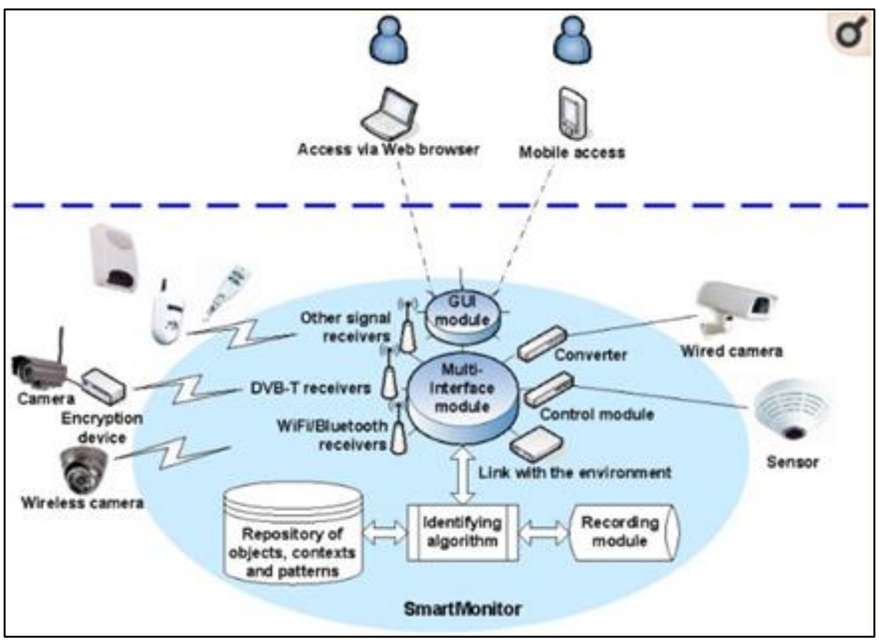

Fig. 2: simplified representation of the system core elements. The elements within light blue area are embedded in the central unit of the system

IV. SOFTWARE

The key part of the software concerns video content analysis, i.e., an automatic analysis of video that aims mainly at detection, recognition and identification of objects and events present in the captured images. There are six main system modules responsible for VCA and other tasks associated with video processing and the interpretation of its results. Each module applies various methods and algorithms, but not all modules are active at a particular moment—the video data is transmitted and processed serially. Background modeling detects motion on the basis of the background subtraction process . As a result of this process, the foreground binary mask is obtained and only objects larger than a pre-specified size are considered as objects of interest (OOIs) for the system. Extracted objects are then tracked under the tracking module. The tracking process is based on the estimation of an object's positions in the subsequent frames. These positions create an object's trajectory. Multiple objects are additionally labeled to maintain the continuity of tracking. Trajectories can be compared in order to recognize potentially dangerous behaviors. The artifacts removal module aims to remove redundant areas from the foreground binary mask, i.e., regions which were mistakenly included in the foreground image. The object classification module enables simple classification of objects on the basis of their parameters or comparison with pre-defined templates. The event detection module focuses on detecting object changes, especially changes in shape and motion. Depending on the user's safety rules or the system's operational status, the system can react to sudden movement, shape change or the lack of movement. System response module determines the system's reaction to the detected event according to the rules set by the user.[6]

V. RESULT ANALYSIS

During the experiments, various video sequences simulating the situation of a fall were used. The position of the human body after the fall in relation to the eye of the camera differs. The video processing model along with the initial system parameters are provided in the fourth section. The input files were retrieved on a sequential read, i.e., at a particular moment only an individual frame was available. It was assumed that the aspect ratio of a standing person's bounding box is close to 0.5. When the aspect ratio rapidly exceeds this threshold and is larger than 0.7, it means that a fall has occurred. The aspect ratio of a bounding box is calculated over several frames, which may represent from 1 to 2 s, depending on the fps. For the second parameter, P, a change of the object's centroid position is verified. If the centroid position does not change significantly during a specified period of time, the alarm is triggered. The area of the object's bounding box is also considered during the analysis of the video sequences.

VI. DATASETS

In our experiments we used two datasets, each one consisting of several video streams captured in real environment. High video compression MPEG4 (Moving Picture Experts Group) which can give artifacts in the image;

- Shadows and reflections (causing false detections);
- Slightly variable illumination level (influencing the background subtraction);
- Disturbing events (entering or leaving field of view).

VII. PARAMETERS USED FOR FALL DETECTION

The main measure responsible for fall detection is the aspect ratio and dimensions of a bounding box representing observed person. It is rather easy to discriminate between standing person and a one falling or laying on the floor. The other measure that suggests a possible fall event is the area of the bounding box. If it changed, there is a possibility that the object changed its orientation, and together with the above discussed aspect ratio, it points to a fall. The last measure is the speed of object's movement. Although, we do not estimate its direction, we are interested in its general value calculated as a proportion of distance between centers of bounding boxes in successive frames. If the speed is small enough, there is a possibility that a person is lying on the floor.

VIII. CONCLUSION

The "SmartMonitor" is a solution that takes advantage of video surveillance, alarm and home automation systems and combines them into one multifunctional system. It is based on video content analysis algorithms and aims to protect individual users and their properties in small areas. Another advantage of the system is its customizability and diversity of applications. "SmartMonitor" is also an autonomous solution because human interaction is required only for the system calibration, not during its operation.

In the paper, a general overview of the "SmartMonitor" system was presented. Attention has been focused on how the system operates in supervising ill persons and in the situation of event detection, particularly a fall. This task requires the analysis of an object's shape, mainly how it changes over time. Therefore, two parameters associated with event detection have been established—parameter P, which defines an object's bounding box aspect ratio, and parameter K associated with the duration of an object's change. The threshold values of these parameters determine the moment in which the alarm is triggered and system response is activated. Experimental results have confirmed the effectiveness of the approach. The developed video processing model appropriately detected, tracked and classified moving objects. The paper also described the logical and physical architecture of the system.

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