VIDEO SURVEILLANCE SYSTEMS

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ABSTRACT

This paper is review of many existing video surveillance systems. With the growing quantity of security video, it becomes vital that video surveillance system be able to support security personnel in monitoring and tracking activities. The aim of the surveillance applications is to detect, track and classify targets. In this paper is described object modelling, activity analysis and change detection. In this paper we will also describe a design of our video surveillance system.

Keywords: *video surveillance systems, surveillance applications, traffic sign detection, security video, security personnel*

1. INTRODUCTION

Video surveillance systems are widespread and common in many environments. Video surveillance has been a key component in ensuring security at airports, banks, casinos, and correctional institutions. More recently, governments' agencies, businesses, and even schools are turning toward video surveillance as a means to increase public security. With the proliferation of inexpensive cameras and the availability of high-speed, broad-band wireless networks, deploying a large number of cameras for security surveillance has become economically and technically feasible [31].

Several important research questions remain to be addressed before we can rely upon video surveillance as an effective tool for crime prevention, crime resolution, and crime protection [15].

Much of the current research in video surveillance focuses on algorithms to analyze video and other media from multiple sources to automatically detect significant events [14].

Example applications include intrusion detection, activity monitoring, and pedestrian counting. The capability of extracting moving objects from a video sequence is a fundamental and crucial problem of these vision systems. For systems using static cameras, background subtraction is the method typically used to segment moving regions in the image sequences, by comparing each frame to a model of the scene background [18, 23].

The remainder of this paper is organized as follows. Section 2 describes visual information acquisition; section 3 describes video surveillance system and applications of visual surveillance. In section 4 is explained video system for urban surveillance that comprises the function of object detection, tracking, recognition and classification. Sections 5, 6, 7 and 8 describe activity analysis, object modelling, change detection and one solution for the tracking system. Our video surveillance system in which people are recognition with their luggage are reported in section 9.

2. VISUAL INFORMATION ACQUISITION

An image or a video, if digitized is represented by a number of frames per unit of time, with each frame in turn represented by a number of components (three colours or more), each again represented by a set of pixel at a given precision (8 or more bits), scanning the frame component on a raster, line by line. This is often referred to as first general representation, and was introduced taking into account practical issues such as camera and scan technologies, as well as simplicity of their representation. First generation image and video can be represented as one or more matrices whose elements correspond to a frame's component pixel. When compared to the first, second generation representation approach represents image and video as set of what is called attributes. A largely popular second general representation is that of object-based representation where to each object has been assigned some colour, texture or motion attributes [17].

The majority of image and video segmentation techniques try to take a first general image or video as an input and provide as output a second generation representation of them. Other image and video analysis tools extract other and provide what one generally calls a content-based representation in form of edges, features points, and others.

3. VIDEO SURVEILLANCE SYSTEMS

Video surveillance is an active area of research. Object detection and tracking in video surveillance systems are commonly based on background estimation a subtraction. The primary focus of today's video surveillance systems act is the application of video compression technology to efficiently multiplex or store images from a large number of cameras onto mass store devices (video tapes, discs) [6].

From the perspective of real-time threat detection, it is well know that human visual attention drops below acceptance levels, even when trained personal and assigned to the task of visual monitoring [33]. On the other side, video analysis technologies can be applied to develop smart surveillance systems that can be aid the human operator in real-time threat detection [2]. Specifically, multiscale tracking technologies are the next step in applying automatic video analysis to surveillance systems.

Application of visual surveillance include car and pedestrian traffic monitoring, human activity surveillance for unusual activity detection, people counting, ect. A typical surveillance application consists of three buildings blocks: moving detection, object tracking and higher level motion analysis.

Multimedia systems can provide surveillance coverage across a wide area, ensuring object visibility over a large range if depths and can be employed to disambiguate occlusion. Techniques that address handover between cameras, in configurations with sheared or disjoint views, are therefore becoming increasingly important. Events of interest identified as moving object and people must be coordinated in the multiview system and events of special interest must be tracked throughout the scene [32].

Several video surveillance products are available on the market for office and home security as well as remote surveillance. They monitor a home, an office, or any location of interest, capturing motion events using webcams or camcorders and detect abnormalities [21]. In the case of webcams, the visual data is saved into compressed or uncompressed video clips, and the system trigger various alerts such as sending an e-mail.

The necessarily of working with complex scenes characterized by high variability, requires the use of specific and sophisticated algorithms for video acquisition, camera calibration, noise filtering and motion detection that are able to learn and adopt to changing scene. Working with scenes characterized by poor structure requires the use of robust pattern recognition and statistical methods.

4. VIDEO SYSTEM FOR URBAN SURVEILLANCE

The system comprises the function of object detection, tracking, recognition and classification. The problem of object detection has been tackled using statistical models of the background image [8, 21, 26], frame differences techniques or a combination of both [11]. Several techniques have also been used for object tracking in video sequences in order to cope with multiple interacting targets.

Object recognition and classification is performed using statistical Pattern Recognition and neural network. Several features, which explore the specific condition of the problem, can be used. These include geometric features such as bounding box aspect ratio, motion patterns and colour histogram [21, 26].

4.1. System description

The surveillance system implemented can be viewed as four independent, but interacting modules: detection, tracking, classification and recognition (see Fig. 1). To perform the detection task, a robust real-time algorithm, suggested by T. Boult [8] was adapted. The approach followed uses two adaptive background images, per-pixel adaptive thresholds and a region grouping algorithm, named quasi-connected components (QCC).

The tracking algorithm determines the overlap between detected regions in consecutive frames, in order to link them, when no ambiguity exists. The linking of an active region in consecutive frames originates a stroke, which describes the evolution of the mass centre over time.

The classification task is performed each frame for all active regions detected, and the classification of a stroke is performed by determining the most voted class.

To cope with tracking ambiguities, a colour-based recognition module is also integrated in the system [28].

4.2. Detection

The main difficulties of such approach lie in the fact that, even in controlled environments, the background undergoes a continual change, mostly use to the existence of lighting variations and distracters (example: clouds

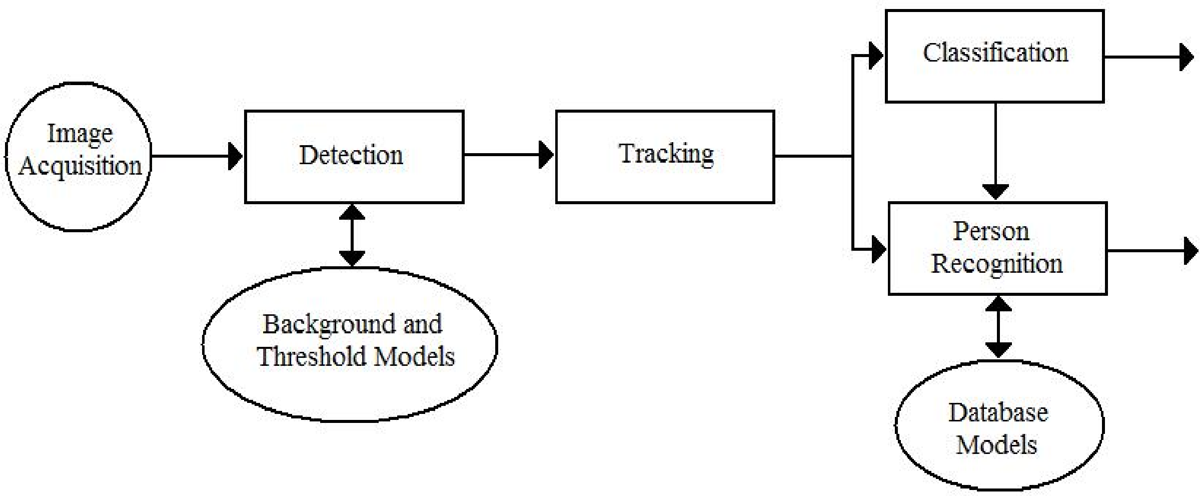

Fig. 1 System block diagram

passing by, braches of trees moving with the wind). The robustness towards lighting variation of the scene is achieved using adaptive background models and adaptive per-pixel thresholds. The use of multiple backgrounds and the grouping technique QCC contribute to the robustness of the algorithm towards unwanted distracters [28].

The system implemented uses two gray scale background models, created during a training phase. The idea is to have both a lower and a higher pixel value, contemplating this way to variations of "non target" pixels in the scene. The per-pixel threshold is then initialized to be above the difference between the two backgrounds.

Event detection, detecting and tracking objects are a critical capability for surveillance. From the perspective of a human intelligence analyst, the most critical challenge in video based surveillance is interpreting the automatic analysis data to detect events of interest and identify trends. Challenges here include: using knowledge of time and deployment conditions to improve video analysis, using geometric models of the environment and other object and activity models to interpret events and using learning techniques to improve system performance and detect unusual events.

Object detection is the first stage in most tracking systems and serves as a means of focusing attention. There are two approaches to object detection: background subtraction and salient motion detection. Background subtraction assumes a stationary background and treats all changes in the scene as objects of interest, while salient motion detection assumed that a scene will have many different types of motion of which some types are of interest from a surveillance perspective.

4.3. Tracking

The purpose of tracking is to determine the spatial-temporal information of each target present in the scene. Since the visual motion of targets is always small in comparison to their spatial extends, no position prediction is necessary to construct the strokes [26]. The association of regions and their classification is based on a binary association matrix computed by testing the overlap of regions in consecutive frames. Whenever there is a match, the stroke is updated.

Tracking also interacts with the detection. When a target stops in the scene for a certain amount of time, the tracker merges the target in the background.

4.4. Classification

For the classification task three main questions must be answered, namely: which classes should be considered which features best separate these classes and which classifiers best adapt to the previous choices? One of the main goals of the classifiers is to achieve low miss-classification probabilities while considering a wide spectrum of classes. At the same time the goal was not to consider time-dependent features, limiting the classifier exclusively to geometric properties. In this way the resulting classifier can be used in different machines, as it is independent of the achieved frame-rate [28].

The classes that comprise several merged targets cannot be described by a gaussian distribution over the feature space. These can assume many different configurations, which make them harder to parameterize. This suggests the choice of a non-parametric classifier, for example the K-Nearest Neighbors algorithm.

The classification task interacts with the tracker in each frame, voting for the class of each detected target. In this way, a final class is chosen for each stroke as being the most voted one.

In several surveillance applications, determining the type of object is critical. Video tracking-based systems used statistics about the appearance, shape and motion of moving objects to quickly distinguish people, vehicle, doors opening/closing, trees moving, etc. Image-based systems such as face, pedestrian, or vehicle detection, find object or certain type without prior knowledge of the image location or scale. These systems tend to be slower than video tracking based systems that leverage current tracking information to locate and segment the object of interest.

4.5. Recognition

As in the classification module, no time information is used to perform the recognition task. This recognition process is aimed at recognizing in a short term period, i.e. targets that become occluded for a few seconds or targets that merge for a few seconds and then split again. The models are characterized by the *pdf* estimates of the chosen feature space, in this colour case [28].

5. ACTIVITY ANALYSIS

Understanding human activity is one of the most difficult open problems in the area of automated video surveillance. Detecting and analyzing human motion in real time from video imagery has only recently become viable with algorithms. These algorithms represent a good first step to the problem of recognizing and analyzing humans, but they still have some drawbacks. Therefore the human subject must dominate the image frame so that the individual body components can be reliably detected [11].

6. OBJECT MODELLING

The purpose of video surveillance systems is to monitor the activity in a specified, indoor or outdoor area. Because the image is usually captured by a stationary camera, it is easier to detect a still background than moving object. Since the cameras used in surveillance are typically stationary, a straightforward way to detect moving objects is to compare each new frame with a reference frame, representing in the best possible way the scene background [24]. The background subtraction is the higher level processing modules for object tracking, event detection and scene understanding purposes uses the results of this process. Successful background subtraction plays a key role in obtaining reliable results in the higher level processing tasks [27, 32].

Background modelling is commonly carried out at pixel level. At each pixel, a set of pixel features, collected in a number of frames, is used to build an appropriate model of the local background [32]. Features used for background modelling can be pixel based, such as intensity or colour, local based, such as edges, disparity or depth and region based, such as block correlation.

The best way to build such a background model would be to capture the empty scene for a number of frames and take the average frame as the estimated background. Unfortunately, such a scenario is hard to be put in practice in many applications, such as the surveillance at an airport terminal, metro station or on highway.

A better way to model the static background is through a random variable or a random vector with an associated probability density function. In some cases, like trees waving in the background or a rotating fan, more than just one variable should be used to proper background modelling.

7. CHANGE DETECTION

For the surveillance application considered, video cameras capture images of a static scene, with illumination changes, most of the time. The entrance of an intruder into the scene can thus be detected by the changes it causes. A change detection segmentation algorithm can be used, with the changing areas typically correspondent to intruders.

The change detection algorithm implements a statistical hypothesis test to decide whether a given pixel has changed, or not, like in [3], and, additionally, the thresholding step makes extra considerations about the differences between the changed and unchanged areas' variations, and on the size of the changed area, to achieve a better behaviour for the thresholding operation [13].

The main modules of the proposed change detection segmentation are:

- *Thresholding* – Classification of pixels as changed or not results from the thresholding of the difference between consecutive images. The threshold value is automatically computed, according to the video sequence characteristics, without any manual configuration.
- *Combination with memory* – The thresholding output is combined with the segmentation masks from a memory, to make the change detection results more stable. This improves segmentation results when the motion of a given object temporarily stops.
- *Smoothing* – Isolated pixels are removed and small holes in objects are filled to make the change detection segmentation result smoother.
- *Memory update* – The final step consists in the automatic adjustment of the memory contents, according to the observed sequence characteristics. The memory stores information about the changed areas detected in past time instants, being essential to keep track of objects even when they temporally stop moving, to ensure a better temporal continuity of change region. However, using a long memory may have the undesired effect of creating segmentation masks for the moving objects that are much larger than the actual objects. The algorithm memory length control parameter represents the number time instants in which the pixel's classification as changed should be kept. This parameter is automatically adjusted according to the sequence characteristics, covering to zero when a considerable amount of motion is detected, and to the maximum allowed value when only slower motions are detected [13, 29].

8. ONE SOLUTION FOR THE TRACKING SYSTEM

The purpose of tracking system is to acquire information about object in the monitored space at several scales in a unified framework. The system uses a combination of active cameras and multiscale models to address the issue of scale variations in the visual tracking applications.

The pan-tilt-zoom cameras are most to obtain detailed or fine-scale information about object of interest in the scene. The video from the static cameras is used to detect and track multiple objects in either two or three dimension. The fixed camera images can be used to extract additional information about at a course level, like object class (person, track, car), or object attributes (position of a person's head, velocity of a car, etc).

The information from the course and fine scale analysis is combined in the internal scene representation. The concept uses several key techniques, including detection of the moving objects in video, tracking in two or three dimensions. Also, the system uses a combination of active cameras and multiscale models to address the issue of scale variations in the visual tracking applications.

9. OUR VIDEO SURVEILLANCE SYSTEM

Tracking accessibility of people to the desired rooms, where there is "Employees only!". At airports, stations, schools and etc., the security is very important for prevention of employees and all others.

We will design system (see Fig. 2) that works follows. We will have video output from CCD camera. This video output will be divided into video sequences that will be input for process called preprocessing. To recognition moving objects on the background, head detection and luggage detection we will use the tracker. *Tracker* contained following blocks*: Motion Detector, Head Detector, Shape Tracker* and *Region Tracker*. Tracking output will be recognized in recognition block. Our system use People Tracking algorithm which was designed by Nils Siebel. The Reading People Tracker is software for tracking people in camera images for visual surveillance purposes. It originates from research work on people tracking for automatic visual surveillance systems for crime detection and prevention [35].

A Motion Detector detects moving pixels in the image. It models the background as an image with no people in it. Simply subtracting it pixel wise from of the current video image and thresholding the result yields the binary Motion Image. Regions (bounding boxes) with detected moving blobs are then extracted and written out as the output from this module.

Main features of a Motion Detector are:

- simple background image subtraction,

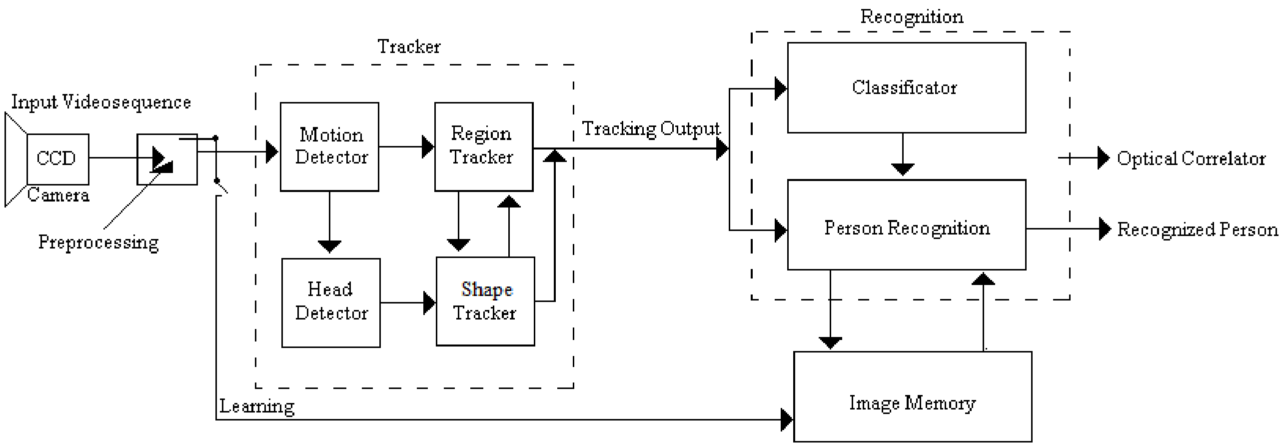

Fig. 2 System block diagram

- image filtering (spatial median filter, dilation) depending on available CPU time,
- temporal inclusion of static objects into the background,
- background modeling using a speed-optimized median filter,
- static regions incorporated into background (multi-layer background).

A Head Detector makes rapid guesses of head positions in all detected moving regions.

Main features of a Head Detector are:

- works in binary motion image,
- looks for peaks in detected moving regions,
- vertical pixel histogram with low-pass filter,
- optimized for speed not accuracy.

A Shape Tracker uses a deformable model for the 2D outline shape of a walking pedestrian to detect and track people. The initialization of contour shapes is done from the output by the Region Tracker and the Head Detector.

Main features of a Shape Tracker are:

- local edge search for shape fitting,
- initializing of shape from Region Tracker, Head Detector and own predictions,
- occlusion reasoning.

A Region Tracker tracks these moving regions over time. This includes region splitting and merging using predictions from the previous frame.

Main features of a Region Tracker are:

- region splitting and merging using predictions,
- adjust bounding box from Shape Tracker results,
- identify static regions for background integration [35].

Recognition block contained two blocks: *Classificator* and *Personal Recognition*. Data from recognition output are compared with data from *Image Memory.*

Image memory is database of static images of human faces, that have guarded enter to this room (employees faces).

Learning is a process of personal identities creation.

An Optical Correlator is a device for comparing two signals by utilizing the Fourier transforming properties of a lens. It is commonly used in optics for target tracking and identification. The correlator has an input signal which is multiplied by some filter in the Fourier domain.

An optical correlator automatically recognizes or identifies the contents of an image by combining an incoming image with a reference image, and the degree of correlation after combining the images determining the intensity of an output light beam.

First task for the optical correlator is to link together person with his luggage, case or package. This is then monitored if this person leaves guarded room with the same luggage, case, etc.

Second task for optical correlator is to compare faces from tracker with database of known faces that have guarded access to the specific room.

A new robust and efficient analysis method of video sequence allows the extraction of foreground objects and the classification of static foreground regions as abandoned or removed objects.

As a first step, the moving regions in the scene are detected by subtracting to the current frame a background model continuously adapted. Then, a shadow removing algorithm is used to extract the real shape of detected objects.

Finally, moving objects are classified as abandoned or removed by matching the boundaries of static foreground regions.

a) b)

Fig. 3 a) Detection of one luggage b) Detection of one abandoned luggage

a) b)

Fig. 4 a) Detection of two luggages, b) Detection of one luggage removed

Figures 3 and 4 show two examples of the abandoned luggage and removed luggage.

Figure 5 shows face detection and recognition system. A facial recognition system is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features from the image and a facial database. The face detection and recognition system utilizes a video camera and a normal PC to perform the person identification task. This technology works by using several facial features in a person's image and comparing these with existing images in the database. It should:

1. Detect faces from the still images (or video sequences). There is no restriction to the background and the number of faces.
2. Handle the varying conditions in a consumer environment.
3. Recognize faces by comparing the captures face images to a database of known faces. A decision is then made about the identity of the person (either one of the faces in the database, or not belong to the database at all).
4. Enable that the face detection and recognition stage can take place at different locations.

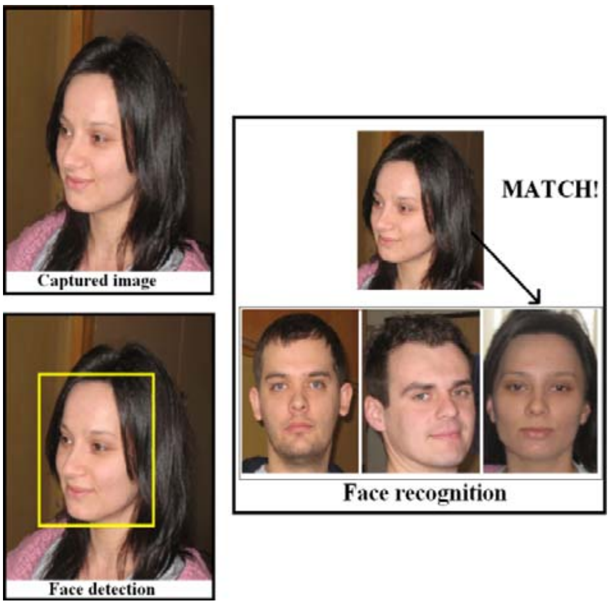

Fig. 5 Face detection and recognition system

10. CONCLUSIONS

Surveillance systems significantly contribute to situation control. Such systems transform video surveillance from a data acquisition tool to information and intelligence acquisition systems. Real-time video analysis provides surveillance systems with the ability to react to an activity in real time, thus acquiring relevant information at much higher resolution [5]. The long-term operation of such systems provides the ability to analyze information in a spatial-temporal context.

Despite the importance of the subject and the intensive research done, background detection remains a challenging problem in applications with difficult circumstances, such as changing illumination, waving trees, water, video displays, rotating fans, moving shadows, inter-reflections, camouflage, occasional changes of the true background, high traffic, etc. Simplistic, static-background models cannot solve such problems. Some are very computationally extensive and cannot be used in applications requiring real-time operation [4].

The problem of remote surveillance has received growing attention in recent years, especially in the context of public infrastructure monitoring for transport applications, safety of quality control in industrial applications, and improved public security. The development of a surveillance system requires multidisciplinary expertise, including knowledge of signal and image processing, computer vision, communications and networking pattern recognition and sensor development and fusion [5].

Our system prevents from entering forbidden person to secure zone or leaving the suspicious luggage in a guarded room. In this mentioned luggage or package could be bomb, gun, drugs, etc. In the other case, the task can be to checking if someone is stealing the luggage, package or the other value things.

Our system will increase security of employees and the other people in schools, stations, airports, etc.

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