A Unified Intrusion Alert System using Motion Detection and Face Recognition

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Abstract—Provision of home security services has become an integral part of our lives in today’s technological society where attackers usually have all the necessary means and resources at their disposal. In light of this problem, we have developed a unified intruder alert system by integrating motion detection with face recognition. The motion detection module is responsible to determine the level of activity while the face detection module differentiates between authorised people and intruders. Several experiments were conducted with live stream video from a camera and the results obtained are very reliable. The system effectively distinguishes between the property owners and other people and alarms are raised when the motion level exceeds a threshold value. The capture image is sent to the owner’s mailbox when such an alarm is raised which he can view from his mobile device, anywhere and anytime. Our system is better than many proposed systems as it combines both motion detection and face recognition in a single system. The motion is also categorised in different levels, each level representing a certain degree of risk. In order not to annoy him with false alarms, he is notified only the risk of intrusion is real.

Keywords—Security, Motion Detection, Face Recognition.

I. INTRODUCTION

An automated home security system, just like a car, has become one of our basic needs. Due to work constraints, people are spending more and more time away from their homes. Most homes are now equipped with state-of-the-art technological devices like digital TVs, digital cameras or camcorders, smart refrigerators, washing machines, etc. It is also common knowledge that these are the favourite items of burglars who finds in them a quick way of making a living. Due to all these luxuries, we are able to have a modern lifestyle. However, it is also incumbent on us to think about the security of these assets and our family as well. Thus, along with the modern way of living, security has a prime value. A visual surveillance system, based on computer vision technology, can be very helpful to achieve this objective. The key to home security is constant monitoring.

CCTV (Closed-Circuit Television) cameras have proved to be very useful for monitoring applications. The first CCTV was installed by Siemens AG at Test Stand Vii in Peenemunde, Germany in 1942 for observing the V-2 rockets launching [1]. Since then the CCTV has been continuously evolving from a simple passive surveillance system to a more advanced and intelligent monitoring system. It can now be considered as an integral part of our society. CCTVs have become ubiquitous in their surveillance tasks and are efficiently performing monitoring of areas to ensure the security of the public. In the UK alone, it is estimated that there are about 4.2 million CCTV cameras for a population of 62.2 million [2]. They have successfully been used in many places such as for traffic monitoring, maintaining law and order, monitoring of chemical processes in production control in various types of industries, etc. They are also very common in shops, department stores [3], supermarkets, hypermarkets and shopping malls where they have successfully been used to detect suspicious behaviour, shop lifting and robberies. They have also proved to be very useful in places where there are huge crowds such as in stadiums.

The main objective of this work is the setting up of an intelligent visual surveillance home security system through the use of computer vision techniques. Computer vision is the ability to make machines ‘see’ through the application of science and technology. Human beings are able to perceive the three-dimensional structure of the world surrounding them without any difficulty [4], but machines do not have these capabilities, unless provided. The system uses motion detection coupled with face recognition to recognise intruders.

Motion detection or activity detection is the process whereby a surveillance system has the capability to detect and capture an event in the camera’s field of view and upon the event, take required actions, such as record video or sound an alarm. In motion detection, sequential images are compared to detect differences between them resulting in motion detection based on the percentage difference between these images. An interesting issue regarding visual surveillance systems is its legality. The law is different for each jurisdiction. According to the Data Protection Act 2004 [5] in force in Mauritius, a data controller cannot collect personal data unless it is collected for a lawful purpose with an activity associated with the data controller. The data controller must also prove that the collection of this data is relevant and necessary for that activity. Thus, the permission of the Data Commissioner must be obtained if individuals wish to install surveillance cameras as their place of residence if the camera’s field of view is outside the boundary their own yard [6]. Furthermore, upon installation of the surveillance system, a notice board should be displayed outside the house, to inform people that the house is under camera surveillance and they will be monitored if they enter the property.
II. RELATED WORKS

The rise in popularity of surveillance systems has been fuelled by the availability of cheap cameras and the ever increasing processing capacity of CPUs. Indeed, significant research work has been done in this field during the past two decades. The following is a brief review of some previous works about visual surveillance systems. Yuan et al. [7] proposed a distributed visual surveillance system by connecting the output from multiple cameras to a local area network. They used a simple background subtraction method to detect pedestrians and vehicles. However, their system could not recognise vehicles or pedestrians, it could only detect their presence. The system was tested under controlled conditions which gave a detection accuracy of more than 95%. However, the authors conceded that the system will perform poorly under when it is raining, when there is little contrast between the objects of interest and the background or when there are many vehicles moving close to each other.

Lee et al. [8] developed a real-time threat assessment system which could effectively distinguish between people, animals and vehicles but cannot recognise them. They used the contours of shapes obtained from each frame and compared it with that in their database in order to differentiate between people, animals and vehicles. An interesting work was done by See and Lee [9] in which they proposed to have a multi-modal home security system. They used a face recognition module to authenticate the user and a motion detection module to detect movement. However, the outputs from these two systems were evaluated separately and were not integrated into a single system to detect intruders.

Ansari et al. [10] described and implemented a sophisticated motion detection system using Matlab to detect motion from a video stream. The video is stored only when motion is detected. However, they do not have different levels of motion and owners are not given any warning messages. Nebel et al. [11] reviewed some of the state-of-the-art approaches for recognising human action from surveillance videos. They showed that even the best performing systems could only recognise a few distinct and basic actions with an accuracy of only 70% under controlled conditions. Thus, they argue that computer vision systems have not matured enough to be useful in human action recognition. Kosba et al. [12] designed and implemented a passive motion detection system which uses the signal strength and waveform of wi-fi signals to detect motion instead of relying on visual systems. They argue that their system is better as it is not limited to line-of-sight vision and it works even in the presence of smoke and at night. Their current system gives a detection accuracy of 93%. However, changes in the physical layout of the building and interference from other devices can have an impact of their accuracy. They are also investigating the effect of size, shape and motion pattern on the performance of their system.

Tuscano et al. [13] implemented a simple but effective surveillance system which upon detection of motion sounds an alarm, start video recording, sends an email and sends an MMS to the mobile phone of the security officer in charge of the building. However, the system does not perform face recognition to eliminate false alerts and motion levels are not categorised. Mahalakshmi et al. [2] proposed an architecture for the setting up of a visual surveillance system using CCTV cameras. They also provided considerable technical details about the equipment required and how to install and to use them. Unfortunately, the system has not yet been tested and therefore results have yet to be provided. Rani [14] used an active infrared motion detector to detect motion in a home environment. If the path between the radiation source and the sensor is interrupted, motion is assumed and this is linked to the activity of an intruder.

III. DESIGN AND IMPLEMENTATION

Fig. 1 shows how the system operates. In the monitoring mode, the camera monitors a specified area from an angle at a resolution of 640 x 480. In motion level exceeds a threshold value of 15%, this triggers the face detection module. The motion level is calculated by taking the difference between the current frame and the previous frame. If a person is detected, the face recognition algorithm tries to track and recognise the face by comparing it to the database of stored images. The face recognition module uses the Eigen face recognition algorithm to recognise and track faces. If that person’s face is
not present in the database, an alert is given which is then sent to the owner mailbox.

IV. EVALUATION OF RESULTS

The system was tested in different light conditions. Motion capture in normal daylight conditions is more responsive than night motion capture. This limitation is due to the fact that the Infra-Red (IR) camera captures only one frame per second in a dark room while the in daylight it captures thirty frames per second. Nevertheless, the system is able to detect motion under both conditions. Thirteen different persons were asked to walk in front of the camera, one at a time. All of them were detected. However, the recognition rate was between only 62%. Furthermore, recognition works only up to a distance of 7m. For detection, the moving object/person can be up 12m. The system is designed to capture 30 frames per second (fps). If fewer frames are captured per second, some part of the action in the event may be missed. 30fps is sufficient and allow selection of useful frames to be retrieved and analysed. These frames are also used to build the video, for streaming purposes. A emailing system was tested when the owner is at a remote place and he receives an intruder alert on his mobile phone via the internet. However, a fast internet connection of at least 256 Mbps is required to have a quick response. For the system to operate in real-time, images are at a resolution of 640 x 480 pixels. This allows for fast processing at 30fps. Small file size also allows for faster uploads and downloads.

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V. CONCLUSION

The aim of this research was to develop an integrated intruder system by combining motion detection with face recognition. The motion detector uses background subtraction to estimate the motion and then associates it with a certain risk level. The face recognition distinguishes between authorized persons and intruders in order to eliminate false alerts. The system has been tested in real-life scenarios and this low-cost home surveillance system shows good performance both during the day and at night when infra-red cameras were used. The owner receives an email with the captured frame as attachment when a high risk alert is raised. The system can be improved by adding more cameras so that one is present in each room. However, additional work is required for the face recognition module to increase its recognition ratio and to make it less sensitive to variations in light intensity.

REFERENCES


