An Integrated Real-Time Vision Based Home Security System

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ABSTRACT

Crime is rampant these days because of which, people are installing security systems in their houses, offices, and so forth. This paper presents a vision based home security system that uses a web camera, modem, and a computer system. A picture is taken from a USB web camera at regular intervals and by using image change-detection technique any change will be identified. In case of any threat, the proposed system will detect, mark the change, and will send an alert SMS message to the designated mobile phone. It also sends an email to the designated mail IDs, with the photographs as attachments. Further, if a voice modem is connected to the system, it dials a designated phone and reads the alert message. The entire system is implemented in Java technology.

Keywords: Home security system, image change-detection, security alerts.

1 INTRODUCTION

The need of security systems is considered as one of the important aspects of our modern life, people are using such systems to be aware about anything could be happen in their places like their houses when they are away, these system also let them feel more secure and that is what the people really need. These systems could be motion detectors, monitoring cameras, door/window sensors, and many others. A home without a good security system is more likely to be a target for burglars, so it is become a necessity to consider a home security solution.

Security systems can be divided into two types depending on the input mechanism:

- First, sensor-based systems which are use a simple contact or movement sensors to trigger an alert. Contact-activation based systems such as fingerprint and palm-print scan, and keypad activation require a contact with an input device (usually a reader or scan pad) to determine entry permission of a building for each individual.

- Second, vision-based systems such as security cameras, Infrared (IR) imagery, and so on, these kinds of security systems require the use of image/video capture devices to obtain input data that could be image or video.

Vision-based security systems have many advantages. Firstly, they can be easily setup through simple wiring and can be interfaced with most processing machines. The setup cost can also be reduced considerably as they only require simple vision devices of reasonable resolutions (cameras) and processing machines or servers. The most important advantage of a vision-based system is its range, the ability to detect a subject of interest from a distance.

In this paper, it has been decided to use a vision-based security system in view of the advantages mentioned earlier. Basically, such a system would require both hardware and software portions to accomplish its task. From practical perspective, a good hardware setup should be well organized to minimize cost (sufficient devices to meet a security requirement), complexity in connection, and wirings. Unnecessary devices could lead to even more setup complications and increase in system cost. On the software aspect, the algorithm that processes the input data plays an important role in the success of the security system. Of course, any vision-based security system requires an input device such as a camera to take the data (like images) from the outside environment into the processing system for farther actions on the input data to produce the required output.

All day long, you will read information informing you about home security systems. Each article you read tells you how monitoring systems can help monitor your place. This project tells you how to protect your home by a security system that will be designed, the proposed security system scans a room’s image taken at regular intervals and identifies any changes that take place. Based on the used change-detection technique, it sends alerts to the designated persons by way of SMS, email, and dials a phone number.

Previous researches in this field introduced various types of home security systems. Some of them are home security system based on Wireless Sensor Network (WSN) [1], building of home security surveillance system [2], robot navigation based security system [3], and many other studies by different researchers are found in literature but there is a need for a quick and cost effective solution to support a home security...
system. This paper demonstrates a way to quickly develop, deploy, and run a vision based home security system using Java technology.

The remainder of this paper is organized as follows. Section 2 explains the proposed system, then Section 3 shows the results of the proposed detection method based on experiments, and some final conclusions and areas for future work are presented in Section 4.

2 THE PROPOSED SYSTEM

The system is designed to provide the following proposed activities:

- A GUI based front end where a user can see the closed-monitored area.
- The system should capture images every specific period of time so that the user can see the current information.
- When a change is detected in the house, the specific change should be marked, alerted, and also a phone call should be made to the owner.
- In the case of internet shut down, the system should get over this problem by checking the internet connection periodically and whenever the connection is okay, the system will send the alert notifications if any.
- The system provides users the ability to monitor the region of interest from a remote computer, where a Java API for XML-based Remote Procedure Call (JAX-RPC) web service should be developed to allow the web service client to get an updated image at regular intervals from the server side where the system works, so the client can dynamically make a call to the developed web service and get an image as a response of that call.

The following system requirements are mandatory to implement the proposed system:

- NetBeans IDE 7.3
  To build the system
- Java Media Framework API
  To capture images from the used USB web camera
- Java Mail API
  To send an email with photos as attachment
- Java Communication API
  To dial a specified phone number
- SMS Gateway
  To send an SMS to a mobile phone
- Web Camera
  To capture images
- Voice/Data Modem
  To dial a phone number

The proposed security system starts capturing images for the monitored area at regular intervals using a USB web camera attached to the computer system. These images are then processed using Java’s Image Processing Classes [4]. It processes consecutive images and as soon as any change is detected, it takes the following actions:

- An e-mail is sent to the designated e-mail (generally the owner of the house) with the image prior to change and after the change is detected, as attachments.
- An SMS is also sent to the owner so that he can act immediately. A free SMS service provider gateway is used to send the messages to a mobile phone.
- The system uses a modem to provide the ability to make a call and play a pre-recorded audio file to the receiver.

The main system consists of several modules, these modules work together as a complete unit to perform the required operations on the captured images and the output from this unit is the detection of any change that could takes place in the closed-monitored area. Fig. 1 shows the coupling modules of main system.
The internal processing of main system is explained in the following steps, which provides the understanding and procedural details necessary for implementing the system. Here, we have many steps to process the captured images to determine if there is a change or not, each step takes the input from the previous step and passes the output to the next step. The processing flow chart is shown in fig. 2.

These steps are:

- **Image Acquisition:**
  
The first stage of any monitoring system is the image acquisition stage. Here our system captures a picture from a USB web camera at a regular interval and save it into the hard disk for further processing in the next stage.
  
In the proposed system, the properties of each image will be as follows:
  
  - File type: JPEG Image
  - Height: 240 pixels
  - Width: 320 pixels
  - Color: RGB-24 bits

- **Image Preprocessing:**
  
  Images from the used web camera are converted to Grayscale images [5] using (1):
  
  \[
  \text{GrayLevel} = 30\% \text{ Red} + 59\% \text{ Green} + 11\% \text{ Blue}
  \]

  Where, each pixel is represented as a byte (the value is between 0 and 255) to make the calculations simple.

- **Similarity Measurement & Decision Making:**
  
  A similarity measurement is used to decide how close the original image is to the captured image and depending on the calculated similarity measurement our system will decide if there is any change. The Pearson Correlation Coefficient (pcc)[6] is used in the system to compare two images taken at different times, as in (2):

  \[
  \text{pcc} = \frac{\sum (X_i - X_m) (Y_i - Y_m) \sqrt{\sum (X_i - X_m)^2 \sqrt{\sum (Y_i - Y_m)^2)}}
  \]

  Where, \(X_i\) is the ith pixel in image 1, \(Y_i\) is the ith pixel in image 2, \(X_m\) is the mean intensity of image 1, and \(Y_m\) is the mean intensity of image 2. In our experience with this security system, we got that if the pcc value for two images of the same scene, one captured immediately after the other using the same web camera, is greater or equal to 0.988 that means both the images are identical otherwise means there is a change.

- **Image Subtraction:**
  
  Here, the absolute image differencing is used for change detection [7]. If the absolute difference between two images is calculated as \(|\text{Grayscale Image1} - \text{Grayscale Image2}|\), and if there is no change in the scene, then the output pixels will mostly be zero values. If however, there is a change, then pixels in regions of the image where the intensity changes spatially, will exhibit significant absolute differences between the two images.
• Image Segmentation:

The aim of image segmentation is to change the representation of an image into another new image that is more meaningful and easy to analyse. It is typically used to identify objects in images; the simplest method of image segmentation is called thresholding method [8]. This method is based on a threshold value to convert a gray-scale image into a binary image that shows the required object.

• Change Marking:

Marking the place of change in the image by putting a colorful rectangle will help users to specify the place of change in the image easily.

• Security Alerts:

Alert email will be sent in case of detecting any change to the specified IDs mails along with the original image and the image that has changed and also sending SMS to the owner’s mobile number. Further it automatically dials, by using AT commands [9], a designated number and plays a pre-recorded message to the receiver through a modem.

3 THE EXPERIMENTAL RESULTS

Here, the experimental results of the proposed system are discussed and some scenarios are given to show how the system is really working with different cases and how it detects any change activity, then sends the required alert notifications using Java language’s API for E-mail, SMS and voice dialling to inform the house’s owner about the current status of his house and let him do some actions as soon as he got the alert notification.

3.1 Scenario 1 (removing something from the scene)

A scene of a room is taken as the base image and it is compared with a bag removed from the scene. The system could identify the change and alerts are generated as expected. Fig. 3 shows the images which are obtained during the process of detection.

![Fig. 3. (a) Color base image, (b) Color image with a bag removed, (c) Grayscale base image, (d) Grayscale image with a bag removed, (e) Absolute difference image, (f) Segmented image, (g) Color image with removed bag is marked.](image)
3.2 Scenario 2 (adding something to the scene)

A scene of a room is taken as the base image and it is compared with a mobile added to the scene. The system could identify the change and alerts are generated as expected. Fig. 4 shows the images which are obtained during the process of detection.

![Images showing a room scene with and without a mobile](image)

After detecting the change and marking it as shown in the previous images, the proposed system will give its alert as: sending email with the required images as attachment, sending SMS, and dialling a phone number.

3.3 Internet Monitoring

The proposed system gives its alerts when there is internet connection, in another words, it uses the internet to deliver the alerts to the owner of the monitored house, but maybe in some cases the internet connection will not be available because of one reason or another, so in that case the owner will not be able to get any notification about the threat that could happen in the time where there is no internet connection, therefore it has been decided to handle this issue by developing one InternetChecker that checks the connection at regular interval, so if there is no internet and there is a change that is detected, in this case the InternetChecker will check the connection every specific period of time waiting the connection to be available and whenever the connection is available, this checker will send the alert to the house's owner notifying him about that change or threat. Table 1 shows the output of the internetChecker during handling the internet connection.

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<th>Time</th>
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<th>Alerts</th>
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</tbody>
</table>

3.4 Web Service Provider and Requester

It has been decided to develop a web service which is a formal way for applications to communicate with each other over a network as a web service image provider to allow users to request images by PC/mobile web service clients of the monitored area as shown in Fig. 5. By using the Dynamic Invocation Interface (DII), web service clients are able to discover the target developed web service dynamically on runtime and then to invoke the methods that are responsible to give back current images of the monitored area to the service requester (PC, mobile).
4 CONCLUSIONS AND FUTURE WORKS

In this paper, an integrated real-time vision based home security system is developed, this system provides the solution to the problems faced by home owners in daily life which tries to detect any change of a specific place of your home or region of interest and inform you about that by using an inexpensive USB web camera, existing PC and a serial modem combining with various technologies of Java that give a high-level of performance.

In future work, various aspects of the developed system, such as hardware components (i.e. distributed wireless high-quality cameras can be used instead of a single web camera to monitor a large area), system requirements, and others can be further studied to improve the quality. Future efforts can concentrate on improving the reliability and robustness of both detection and security alerts tasks to achieve better performance.

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REFERENCES


Qusay Idrees Sarhan received the Master of Technology in Software Engineering from Software Engineering Department of Jawaharlal Nehru Technological University, India in 2011. Currently, he is with the University of Duhok. He has a couple of international publications and his research interests include Software Engineering, Web Services and Technologies, Wireless Sensor Networks, Real-Time Security Systems, Distributed Computing and Systems.