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Video Security System for Intrusion Detection

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***Abstract*— Due to the large-scale development of technology in the modern world, institutions, businesses and residential areas need to secure their facilities leading to the need for a security system. There are several ways to help increase the security; one of these methods is to install a surveillance security system. Conventional surveillance systems have disadvantages where they are often human-based, allocated a numerous number of video cameras to monitor the entire environment, and Collecting a large amount of video data requires considerable calculation and manpower to analyze. Broadly, the recorded video files consume much storage space and someone must always monitor to check whether events occurred or not in the surveillance zone. In order to eliminate these problems a need to use effective surveillance security system which only records when motion is detected, which is the purpose of this paper. The system analyzed of an "area of environment being monitored" through used Sum of Absolute Difference (SAD) algorithm to detect motion in real time. Where web camera captures the images which are analyzed to detect the motion (intervention) and generating alarm. The obtained results were satisfactory, where all intrusion scenes were detected without errors. Hence, storage requirement reduced significantly.**

Keywords—Surveillance Systems, SAD, CCTV, Image Processing, GUI.

I. INTRODUCTION

Security is essential in all walks of life to ensure public safety and property. As the technology evolves widely in modern world, it is necessary for all to be able to safeguard their property, there are several ways to help increase the security; one of the most effective is to install a surveillance security system. The latest technologies used are the video surveillance in a real-time.

Existent video surveillance systems depend on human to detect a certain event in a real-time. The human eye couldn't notice events in all surveillance monitors. Motion detection in advance video security systems has become one of the prominence research topics in the field of computer vision [1].

The Conventional surveillance systems such as Closed-Circuit Television (CCTV) systems need manual operation to start and stop recording the video. Since it is not possible to schedule a start and stop recording, videos require a large storage space and often contain useless data. In addition, the reviewing of the stored videos take time [2].

There are many proposed systems for Video Security System for Intrusion Detection in the literature such as [3-6].

Harshal Suradkar etal. used a system which neglect the idle frames from the video with the SOBEL operator algorithm for motion detection in real time to take out the redundant from the video and decreasing the storage space. When the motion is detected the SOS will send by the system and activates the alarm and storing the video is started. The results of this system were satisfactory [3].

Shikhar Arora etal. have improved the storage space by comparing the adjacent frames using Mean Squared Error (MSE) between the adjacent frames of the video and clearing the redundancy frames; which lead to improve the quality of the video and reduce video size. This algorithm reduces average space of any partially dense area footage and the results of this system were good. The platform used for implementing various image processing and computer vision techniques was Python [4].

Ferry Wahyu Wibowo and Muhammad Andari Ardiansyah have suggested the monitoring system using the Raspberry Pi as a server and it is embedded operating system of Raspbian and the webcam as a motion detection sensor. Principle of the motion detection in this paper is changing of the video image that could be obtained from previous video image and new video image. The video streaming has format of mpeg and swf, the video streaming is functioned as a real-time image within accessing of internet protocol. A data storing of video files applying cloud storage in order to reduce storage space of secured data card [5].

Zipporah Tarus designed a system by using passive infrared sensors and raspberry pi. The human motion causes changes in the infrared radiations which sensor use for detection. When motion is detected, the pi camera starts capturing images and recording videos. The recorded video with image attachment is sent to a specific mail address who is the house owner. The system was energy efficient, overcomes on cost, extra space required and humans to detect motion [6].

In this paper we proposed video security system that continuously monitors but only records when motion is detected. Our hypothesis is that motion detection is sufficient to support system to detect intrusions. Hence, storage requirement can be reduced significantly.

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II. METHODOLOGY

The proposed system is built using a processing unit (laptop), detection algorithm (MATLAB program) and image acquisition device (webcam). It consists of three main functions: capture, comparison and storage. In this system, motion is detected from a sequence of images taken from the webcam in the real time where these images are processed to detect the motion by using Sum of Absolute Difference (SAD) algorithm. Upon confirming presence of motion; the system starts recording and activates alarm. Fig.1 shows the block diagram of the proposed system.

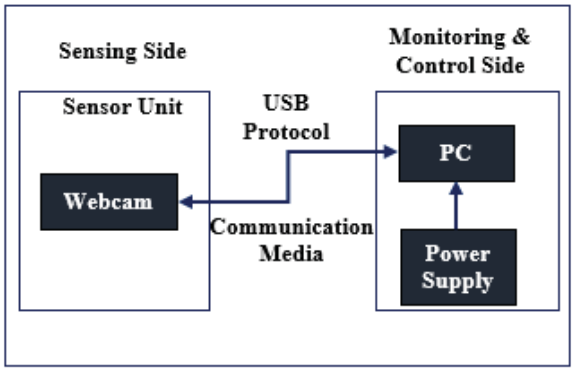

Fig. 1. Block diagram of the proposed system.

The methodology for designing and implementing the proposed system contain following:

1. Acquisition device

A web camera or also known as webcam is a mini video camera functioned as acquisition device or monitoring device [5]. In this system, a webcam employed as image or video input device and a motion detection sensor. The webcam has resolution of 160x120 up-to 1280x720 pixels with frame-rate up-to 30 frames per second (fps).

2. Motion Detection Algorithm

Motion detection needs performing two major steps: the first step is to set up the hardware to capture images and the later step is an algorithm by which the motion will be detected.

A simple algorithm called SAD was used to measure the similarity between images. It calculates the absolute difference between each pixel in the original frame and the corresponding pixel in the frame used for comparison. The summation of these differences is used to create a simple metric of frame similarity. The algorithm can be given by the following equation [7]:

$$SAD = \sum_i \sum_j |I_k(i,j) - I_{k-1}(i,j)\| \quad (1)$$

Where:

I_k (i, j): reference frame.

I_{k-1}(i, j): captured frame.

The algorithm of the proposed system is shown in Fig. 2

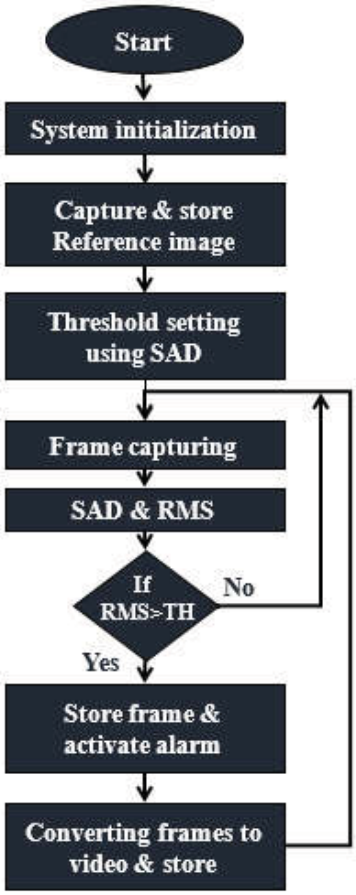

Fig. 2. Motion Detection Algorithm.

The algorithm works with the following steps:

Step (1): System initialization

The system waits for a time period to start working.

Step (2): Capture image by using a webcam

Capturing and Storing reference frame of the area to be monitored. Then converting the reference frame to gray scale image (rgb2gray).

Step (3): The threshold setting

Capturing (i) frames from (i = 1 to 10) for the area to be monitored to determine the threshold by using a webcam, converting the (i) frames to gray scale image (rgb2gray), finding the absolute difference for reference frame and (I) frames, the sum of absolute difference (SAD), the root mean square value (RMS), and the threshold value by calculating the mean for root mean square value and addition the constant known as compensation constant.

Step (4): Comparison for motion detection

Capturing a sequence of frames continuously at a certain speed of frames per second (FPS) and converting them to gray scale, then comparing frames with the reference frame using the SAD algorithm and RMS to check whether motion is present or not, then comparing the RMS value with the threshold value.

If RMS value > threshold value, "that means there is motion otherwise there is no motion".

Step (5): Store frames and activate alarm

In case of motion, the system stores frames containing motion and activates the alert; so the user can view them later.

Step (6): Frames to video conversion

Converting frames to video and storing them in a hard disk.

3. Storage Device

Laptop's hard disk with 500GB disk space was used to store images and videos. Whenever an unauthorized entry is detected, in motion detection, the system automatically trigger to recording this motion at fixed location in hard disk that operator can accesses.

III. Graphical User Interfaces Design

Modernistic operating systems allow every program to run using visual icons and Interfaces. MATLAB provides the programmer with GUIDE which is a tool for generating Graphical User Interfaces (GUI) programs [8].

MATLAB R2012b was used to develop the system; because it provides Image Acquisition and Image Processing Toolboxes which support creation of a good GUI and an excellent code.

An interface application was designed using GUI so the administrator or user could easily manage and control the system. The application contains the following:

1. Login window

This window appears when you run the system to verify your identity. The login is done by entering the username and password in the login window as shown in Fig.3.

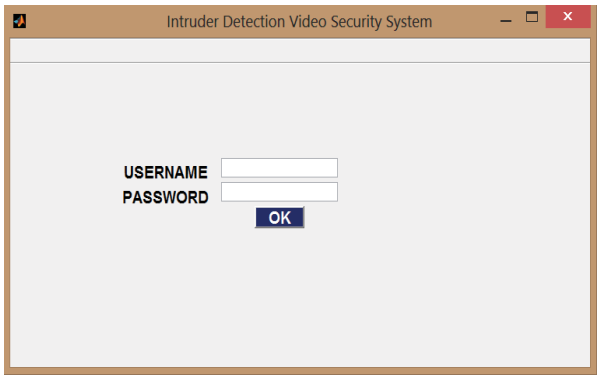

Fig. 3. proposed system Login window

2. The main system interface

The system is handled and controlled through it, containing a toolbar, set of buttons, and a display as in Fig.4.

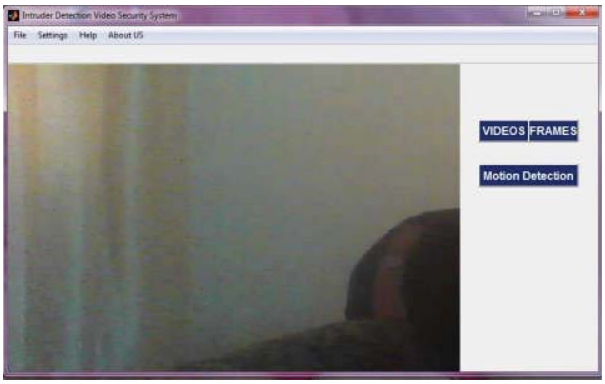

Fig. 4. Main system interface

The Toolbar consists of the following:
File: Contains a button to exit from the program.
Settings: Contains buttons to change some general settings of the system (Password, frame directory, video directory).
Help: Contains special instructions for using the program and searching for additional information.
About Us: Contains information about the program for user to recognize about this product.

The set of buttons consists of the following:
Frames: To show and review saved frames.
Videos: To show and review recorded videos.
Motion detection: Push button with two states (on/off), when it's on "that will Turn on the motion detection mode", and when it's off "that will turn off the motion detection mode and returns to the display mode only".

IV. Results and Descussion

This section of the paper presents the test environment and the experimental results of the algorithm. The proposed system was tested on a home on person's movement with value of error frame threshold 2.2193 and by using 1MP webcam already exists in DELL laptop. The results are shown in Table I which shows the RMS values of ten frames with time interval 1 sec, these values were used for threshold setting as shown in equations (2) and (3).

TABLE I. RMS VALUES FOR THRESHOLD SETTING FRAMES

Frames	*RMS of SAD*	*Frames*	*RMS of SAD*
1	1.7103	6	1.4222
2	1.4377	7	1.6336
3	1.4217	8	1.6428
4	1.5603	9	1.6308
5	1.1853	10	1.5485
		Sum	15.1932

$$\text{MEAN RMS} = \frac{\text{Sum of RMS}}{\text{Number of RMS values}} \tag{2}$$

$$\text{MEAN RMS} = \frac{15.1932}{10} = 1.5193$$

$$\text{Threshold} = \text{MEAN RMS} + k \tag{3}$$

Where: k is compensation constant.
Therefore, Threshold = 1.5193 + 0.7= 2.2193

Table II shows the results of SAD algorithm; the underlined values represent frames which include motion; their RMS values are greater than threshold. Fig.5 shows some frames which include motion.

TABLE II. RMS VALUES FOR 50 FRAMES

Frames	*RMS of SAD*	*Frames*	*RMS of SAD*
1	1.6475	26	1.8122
2	1.2551	27	1.7496
3	1.4950	28	1.8341
4	2.6033	29	2.0058
5	2.3707	30	1.6675
6	2.2956	31	2.5263
7	2.2550	32	2.4972
8	2.3194	33	2.6415
9	2.3605	34	2.5887
10	3.3096	35	2.2734
11	2.8378	36	2.4940
12	2.9055	37	2.4041
13	2.1028	38	1.9277
14	2.2838	39	2.7980
15	2.7754	40	2.7847
16	3.1449	41	2.1283
17	1.8950	42	1.9308
18	2.4990	43	1.8117
19	2.3906	44	1.9086
20	2.7101	45	2.2614
21	3.4213	46	2.2940
22	3.3651	47	2.2023
23	2.5025	48	2.3743
24	2.5992	49	2.7905
25	2.2316	50	2.8671

Fig. 5. Frames include motion

The proposed system optimizes storage space by storing only frames which contain motion and then converting these frames into video rather than recording all scenes that may not contain motion, thus saving storage space. For example, when record video for 5 minute with frame rate of 30 frame per second and camera resolution of 1 Megapixel by a traditional video security system and Intrusion Detection System, the video will occupy the storage space shown in Table III. The Intrusion Detection System is giving satisfactory results by reducing storage space by 96.8%.

TABLE III. COMPARISON BETWEEN TRADITIONAL SYSTEM AND INTRUSION DETECTION SYSTEM

SYSTEM	*STATE*	*REQUIRED STORAGE SPACE(MB)*
Traditional System	No Motion	39.8
	Motion	39.8
Intrusion Detection System	No Motion	0
	Motion	1.28

V. CONCLUSIONS AND FUTURE WORK

After implementing and testing of the proposed system, the experimented results show that the system can detect all intrusions that get in front of the camera, store it and activate alarm. Hence, storage requirement can be reduced significantly, in addition it provides easy interface to use.

The system can be equipped with extra alert methods (call, SMS or email).

In the future, recorded videos with can be automatically transferred to an email account or web site for extra backup. Also, adding a set of cameras to the system. In addition, the user can be provided with remote access to this software over the Internet.

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