A New IoT Combined Face Detection of People by Using Computer Vision for Security Application

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***Abstract*— In nowadays situation, the security forms the most important section of our lives. Security of the house or the near and dear ones is important to everybody. Home automation is an exciting area for security applications. This field has enhanced with new technologies such Internet of things (IoT). In IoT, every gadget behaves as a little part of an internet node and every node interact and communicate. Lately, security cameras are utilized in order to build safety places, homes, and cities. However, this technology needs a person who detects any problem in the frame taken from the camera. In this paper, an Internet of Things is joined with computer vision in order to detect the faces of people. For this purpose, to execute this system, a credit card size computer that utilizes its own camera board for the security system, such as raspberry pi 3 utilized. Likewise, Passive Infrared Sensor (PIR) mounted on the Raspberry PI is utilized to detect any movements. So it helps to monitor and get notifications when motion is identified, captures the image and detect the faces, then sends images to a Smartphone via utilizing telegram application. Internet of things based on telegram application used to see the activity and get notices when movement is detected.**

***Index Terms*—Face detection, Raspberry PI, Computer Vision, Internet of things, telegram.**

I. INTRODUCTION

Nowadays, humans live in the information period. There are various ways in daily life for preparing to the Internet and to make our day by day life simpler and more pleasing like Smartphone, computers, tablets, smart cars and some Smart TVs. The new gadgets can run any projects, in much best and more viable path for doing diverse errands for example power on or power off the gadget, making cautions through the built-in or outer sensors. These items can be characterized as Smart Objects. Smart Objects can be more helpful to each other and with other objects, for example actuators or sensors. In like manner, smart systems can be given IoTs and besides allowed creating either large or small system due to obtain an aggregate intelligence through the processing of object's information [1].

The IoTs can be connected in Smart Cities in order to give variety advantages that improve residents [2- 3]. In different terms, brilliant homes can be made through using the Internet of Things which can control and robotize correct things of our houses for example doors, lights, windows, distributed multimedia, fridges, and irrigation systems.

Computer Vision gives face detection and recognition for people that are an extremely fascinating application for the Internet of Things. Computer Vision combinations can exhibit greater security system in an IoT platform for intelligent homes since they have capacities to perceive a human in the incorrect place since this human might be a bad human for the environment [4].

Monitoring assumes an exceptionally important role to fulfill our safety. Security system sensors assume a very important role in this area. There are two principle kinds of sensors: indoor sensors which ensure and protect the inside of the home and sensors that ensure and protect the outdoor of the home. The most widely sensors are microwave sensor, Passive Infrared Sensor (PIR), photo-electric sensor, noise detector, and ultrasonic sensor. The wireless system gives a capable, stylish and strong solution for the problem of remote house access, safety, and monitoring with face detection. Real time face detection systems are important for photography, security, and surveillance applications [5]. Mostly, it perceives and track people in public place like homes, airports, shopping centers, offices, bank, in regions with limited access sensors.

There are some documents proposed for the field of security system. Every security system applications are used for different purpose, and in the writing, there are a small amount of studies through utilizing a camera in IoTs and sensors. The Internet of Things could help to learn and demonstrate different information amongst master and understudies through gathering information and find the best route to train. Thus, they can assistance to protect the right and people of cities. Creating or studying on maps, which is called Cartography, is another utilization of Computer Vision. The most famous sample of cartography is Bing Maps or Google Maps, which is a useful service for people. Along these lines, Computer Vision is programmed for perceiving some specific parts in maps: for example roads, water, buildings, or fields. This is an instance of how to relate Computer Vision in Smart Earth [2]. Prof. Vijay Bagdihave, Ms. Renuka Chuimurkar showed a smart monitoring system utilizing PIR sensor, Raspberry Pi, and mobile device. They likewise should utilize smoke detector for detecting fire. After capturing the image to customer mail via Wi-Fi, user will be alerting about the fire or thief. They used smoke discovery algorithm and background subtraction algorithm for motion detection [6]. The image of a person sent to twitter and email after captured [7].

In this paper, Raspberry PI 3 is used and PICAMERA associated to it, the application will take a picture immediately after PIR sensor finds any motion. After, we apply haar cascade algorithm to detect the faces in the captured image. Then, we

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send these pictures to a Smart phone through the internet. For this situation, Internet of things established telegram application used to see the action and get notifications and pictures. The Adaboost learning is used to detect the face from the Haar-like features called as the Viola-Jones technique. In general, the face detection method is established on the Viola-Jones method. It gives better detection rate by comparison to other methods. The calculation cost of the Viola-Jones method is relative low. Along these lines, this face detection strategy becomes the most superb technique. However, when the face is overlapping by the other objects the technique fails to detect the face [8].

II. THE INTERNET OF THINGS

These days, the Internet of Things is rapidly increasing technology with business situation. IoT is the conjunction of internet, wireless network, and computing. As of late, the Internet of Things is one of the mainly used technology together benefit for a little country. IoT connects the physical things like vehicles, buildings, and various devices with embedded intelligent sensors and empowers these objects to replace and collect data [9-12].

The IoT is becoming popular in many sides of life, such as smart security, smart cities, health care, smart transportation, smart grids, online business, and so on. Our target in using Internet of Things is to share our data and learning to everybody in wherever around the earth, from food to computer's and computerize diverse actions to improve our day by day living [2, 13]. The IoT is an active overall system of day by day objects linking to the internet. The IoT is the interconnection of physical and virtual things oncoming via the internet. The IoT is the name of internet of objects, belongs to a wireless network among objects. The Internet of Things let making a Smart World, which is the fusion of different and ubiquitous things, Smart Homes, and Smart Cities, with all gadgets fit for cooperating amongst themselves [2].

Wireless Sensor Networks is the most essential, which are the center of the Internet of Things. A Wireless Sensor Network (WSN) interconnects sensors, in order to obtain data, by a server or unique scheme to work and may be, computerize everyday jobs in one position [14]. The best definition for IoT is that it is an interconnection of different and ubiquitous objects among themselves via the Internet. The aim of the IoT is to be linked the whole world through the building of diverse intelligent areas to computerize, facilitate and improve our routine life [15]. These days, IoT is turn into a part of all part of our lifetime. IoT applications not only enhance the convenience of our lifetime. Besides, it allows us too much control through simplify style work days and task of personals. The application areas of IoT are given in Fig. 1.

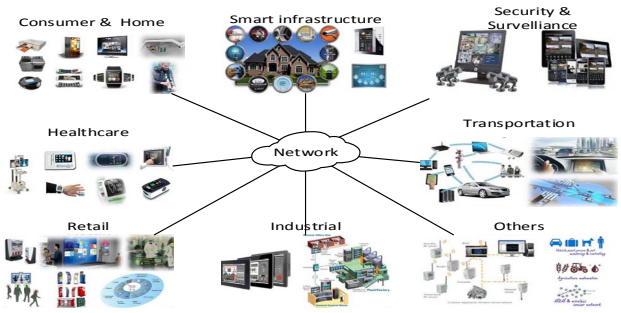

Fig.1. The application areas of IoT

In Fig.1, IoT has been used in many application areas. Some of these IoT platforms have attributes that others don't have. Be that as it may, none of them has a module of Computer Vision that permits working with images as sensors and images with sensors. Our proposal is one possible solution to utilize the camera with a sensor utilizing Computer Vision to detect a specified thing in images.

III. THE PROPOSED METHOD FOR FACE DETECTION

In the proposed system, we use the camera to accomplish the pictures when a motion detect via PIR sensor. Subsequently, we will apply computer vision module to the caught pictures to discover the faces, after that, we will mail it to Smartphone. This system is extremely helpful and vital if we want to protect an area. The application can be divided into two parts which are motion detection and face detection. The system will not go to face detection if there is no motion discovered. But, if a movement has detected, then the detected movement of the current frame will be processed by the algorithm of face detection. Fig. 2 demonstrates the flow chart for the proposed scheme.

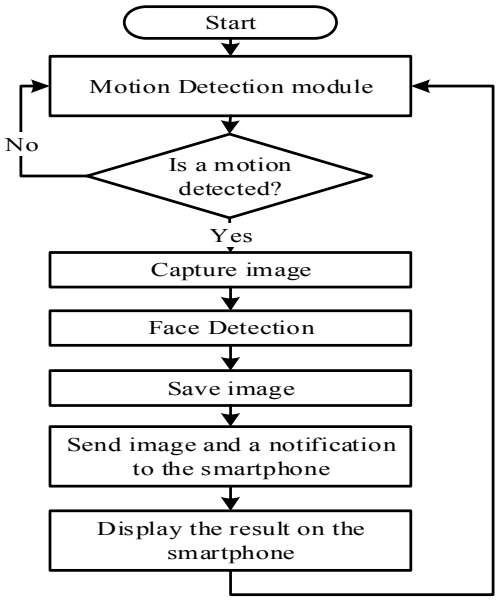

Fig.2. Flowchart for proposed system

We used the following hardware's to develop this research work: Raspberry Pi 3, PIR Sensor, Raspberry Pi Camera, Smart Phone, SD Card Memory, and Power Supply.

A Raspberry Pi is a small controller, which has four USB modules. Raspberry Pi Camera and PIR motion sensor associated to Raspberry Pi. Raspberry pi connected with smart phones through the internet. The essential stand for pictures processing and signal warn can be used as Raspberry Pi. The pictures are captured via a PICAMERA. Via the PIR motion sensor, the system has the capability to identify motion of things. At the point, the ruling signal goes to the embedded board GPIO port when the moving object is discovered. Camera will be power on by the python script for capturing pictures and the system cans fruition if a face is detected or not. If a face is detected or not then it will save the images on the local drive and send it to the smart phones. The captured images and notifications on the Smartphone can be seen by a client via the Internet. Fig. 3 illustrates the proposed scheme block diagram.

The primary function of our project is the detection of a movement. When a movement is detected, the Raspberry Pi sends a notification message and captured images to the Smartphone. The security system can utilize two types of movement detectors: microwave movement detectors and passive infrared (PIR) detectors. PIR motion sensors are the mainly common motion detector [16-17]. When an object moves in the sensor's range, the PIR sensors utilized to detect it. This is required to detect when a person has entered. PIR motion sensor sends a signal to the microprocessor when a motion is discovered.

Face detection is utilized in different applications. Facial features are detected and others are ignored. Haar cascade features detection is the most popular algorithm for face detection. It is utilized to detect single or multiple faces. OpenCV library is utilized for face detection because they are the best open source library obtainable to perform image processing and they are not too much complex. In the proposed system, the face detection part is executed in python by utilizing OpenCV library. The detection of frontal human faces is focused on face detection algorithm. The Haar cascade algorithm looks for specified Haar-like features of a human face.

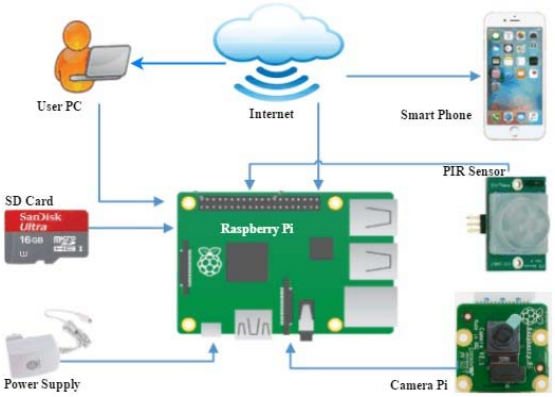

Fig.3. System design

The Haar-like face detection algorithm permits the face candidate to pass to the next phase of detection when any of these features is discovered. A face candidate is a rectangular part of the original image known as a sub-window. Generally the size of sub-window is about 24×24 pixels. To getting a set of various sized faces, the sub-window is often rotated in an order. The Haar cascade algorithm scans the entire image with this window and denotes all respective part as a face candidate [18-19]. In our method, when a movement is detected, the camera captures an image. Then, the captured image is converted to grayscale to improve speed and detection rate. By using Haar Classifier, the converted image will be processed. The program considered it as the non-face when a shoulder and head feature is not detected, then the program will send the captured image with non-faces as notification to the user's Smartphone.

The face detection algorithm has mainly 4 phases: integral image calculation, haar-like features, AdaBoost training, cascade classifier. The initial step of the Haar-like algorithm is to transform the input image into an integral image. The layout of the pixel values in the original images is determined the meaning of the integral image. The integral image is utilized to detect quick feature detection.

The integral image is an array which containing of the addition pixel values of the original image. In the integral images the value at any position (x, y) is the total of the picture's pixels over and to the left of position (x, y). This procedure is demonstrated in Fig. 4. The shaded zone appears the total of the pixels over to place (x, y) of the picture. It demonstrates a 3×3 picture and its integral image portrayal.

In Fig. 4, the sum of pixels within rectangle can be computed with four values in the integral image. The sum of pixel values in a rectangular region can be computed by using four array references as shown in Figure 4.

```
for each row i
    temp=0;
    for each column j
        temp=temp+Image(i,j);
        if i==1 then
            II(i,j)=temp;
        else
            II(i,j)=II(i-1,j)+temp;
        endif
    endfor
endfor
```

Original image (Im)

5	2	3	4	1
1	5	4	2	3
2	2	1	3	4
3	5	6	4	5
4	1	3	2	6

The sum of pixels
5+4+2+2+1+3=17

Integral image (II)

5	7	10	14	15
6	13	20	26	30
8	17	25	34	42
11	25	39	52	65
15	30	47	62	81

Sum of pixels in a rectangle region=34-14-8+5=17

Fig.4. The pseudo code of integral image calculation and a numeric example

To detect variation in the black and white segment of the images, Haar-like features are utilized. This calculation is similar to a singular rectangle around the detected face. The number of possible rectangular features is 180,000 for a 24x24 detection zone. Face candidates are searched and scanned for Haar-like features in this phase. Fig. 5 illustrates the various kinds of features.

Haar features are being characterized through partitioning the human face into various regions. The facial region is divided by considering the size and brightness variation and computed like:

Value = Σ (pixels in black zone) - Σ (pixels in white zone)

Every feature results in a single value computed through subtracting the addition of the white rectangle from the addition of the black rectangle. The example of two features of Haar is given in Fig. 6.

AdaBoost is an algorithm in machine learning that is resourceful of building a solid classifier via a weighted group of powerless classifiers. It utilizes an important idea of Bagging that is a technique for joining various classifiers built utilizing similar information set. AdaBoost algorithm gives a desirable area of the things repercussion not necessary background. The determination of the better feature, threshold and polarity is an important section of the AdaBoost algorithm. The better performance feature is selected based on the weighted error it generates. The weighted error is a function of the weights belonging to the training instances. The weight of a correctly classified case is decreased and the weight of a misclassified case is stayed fixed [20- 21]. AdaBoost learning procedure is quick and gives a number of desired information.

Cascade classifier phase is the final steps for Viola-Jones face detection algorithm. Cascade stage is utilized to eliminate face candidates speedily. A cascade classifier comprises of numerous phases of filters, determine if a given sub window is definitely not a face or perhaps a face is the work of every phase. When pass all phases or fail any phase the candidates exit the cascade. The cascade classifier will directly reject the area as a face when the input area fails to pass the threshold of a phase. If a candidate passes all phases, the face will be detected. This procedure is demonstrated with three phases in Fig. 7.

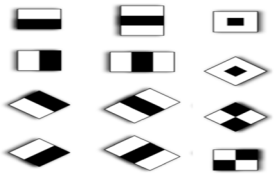

Fig.5. Different kinds of features

Fig.6. Haar like Feature Example

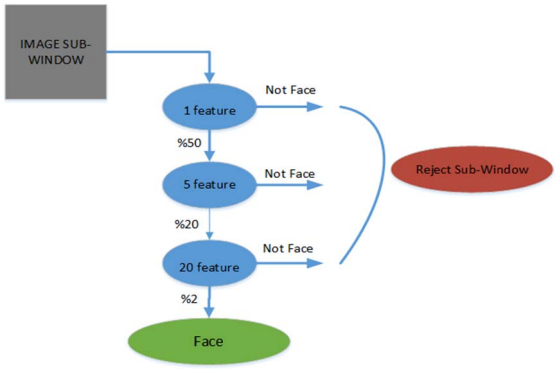

Fig. 7. Example for Cascaded of Phases

Through selecting the false-alarm rate and desired hit-rate at all phases and some of phases, it is possible to accomplish great detection execution. In really, the detection rate of the full cascade is given through:

$$D = \prod_{t=1}^{T} d_t$$

Wherever *dt* is the detection rate of the t-th phase and T is the number of phases. The false positive rate of the full cascade is given through:

$$F = \prod_{t=1}^{T} f_t$$

Wherever *ft* is the false alarm rate of the t-th phase and T is the number of phases [22- 23].

IV. Experimental Results

Smart phone application incorporated with the proposed system to improve a smart motion detecting camera security system and find human faces for houses and offices. The experimental setup of the proposed scheme is shown in the Fig. 8. Other than the hardware configuration the software's necessary should also be installed

The PICAMERA has been effectively grabbing the pictures when any motion is discovered through PIR motion sensor and face detection is executed. The system was capable to effectively discover the faces in the take pictures. The algorithm has been used to entire the pictures. The real time face detection is prepared by means of Cascade Classifier. Viola-Jones face detection algorithm is extra reasonable for real time face detection, since they require fewer CPU resource and little expenses.

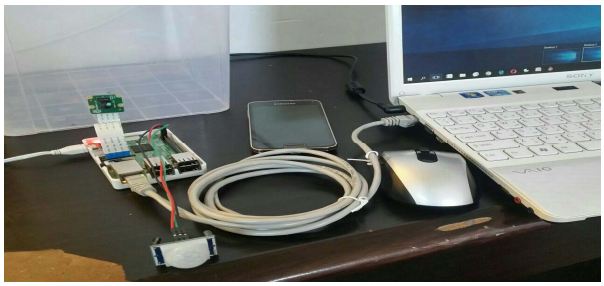

Fig.8. Experimental setup

This paper apply four operations like find motion, grab pictures, find human faces and sending result and notification to the user's Smartphone. The system starts running once running the code. The application will be worked only when the motion discovered. When the motion is discovered, the output screen displays the message “motion detected” which is shown in Fig. 9. Simultaneously, the camera grab the events and the pictures and notifications are sent to a Smartphone program used here is “Telegram” as appeared in Fig. 10. Raspberry Pi 3 has a Wi-Fi wireless technology and Bluetooth. This is helpful to "see activity" and display pictures at once on the Smartphone device.

The received notifications and result pictures on the Smartphone are shown in the Fig. 11, Fig. 12, and Fig. 13.

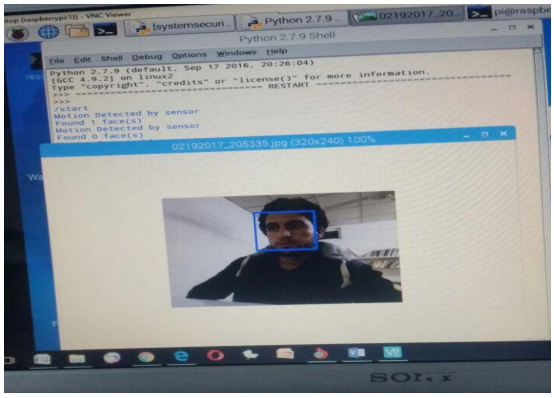

Fig.9. Show result on the computer screen

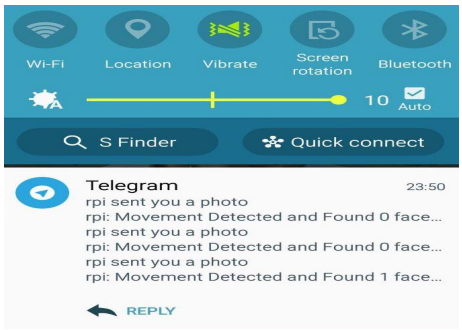

Fig. 10. Screenshot of received notification on the smart phone

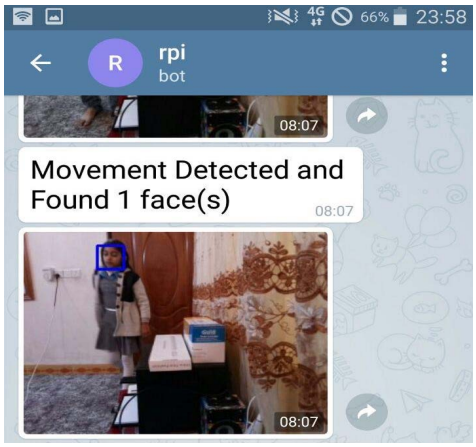

Fig.11. Result when face is discovered

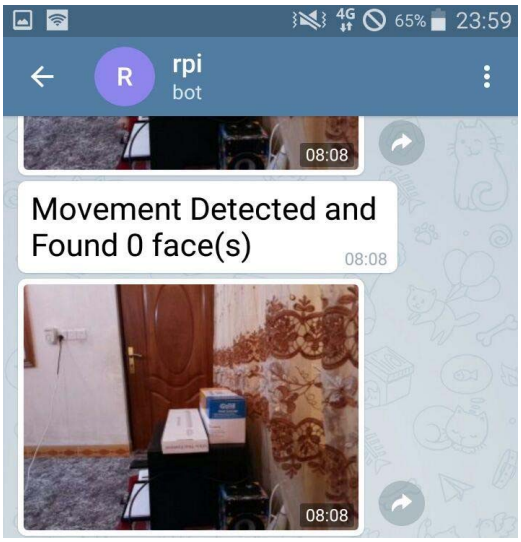

Fig.12. Result when Face not discovered

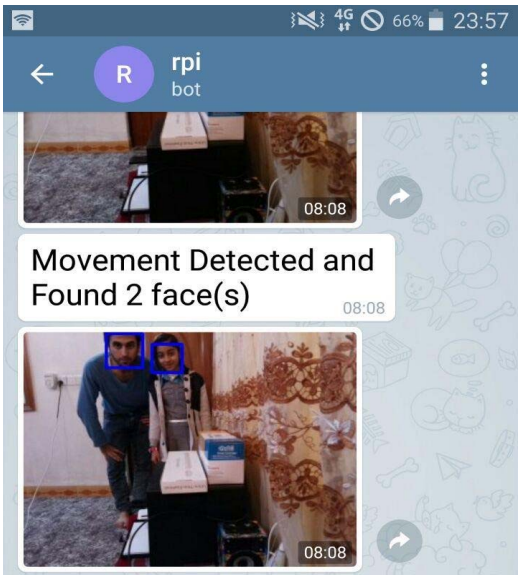

Fig.13. Result when Multiple Face Discovered

The performance of the proposed method is calculated for rasberry PI 3. The calculation results are given in TABLE I. As shown in TABLE I, the performance of the face detection method is good for raspberry PI 3. The execution time consists of motion detection, capturing image, face detection, and sending the image to a smartphone.

TABLE I. EXECUTION TIME AND DETECTION RATE

Number of images	Exectution time(second)	Detection rate (%)
5	4.3±2.5	100±0.0
9	31±3.7	96.87± 4.3
25	74±8.	97.36± 3.7

V. CONCLUSIONS

In this study, we have outlined embedded face detection with an intelligent security system which is capable to catch picture and mailing them to a Smartphone. In the proposed system, we have used Computer Vision in the IoT. This could allow using Pi camera and sensors. The real time surveillance of the house is necessary for security application. In this paper, a security system is offered and real time face detection is implemented. The system will alarm the user whether every intruder has gone the office or home. A Smartphone is the core gadget of the system that is used via the user to get notifications with the captured pictures. With Computer Vision, we could make simpler the use of the Internet of Things in our daily time and we could build a new path to contact us with our environment. To improve and computerize the security of our cities, industries, towns, house and the Earth, this technology can be utilized. Raspberry Pi 3 has extremely excellent features and little price embedded equipment platform. The Pi camera module in particular designed for the Raspberry Pi. For implementing the house automation, the Raspberry Pi is an efficient gadget. Thus, we have used PIR sensor and Pi camera module to catch the motion when detected.

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