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Video surveillance-based security system using OpenCV and Arduino uno.

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Abstract:
The main purpose of this system is to keep your property inside it safer. Security system plays a major role in now a day to help protection from culprit, theft, and burglary incidents. We have already CCTV based security system, but it is not real-time because it records the activities and stored in database, owner get information after the unexpected situation happens. To overcome this problem many products have come into existence, but some are not good at cost efficient. Video surveillance-based security systems using OpenCV and Arduino uno were implemented for the effectiveness of motion capturing. Using this system will help to detect in real time and send alerts in the same period. It will keep protection from culprits, theft and burglary incidents, and it is also cost efficient. This system uses a model of Haar-Cascade coupled with background subtraction during the development stage. This system was tested in different situations to catch better accuracy results of motion identification. This system depends on the PIR sensor to trigger when it captures. From the results obtained, this video surveillance-based system has a detection rate 86%.
Keywords: OpenCV, Face Detection, Motion Detection, Authentication, Arduino Uno.

1. Introduction:

Security is an important aspect of today's world. Video surveillance has been widely used as an important component of the security system. The technology is being evolved exponentially over the years. The work done by humans is being automated by Machines. Applications such as face detection, video surveillance systems have been more importantly used in computer vision topics these days. These systems are more useful in image processing systems based on video streams to show the required results according to users.

OpenCV is a source computer vision library which is written in c and c++ and runs on major operating systems. By using it, one can process images and videos to identify objects, faces, or even handwriting of a human. When integrated with various libraries, such as NumPy, python is capable of processing the OpenCV array structure for analysis. To detect image pattern and its comparison features we use vector space and perform mathematical operations on these features.

Image processing is a method to perform some operations on an image, in order to get an increased image. If we talk about the basic definition of image processing then “Image processing is the analysis and control of a digitized image, especially in order to improve its quality”. We can use these techniques to build the effective security system by using the video stream and using opencv to process the stream and detect the humans by using the face recognition algorithms. Here we are using the haar cascade model to detect the human faces in the video stream.

The Haar cascade model is the example for object detection based algorithm which was done by Paul Viola and Michael Jones in their paper, “Rapid Object Detection using an improvement of Simple Features” in 2001. The Haar cascade classifier is basically a ML approach where cascade function is trained from a lot of images of both negative and positives. Based on training it is then used to detect the items in the other videos.

Here we used a Microcontroller ATMEGA328P (Arduino UNO) to connect RFID and PIR sensors. The output of Arduino is read by the python by using the library Pyserial. Based on the output of arduino our model will take the images of the intruder and send the pictures to the mail. After sending the images over mail we will write the data into the arduino based on that alert will be started ie., buzzer and lights.

The CCTV cameras generally used don't give the real time alerts we have to check after the incident happened, so here we will give the alerts based on the conditions satisfied. The motion is detected by the pir sensor and sent to the serial monitor which is read by python via pyserial and written back to the arduino which triggers the alarm. If the authorised persons came into the location then they can use the rfid card and the system doesn't give the alerts. In this system we will give the alerts in real time if the face and motion is detected, which the situation is handled fastly rather than checking the whole footage and acting accordingly.

2. Literature Survey:

P. Vigneswari et al. [2] and V. Indhu et al. [2] showed an automated security system by using video surveillance. They did work on a higher-level using security applications using raspberry pi board. Anybody entering the room automatically lights and fans will turn on and when they are leaving the lights and fans should automatically turn off. At the same time the raspberry pi camera turns on and captures pictures of the person who has entered the room. Those captured images are sent to the user through SMS (Short Message Service) link using GSM (Global System for Mobile) modem. Users can see those images by clicking on those links. When there is no person in the room, lights and fans automatically turn off.

Suresh et al [5] presented this security system based on Arduino uno microcontroller, motion, and temperature sensor. It is cost efficient and high-level security system. They introduced one more sensor unit called temperature sensor which is improve the accuracy of instructor and reducing false detection based on line of sight. When change in motion detection as well as temperature rises above the threshold level, system will send a message to owner's mobile through GSM module.

prasad et. al. [7] presented a smart surveillance monitoring system using PIR sensor and raspberry pi. This security system includes motion detection and camera. When any person enters the room, motion is detected by the PIR sensor and camera. They used a 3G dongle to transmit data into web applications. The videos are automatically stored in cloud for future identification recording automatically and triggers SMS service to send SMS to owners Mobile. Raspberry pi interacts with web applications on the mobile and some server scripts will run on cloud to store recorded data.

Thinesh Prathaban and Weilynn Thean [3] presented a Vision based home security system. This security system provided accuracy score around 76%. This system includes PIR sensor, camera, and raspberry pi. They provided a security system at prominent level when any person enters a room, motion sensor detects and send signals to microcontroller as well as computer vision to detect face of peoples, if both conditions satisfy the system send alert mail to user's registered mail id.

Ibrahim Mohammad presented an integrating face recognition security system with the internet of things. They developed a system for a more expensive solution based on raspberry pi. They use a raspberry pi camera for face recognition and learn to detect those with granted access to specified areas under protection. During the process, the system recognizes faces with matches with the same dataset, then the camera shows the matching name and at the same time it captures a photo and sends it to the authority's person's mail. This system recognizes even the poor-quality images performing.

All these systems were developed in surveillance systems. For example, in low light this PIR sensor might work from rapid heat from the sun. One more sensor is used in our project called RFID sensor which is used for authentication. For example, when owner returns to home while this system is running so they will be false alarm trigger, to avoid that we implemented a RFID authentication sensor with is authenticate users can enter room with help of authorized card while this system will turn off.

3. Methodology

This section paper presents the detailed methodology proposed for the implementation.

3.1 RFID:

RFID (radio-Frequency identification) is an acronym for "radio-Frequency identification" tags used to track the radio frequency to detect, search, communicate with things and people. It refers to a technology whereby digital data is encoded in RFID tags. It works by RFID scanner recognizing locations and identification of tagged items, it extents low-power radio frequencies to store data.

FIGURE 1: Radio-frequency identification

It transmits signals through radio waves that activate the tag. After activated, the tag sends a wave back signal to the antenna. These tags are smart labels that can store an enormous range of information from serial numbers to a brief description. RFID used in various applications like ID Badging, Personnel tracking, Supply chain Management, etc.

3.2. **Passive Infrared Sensor (PIR)**

Passive infrared sensor uses a pair of pyroelectric sensors to detect heat energy in the surrounding environment. It allows to sense motion and is cost efficient, easy to use, and small.

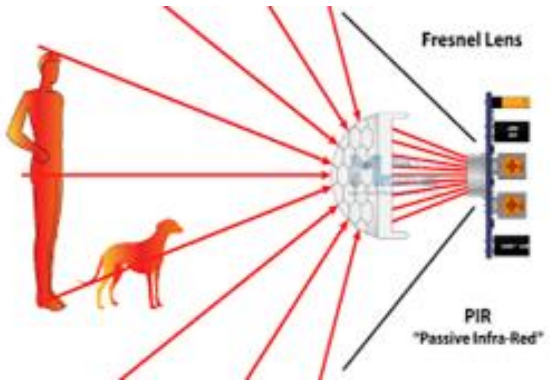


FIGURE 2: Passive Infrared (PIR) Sensor

The working principle of the module consists of a pyroelectric sensor which generates energy when exposed to heat that mean, when a human or animal body will get in the range of the sensor it will detect the movement because the human or the animal body emits heat energy in the form of infrared radiation that is where the name of the sensor comes from a passive infrared sensor. The term passive means not using any energy for detecting purpose, it works by detecting the energy given off by other objects.

3.3. Arduino Uno

Arduino uno is a microcontroller board based on the ATmega328P processor. It has 14 digital input/output pins, 6 analog input pins and clock speed 16 MHZ. It is cost efficient, flexible, easy to use programmable open-source microcontroller board. It is one of the most common Arduino boards available, and a large USB (Universal Serial Bus) B connector for connecting to a PC. These are able to read inputs-light

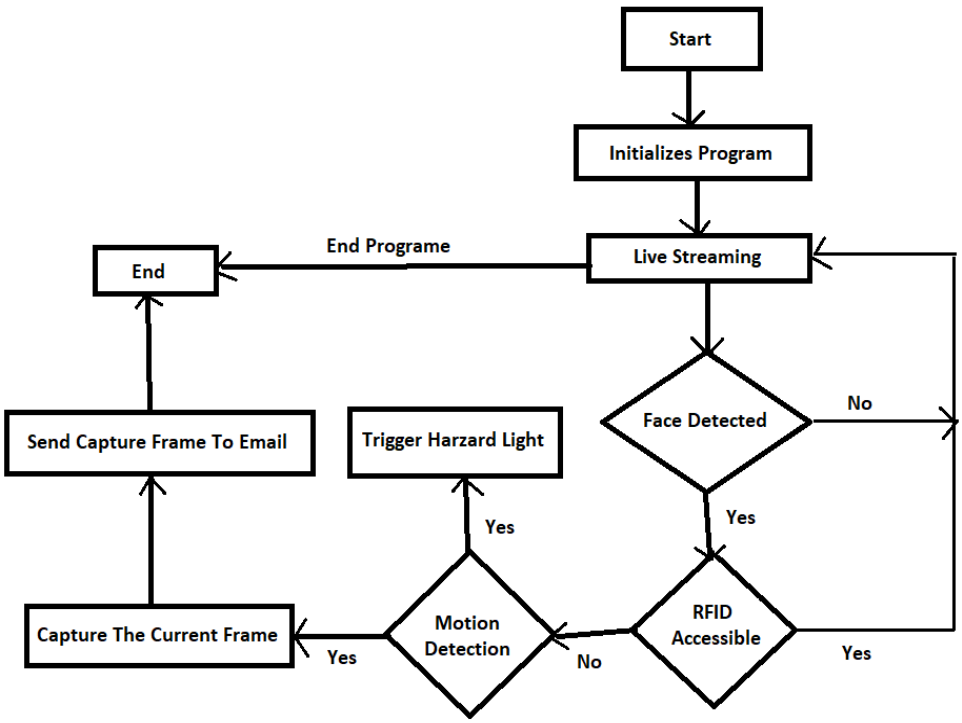
on a sensor, a finger on a button. Arduino code is written in C++ programming language. It will interact with buttons, LEDs, motors, speakers, GPS (Global Positioning System) units, cameras, the internet, and even your smart-phone.

Arduino consists of both a physical programmable circuit board and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write, and upload computer code to the physical board.

FIGURE 3: Visualization of Arduino Uno board.

3.4. SYSTEM IMPLEMENTATION

This is the design. A few implementations in our system are RFID, Arduino, motion detection using PIR sensor and video streaming with OpenCV integration.



. **FIGURE 4: Flow chart of security system using camera with OpenCV implementation**

Video is streaming continuously and when a person is detected it will check with motion detection, if both conditions satisfies then the system will capture the current frame and send the captured frame to Owner's email and as well as system will trigger the hazard lights to alert the surrounding peoples.

4. Results and Discussions:

We implemented a hardware part as shown in Figure 5, with the usage of PIR Sensor for motion detection and RFID detector to access authorized persons. We took LED lights instead of hazard lights to alert the surrounding people. We use Arduino uno for cost efficiency and small size.

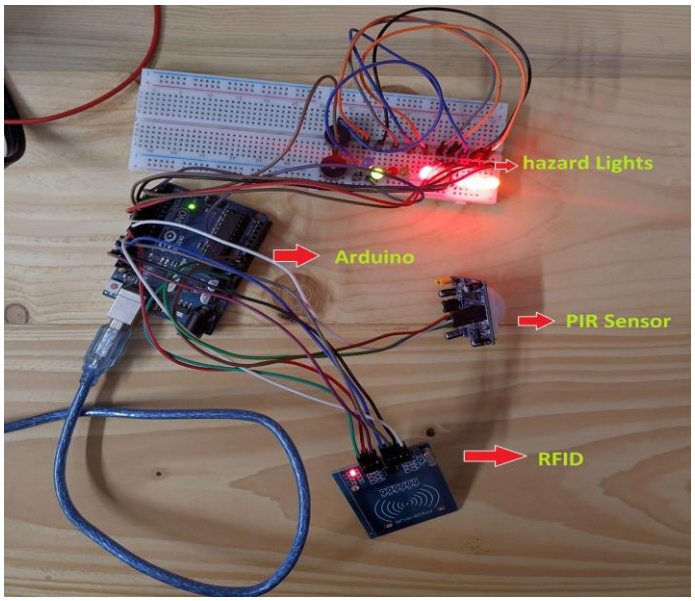


FIGURE 5: Hardware part of RFID,PIR Sensor, Arduino and Hazard lights.

As shown in the FIGURE 6 security system implemented in pycharm with a web camera. This live video streaming demonstration will also be implemented in the CCTV security system. We implemented a Haar-Cascade frontal face algorithm.This algorithm for face detection was used coupled with the PIR sensor for motion detection. If a face is detected in live streaming as shown in FIGURE 7, next it will check with motion detection (PIR sensor) these two conditions satisfies then it will trigger hazard light to alert the surrounding people.As well as it will capture the frame when it's detected and send mail to owner's email with attached captured photo.

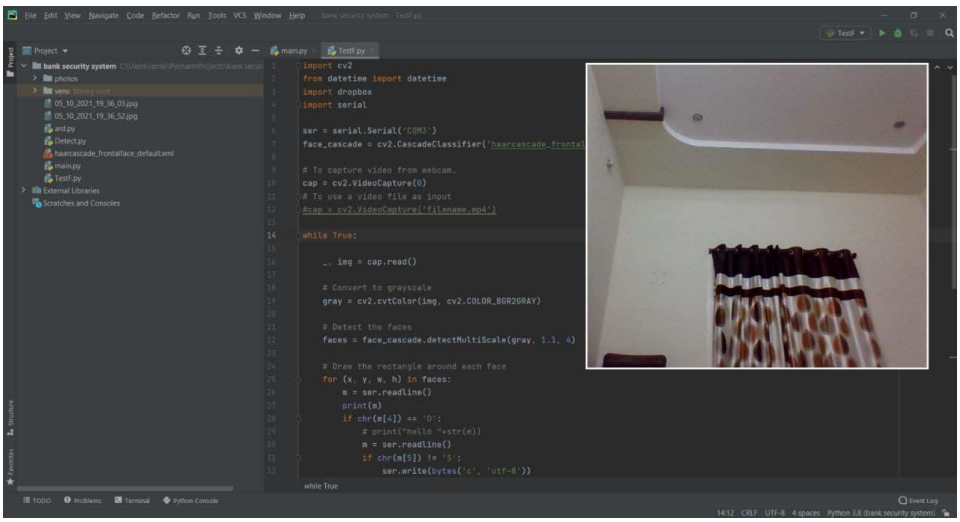


FIGURE 6: Live video streaming

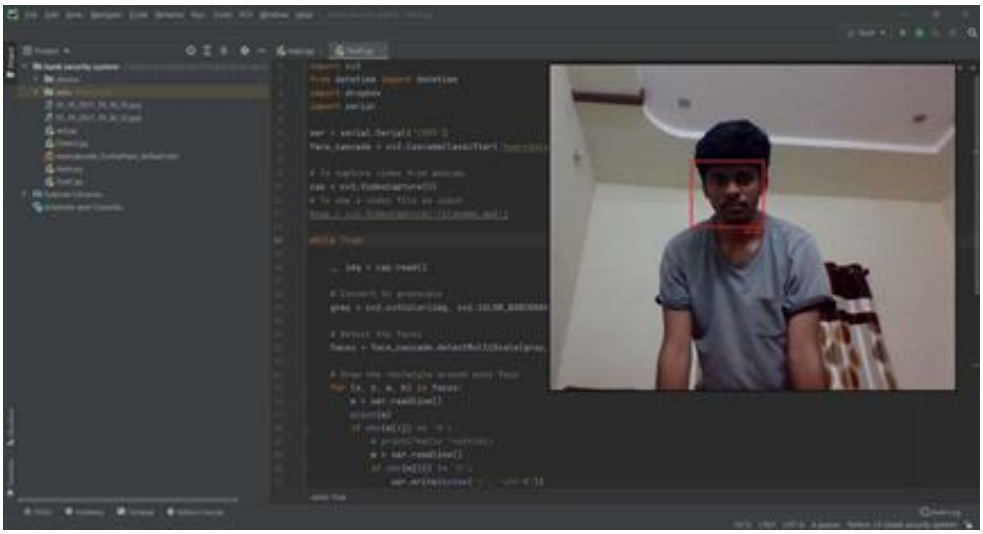


FIGURE 7: Captured frame using Haar-Cascade frontal face and motion detections

In each experiment, 15 trials were conducted and positive results were recorded. The face detection is maintained with good accuracy all the time, The PIR Sensor accuracy depends on the distance as it gives more accuracy if the motion happened near approx 4m. When the motion detected by the pir sensor and rfid detection is not done then the alert lights are started and mail will be sent to the authorised person along with the picture of the detected face.

Table 1:

Experiments	PIR motion detection		OpenCV camera motion detection	
	Accuracy (%)	Streaming latency (fps)	Accuracy (%)	Streaming latency (fps)
Processing the surveillance data in full light	92	30	100	15
Processing the surveillance data in moderate light	87	32	100	17
Processing the surveillance data in failed light	79	35	100	23

Conclusion:

In this project, our video surveillance-based security system using opencv has been successfully implemented with Arduino uno. We implemented it with both hardware and software. The design flow of the developed prototype for this security system using opencv Arduino uno. A few implementations in our system are RFID, Arduino, motion detection using PIR sensor and video streaming with OpenCV integration. This system helps to detect culprits and send pictures to owners, so it will help to take immediate action. We can implement this system in various areas like home security, any secure places like banks and gold shops etc.

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