International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 05 | May 2024 www.irjet.net p-ISSN: 2395-0072

AI Based Smart CCTV video Surveillance Application

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Abstract - *Video surveillance nowadays is getting popular day by day. Schools, hospitals, homes, market places, roads require costly high end video cameras require mostly RFIDS features which are mostly expensive hence security and all becomes costly. In this paper, AI based surveillance camera application has been proposed named " smart CCTV video surveillance "to identify and report suspicious events. The proposed model for the Smart CCTV will involve using a combination of different computer vision and machine learning techniques to detect and recognize different objects and events in the surveillance area. This paper mainly focuses on object detection algorithm (YOLO) to detect and track weapon within the video frames, applying non maximum suppression (NMS) to remove redundant boundary boxes and finally triggers an alarm or alert indicating if a weapon is detected within the surveillance area. In this research paper an algorithm has been also developed successfully that uses the HSV color space for fire detection and Simple Mail Transfer Protocol (SMTP) can be used to notify relevant parties when a fire is detected by sending an email with relevant information.*

Key Words: Surveillance system, RFIDS, AI, CCTV,YOLO,NMS

1.INTRODUCTION

The research is based on a smart CCTV camera surveillance system. A security system based on CCTV cameras currently exist in different parts of our city, state or country. The system is designed using wireless CCTV cameras Technology. Using surveillance systems, image recognition is becoming more important in today's life [1]. An embedded surveillance systems are often used for home, office or factory for image processing and traffic monitoring. Here in our case, we build our research with many important features, like a smart guard, which gets all the information like entering the area/room, fire detection etc. The current CCTV security system provides very basic security, which need to be modified or modernize rise with time. Today's modern CCTV will easily be able to take all decisions by itself and this multifeatured CCTV system will be able to recognize a person, detect whether a person is carrying a firearm or weapon. In our opinion, modern day CCTV can't make our life so much secure, we feel a bit secure with the current CCTV system. Let's dive into our project details. First and foremost, it's a smart AI-based security camera mobile app. With this app, you can connect to any Wi-Fi-enabled camera to safeguard the area it covers. Our goal is to enhance a regular camera through this app, making it accessible to everyone at a very affordable price.

Simply purchase a basic, low-cost Wi-Fi-Bluetooth camera from the market, connect it to our app, and open the app. You'll find four main buttons on the home screen. When you activate these buttons, four screen tabs will appear on your mobile screen, each for a different function.

These tabs serve distinct purposes: one for recording regular footage, another for verifying individuals entering the camera's vicinity, a third for detecting fire and issuing immediate alerts, and the last for identifying weapons and notifying accordingly.

So, we have taken up these challenges on our project to bring all those facilities to smart CCTV.

2. Literature Review

G. Sreenu, et al. had described in 2019, their paper is a applications of deep learning and the smart security-based surveillance system. According to this paper all the information about how to improve the CCTV system with deep learning and its use are provided.[2]

Prof S.B. Kothari et al. had published in Dec 2021, a paper which was based on survey on smart security surveillance system. This paper is based on some idea of motion detection and clear image detection using an image processing method.[3]

Smart CCTV security service in IOT Environment ,in this paper the author Cho, Jeorg, Rae ,published his research paper provide how we can prevent crime in any CCTV monitored area by using IOT system. What is IOT and its usage rules also mentioned in this paper. [4]

Automated Detection of Firearms and Knives in a CCTV Image ,in their paper Micha Grega et al. in 2016 .In this paper, there are some idea of detection the weapon inside the surveillance area and know about the danger notification alert process from SURF feature detection algorithms.[5]

IoT Based Weapons Detection System for Surveillance and Security Using YOLOV4 ,the authors Anuj Singh et al. in 2016 In their paper the detection of Weapons and identification process mentioned, here the notification alert to authorities also indicate, the system use the YOLO V4 algorithm for it.[6]

Josh P. Davis et al. their paper provides how to spot the Face in a Crowd and the notification alert after detect the face in crowd.[7]

Jareerat Seebamrungsat et al. in 2014 ,in their research article introduced electronic measurement using the light detection and analysis process which is used for fire detection in the buildings using image processing In this process using the HSV and YCbCr color models, it separate highlighted background color and also detected orange and yellow colors for this experiment. [8]

Table -1: Literature Summary

Literature Summary		
Author	Year	Major Findings
1. Prof S.B. Kothari, Mr Visal	Dec, 2021	This paper is based on some idea of motion detection and clear image detection using an image processing method [3].
2.G. Sreenu, M.A. Saleem Dura	2019	This paper provides all the information about how to improve the CCTV system with deep learning [2].
3. Josh P. Davis et al	2018	This paper provides how to Spot the Face in a Crowd and the notification alert after detect the face in crowd [7].
4. Cho, Jeorg, Ra	2017	This research paper provide how we can prevent crime in any CCTV monitored area by using IOT system [4].
5. Michał Grega et al.	2016	In this paper, there are some ideas of detection the weapon inside the surveillance area and know about the danger notification alert process from SURF feature detection algorithms [6].
6. Jareerat Seebamrungsat et al.	2014	This article introduces electronic measurement using the light detection and analysis process are include using YCbCr ans HSV model [8].

3. Background Study

What is CCTV and how to make this modern CCTV [9], at first, start from the question that what is CCTV and how it will prepare - CCTV stands for Closed Circuit Television [10] and is commonly known as Video Surveillance. Python is a high-level programming language. In machine learning, web development and many other fields we are easily use python. For beginners, Python is an easy to-use language. Now we must be aware of python-libraries and packages needed for this project –

3.1 NumPy

NumPy is a Python library that is used for performing mathematical and scientific operations on arrays and matrices. It provides a powerful set of tools for working with multi-dimensional arrays and matrices. NumPy is often used in conjunction with other scientific Python libraries, such as SciPy, pandas, and scikit-learn.[11]

3.2 Cv2

OpenCV (cv2) is a popular computer vision library that can be used in smart CCTV projects to perform various tasks such as object detection, tracking, and classification.

Capturing video stream. The first step in any CCTV project is to capture the video stream from the camera. OpenCV provides a Video Capture object that can be used to read video frames from a camera or video file.

Object detection. OpenCV provides a variety of methods for detecting objects in images or video streams, including Haar cascades, HOG (Histogram of Oriented Gradients), and deep learning-based models like YOLO (You Only Look Once). These methods can be used to detect objects like humans, vehicles, or specific items of interest.

Object tracking. Once objects have been detected, you may want to track them over time to monitor their movements and behavior. OpenCV [12] provides several tracking algorithms that can be used for this purpose, such as KCF or MOSSE.

3.3 Skimage

Scikit-image (skimage) is a popular image processing library in Python that can be used in smart CCTV projects for tasks like image segmentation, feature extraction, and object recognition. Here is an overview of how you can use scikit-image in a smart CCTV project in Python:

Image processing. The first step in many image-based tasks is to preprocess the images to enhance features and remove noise. scikit-image provides a variety of image processing functions that can be used for this purpose, such as filtering, thresholding, and morphological operations.

Image segmentation. Once the image has been preprocessed, segmentation is done ,into regions corresponding to different objects or parts of objects. scikit-image provides several methods for image segmentation, such as thresholding, region growing, and watershed segmentation.

Object detection. Once the image has been segmented, use scikit-image [13] or other libraries like OpenCV to detect and track objects of interest. scikit-image provides several feature detection and extraction methods that can be used for this purpose, such as corner detection, blob detection, and HOG (Histogram of Oriented Gradients) feature extraction.

3.4 python

Python is a popular programming language that can be used in smart CCTV projects for various tasks such as image processing, object detection, and machine learning. Python is widely used in the computer vision field because of its ease of use, large community, and availability of many libraries and frameworks.[14]

3.5 Local Binary Pattern on OpenCV

Local Binary Pattern (LBP) is a texture descriptor that can be used in image processing and computer vision applications. It is a powerful feature extraction method that can be used for tasks such as object recognition, face detection, and texture analysis.[15]

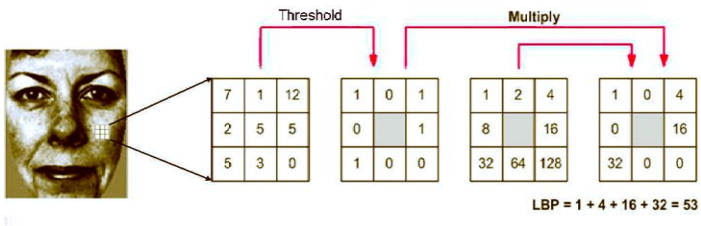

Fig. 1. Example of an LBP calculation

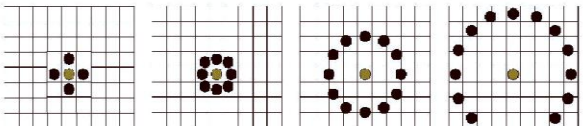

Figure 1: LBP Calculation Diagram

3.6 HSV color Algorithm

HSV (Hue, Saturation, Value) is a color space that is commonly used in computer vision applications, including fire detection. The HSV color space represents colors in terms of their hue (color), saturation (purity), and value (brightness). Here is a simple algorithm that uses the HSV color space for fire detection in Python:

Step a) Convert the image to the HSV color space.

Step b) Threshold the image using the hue, saturation, and value channels.

Step c) Apply a series of morphological operations to the mask to remove noise.

Step d) Find contours in the mask and draw bounding boxes around them.

Step e) Display the results.

This algorithm provides a simple and effective way to detect fire in an image using the HSV color space in Python. It can be extended to detect fire in live video streams by applying the algorithm to each frame of the video.[16]

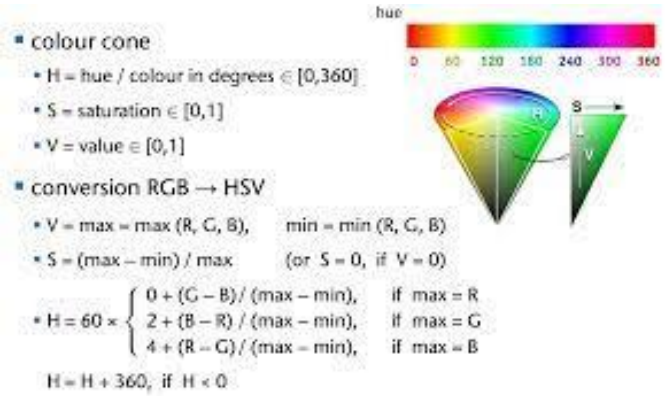

Figure 2: HSV Color Algorithm Diagram

3.7 SMTPLIB

SMTP (Simple Mail Transfer Protocol) is a protocol used for sending emails over the internet. While SMTP is not directly related to fire detection, it can be used to notify relevant parties when a fire is detected by sending an email with relevant information.[17]

3.8 Object detection algorithm

To detect weapons in an image or video, you can use object detection algorithms in Python. There are several popular object detection algorithms available, including YOLO, Faster R-CNN, and SSD. Here we use the YOLO algorithms as an object detection algorithm with the goal of detecting weapons.[19]

3.9 Others

Computer Vision:

Computer Vision involves the development of algorithms and techniques to enable computers to interpret and understand visual information from digital images or videos, mimicking human vision capabilities.

Image Processing:

Image Processing encompasses a range of methods and algorithms used to manipulate and analyze digital images, including tasks such as enhancement, restoration, compression, and segmentation, to extract useful information or improve visual quality.

Machine Learning:

Machine Learning is a branch of artificial intelligence (AI) that focuses on developing algorithms and models capable of learning from data and making predictions or decisions without explicit programming instructions.

Deep Learning:

Deep Learning is a subset of machine learning that utilizes artificial neural networks with multiple layers (deep architectures) to automatically learn intricate patterns and representations from large datasets, enabling powerful feature extraction and complex decision-making tasks.

Face Recognition Algorithms:

Face Recognition Algorithms employ computer vision and machine learning techniques to identify and authenticate individuals by analyzing facial features and patterns, enabling applications such as security systems, access control, and personalized user experiences.

Kivy:

Kivy is a Python framework that helps developers create user-friendly apps for various platforms like desktop and mobile. It's known for its simplicity and allows for interactive and visually appealing interfaces.

Android Studio:

Android Studio is Google's official tool for building Android apps. It provides everything developers need, including a code editor and debugger. With support for Java and Kotlin, developers can create powerful apps with ease.

Java:

Java programming language is widely used for building all kinds of applications. It's known for its reliability and scalability. Java follows an object-oriented approach, making it easy to write and maintain code. Plus, its vast ecosystem offers tools and libraries for almost any project.

4. OUR PROPOSED MODEL

The proposed model for the Smart CCTV Project will involve using various computer vision techniques and machine learning algorithms to detect and recognize different objects and events in the surveillance footage.

The project will consist of four main functions: fire detection, face detection, and weapon detection. Each function will use a combination of different algorithms to achieve its specific task.

4.1 Fire Detection Function

The flowchart for the fire detection function will involve the following steps:

Step a) Get video frames from the CCTV camera:
Regularly grab frames from the CCTV camera.

Step b) Process frames by turning them into grayscale and using a pre-trained CNN for finding features:

Change each frame to grayscale to make it easier to work with.

Use a pre-trained CNN model to spot features. This model has learned from lots of data to recognize patterns, including ones related to fire.

Step c) Use a threshold on the CNN-detected features to identify possible fire areas:

Decide on a threshold to judge if an area might have fire, based on the CNN's findings.

Spot areas where feature intensity is higher than the set threshold, suggesting potential fire presence.

Step d) Measure the fire's intensity percentage and take action:

Calculate how much of the identified areas contain fire.

If the percentage goes beyond a certain limit, activate an alarm or notify authorities.

Algorithm use in Fire Detection Function.

Convolutional Neural Network (CNN) deep learning algorithm

4.2 Face Detection Function

The flowchart for the face detection function will involve the following steps:

Step a) Capture the video feed from the CCTV camera.

Step b) Apply Haar Cascades algorithm to detect faces in the video frames.

Step c) Apply Local Binary Pattern (LBP) algorithm to extract features from the detected faces.

Step d) Use the extracted features to classify the faces as either known or unknown individuals and trigger an alarm or send an alert if an unknown face is detected.

Algorithm used in Face Detection Function.
Haar Cascades Algorithm
Local Binary Pattern (LBP) Algorithm
Classification Algorithm

4.3 Weapon Detection Function

The flowchart for the weapon detection function will involve the following steps:

Step a) Capture the video feed from the CCTV camera.

Step b) Use object detection algorithms, such as YOLO, to detect and track weapons in the video frames.

Step c) Apply non-maximum suppression (NMS) to remove redundant bounding boxes.

Step d) Trigger an alarm or send an alert if a weapon is detected.

Algorithm use in Weapon Detection Function.
Object Detection Algorithm (YOLO)
Non-Maximum Suppression (NMS) Algorithm

Overall, the proposed model for the Smart CCTV Project will involve using a combination of different computer vision and machine learning techniques to detect and recognize different objects and events in the surveillance footage. The flowchart and algorithms mentioned above can be used as a starting point for developing a more comprehensive and efficient system for smart CCTV surveillance.

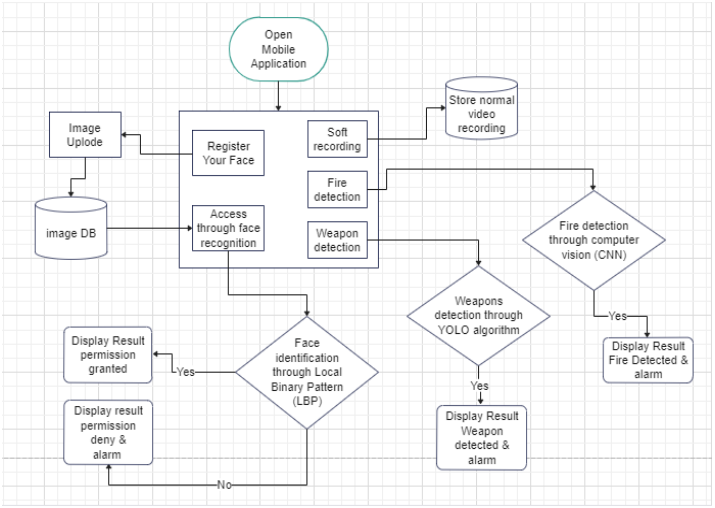

Figure 1: Proposed Model Diagram

5. Implementation

To implement fire detection, continuously capture CCTV video frames. Process frames using a pre-trained CNN to identify fire areas, setting a threshold for detection. Calculate fire intensity and trigger alerts if it exceeds the threshold.

For face detection and recognition, capture video frames and detect faces using Haar Cascades. Use LBP for feature extraction and a classification algorithm to identify known faces. Trigger alerts for unknown faces.

For weapon detection, capture video frames and use YOLO to detect weapons. Apply NMS to filter redundant detections. Trigger alerts for surviving weapon detections.

Implementation fire detection function.

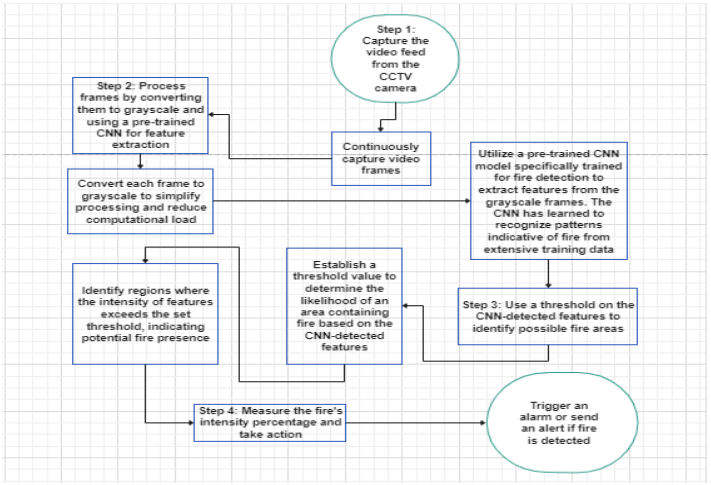

Fig 2: Fire detection function diagram.

Implementation face detection function.

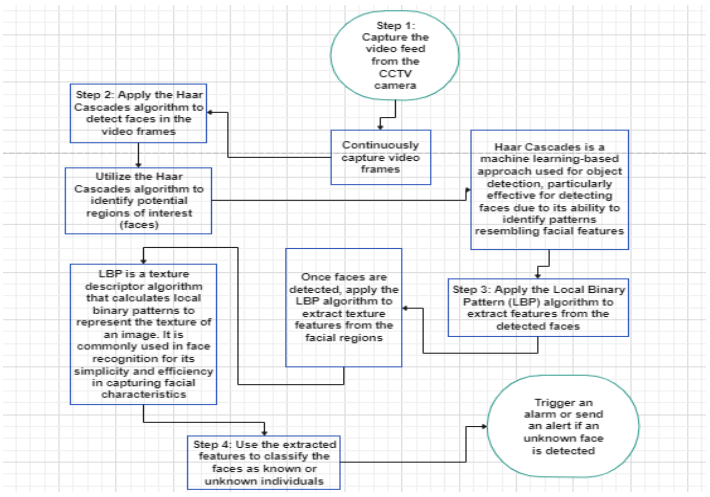

Fig 3: Face detection from crowd function diagram.

Implementation weapon detection function.

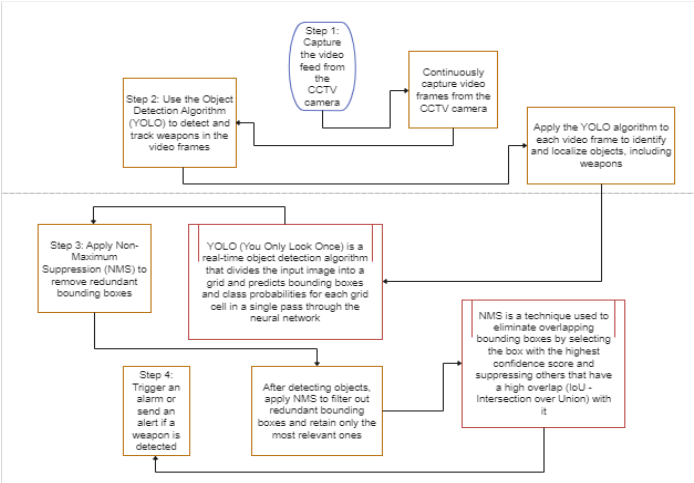

Fig 4: weapon detection function diagram.

6. Results and Discussion

6.1 Detect face

Through facial detection, the CCTV system verifies individuals against the database. Authorized persons are granted entry to the secured area, while unregistered individuals trigger an alarm, preventing unauthorized access. See output from feature 'a'.

Feature a: Face detection in monitor.

6.2 Weapon detection

The system is also capable of detecting firearms or other types of weapons within the monitored area. If there is any weapon present surveillance area and it is purely visible to the camera then the CCTV will detect the weapon and provide notification to the authority, depicted in fig 2a.

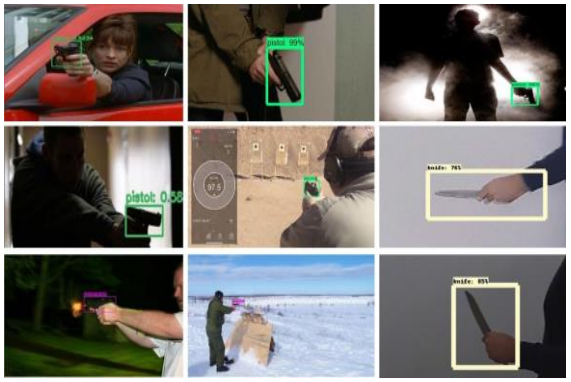

Fig 2a: Weapon detection in monitor.

6.3 Fire detection

Inside the surveillance area if there is any fire activity detected then the system provides the quick notification alert to the authority ,shown in Fig 2c.

Fig 2c: Fire detected in monitor.

7. Conclusion

In conclusion, our research aims to address the shortcomings of traditional CCTV systems by introducing a smart AI-based security camera mobile app. While acknowledging the importance of existing surveillance technology, recognize the need for innovation to enhance security measures and keep pace with evolving threats. By leveraging the capabilities of our app, users can easily transform basic Wi-Fi-enabled cameras into advanced surveillance tools, accessible to everyone at an affordable price. The app's features, including real-time monitoring, fire detection, and weapon identification, signify a significant step forward in bolstering security measures and ensuring the safety of individuals and communities. Through our research, we strive to contribute to the advancement of smart CCTV technology, making security solutions more accessible, efficient, and effective for a wide range of applications.

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