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Weapon Detection in Real-Time CCTV Videos Using Deep Learning

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Abstract: *Security and safety are a big concern for today's modern world. For a country to be economically strong, it must ensure a safe and secure environment for investors and tourists. Having said that, Closed Circuit Television (CCTV) cameras are being used for surveillance and to monitor activities i.e. robberies but these cameras still require human supervision and intervention. We need a system that can automatically detect these illegal activities. Despite state-of-the-art deep learning algorithms, fast processing hardware, and advanced CCTV cameras, weapon detection in real-time is still a serious challenge. Observing angle differences, occlusions by the carrier of the firearm and persons around it further enhances the difficulty of the challenge. This work focuses on providing a secure place using CCTV footage as a source to detect harmful weapons by applying state-of-the-art open-source deep learning algorithms. We have implemented binary classification assuming pistol class as the reference class and relevant confusion objects inclusion concept is introduced to reduce false positives and false negatives. No standard dataset was available for real-time scenarios so we made our own dataset by making weapon photos from our own camera, manually collected images from the internet, extracted data from YouTube CCTV videos, through GitHub repositories, data by the University of Granada, and Internet Movies Firearms Database (IMFDB) imfdb.org. Two approaches are used i.e. sliding window/classification and region proposal/object detection. Some of the algorithms used are VGG16, Inception-V3, Inception-ResnetV2, SSDMobileNetV1, Faster-RCNN Inception-ResnetV2 (FRIRv2), YOLOv3, and YOLOv4. Precision and recall count the most rather than accuracy when object detection is performed so these entire algorithms were tested in terms of them. Yolov4 stands out best amongst all other algorithms and gave an F1-score of 91% along with a mean average precision of 91.73% higher than previously achieved.*

Keywords: Weapon Detection

I. INTRODUCTION

The crime rate across the globe has increased mainly because of the frequent use of handheld weapons during violent activity. For a country to progress, the law-and-order situation must be in control. Whether we want to attract investors for investment or to generate revenue with the tourism industry, all these needs is a peaceful and safe environment. The crime ratio because of guns is very critical in numerous parts of the world. It includes mainly those countries in which it is legal to keep a firearm. The world is a global village now and what we speak or write has an impact on the people. Even if the news they heard is crafted having no truth but as it gets viral in a few hours because of the media and especially social media, the damage will be done. People now have more depression and have less control over their anger, and hate speeches can get those people to lose their minds. People can be brainwashed and psychological studies show that if a person has a weapon in this situation, he may lose his senses and commit a violent activity.

CCTV cameras play an important role to overcome this problem and are considered to be one of the most important requirements for the security aspect. CCTVs are installed in every public place today and are mainly used for providing

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safety, crime investigation, and other security measures for detection. CCTV footage is the most important evidence in courts. After a crime is committed, law enforcement agencies arrive at the scene and take the recording of footage with them . If we look at the surveillance systems of different countries around the world, the UK has about 4.5 million cameras, which are used for surveillance. Sweden has about 50000 cameras installed around 2010. The government of Poland was able to reduce drug cases by 60% and street fights by 40% by installing just 450 cameras in the city of Poznan . China has the world's biggest surveillance system and 170 million cameras around the nation, and these are expected to expand three times, through an additional 400 million to be connected by 2020. It took only seven minutes for Chinese officials to find and apprehend BBC reporter John Sudworth using their strong CCTV cameras network and facial recognition technology and put the criminal behind the bar.

The main contributions of this work are: presentation of a first detailed and comprehensive work on weapon detection that can achieve detection in videos from real-time CCTV and works well even in low resolution and brightness because most of the work done earlier is on high definition training images but real time scenario needs real time training data as well for better results, finding of the most suitable and appropriate CNN based object detector for the application of weapon detection in real-time CCTV video streams, making of a new dataset because real-time detection also needs real time training data so we made a new database of 8327 images and preprocess edit using different OpenCV filters i.e. Equalized, Gray scale and clahe that helped in detecting images in low brightness and resolution, introducing the concept of related confusion classes to reduce false positives and negatives, training and testing of our novel database on the latest state of the deep learning based classification and detection models among them Yolov4 performed best in terms of both speed and accuracy and our selected trained model predict images at almost every orientation, angle, and view, achieving the highest mean average precision of 91.73% along with a F1-score of 91% on Yolov4.

1.1 Motivation of the Project

The crime rate across the globe has increased mainly because of the frequent use of handheld weapons during violent activity. High incidents were recorded in the past few years with the use of harmful weapons in public areas. These kinds of activities pose a threat to the public domain and to reduce this kind of attack, weapon detection in real-time CCTV footage is a convenient and feasible way to tackle this problem.

II. Description of the Problem

2.1 Goals and Objectives

- To detect a weapon in real-time CCTV footage using Deep Learning.
- To Detect a weapon in real-time CCTV footage.
- To help in improving the security, law, and order situation for the betterment and safety of humanity

III. Methodology

Deep learning is a branch of machine learning inspired by the functionality and structure of the human brain also called an artificial neural network. The methodology adopted in this work features the state of art deep learning, especially the convolutional neural networks due to their exceptional performance in this field. The aforementioned techniques are used for both the classification as well as localizing the specific object in a frame so both the object classification and detection algorithms were used and because our object is small with other objects in the background so after experimentation we found the best algorithm for our case. Sliding window/classification and region proposal/object detection algorithms were used, and these techniques will be discussed later in this section.

We had started by doing the classification using different deep learning models and achieved good precision but for the real-time scenarios, the low frame per second of classification models was the real issue in implementation. Oxford VGG, Google Inceptionv3, and Inception ResnetV2 Were trained using the aforementioned approach. To achieve high precision, increase the number of frames per second and improve localization, we moved to object detection and

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region proposal methods. The different state-of-the-art deep learning models for object detection were used and the results were compared in terms of precision, speed, and standard metric of F1 score.

State-of-the-art deep learning-based SSDMobileNetv1, YOLOv3, FasterRCNN-InceptionResnetv2, and YOLOv4 were trained and tested. Different datasets were made keeping in mind the classification and detection problem as both have a separate requirement for performing the tasks to achieve high accuracy, mean average precision as well as frame per second for the real-time implementation. To understand object classification and detection let us first briefly understand object recognition as both the aforementioned types come under the umbrella of this and combined classification and localization make detection possible for any kind of detection problem giving the class name as well as the region where our desired object is in the frame.

IV. LITERATURE REVIEW

The problem of detection and classification of objects in real-time started after major developments in the CCTV field, processing hardware, and deep learning models. Very littlework has been done in this field before and most of the previous effort was related to concealed weapon detection (CWD).

Starting with concealed weapon detection (CWD), before its use in weapon detection, it was used for luggage control and other security purposes at airports and was based on imaging techniques like millimetre-wave and infrared imaging. Sheen suggested CWD method based on a three dimensional millimeter (mm) wave imaging method, for detecting hidden weapons at airports and other safe locations in the body. Z. Xue et al. suggested a CWD technique based on a fusion-based technique of multi-scale decomposition, which combines color visual picture with infrared (IR) picture integration. R. Blum et al. suggested a CWD method based on the inclusion of visual picture and IR or mm wave picture using a multi-resolution mosaic technique to highlight the hidden weapon of the target picture.

4.1 Detecting Hidden Weapons using CWD technique and Image Fusion

Detects hidden weapons in a situation where the image of the scene was present over and under the exposed area. Their methodology was to apply a homomorphic filter captured at distinct exposure conditions to visual and IR pictures. Current techniques attain high precision by using various combinations of extractors and detectors, either by using easy intensity descriptors, boundary detection, and pattern matching or by using more complicated techniques such as cascade classifiers with boosting.

4.2 Object Tracking and Detection in Surveillance Camera.

Several object detection algorithms were proposed in the field of computer vision to make the surveillance system is better. Object detection algorithms were used in several sectors like anomaly detection, deterrence, human detection, and traffic monitoring. R. Chellappaet.al. discussed briefly object tracking and detection in surveillance cameras. The authors had explained the tracking of an object using mul.

4.3 Techniques for Detecting Objects that Come into Contact with another Object and are Occluded

Author addressed techniques for detecting objects that come into contact with another object and are occluded. They also wrote regarding the segmentation of mean fluctuations. They outlined how mean segmentation of shifts can help detect objects. They used a Bayesian Kalman filter with a simplified Gaussian blend (BKF-SGM) algorithm to track the detected Object.

4.4 Firearm Detection using the Images and Videos

The idea of firearm detection using the images and videos was proposed and false alarms were reduced by classifying neural networks with region-based descriptors and determining region of interest (ROI) using the sliding window technique and then trained the neural Network region of interest (ROI) using the sliding window technique and then trained the neural network classifier with image pixels

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4.5 CCTV as an Automated Sensor for Firearms Detection: Human-Derived Performance as a Precursor to Automatic Recognition

With the development in CCTV's, object detection for different computer vision problems for real-time were performed and the idea to detect firearms were introduced first by L. Ward etal. in 2007 and a surveillance system was also implemented by them a year later in 2008.In the aforementioned work, writers created an accurate pistol detection model for RGB pictures. However, in the same scene, their method did not detect various pistols. The approach used comprises of first removing non related items from the segmented picture using the K-mean clustering algorithm and then applying the SURF (Speed up Robust Features) method to detect points of interest. Darker gave the concept of SIFT based weapon detection algorithm and for ROI estimation, used the motion segmentation method

V. System Design And Flow

As the name suggests, it is the process of predicting the real class or category of an image to which it belongs by making probability high only for that particular class. CNN's are used to efficiently perform this process. Many state of the art Classification and Detection algorithms use CNN as a backend to perform their tasks.

Fig. 1 depicts that classification and localization come under the category of recognition and combined classification and localization are performed to do object detection. Let us have a brief overview of object classification, localization, and detection.

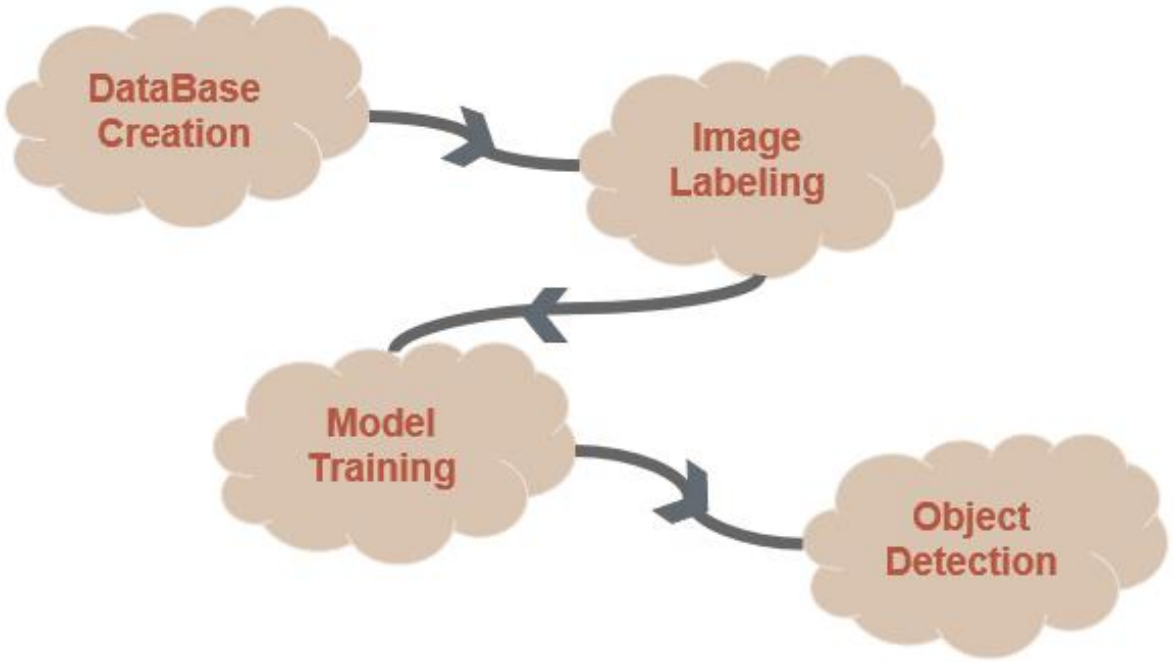

Figure 1: System Architecture

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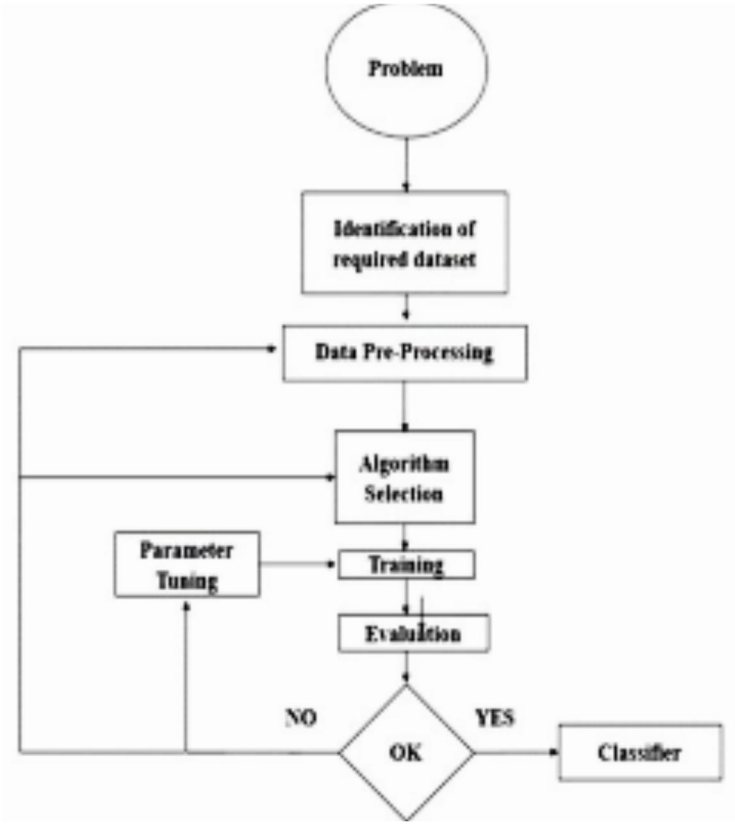

Figure 2: Training and Optimization Flow Diagram.

VI. PROJECT IMPLEMENTATION

Figure 3: Dataset samples for pistol Class- Top left to bottom right [a-d]: (a) CCTV image (b) Medium Resolution Image (c) Image with Dark background and Low Resolution, (d) Filtered Image.

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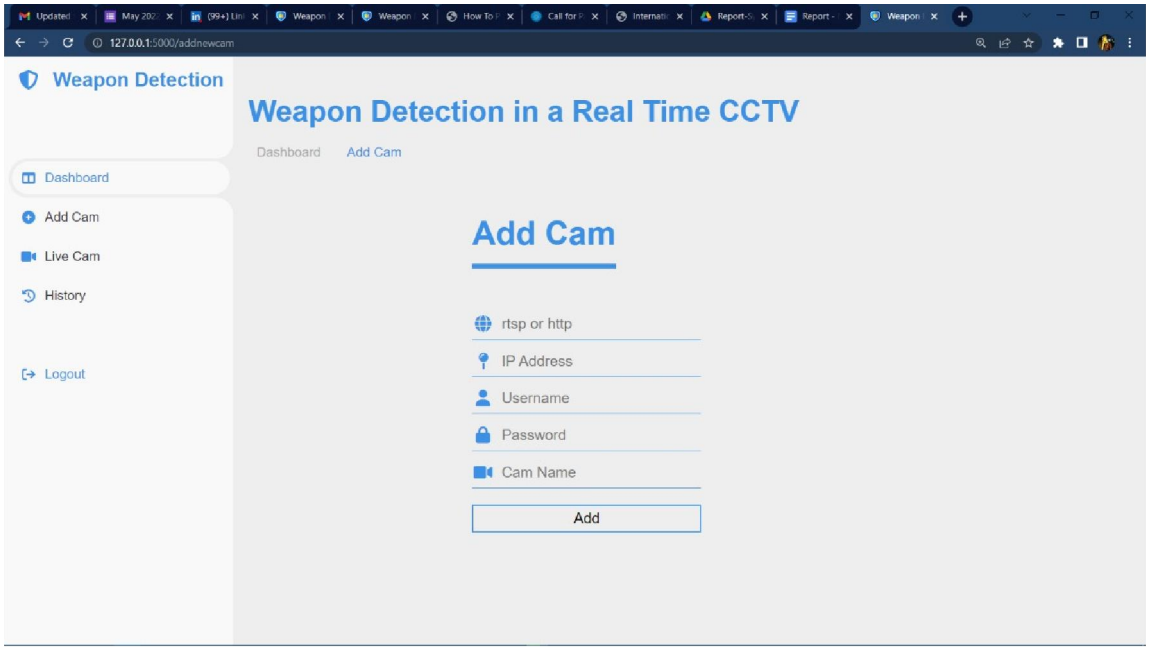

Figure 4: Output

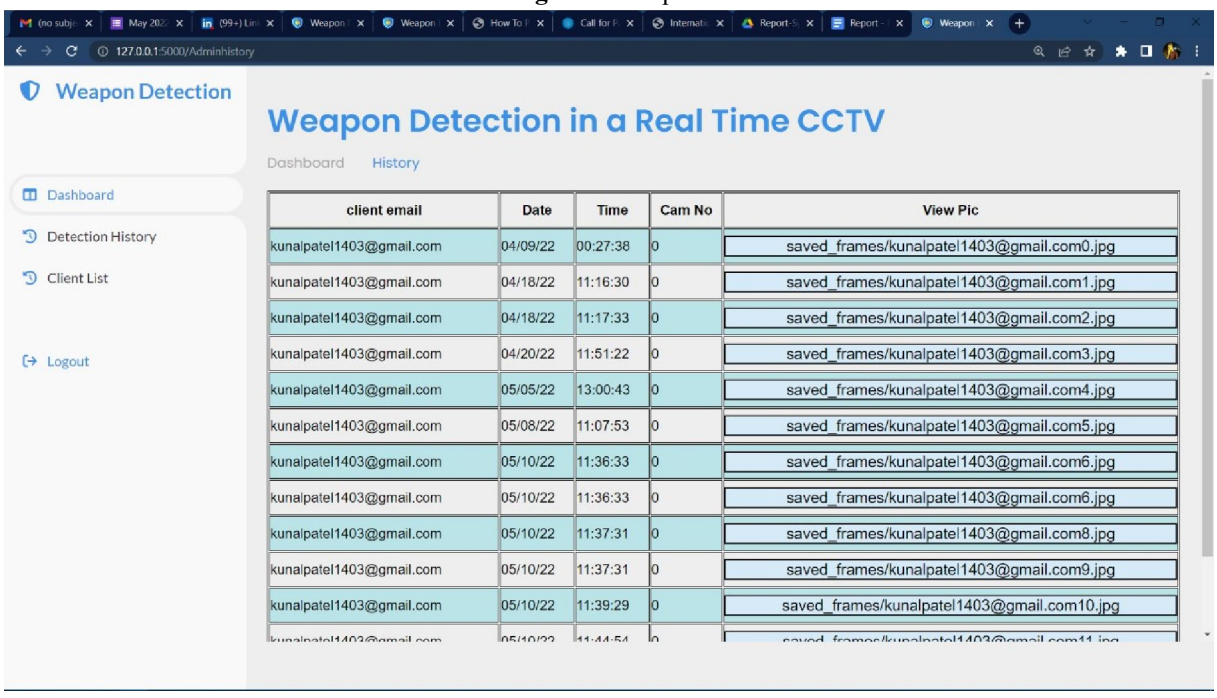

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Figure 5: Output

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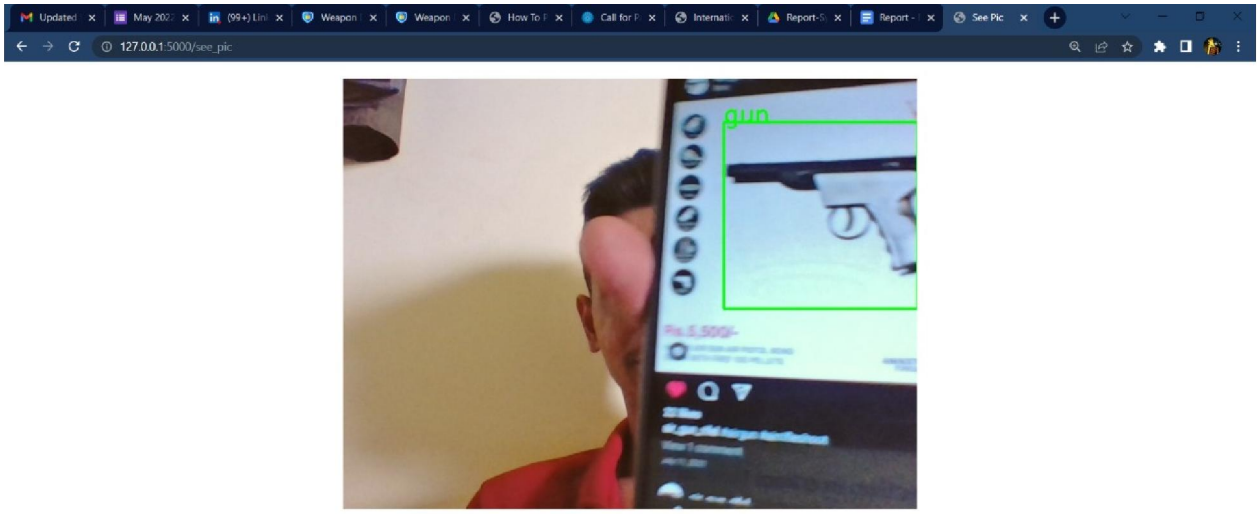

Figure 6: Output

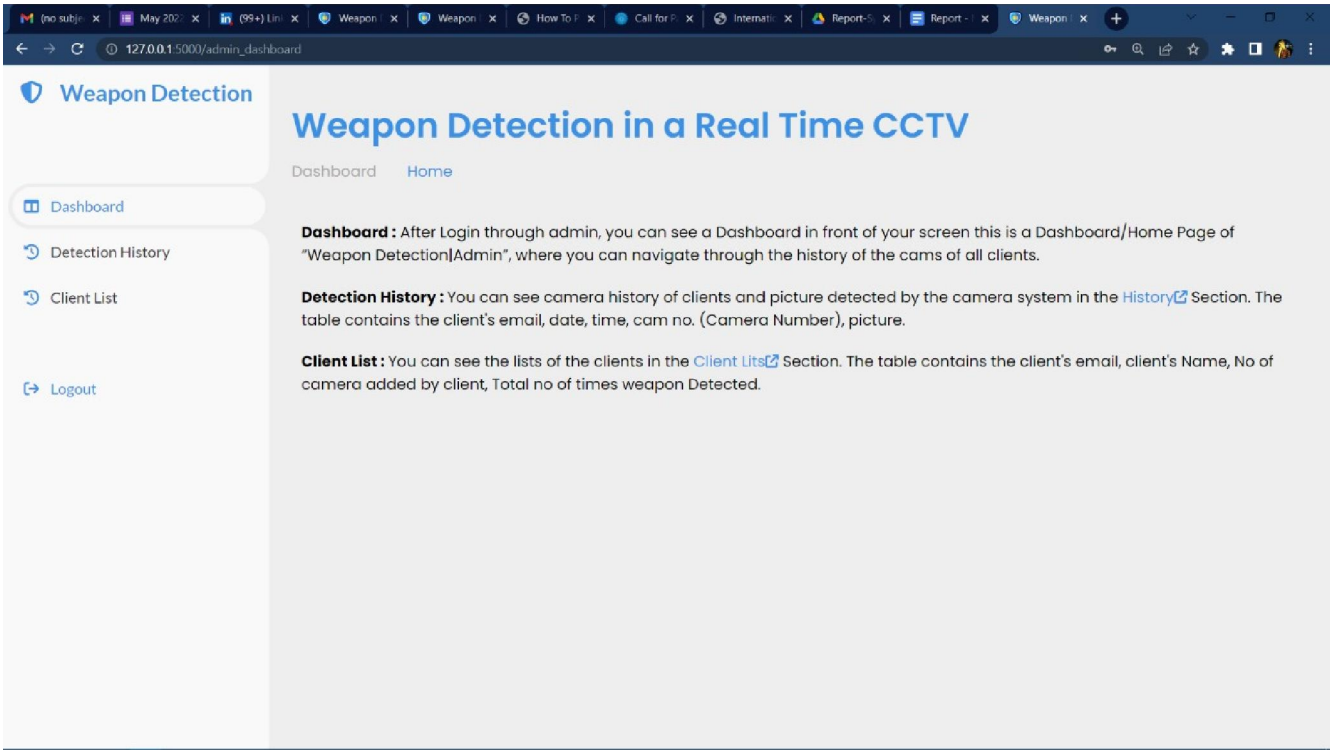

Figure 7: Output

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VII. Advantages and Disadvantages

7.1 Advantages

- Help in improving the security, law and order situation for the betterment and safety of humanity.
- This system will decrease a crime rate occurring due to handheld weapons.
- This algorithm will reduce the false negatives and will provide better effective result.

7.2 Disadvantages

- This algorithm required huge dataset which is used to train the model.
- Unable to detect in videos with very low resolution and with high playback speed.

VIII. Conclusion

For both monitoring and control purposes, this work has presented a novel automatic weapon detection system in real-time. This work will indeed help in improving the security, law and order situation for the betterment and safety of humanity, especially for the countries who had suffered a lot with these kind of violent activities. Two Different algorithms were investigated to get good precision and recall. Through a series of experiments, we concluded that object detection algorithms with YOLOv5 perform better than Faster R-CNN.

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The completion of our project brings with it a sense of satisfaction, but it is never complete without those people who made it possible and whose constant support has crowned our efforts with success. One cannot even imagine our completion of the project without guidance and neither can we succeed without acknowledging it. It is a great pleasure that we acknowledge the enormous assistance and excellent co-operation to us by the respected personalities.

References

[1]. E. M. Upadhyay and N. K. Rana, ‘‘Exposure fusion for concealed weapon detection,’’ in Proc. 2nd Int. Conf. Devices, Circuits Syst. (ICDCS), Mar. 2014, pp. 1–6.

[2]. A. C. Sankaranarayanan, A. Veeraraghavan, and R. Chellappa, ‘‘Object detection, tracking and recognition for multiple smart cameras,’’ Proc. IEEE, vol. 96, no. 10, pp. 1606–1624, Oct. 2008.

[3]. S. Zhang, C. Wang, S.-C. Chan, X. Wei, and C.-H. Ho, ‘‘New object detection, tracking, and recognition approaches for video surveillance over camera network,’’ IEEE Sensors J., vol. 15, no. 5, pp. 2679–2691, May 2015.

[4]. M. Grega, S. Lach, and R. Sieradzki, ‘‘Automated recognition of firearms in surveillance video,’’ in Proc. IEEE Int. Multi-Disciplinary Conf. Cognit. Methods Situation Awareness Decis. Support (CogSIMA), Feb. 2013, pp. 45–50.

[5]. I. Darker, A. Gale, L. Ward, and A. Blechko, ‘‘Can CCTV reliably detect gun crime?’’ in Proc. 41st Annu. IEEE Int. Carnahan Conf. Secur. Technol., Oct. 2007, pp. 264–271.

[6]. I. Darker, A. Gale, L. Ward, and A.Blechko, ‘‘Can CCTV reliably detectgun crime?’’ in Proc. 41st Annu. IEEE Int.Carnahan Conf. Secur. Technol.,Oct. 2007, pp. 264–271