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Weapon Detection using YOLOv4, CNN

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Abstract: A Weapon Detection software is a very efficient way to monitor the streets and alert the operator only when there is a situation where people carrying a weapon like a gun or knife can be detected and analyzed with the help of YOLOv4 object detection algorithm. And the notification of the same will be given via email to the CCTV operator with the photo where people carrying a gun or knife can be seen and also the location of the CCTV. So this will enhance the safety and security of any city with the requirement of limited man power. The proposed paper focuses on different approaches and algorithms that could potentially help in Weapon detection.

Keywords: Weapon Detection, YOLOv4, Google Colab, CNN

I. INTRODUCTION

To monitor and notify only when there's a situation where a person or group of people carrying weapons like gun, rifle or even a knife can be detected and notified via email to the CCTV operator. Using YOLOV4 Object detection algorithm objects can be classified using pre trained custom files trained from google colab, it is free for the public and it can be used for machine learning applications. With the free cloud service and most importantly free GPU with limited hardware requirements we can custom train the files using google colab. CNN is used for Deep learning for object recognition. It achieves excellent object recognition accuracy by using a deep ConvNet to classify object proposals. R-CNN has the ability to scale to thousands of object classes without resorting to approximate techniques and including hashing. These custom trained files can be used to detect specific types of objects in our case, the weapons like guns, pistols, rifles and even a knife. Such objects can be detected and when in a CCTV footage such objects are detected then using the SMTP Library in python an email notification is sent to the CCTV Operator with details such as image of guns and the location of the CCTV camera.

II. LITERATURE SURVEY

Sr. No.	Title	Methodology	Conclusion
1.	Weapon Detection Using YOLO V3 for Smart Surveillance System	In this work, we have attempted to develop an integrated framework for reconnaissance security that distinguishes the weapons progressively, if identification is positively true it will caution/brief the security personals.	In this study, the YOLO V3 object detection to identify the unsafe weapon and can also alert the human administrator, This model was implemented and trained over the collected dataset for weapon detection.
2.	Automatic Handgun and Knife Detection Algorithms	Image segmentation algorithms which include Point, Shape and edge detection. Harris interest point detector and active appearance models are the two main image segmentation algorithms. These algorithms work well when there is high contrast in images.	The detection of handguns and knives algorithms is classified into two major categories namely Non-deep learning and Deep learning algorithms. Non-deep algorithms are heavily depending on the quality of image.
3.	Experiments on Concealed Weapons and Threatening Materials Detection	A low cost high gain MC-AFTSA-SC probe is utilized in imaging and detection. Different images are reconstructed using a mechanical 2D linear scanning platform with a field resolution.	The initial experiment is to elaborate on the idea of concealed weapons behind clothing.

4.	Firearm Detection using Convolutional Neural Networks	In this method automatic detection of dangerous situations in CCTV systems, with the help of image processing and machine learning. Sliding window techniques, fuzzy classifiers and canny detectors were used for detection of knives and firearms in a video	This work demonstrated the feasibility of using CNN's to create a generic firearm detector. The method used proved to be robust and able to correctly detect weapons that were not presented during the training (different models and in many environments). The dataset constructed for this work proved sufficient variation to allow
			the system to be able to understand the concept of a firearm.
5.	Concealed Weapon detection Using	Many techniques have been developed to improve the quality of MMW images in this	Imaging techniques based on a combination of sensor technologies and processing play a key role in
	Digital Image Processing	section, we describe a technique for simultaneous noise suppression and object enhancement and object enhancement of passive MMW video data and show some mathematical results.	addressing the concealed weapon detection problem. Here we reviewed the sensor technologies being investigated for the CWD application.
6.	Weapon Detection in Real-Time CCTV Videos Using Deep Learning	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 domain. 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.	For both monitoring and control purposes, this work has presented a novel automatic weapon detection system in real-time. Different algorithms were investigated to get good precision and recall. We concluded that object detection algorithms with ROI (Region of Interest) perform better than algorithms without ROI.
7.	Concealed Weapon Detection : A Data fusion perspectiv	The core of CWD is the capacity to detect and recognize weapons. The CWD sensor and display system must have the capacity to separate the weapons from other objects and items. Segmentation of imagery, clustering, and thresholding techniques will contribute to this process.	There are defined homogeneous featural characteristics of pixels such as intensity that could be used. Segmentation of imagery, clustering, and thresholding techniques will contribute to this process

III. ALGORITHMS

After reviewing the literature, we found that for weapon detection two main algorithms were used. In this section, we are discussing those algorithms.

A. YOLOv4 Algorithm

YOLOv4 is a real-time object detection algorithm that stands for "you only look once" identifies specific objects in videos, live feeds, or images. YOLO uses features learned by a deep convolutional neural network for detecting an object. YOLOv4 is an upgraded version of YOLOv3. It is a real-time object recognition system that can recognize multiple objects in the single frame. YOLO is also known for its speed. As speed and accuracy are inversely proportional. Accuracy remains still in the area of development. But in YOLO v4 the accuracy rate has also been improved. It can predict up to 9000 classes and even unseen classes. The real-time recognition of system will recognize multiple objects from an image and also make a boundary box around the object. It can be easily trained and deployed in a production system. YOLO is based upon a single Convolutional Neural Network (CNN). The CNN divides an image into regions and then it predicts the boundary boxes and probabilities for each region. It simultaneously predicts for multiple bounding boxes and probabilities for those classes. YOLO sees the entire image during training and test time so it implicitly encodes for corresponding information about classes as well as their appearance.

YOLOv4 is almost twice as fast as EfficientDet (competitive recognition model) with comparable performance. In addition, AP (Average Precision) and FPS (Frames Per Second) increased by 10% and 12% compared to YOLOv3.



Fig 1: YOLOv4 Object Detection Algorithm

B. Harris Corner Detection Algorithm

Harris Corner Detector is a corner detection operator that is used to extract corners and infer features of an image. Corner can be interpreted as the junction of two edges, where an edge is sudden change in an image brightness.

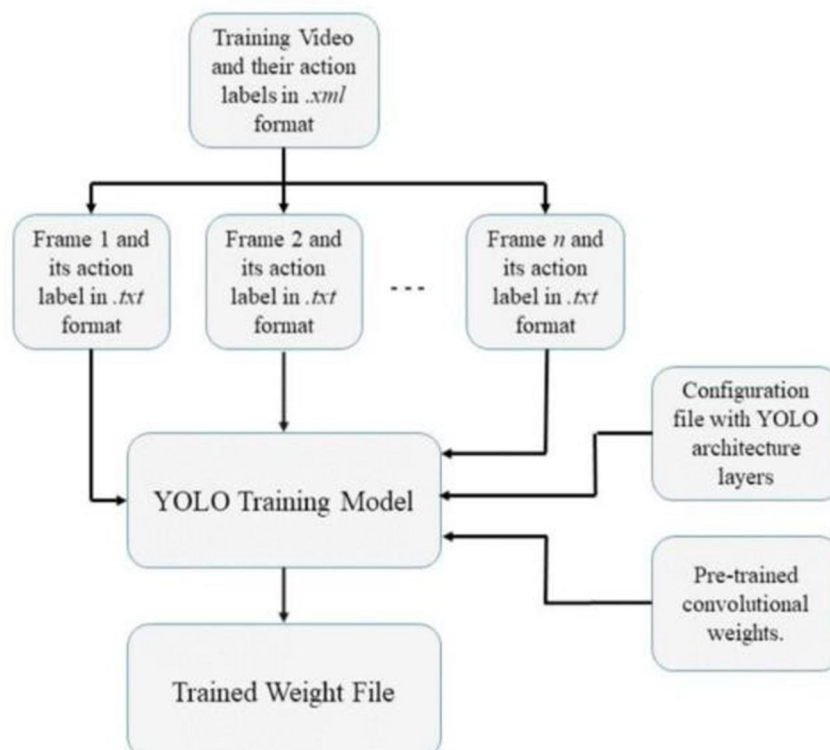


Fig 2: Harris Corner Flowchart

The steps for detecting corners are

- 1) Converting the color image into grayscale
- 2) Calculation of spatial derivative
- 3) Setting up tensor structure
- 4) Calculation of Harris response
- 5) Non-Max suppression to consider only the closet one

It is a single point feature extraction algorithm. It is the difference in intensity of all the directions for a displacement of (u, v), can be shown in equation.

$$E(u, v) = E_{xy} w(x, y) [1(x + u, y + v) - 1(x, y)]^2$$

Here, window function can be a gaussian window giving weights to pixels underneath or a window which is rectangular. For corner detection $E(u, v)$ must be maximized and this can be done by applying Taylor Expansion which will give us final equation stated as equation 2 and 3.

$$E(u, v) \approx [u \ v] M [u \ v]^T$$

$$M = \begin{bmatrix} I_x I_x & I_x I_y \\ I_x I_y & I_y I_y \end{bmatrix}$$

Here I_x and I_y are the derivatives of image in (x, y) and finally we measure the corner response as equation 4 $R = \det(M) - k(\text{trace}(M))^2$

$$\text{Where } \det(M) = I_x^2 I_y^2 - (I_x I_y)^2$$

A_1 and A_2 are the eigen values of M k is a constant

C. CNN (Convolutional Neural Network)

CNN stands for "Convolutional Neural Network" and is largely utilized in image processing. The number of hidden layers employed between the input and output layers determines the CNN's strength. A set of features is extracted by each layer. A series of filters are applied to the input to create feature maps. Each filter multiplies its weights by the input values after going over the full input. The result is sent to a Rectified Linear Unit (ReLU), sigmoid, or the activation function. The set of weights is evaluated using a loss function. The feature maps that the filters produce highlight various aspects of the input.

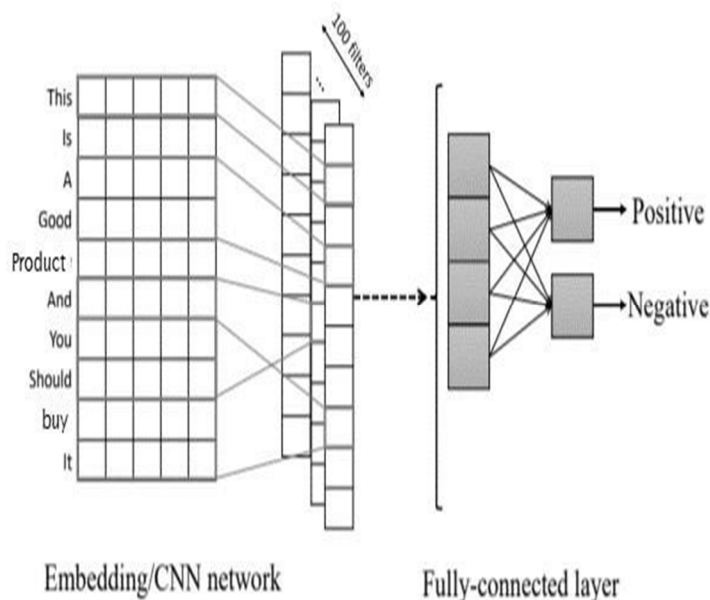


Fig 4: CNN Model

Even though CNN is commonly utilized in image and video processing, recent approaches to NLP utilize CNN. A pre-processing step in NLP converts the text input to a matrix representation. Sentence characters are used as rows, and alphabet letters are used as columns, in the matrix form. In NLP, a filter is slid across the matrix's words. As a result, the words are detected using the sliding window technique.

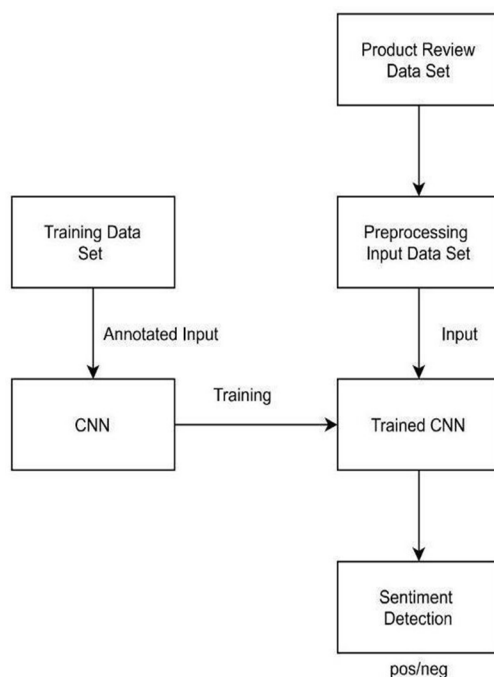


Fig 5: Basic Architecture of CNN

IV. CONCLUSION

YOLO is a futuristic recognizer that has faster FPS and is more accurate than available detectors. The detector can be upskilled and used on a conventional GPU which enables extensive adoption. New features in YOLOv4 improve accuracy of the classifier and detector and may be used for other research projects.

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