Deep Learning Based Model for Fire and Gun Detection

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Abstract. Real-time object detection is one of the most important applications for surveillance and a prominent computer vision task. This paper proposes a new deep learning-based model for fire, pistol, and gun detection in areas monitored by cameras like home fires, industrial explosions, and wildfires, as they happen frequently and cause adverse effects on the environment. Gun violence and mass shootings are also on the rise in certain parts of the world. Such incidents are time-sensitive and can cause a huge loss to life and property. Hence, the proposed work has built a deep learning model based on the YOLOv5 algorithm that processes a video frame-by-frame to detect such anomalies in real-time and generate an alert for the concerned authorities. Our model has validation with more speed and more accurate manner. The experimental result satisfies the goal of the proposed model and also shows a fast detection rate.

Keywords: deep learning · computer vision · fire detection · pistol detection · gun detection · YOLOv5

1 Introduction

Object detection is a computer vision task that involves predicting the presence of one or more objects, along with their classes and bounding boxes. The object detection has attracted an increased amount of attention in recent years due to its wide range of applications. This mission is subject to extensive investigation both in academic domain and in real-world applications, such as security monitoring, autonomous driving, transportation monitoring, drone scene analysis, and robotic vision [1]. The main purpose of object detection is to indicate, classify and locate the location and type of object in images or videos [2]. There are other purpose of object detection is to detect all states of objects of a known class, such as cars, people, or faces in an image [3]. Fires and guns hit many people and cause damage to their properties in the whole world. Thus,

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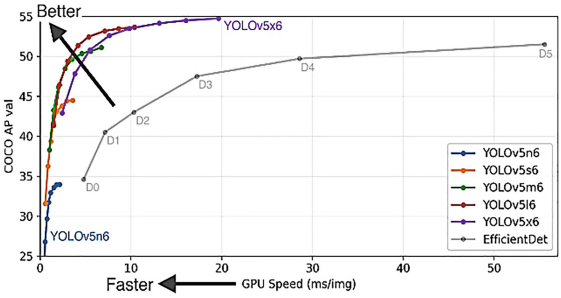


Fig. 1. YOLOv5 (Source [12])

to prevent such loses we need accurate systems to detect the fires and guns early in private and general places. Forest fires are occur always in different countries and cause tremendous damages. Crime rates caused by pistols and guns' fire are increasing as ones of the most common disasters that threaten the world at the present time [5]. The latest statistics reported by the United Nations Office on Drugs and Crime (UNODC) reveal that the number of crimes involving firearms per 100,000 inhabitants is very high in many countries, for example, 21.5 in Mexico, 4.7 in the United States and 1.6 in Belgium [6]. It is very imperative to reduce this type of violence through early detection of guns and pistols' fire.

YOLO "You only look once" is one of the modern and most popular and preferred algorithms for artificial intelligence engineers as object detector that can perform real-time object detection with good accuracy [4]. It has always been the first preference for real-time object detection [7] as one of the finest family of reveal models with start of the art. YOLO algorithm splits images into a grid system. Each cell in the network is responsible for discovering things within itself. The series of YOLO was introduced in May 2016 by Joseph Redmon who released YOLOv1 [8], as one of the biggest advances in real-time object detection. In December 2017 joseph introduced second version which was known as YOLO 9000 [9]. After one year in April 2018 new version called YOLOv3 was released by Joseph and his partner, which was considered as the most popular and stable version [10]. Finally, in April 2020 Alexey Bochkovskiy introduced YOLOv4 [11] with additional amazing features. YOLOv4 outperforms YOLOv3 by a high margin and also has a great deal of average accuracy when compared to the EfficientDet family. After few days on 9 June 2020 Glenn Jocher released YOLOv5. There are a lot of disagreements about the choice of the name "YOLOv5" and other things. Glenn introduced a PyTorch-based version of YOLOv5 with exceptional improvements. Hence, he has not released any official paper yet. This version beats all previous versions and comes close to EfficientDet AP with higher FPS as shown in the chart in Fig. 1.

2 Related Work

There are several valuable research articles and project works in Deep learning-based fire and gun detection in images and videos. This section reviews some of the essential articles and research woks on object detection and fire and gun detection.

2.1 Object Detection Methods

The object detection is the process of locating objects in an image or a frame in video sequence [13]. There are many research articles have published recently that explain the accelerated development in object detection field and its approaches. Ross Girshick et al. [14] have proposed method that combines convolutional neural network CNN with regions called R-CNN. This method was good compared with previous methods. Fast Region-Based Convolutional Neural Network, also called Fast R-CNN, has developed by Ross Girshick [15] as a training for object detection, it has written in python and C++. This method mainly fixed the disadvantages of SPPnet and R-CNN. It has more speed and more accuracy than previous methods. Ross Girshicl et al. [16] have proposed a new algorithm that provides a scalable and simple detection. It has been improved in mAp by 30% more than previous algorithms and achieved 53% of mAp. The authors called their algorithm R-CNN. In [17], Jifeng Dai et al. have presented region-based fully convolutional network for accurate and detect objects efficiently. They proposed position sensitive score maps, the achieved competitive results as 83% mAp on the PASCAL VOC datasets. Their method achieved a speed of 170ms per image. In [18], Wei Liu et al. have presented new approach for detecting objects in image using a single deep neural network, their method called SSD. This method work by sorting the output area of bounding boxes into a set of default boxes at different aspect ratios and scales for each feature map location as a simple method compared to others. The SSD results on PASCAL VOC and COCO datasets for 300*300 input images achieved 74.3% mAp. Joseph Redmon et al. [8] have introduced a new unified object detection approach called YOLO (You Only Look Once). YOLO uses a single neural network on the full image to determine classes' probabilities and bounding boxes in a one-time evaluation. This approach is a very fast real-time object detector that can process an image with a rate of 155 frames/second. The authors claimed that YOLO has less probability of predicting false positives on the image background and has shown better detection results than other traditional methods.

2.2 Fire and Gun Detection

Borberto Olmas et al. [5] has presented a system to detect handgun in videos for surveillance and control purpose, the researchers reformulated this detection problem into problem to reduce and resolve false positives by building core training of data set guided by the results of deep convolutional neural networks (CNN). They evaluated the best classification model under two approaches, sliding window approach and area proposal approach. Their results obtained with Faster R-CNN model. Parth Metha et al. [19] have presented a system to detect the fire and gun in public places monitored by cameras. They used yolov3 object detection method that process video frame by frame to detect objects in videos in real-time and generate alarm for the authorized person. The experimental results satisfied the goal of their proposed model with good accuracy, i.e., a loss value of 0.2864 and 85% accuracy. Sanam Narejo et al. [20] have implemented yolove3 based model to detect weapons which trained on their dataset. The training results has confirmed that yolov3 gave results better than yolov2 and traditional CNN. Zhentian Jiao et al. [21] have proposed algorithm to detect forest fire. They have used

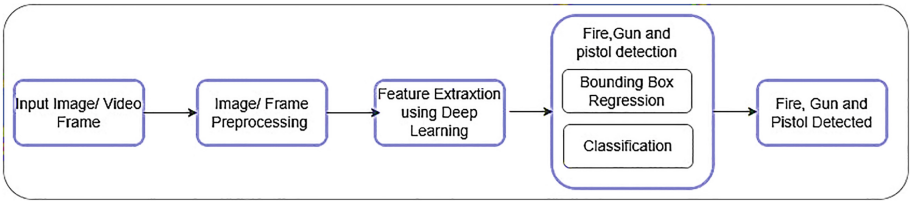


Fig. 2. Fire, gun and pistol detection model

yolov3 and UAV. In their work, CNN has implemented with yolov3 method. The result has given accuracy of 83% and the frame rate of detection was 3.2 fps. Aysegul Yanik et al. [22] have proposed a new machine learning based system to detect forest fire early in low cost and more accurate manner. M.Milagro et al. [23] have presented a system based on faster R-CNN Method. They have compared two approaches as CNN base, a GoogleNet and SqueezeNet architecture. They have achieved results at 85.44% accuracy using squeezeNet and 46.68% using GoogleNet gun and knife respectively. Rana. M. Alaqil et al. [24] have proposed a gun detection system using faster R-CNN model. They have used MobileNet, ResNet, VGG16 and ResNetv2 for feature extraction and compared them with YOLOv2. The results showed that the YOLOv2 is faster than used MobileNet, ResNet, VGG16 and ResNetv2.

3 Methodology

We design a model to detect fire, gun and pistol, based on YOLOv5 object detector. This model works in several stages. It starts by collecting and labelling dataset images for fire, gun and pistol. In this research we used general dataset for fire, gun and pistol, which is available on kaggle [25]. We use YOLOv5 to train our dataset on three classes' fire, gun and pistol. As discussed above. We choose YOLOv5 which is better than previous versions of YOLO. The aim is to train and test dataset to produce new model that can detect fire, gun and pistol in public places such as home fires, industrial explosions and crimes. After model training, our model will be able to detect fire, gun, and pistol by drawing boxes around it and shows the name of object and accuracy of objector. The block diagram of our model for fire, gun and pistol detection is show in Fig. 2. The model starts by receiving image, video or capture live video using dedicated camera. The second step makes reprocessing for input image or frame extracted from video, then do feature extraction from that image depends on deep learning techniques. After detecting the objects which is fire, gun or pistol, the model draws boxes around the detected object. Finally mention the name of the object and the prediction value for the object.

4 Experimental Result

We have trained our model with parameters of YOLOv5 as shown in Table 1.

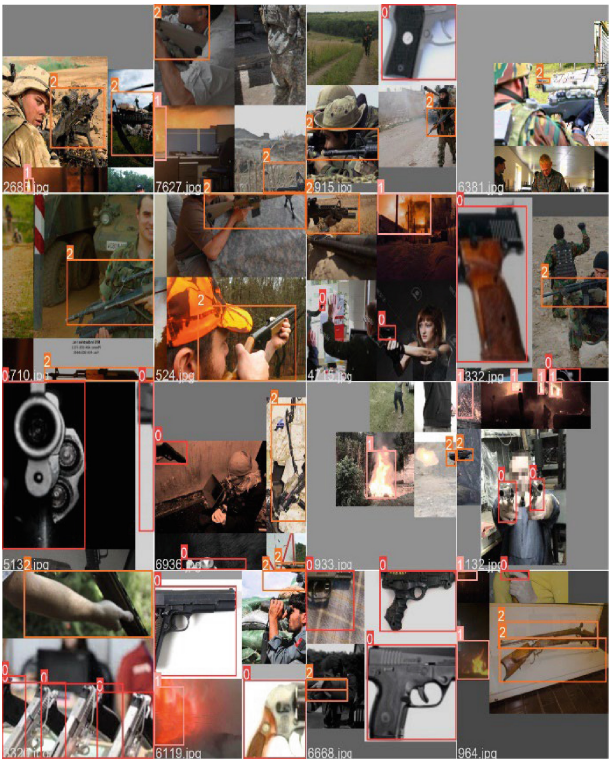
The training results give very good results compared with previous studies. We have used YOLOv5 which is faster and more accurate than previous family series of YOLO.

Table 1. Model Parameters

Parameters	Description
Image Size	640
Batches	16
Epochs	10
Classes	3

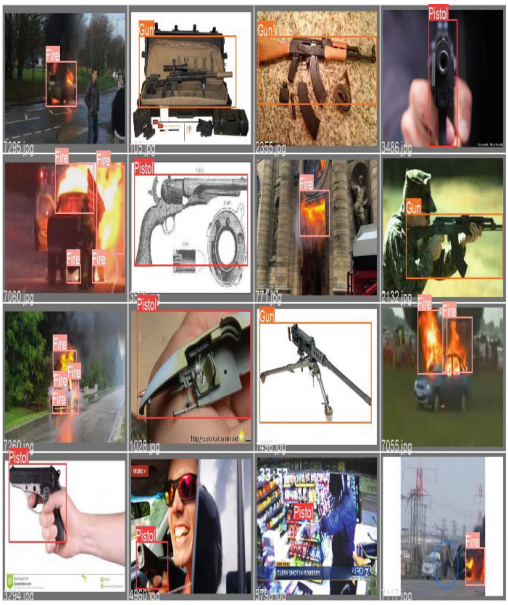
Pistol is represented by label 0, Fire is represented by label 1 and Gun is by label 2. Figure 3(A) presents the training results by showing the number of the class. Figure 3(B) presents the training results by showing the name of class. Figure 3(C) presents the training results by showing both the name of class and the prediction value.

The following charts in Fig. 4 were produced after training YOLOv5 with input size 640x640 on the fire, gun and pistol dataset for 10 epochs.



(A)

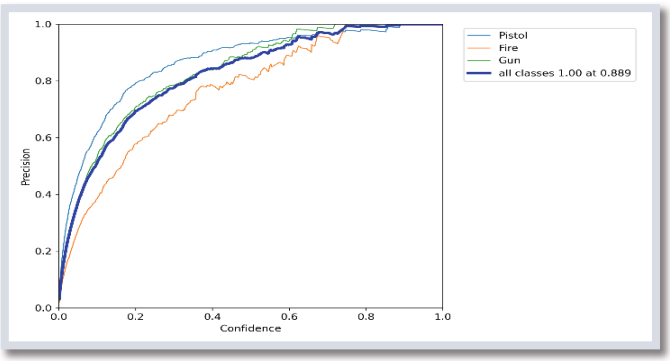
Fig. 3. Training results, (A): with the number of the class, (B): with the name of the class, and (C): with the name of class and the prediction value.



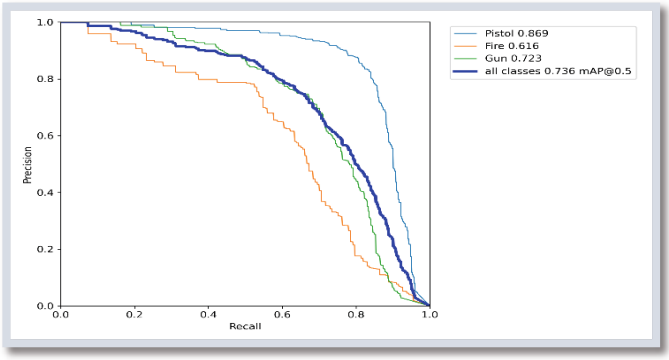
(B)

(C)

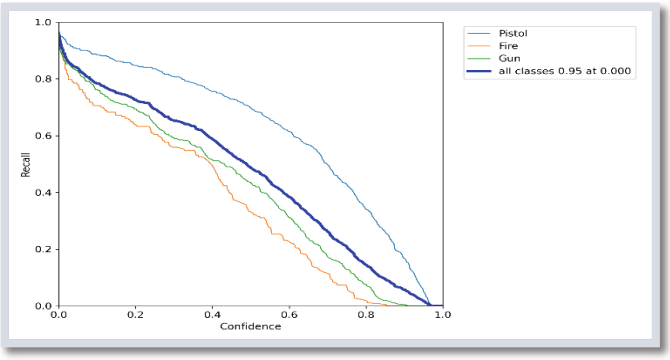
Fig. 3. (*continued*)



(A) P Curve



(B) PR Curve



(C) R Curve

Fig. 4. P, PR and R Curves of YOLOv5 trining

The fire, gun and pistols detection results were fairly good even though the model was trained only for a few epochs.

5 Conclusion

In this paper, a YOLO-based model is introduced for detecting fire, pistol, and gun in the real-time. This deep learning-based model is very useful for arears covered by the cameras including industrial areas, forests, homes, etc. to reduces damage, prevent property loses, and save human life. YOLOv5 algorithm has been utilized in this model, where the videos' frames are process and analysed in order to identify one of the three anomalies: fire, gun and pistol. Then, it generates a real-time alert so that preventive actions can be taken by the concerned authorities. The validation results showed the higher accuracy and speed of the provided model compared the existed ones.

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