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Low Costweapon Surveillance System Using Yolor

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ABSTRACT: Everybody at all the times, need the maximum possible security in all possible ways and in all situations. In this digitally transforming world, security is a main concern and that is been served from different aspects. One such aspect is use of surveillance systems. In general, Security sytems(mostly of cameras) serves basic purposes for buildings and public places. But, most of the system architectures that are designed for serving schools, homes and various public places are lacking of advanced features like weapon detection system which are very much needed in this armed world .Our aim is to make a low cost integrated surveillance system with advanced features like weapon detection system using the modified version of latest algorithm like YOLOR in such a way that it becomes more compatible and more lighter.Thus, more advanced systems like weapon detection systems can be incorporated into the society for better security. Through this research, we are trying modify YOLOR algorithm which improves ease of use of algorithm and which can be used in microprocessors like RaspberryPi, using minimum possible resources with no much impact on the performance of algorithm and helps to achieve minimal cost possible.

KEYWORDS: Raspberry-Pi, Machine learning, Camera, Surveillance, Weapon Detection System ,Yolo, YoloR

I. INTRODUCTION

Weapon violence is a very important issue in terms of safety in the world. The basic human right is in danger by this weapon violence. According to the statistics, the death proportion because of weapon usage is around 500 individuals every day[3]. According to the National survey on Crime Victimization in 2011,around 467,321 persons are sufferers of a crime committed with a firearm. According to FBI in 2011, every 68 of 100 murders, 41 of 100 robbery offenses and 21 percent of aggravated assaults nationwide use firearms(source: nij.ojp.gov). There are 44 assassinations out of 100 are occurring frequently, which involves violence with weapons worldwide. In the mid of 2012 and 2016, more than 1.4million people's deaths were recorded on firearms violence [3]. Surveys and studies exhibit that having a surveillance system improves reduction of about 50% in crime rate. With the extra benefit of experience, one will have valid evidence of criminal activity if happened. These systems can also be used to alert individuals in real time. Smart surveillance is commonly used for monitoring as protection against theft, dishonest employees, burglaries as a pre-active measure. Event video surveillance is also used for crowd control as well as plays major role in prohibiting crimes. According to a study from the University of North Carolina's Department of Criminal Justice Criminology, Cameras play vital role in security, as 60% of burglars will choose another target if they find surveillance or security systems such as alarms or cameras. For crimes, where surveillance systems are active, the chance of prohibition is much higher. With advanced technology like weapon detection systems, facial recognition, in security cameras the scope of better identification of known and unknown people which indirectly alerts and inform prior to any incident to occur.

II. PROBLEM STATEMENT, IDEA ANDMOTIVATION

Smart home security systems like auto door locking and unlocking, fire alarm systems, face recognition system etc.,were available and in use. We have high security systems for office access such as profile based access, fingerprint access etc,.Weapon detection systems are mostly seen and used in highly populated places like airports, railway stations, vip office buildings etc., which are way costlier. But, when security systems used for home, schools and public places are considered, the feature improvements and advancement is lacking. The systems are not updated in advancement of features and better combinations to provide optimal

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functionality and use. Algorithms which are powerful and also heavier such as YOLOR is loosing its usability due to resource consumption, memory consumption (in terms of size also) and processing power.Its big in-terms is halting the use of yolor in micro systems and many others alike. The story of yolov5 best gives the importance of usability and time and memory usage.The efficiency of algorithms not only depends on the metrics such as accuracy, precision, or recall alone but also depends on the usability or ease-of-use to user. So, this research, for experiment uses raspberrypi to achieve objective in low cost.

III. RELATED WORK

A. NEURAL NETWORK BASED MODELS

YOLO SERIES :Yolo is one among those algorithms that are fastest out there to detect objects. Although accuracy is slightly effected for object detection, in real-time , yolo gives the results without losing too much precision. YOLO is a very good choice in real-time if it is live feed. It uses a single convolutional neural network(CNN) to predict class probabilities for the multiple bounding blocks or boxes at the same time[9]. YOLO algorithms have a variety of limitations corresponding to detection. Error analysis performed on YOLO when compared with Fast R-CNN showed that, YOLO made significant number of localization errors[10], but can be better when used as combination with other techniques such as YOLO9000. YOLO algorithms solve real-time problems like public security, monitoring traffic and also assisting visually impaired people etc.,.[16]

i. YOLOv1 - The main idea of YOLOv1 is to use entiregraph as input and directly navigated to category and location of bounding box in output layers. Comparing with many algorithms the yolo is very fast[5]
ii. YOLOv2 - YOLOv2 is state-of-the-art and faster than itsprevious version and also other detection systems[10]. Some features like high-resolution classifiers, batch normalization, convolutional anchor boxes, dimension clusters and Darknet19 network are highlights of this algorithm[5]. With the increase in use of autonomous vehicles, smart surveillance, recognition techniques and number of tracking applications, the need for rapid and accurate detection systems is rising. Object detection can be classified as a problem of classification problem. In object detection, all possible locations of taken gaps of constant sizes from the input image or object to feed these gaps into an classifier.[9]
iii. YOLOv2 + YOLO9000 - YOLO9000 framework ismade for identifying about 9000+ categories of objects by combinely standardizing detection as well as classification tasks. Even though some yolo series algorithms suffer with accuracy problem slightly, but some models like YOLOv2 works better and fast when are combined with some frameworks like YOLO9000. This particular work combined real time object detection models like yolov2 with yolo9000 framework and trained data jointly for both detection and classification[10]
iv. YOLOv3 - YOLOv3 is a detection algorithm in realtime that identifies specific objects from images, recorded video clips, live feeds from camera's and more..Theregiondependent convolutional neural networks(RCNN) algorithm, needs number of network evaluations for making predictions on an image which is a more time-consuming task and optimization is also difficult. It takes whole image into one object and predicts edging box, it's coordinates and also class probabilities [12].
v. YOLOv4 - YOLOv4 YOLO is at its top notch, withits super speed detection. Unlike previous algorithms that scan pictures with a sliding window, YOLO passes the entire image through a convolutional neural network in one run and predicts the result. [12]. When state of art models, YOLOv3 and YOLOv4 are compared, YOLOv4 performs much better than YOLOv3. The version 4 is superior to its previous version in terms of precision and time of processing [3].
vi. YOLOv5 - Unlike older versions of YOLO algorithmwhich have been developed using Darknet research framework and also the first version of YOLO which is developed in framework called PyTorch. This framework is more flexible to configurations. YOLOv5 a little faster than it's previous version which is built on same library [8].

B. CONVOLUTIONAL NEURAL MODELS

vii. RetinaNet, Faster R-CNN and YOLOv3 - The three neural techniques, retinaNet, faster R-CNN and yolov3 are compared and analyzed the influence of fine-tuning using a backbone network for RetinaNet model. RetinaNet, which was trained on data without pose information using unfrozen backbone, performed well in terms of accuracy (96.36 percent) and recall (97.23 percent). The maximum of recall (97.23 percent) and accuracy (96.23 percent) were attained by RetinaNet and YOLOv3, respectively. By training on data that included explicit posture information, YOLOv3 was able to enhance the evaluation measure with increased precision of 1.44, recall of 1.78, recorded an improvement in F1 score of 1.62 and AP by 1.60[7]

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vii. Faster R-CNN and YOLO - The considerable changes done in YOLOv3 network in order to absorb it to the characteristics of satellite. Here training the network using a dataset consisting of satellite images and using K-means algorithm the anchor points are chosen. The bounding blocks are generated from the anchor points chosen[8].

TABLE I. RESULT SUMMARY

Methodology	Result
YOLO SERIES	All the referenced papers discussed about the yolo series and depicted different versions of the yolo algorithms, their evolution, their mechanisms and work flows. Of all the versions YOLOV5 is latest and best in class
Faster R-CNN, RetinaNet, YOLOv3	RetinaNet by unfrozen backbone without pose information, 1. 1.precision (96.36%) 2. 2.recall(97.23%) RetinaNet and YOLOv3 achieved 1. highest recall (97.23%) 2. precision(96.23%). YOLOv3 with pose information improved by given units below, 1. precision - 1.44 2. recall - 1.78 3. F1 - 1.62
Faster R-CNN and YOLO	Modified YOLOv3 combined with Faster R-CNN performed well than regular version

IV. PROPOSED METHODOLOGY

Now the use of advanced systems are been neglected as an act of unnecessary measure in improving the safety for public places and high rise buildings. But the statistics state that, there is a rise in number weapon attacks in public level.Regular weapon detection systems like thermal based scanners, X-ray are heavy in terms of installation and use.They are much costlier to be used by a household consumer or organisation. Now to overcome this problem,we need to update the systems with advanced algorithms like You Only Learn One Representation(YOLOR).

A. Multimodal unified network

YOLOR implements the implicit and explicit knowledge to the model training at same time so that it will learn a common representation and execute various tasks through that representation. The implicit knowledge can be modeled by vector z, neural network Wz, or matrix factorization ZTc, through the kernel space alignment, refinement of prediction and multi-task learning. Implicit learning with all these techniques is integrated into explicit learning enormously improve the generalization ability and performance of model[5].Fig1 shows the sample flow of yolor architecture and how its been accomplished.

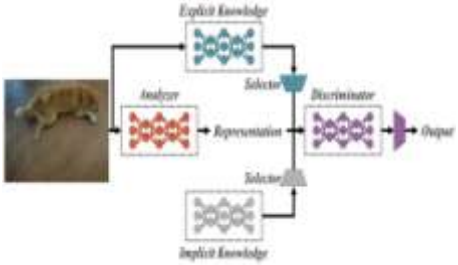

Fig1.YOLOR-Multimodal unified network

The results obtained shows that when implicit-knowledge fused into the neural network and combined with explicit knowledge, it is benefited in performing of all tasks. The analysis on implicit representation that is learnt from unified network proposed, showed impressive capability in grabbing the common physical definition of various tasks[6].

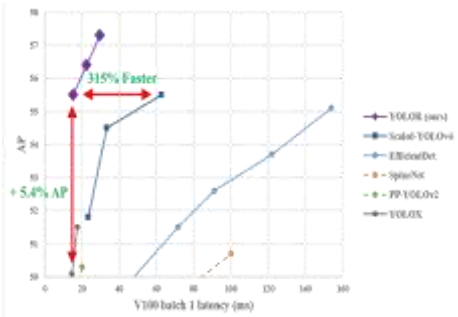

Fig2.YOLOR vs OTHER ALGORITHMS

The Fig2 shows, the supremacy of YOLOR with various other algorithms. As a test, when validated with other detection methods on COCO dataset, the mAP of YOLOR is 3.8 percent more than PP-YOLOv2 at the equal inference speed. The inference speed has been improved by 88% at the same accuracy when compared with Scaled-YOLOv4-P7[5].

The stats ultimately depicts the processing power, speed of detection, frame rate, MAP details and positives than other algorithms of YOLOR. This capability also comes with heavy dependency installations, heavy libraries and massive use of hardware and software resources. These massive amounts decreases the usability of algorithm across the platforms and micro systems. Since, there will always be need for improvements, this project aims to design a lighter version of efficient algorithm YOLOR. Our project design contributes to make algorithm that is lighter in terms of resource consumption.

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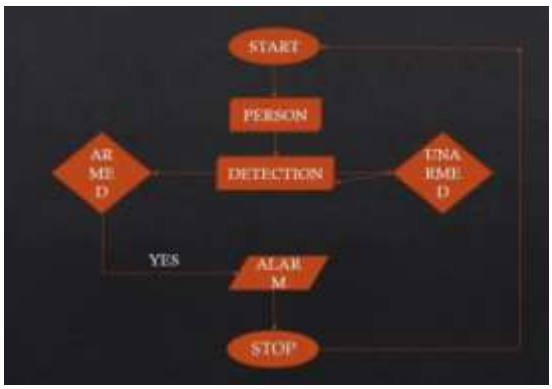

Fig3. Process Flow

Our proposed methodology aims to design a integrated surveillance system as mentioned in Fig3. The scaled version of algorithm flow starts to identify a person. While the person is in frame it starts identifying the objects he/she carries such that there is an alarm sounding occurring if the person is armed. If the person approaching or entering the house has no armed traces, it will just specify about the presence of person. This whole process flow which includes some hardware parts like raspberrypi, speaker and a camera module is powered with the modified version of YOLOR. The figure4 below, shows the whole hardware setup of system.


Fig4. System Setup

We for this research, prepared a custom weapon dataset in yolov5 format and use it as part in training weapon detection system by customized yolor.The results seen in Figure5 is obtained with the augmented data.


Fig5. Test Results(Augmented Data)

We have used the pre-trained weights of yoloR-p6. If we compare the metrics that are obtained through this research, with the original research paper of YOLOR, there can be a difference seen in the categories of recall, precision and mAP. If we take the best training result that obtained this research and compare it with the official research paper of the algorithm, there is an improvement in the metrics and also, decrease in the loss of data. The figure6 below shows the detection of weapon, ainference detection results.


Fig6. Results

The table 2 below is showing, the comparitive result between the original yoloR research paper result and our research result.While at 50 epochs yoloR with coco dataset with no augmentation gave 70.6% of AP while our research experiment delivered about 87.53% of AP.From the table its clearly been observed that the research result that is obtained is better than the existing version in it's respective category.

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Model	Size	AP50
YOLOR-P6 (from official paper)	1280	70.6%
YOLOR-P6 (our research result)	448	87.53%

Table 2. Comparative Result

V. CONCLUSION

Through this research, we found that, research related to improvement of safety using different kinds of security systems and methodologies is been carried out extensively.On the custom weapon dataset, the algorithm returned better performance in metrics when compared to the official experiment on COCO dataset that was explained in official yoloR paper. Even though the accuracy of existing systems are nearer to perfection, there is still scope to improve them in terms of speed, refresh rates, ease of use and resources consumption. This research is an exclusive study of the current algorithms including state-of-art algorithms like yolo and also the combination of them with neural network models.

Through the surveillance systems most of the crimes and thefts are prohibited. The aim is to develop a low-cost integrated system which is advanced in-terms of features and speed. The system is designed in such a way that upgradation of existing systems along with the integration. This project tries to make the existing systems better with latest algorithms like YOLOR.

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