IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Helmet Detection System Using YOLOv5

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***Abstract*—A helmet detection system is a computer vision technology that can be used to ensure the safety of workers in various industries where helmets are required, such as construction, mining, and transportation. The system uses artificial intelligence algorithms to analyze images or videos and identify the presence of a helmet based on its color, shape, and texture. The detection system can also differentiate between different types of helmets, such as hard hats and motorcycle helmets.The primary objective of a helmet detection system is to reduce the risk of accidents and injuries caused by workers not wearing helmets. This system provides real-time feedback to workers who are not wearing helmets, reminding them of the importance of wearing one, and ultimately leading to better compliance with safety regulations. Overall, a helmet detection system is an essential tool for ensuring the safety of workers in hazardous environments. It provides an automated and accurate method for detecting the presence of helmets, leading to better compliance with safety regulations and ultimately reducing the risk of accidents and injuries.**

Keywords*—Helmet detection,YOLOv5 model ,Deep learning,Real-time ,Object detection,Road safety,Neural network,Processing time ,Efficiency,Head injuries

I. INTRODUCTION

Throughout the years in many countries scooter or motorcycle accidents have been increasing at a huge pace. Due to many social and economic factor as well as cheaply available with less transportation time in compare to car this type of vehicle is preferred highly.To keep the motorcyclist safe from fatal accidents while traveling in this vehicle "Helmet" is the main safety.Although there are many other protection gear for bike and motorcycle but helmet is considered very important as helmet are generally preferred to keep the main and part of human body safe that is Human Brain(Skull).In the case of accident if rider do not wear a helmet that accident could be fatal .This paper aim to propose a system which detects the rider/motorcyclist which do not wear helmet. Today, motorcycles are the most popular means of transportation. While it is highly desirable for cyclists to wear helmets, helmet use is often neglected by riders around the world, leading to accidents and fatalities. To combat this problem, most countries have laws that require cyclists to wear helmets. In addition to the law, there is a sizable portion of police who discourage this behavior by issuing traffic tickets.Currently, this process is manual and cumbersome. The proposed system aims to solve this problem by automating the process of detecting drivers driving without helmets.This system uses the pretrained weights of datasets and is implements the test on real time video.

According to the Ministry of Transport, about 28 cyclists die each day in 2016 for not wearing a helmet. In 2017, 31 out of 100 people died in road accidents, and in 2005, he increased his fatality rate to 21.6 per 100 accidents. There are 1.4 million traumatic brain injuries (TBI) in India each year.About $76.5 billion is spent treating these injuries Over 50,000 people have died from her TBI. The proposed system aims to provide cyclists with complete safety.Wearing a helmet has become compulsory recently, but there are still people who do not wear a helmet. The number of deaths is increasing every year, especially in developing countries. Therefore, with public safety in mind, there is a need for an automatic helmet recognition mechanism that can extract the license plate of people not wearing helmets on the street. This type of automation is intended to help administrators issue tickets for helmet violations more efficiently and ultimately prevent violations by cyclists.

Motorcycles are a very popular means of transportation in almost every country. Recognizing the utility of helmets, governments criminalized driving without helmets and implemented manual strategies to catch offenders. However, existing methods based on video surveillance are passive and require significant human assistance. In general, such systems are not viable due to the involvement of people that become less efficient over time. Automating this process is highly desirable for reliable and robust monitoring of these violations, and also greatly reduces the manpower required. Also, many countries have installed surveillance camera systems in public places.

II. Literature Review

"Helmet Detection under the Power Construction Scene Based on Image Analysis"[1] in this paper author Bo Yang,et al. presents the technologies designed for the electric power construction system to detect whether workers wear helmets correctly or not . The YOLOv3 objective detection algorithms were used for fine-tuning the datasets for the electric power construction scene which is made by themselves. ."Automated Helmet Detection for Multiple Motorcycle Riders using CNN"[2]in this paper author Sanjay Chatterji,et al. explained the proposed approach. At the first stage, motorcycle riders are detected using the YOLOv3 model which is an incremental version of the YOLO model, the state-of-the-art method for object detection. In the second stage, a Convolutional Neural Network (CNN) based architecture has been proposed for helmet detection of motorcycle riders. "Design and Implementation of Safety Helmet Detection System Based on YOLOv5"[3] in this paper author Qun Hou, et al. proposed a helmet detection algorithm based on YOLO v5 proposed, which can realize real-time detection of helmet wearing. The deep learning part uses the K-means algorithm to cluster the dimensions of the target frame, and Yolov5s.pt is used for deep learning training. "Safety Wearing Detection Based on Image Processing and Deep Learning"[4] in this paper author Wei Zhang,et al. have developed a system for detecting the helmet of workers working in the steel factory.For this they have used manual labeling and faster-RCNN.Collected many pictures of people wearing helmet and not wearing helmet and tagging,training and testing them manually."Helmet Detection using Single Shot Detector"[5] in this paper author Vignesh Raj A G ,et al. presents the open-source TensorFlow architecture and SSD algorithm which is a widely used algorithm. It is a deep neural network model which can do both image segmentation and classification in a single Execution. The SSD dataset is used to learn about the helmet's features in the current dataset, which saves time and computing power.

III. Methodology

There are many methods and algorithms availabe for object detection like convolution neural network(R-CNN,Region Based Convolution Neural Network),Fast RCNN,YOLO(You Look Only Once).Our method uses the YOLOv5 model for object detection.

A. *What is YOLO ?*

YOLO(You Only Look Once) actually works on CNN.Yolo is the state of art objet dectection ,first sliding window object detection was used, then many fast algorithm were invented RCNN , fast RCNN , Faster RCNN then YOLO was invented which outperformed all the previous algorithm. YOLO (You Only Look Once) is a state-of-the-art real-time object detection algorithm that was first introduced in 2016 by Joseph Redmon, Santosh Divvala, Ross Girshick, and Ali Farhadi. YOLO operates on an entire image at once, and it divides the image into a grid of cells. For each cell, YOLO predicts a fixed number of bounding boxes and their corresponding class probabilities. The algorithm then uses non-max suppression to filter out overlapping boxes and outputs the final detections with their corresponding confidence scores.YOLO has several advantages over traditional object detection algorithms. It is very fast, achieving real-time performance on a GPU. It also has a single-stage architecture, which makes it simpler and easier to optimize. Finally, it performs well even on small objects and objects with low contrast, thanks to its multi-scale feature extraction.

B. *How YOLO works?*

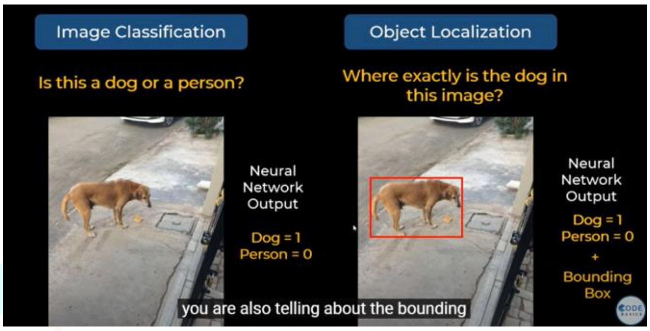

Fig 3.1 YOLO Image classification

First the image will be classified into two parts according to the class name given in Fig3.1 two classes are given named as person and dog so the output is classified accordingly with the bounding box.

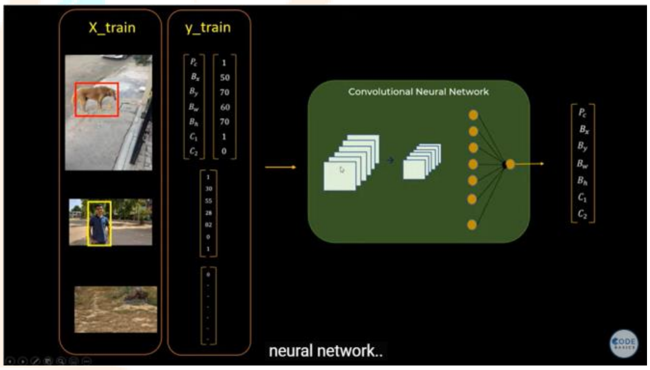

Fig 3.2 Vectors for single object

Pc:-Probability of class
Bx,By:-Co-ordinate of the centre of the bounding boxes
Bw,Bh:-Width and Height of Bounding Boxes

Neural Networks only understands numbers.so, you have to convert your image to vectors like in the above image. But,this works only for one object in an image like in Fig 3.2.So for multiple objects what YOLO do is divide the image in multiple grid cell and then for each grid cell it will find the vector of size seven just like in Fig 3.3

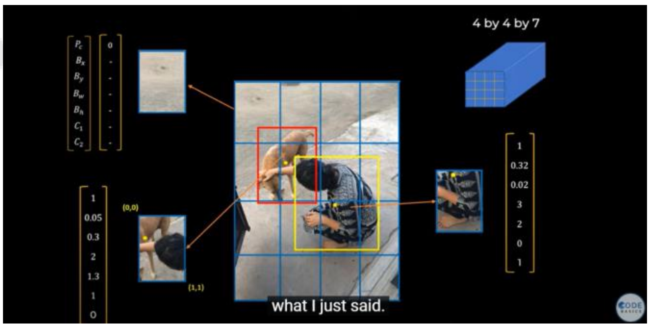

Fig 3.3 Vectors for Multiple Objects

Now the image is divided into 4x4 cell like in Fig 3.3 and each cell is a vector of size seven.Eg if you take a top left cell and expand it in the z-direction(in the direction of red arrow) it will this vector of size seven .So now your single image will have 16 such vector(if your grid size is 4x4) per training image.

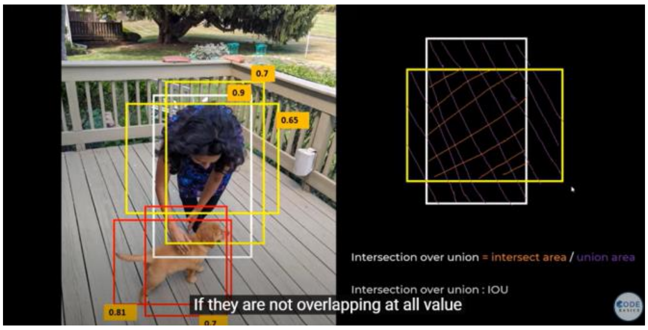

Fig 3.4 Multiple Bounding Box

But,It can detect multiple bounding box like in Fig 3.4.So to tackle with it the value of Pc probablity class which of the bounding box has the hightest Pc value can be considered as proper bounding box.Here in the image we can see by visual that white box is the proper bounding box.It also has the highest Pc value of person class (i.e 0.9>0.7>0.65).But In this way it cannot be done as there can be more than one object in same image i.e there can be more than one person in the above image,so by this method it will one dectect for one person.So what is done IOU is for each box is calculated by the above formula.So one threshold value is selected between 1 and 0 so the boxes overlapping will be having more value take example 0.65 or greater value.So now the boxes which are having value 0 that or near to 0 are not overlapping.So now,among the overlapping bounding boxes MAX Pc value is selected and other boxes are discarded.This method is called Nomex Operation.
So will concatenate two vectors.So with two anchor boxes vector size will be of 14.If 3 anchor boxes vector size will 21.

IV. Proposed System

The YOLOv5 model trained on a custom dataset to detect whether a person is wearing a helmet or not. The trained weights would be used to make predictions on the input from the user. Streamlit is used as frontend for users. Where users will be given an option to select either a media file or another option to use the camera and do the real time capturing. In case if the user selects the web camera option for inference, the user can either use the default camera from the system or also can use the external camera. In case if the input image file is selected, then valid file type will be checked. Then image pre-processing is done and further passed to the YOLOv5 model for the inspection of whether the person is wearing the helmet or not. Bounding Boxes are created in the head region of the person (if present) showing that person is wearing the helmet or not and display the results of the modified image with bounding boxes and label to the user.The flow diagram of the proposed system can be seen in Fig 4.1

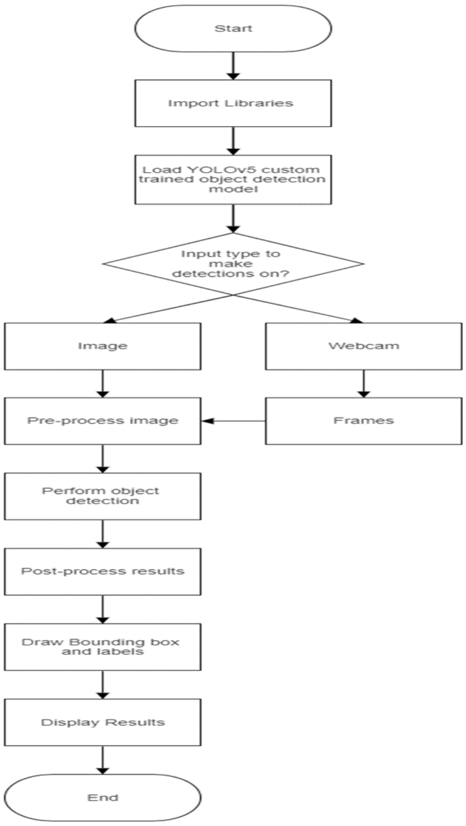

Fig 4.1 System FlowChart

V. System Evaluation

A. Dataset Preparation:

Dataset containing images of riders with and without helmet were collected from Kaggle. Then collected dataset was annotated using rectangular bounding box and labelled for two classes namely, helmet and no-helmet. To train the model the dataset was first made to go through the data pre-processing and augmentation process which helps in reducing training time and improves performance of model. Then the dataset was split into three categories training set, testing set and validating set.

B. Model Selection:

For selcting model the Mean Average Precision and inference time were selected as factors. The You Only Look Once (YOLO) V5 was selected as it was faster and accurate as compared to earlier versions of YOLO and ligthweight compared to later version YOLOv7. Depending on the need of the project the YOLOv5m model was selected. YOLOv5 is an object detection algorithm that was introduced in 2020 as a successor to the previous versions of YOLO (You Only Look Once) algorithm, which were YOLOv1, YOLOv2, YOLOv3.YOLOv5 was developed by Ultralytics, and it is a single-stage detector that is based on a deep neural network architecture.The YOLOv5 model is different from the previous versions of YOLO in several ways. Firstly, YOLOv5 is built using a fully convolutional architecture that utilizes a larger number of convolutional layers. Secondly, it incorporates a bag of tricks to enhance the performance of the model such as data augmentation, mixup, and cutmix. Thirdly, it utilizes a larger and more diverse training dataset.

C. Model Training

The training dataset from the divided dataset was used to train model. The model was trained using an appropriate optimizer, loss function, and learning rate. The training process was monitored using various metric graphs such as accuracy, loss, and precision over the period of training duration.

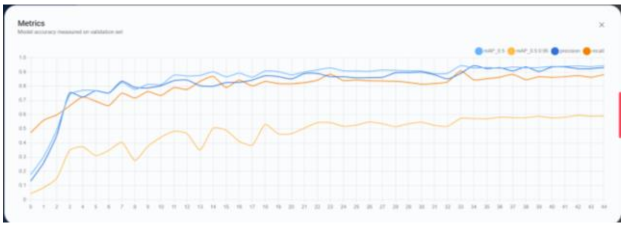

Fig 5.1 Graph of losses

Fig 5.2 Graph of metrics

D. Model Testing

The test dataset was used to perform testing, by applying trained model weigths to make inference on images,video and live webcam. The various performance matrix such as accuracy, precision, recall and F1 score graphs understanding helped to assess the results of the test dataset inference.

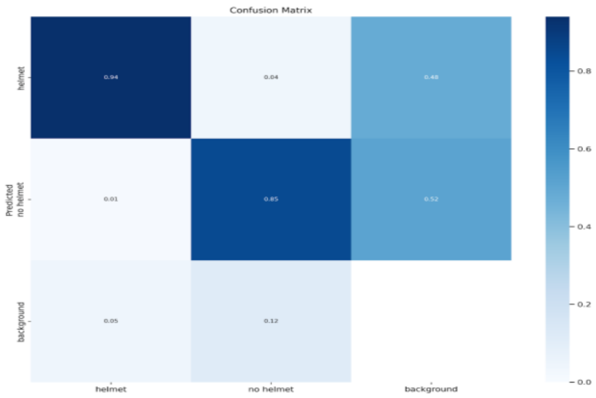

Fig 5.3 Confusion Matrix

VI. RESULTS

The YOLOv5 model was trained on custom dataset for helmet detection. The trained model achieved 59.47 mAP (Mean Average Precision). The model was able to detect persons with a helmet and without helmet in image file as input and also detect on live web camera. The confidence of the predicted results was affected by several factors including the positioning and angle of the camera, number of objects in the frame, occluded objects, light effects, different weather conditions influencing the visibility.

VII. CONCLUSION

In conclusion, a helmet detection system is an essential safety measure that can be implemented to ensure the safety of individuals in various settings, such as construction sites, industrial facilities, and transportation systems. Such systems use computer vision and machine learning algorithms to identify whether a person is wearing a helmet or not, and can alert safety personnel if a violation is detected.Implementing a helmet detection system can significantly reduce the risk of head injuries and fatalities, which are among the most common types of injuries in workplace accidents. Additionally, such systems can help promote safety culture, raise awareness of safety practices, and improve compliance with safety regulations

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