Helmet Detection on Two-Wheeler Riders with Deep Learning

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Abstract *— This project focuses on building a software that determines whether a motorcyclist is wearing a helmet using Machine Learning (ML). The system is able to detect this through video capture. It hopes to help in detection of riders without a helmet. The system is successfully able to detect helmets with a probability of 80%. It makes use of OpenCV, TensorFlow, and YOLOv5.*
It recognizes the number plate of the bike if its rider is without a helmet and captures its cropped image and saves it on the local storage of the system.
Keywords —Haar-cascade, Helmet detection, Machine Learning, Number plate capturing, OpenCV, Python, TensorFlow, YOLOv5

I. INTRODUCTION

According to research of India today it is found that 4 people die every hour in India due to not wearing a helmet. Whenever an accident occurs the people who are most prone to highest damage are the motorcyclist. but if a person is not wearing a helmet and comes across an accident, he is most likely to die even with a small damage to his skull. The brain is the most important part of our body that operates everything. If the brain is damaged a person is likely to die. helmets are a great boon to protect our head, that is skull and brain from damage during an accident. Though having such a great boon most of the people ignore it and we get such death statistics. This is the reason that wearing a helmet is an important traffic rule for motorcyclists. but most of them tend to neglect it. Automatic helmet detection can contribute to saving lives and reducing the work of cops. as traffic has now considerably increased it has become more difficult to track people not wearing a helmet. with the help of our project the people not wearing a helmet can be detected. data of such people can be stored, and necessary action can be taken against them. This would not only reduce human effort but also save many lives.

Many projects have been done for helmet detection, whether it be for monitoring its use or to simply get data for analyzing. We looked at two such projects.

First proposed methodology detects helmets using image descriptors and classifiers. First stage is the vehicle segmentation and classification wherein it is determined which objects are moving and are classified. To achieve this, there is first calibration done after defining a cross line (CL). A wavelet transforms (WT) is used to classify motorcycles and non-motorcycles with the extracted vectors. The multilayer perceptron (MLP) algorithm is used to identify helmets. MLP is a supervised learning method wherein the multilayered neural network is directed into a single graph.[1]

Another proposed methodology is using COCO dataset, Dark flow and OpenCV implemented on Arduino. Here, the processed image is fed into the neural network developed using Dark flow and then

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YOLO (you only look once) algorithm is applied for detecting the helmet.[2]

II. LITERATURE REVIEW

The paper named Real-time automatic helmet detection of motorcycle in urban traffic using improved YOLOv5 detector, having the objectives of enforcing strict traffic laws and reducing the cost of employing the traffic police. Used yolov5-MD to detect bikes having at least one rider and Yolo-HD algorithm to detect whether the riders are wearing helmets or not. It could detect the motorcycle in the video or image, and check whether the rider is wearing a helmet. Also, it can determine whether the motorcycle is overloaded or not. The authors of this paper are **Wei Jia, Shiquan Xu, Zhein Liang. Yang Zhao, Hai Min, Shujie Li, Ye Yu.**

The paper named Detection of the helmet on motorcycles proposes the project for detecting the helmets. In this, a line is marked on the video frame. Then executes extraction of the background, edge and contour detection and then segmentation of the moving objects. Then it classifies the vehicle and detects the helmet on the bike riders. It achieved the accuracy of 0.9137 for helmet detection and for vehicle segmentation 0.9778. The authors of this paper are **RomuereR.V.eSilva, Kelson R. T. Aires, Rodrigo de M. S. Veras.**

The paper named Deep Learning-based safety helmet detection in engineering management based on convolutional neural networks, for the safety of the people working at the construction sites and reducing costs of traditional supervising methods. Used open source TensorFlow framework for model training. To reduce the training time already trained ssd-mobile-v1-coco model is used with coco dataset to learn the characteristics. The authors of this paper are **Yange Li, Han Wai, Zheng Han, Jianling Huang, Weidong Wang.**

The paper named Automatic Safety Helmet Wearing Detection describes a helmet detection project. It includes three major parts viz.- detecting the moving objects within the frame by using ViBe algorithm. Then pedestrian classification by using C4 algorithm executing around the moving objects. Implementing color space transformation and color feature discrimination for detecting the workers and HSV transformation and adaptive threshold selection image processing. The searching range is shrunken by the ViBe background algorithm. Weather changes and other such varying environments are not adaptive for the C4 algorithm with color feature discrimination with fixed parameters, so it needs to modify parameters on different scenes. The authors of this paper are **Kang Li, Xiaoguang Zhao, Jiang Bian, and Min Tan, The State Key Laboratory of Management and Control for Complex System, Institute of Automation, Chinese Academy of Sciences, University of Chinese Academy of Sciences, Beijing, China.**

The paper named Multi-Scale Safety Helmet Detection Based on SAS-YOLOv3-Tiny proposed the modified model SAS-YOLOv3-tiny to balance detection accuracy and model complexity. To replace original convolutional layer a module based on depth wise separable convolutional called Sandglass-Residual and channel attention mechanism is constructed. Three scale feature prediction is used to power the detection of small objects. To extract local and global features with good semantic details an improvised spatial pyramid pooling module is added. CIoU loss is introduced for promoting positioning accuracy improvisation. This improved SAS-YOLOv3-tiny algorithm has improved all parameters including Precision(P), Recall(R), Mean Average Precision (mAP), F1. It is also lightweight, accurate and faster algorithms. **College of Mathematics and Computer Science, Zhejiang Normal University, Jinhua 321004, China.**

The paper named DWCA-YOLOv5: An enhance the Single Shot Detector for Safety Helmet Detection proposed a new algorithm for improving YOLOv5 algorithm. To improve the size matching degree of priori anchor box K-means++ is used. Depth wise Coordinate Attention (DWCA) mechanism is integrated in the backbone network. The average accuracy rate achieved is 95.9% and accuracy rate of helmet detection and worker's head detection reached 96.5% and 95.2%. This model has a 3% increase than YOLOv5 algorithm. The authors of this paper are **Zhang Jin, Peiqi Qu,**

Cheng Sun, Meng Luo, Yan Gui, Jianming Zhang and, Hong Liu.

The paper named A lightweight YOLOv3 algorithm used for safety helmet detection describes a helmet detection project. They have integrated GhostNet and Cross Stage Partial Network and designed a more efficient CSP-Ghost-Resnet. Designed a new backbone network, the ML-Darknet by combining CSPNet and Darknet53 to realize its gradient diversion. PAN-CSP-Network a lightweight multiscale feature extraction network is designed and used. The FLPSs and parameter sizes of this are only 29.7% and 29.4% of those of YOLOv3, and this has also advantages in calculation cost and detection effect. The authors of this paper are **Lixia Deng**, **Hongquan Li**, **Haiying Liu** & **Jason Gu** .

A paper named SHEL%K: An Extended Dataset and Benchmarking for Safety Helmet Detection describes a project which proposes a dataset with 5K images called Safety HELmet dataset which is an enhanced version of SHD. This dataset consists of 6 classes viz- helmet, head, head with helmet, person with helmet, person without helmet, and face and was tested on multiple models like YOLOv3 (YOLOv3-tiny, and YOLOv3-SPP), YOLOv4(YOLOv4, YOLOv4pacsp-x-mish) and YOLOv5 (s, m and x.), Faster-RCNN and the inception V2-architecture, YOLOR. This dataset showed improvement in mean Average precision (mAP). The authors of this paper are **Munkh-Erdene Otgonbold, Munkhjargal Gochoo,, Fady Alnajjar, Luqman Ali,Tan-Hsu Tan, Jun-Wei Hsieh and Ping-Yang Chen**.

The paper named Automatic Helmet Detection on public roads describes a project having an objective of preventing the accidents on roads and bike riders' safety. It detects helmet by Hough transform descriptor and background subtraction. It extracts the number plate of the bike if the fall is detected, and immediately reports to the hospital and family members about the accident. The authors of this paper are **Maharsh Desai, Shubham Khandewal. Lokneesh Singh, Shilpa Gile.**

The paper named Machine vision techniques for motorcycle safety helmet detection used K-Nearest Neighbour (KNN) classifier to classify the moving objects into motorcycles or other moving objects. Projection profiling is used to count and segment heads of the riders of the motorcycles. Then this system detects whether helmets are present on the segmented heads using 4 sections of segmented head region. The average correct detection rate for the near lane is 84% for the far lane is 68% and 74% for both the lanes. The authors of this paper are **Rattapoom Waranusast**, **Nannaphat Bundon**, **Vasan Timtong**, **Chainarong Tangnoi**, **Pattanawadee Pattanathaburt**.

III. METHODOLOGY/EXPERIMENTAL

A. Method**:**

We used the YOLOv5 algorithm for training our model. We used the Google Colab environment to train our model using The NVIDIA T4 GPU freely provided by the Google Colab.

YOLOv5:

YOLOv5 is the latest version of the YOLO object detection algorithms. It is obviously based on the previous YOLO versions (YOLOv1 – YOLOv4). Continuous improvements in the older versions have resulted in this version 5 of the algorithm. It can perform training on two official objection datasets viz. Pascal VOC (visual objects classes) and COCO (common objects in context). This version is developed by Joseph Redmon. This is the second model of the algorithm that was not developed by the original author. And is the first version that runs on the Darknet framework, which was purposely built to execute YOLO [1]. YOLOv5 has further 4 versions viz. s, m, l, and x. In our project, we have used YOLOv5s.

As with any other objection detection algorithm, YOLOv5 do has three important stages: model backbone, neck, and head. Model backbone mainly used for extracting important features from the given image is based on CSPNet (Cross Stage Partial Networks). These CSP networks used as a backbone, to retain rich informative features from a given input image, have shown appreciable improvement in processing time with deeper networks.

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Mainly used to generate feature pyramids, Model Neck is the second stage of the algorithm. It helps models to make generalized object scaling. Mainly it identifies the same object with different sizes and scales. Feature pyramids are very essential and help models work well on unseen data. There are other types of pyramid techniques like FPN, BiFN, PANet, etc. In YOLOv5 PANet is used as a neck to get feature pyramids.

The Model Head does the final detection part. Anchor boxes are applied on features and final output vectors are generated with class probabilities, object scores, and bounding boxes.

YOLOv5 authors chose to use Leaky ReLU and Sigmoid as activation functions, and SGD as the default optimization function but it can be changed to Adam by using the "__ adam" command-line argument. Binary Cross-Entropy with Logits Loss function from Pytorch is used by Ultralytics for loss calculation of class probability and object score.

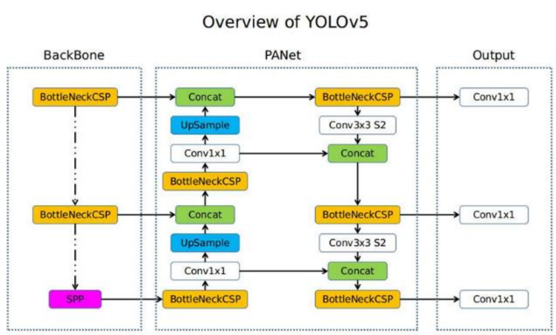


Figure 1: Internal working architecture of YOLOv5

<u>Dataset:</u>

For training our YOLOv5 model we used a set of 765 mixed images of bike riders with helmets and without helmets. We prepared our dataset using the Roboflow platform. The labeling of the images was done in two classes: With Helmet and Without Helmet. The labeling of the images was done in Pascal VOC format. This dataset is split into three different categories of training, validation, and test in the ratio of

70% : 20% : 10% respectively.

<u>Sample images from the dataset:</u>

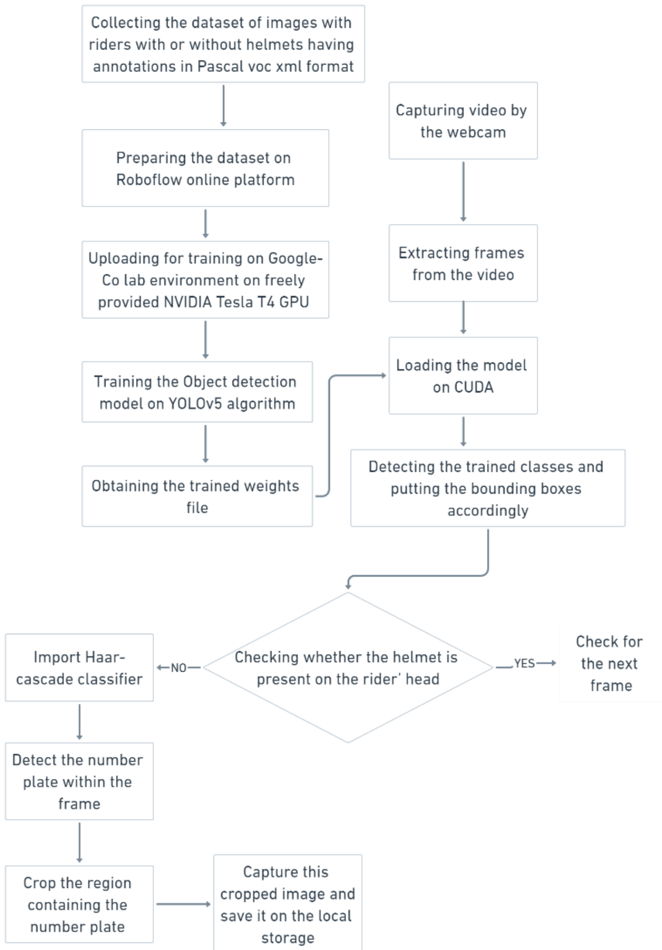
Figure 2: Some sample images highlighting helmets from the dataset.

This trained-weights file was then imported as best.pt after the training was fully completed and implemented in the python code for custom object detection. The use of different packages was done in this python code for custom object detection. Some of the python packages used are Torch, NumPy, and OpenCV.

<u>Number plate capturing:</u>

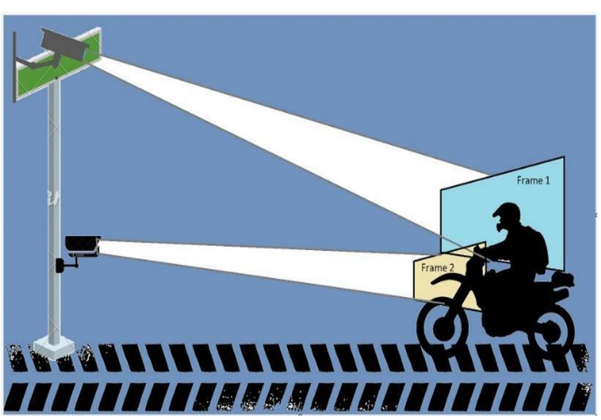
For the detection of the number plates of the bikes we used the Haar cascade classifier. The Haar cascade is divided into three key contributions. Integral Image is the first one which is actually the introduction of a new image. Based on AdaBoost the second contribution is about learning algorithms, it selects a compact number of attributes with critical visuals from a sizable set and further yields immensely efficient classifiers. The third contribution focuses on integrating even complexer classifiers in a cascade which discards the background regions and enables the computation to focus on more promising object-like regions. This cascade provides statistical guarantees and discards the regions having no object of interest, is an object specific focus-of-attention mechanism.

Using this classifier detecting the number plates rapidly as soon as a rider without helmet is detected. As the number plate is recognized this



system captures a clear cropped image of the number plate and saves it on the local storage of the system, maybe a folder/directory. This captured image is decently readable, so the rider is easily identified and tracked by this number on the number plate.

Setup of the cameras in real time:



This is the plan for setting up the system of two cameras. Two cameras must be fixed one below the other, in such a way that their frames are aligned one below the other along the same axis of symmetry. The zoom level of the camera-2 must be at a higher level so that it efficiently captures the clear picture of the number plate.

IV. RESULTS AND DISCUSSIONS

Results of our trained dataset projected on the Tensor board:

Metrics:

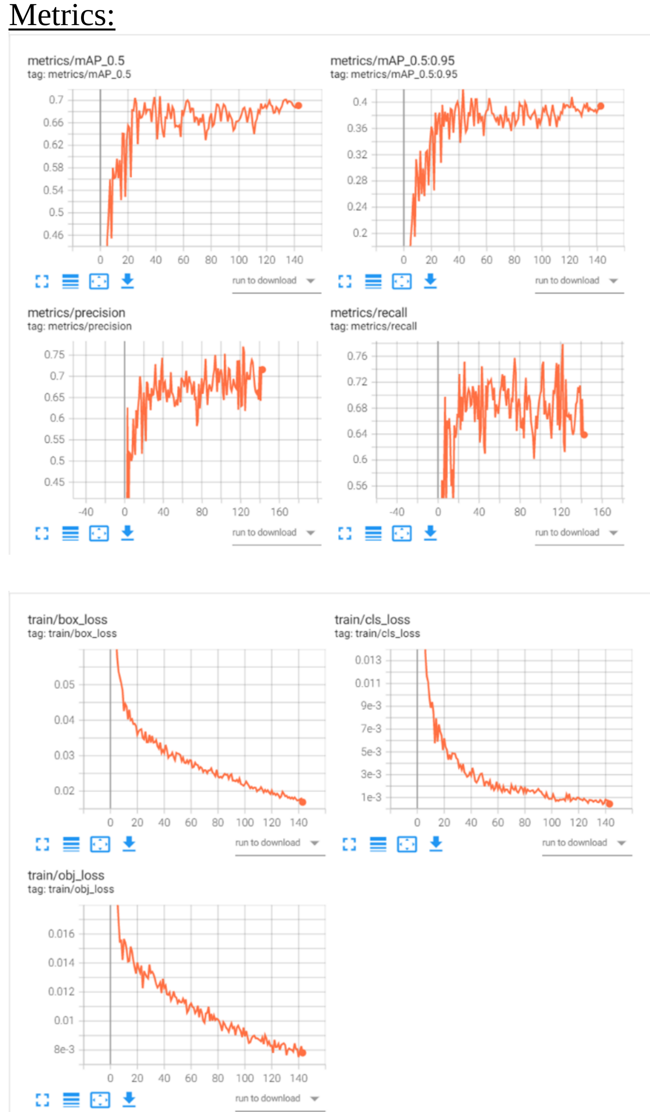
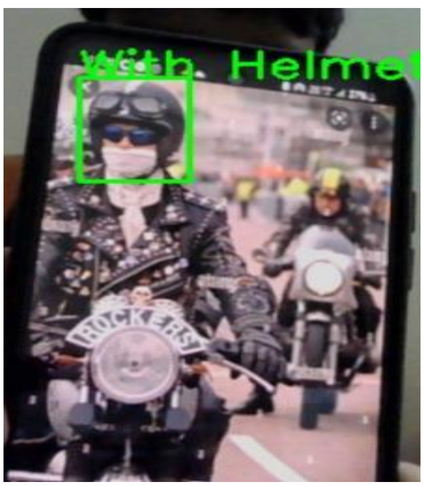


Figure 5: The resulting statistical parameters of the trained model.

An open-source TensorFlow framework with the YOLOv5 algorithm is chosen to train the model. Training dataset is used to train the model and to determine the values of the parameters of the model. Twenty percent of the features from the dataset are used to test and evaluate the model. During training, the rate of change of the mean average precision (mAP), recall and the loss functions after the training were presented by the Tensor Board. As a measure index, the mean average precision is normally used in the field of object detection. The probability of recognizing the safety helmets is 80%.



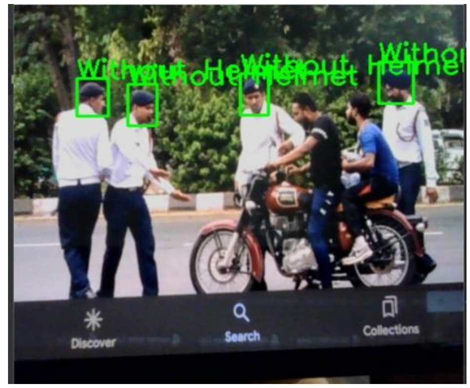


Figure 6: The detection of the presence of helmets on the riders' head.

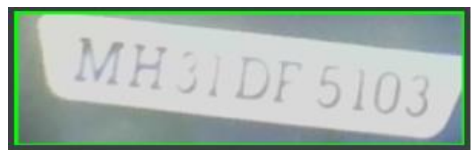


Figure 7: The cropped captured image of the number plate of the bike of the rider without helmet saved at the system's local storage.

V. FUTURE SCOPE

With this project we understand how machine learning can give promising results while performing helmet detection even with the help of limited dataset. The accuracy of the project can be improved by increasing the dataset and training more models based on it. It would improve the helmet detection when vehicles are in motion. The drivers of vehicles not wearing a helmet can be captured and stored in order to take necessary actions. Number plate of the vehicle can be extracted and stored in an excel file using similar data models. It can also be trained to detect helmets with blurred, unclear images or videos. Not only on road but its application could be expanded to helmet detection in construction sites and other places where use of helmet is mandatory. Application of this project would make the traffic rules stricter and people would follow it due to fear. This project can be improved even more by incorporating advanced safety features such as collision detection, taking photographs of vehicles that violate rule by overspeeding, and capturing images of drivers who are talking on the phone while driving. This reduces the number of on site traffic cops. As this is software based the it can be implemented with minimal cost. This system will work and generate databases for a longer amount of time if implemented correctly. Use of this system would cause less accidents.

VI. CONCLUSION

This project is about helmet detection using OpenCV and deep learning. We have used YOLOv5 algorithm for object detection. Therefore, the proposed system is very much potent in ensuring the safety of the motorcycle riders. If a person is riding a bike, he must put his helmet on and must follow all the traffic rules. This project is very effective for implementing the strict rule of wearing the helmet while riding the vehicle. It provides better security to the biker. The proposed system is very much capable of identifying whether the rider is wearing a helmet or not. This system can be implemented in all certain situations with a high level of accuracy. Because of this system we can avoid bribes which are taken by the traffic police. The proposed system can be practically implemented on roads, toll gates and traffic signals for safety concerns. This system can be further enhanced in future by testing in various scenarios like different angles, whether situations, absence or presence of light, speed of vehicles. These measures could increase the accuracy of and efficiency of our project.

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