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INTELLIGENT HELMET DETECTION USING OPEN CV AND MACHINE LEARNING

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Abstract
As we all know Helmet is essential for our daily lives. Our brain is a crucial organ where it controls our thoughts, memory and emotions. In 2020 there were nearly 159,000 deaths due to on account of motor cycle riders not wearing a helmet. Concerning total percentage of road accidents two-wheelers constituted the highest proportion of 44.5% and the age group of persons involved in those tragedies are in-between 15 to 49 years. In this regard we want to curtail this risk and we have developed a project using Machine Learning and OPEN CV tools for Helmet Detection. We also use a camera module to detect the face of a person. The dataset is a set of images which is fed to the ML model and it processes it and outputs the real time status of the person/driver is wearing a helmet or not.By using YOLO algorithm, I created a predictive model that can be able to detect persons who are riding motorcycles without helmet in any condition.

Keywords: Machine Learning, OPEN CV, Helmet Detection, Camera Module, Face Detection, ML model, YOLO algorithm.

1. Introduction

Emy Barnabas and Amritha [1] has explained on how the helmet can be detected with the help of Convolutional Neural Network (CNN). By differentiating between people who wear helmets and those who don't, the model can efficiently detect helmet compliance [1]. Chalavadi Vishnu, Dinesh Singh [2] also used a Convolutional Neural Network (CNN) to identify motorcycle riders who wear helmets. The device successfully detects if a motorcyclist is wearing a helmet, resolving a significant safety enforcement issue.So providing efficient solution for image classification has been major focus in computer vision.
Kunal Dahiya, Dinesh Singh [3] used Scale-invariant feature transform (SIFT) and Histogram of oriented gradients for Helmet Detection in real time. In safety monitoring applications, it enables real-time helmet detection, which is beneficial for prompt response.R. Rodrigues Veloso, K. Teixeira Aires [4] used Image descriptors and Classifiers for Helmet Detection. Used certain classifiers to identify photos, which is advantageous for helmet usage classification. But this approach may not work as well in real-time applications or in different environmental settings.J. Chiverton [5] employed combination of tracking algorithms and classification techniques to detect the presence of helmet. By continually monitoring the same rider, the tracking component increases accuracy. The study uses traditional tracking methods and picture processing, which might not be as reliable. R.L. Galvez, A.A. Bandala [6] used a CNN model architecture for training and processing the images in the datasets in-order to detect object (helmet). CNNs automatically extract significant characteristics without

human interaction, in contrast to traditional image processing. But, CNNs are accurate, but without optimization, real-time detection might be difficult because of their potential processing performance issues. Deep learning is a powerful technique that can be widely used in various visual processing tasks. In particular, Convolutional neural networks (CNN) and Deep Convolutional Neural Networks (DCNN) obtain the modern results for automated object detection and classification in remote sensing imagery. Waranusat et al. [7] classified helmets using a technique to detect moving objects based on a KNN classifier. The degree of precision that might be attained by these models, which were postulated based on statistical data from photographs, was constrained.

A CNN-based technique for object recognition and classification was introduced by Alex et al. A. Hirota et al. [8] classified riders using a CNN. Even when they employ CNN, the precision of their helmet detection is limited.

This paper has been organised as follows: Section 2 covers literature work of the proposed work. Section 3 includes the architecture of proposed work. Section 4 provides description about the benchmark dataset and performance metrics. Section 5 discusses about the experimental result and analysis. Finally conclusions are given in Section 6.

2. Related Work

Now a days, YOLO algorithm is broadly used for image classification from remote sensing imagery. The aim is to detect the required objects by forming a bounding box. It's an effective method to develop accurate object detection system. This YOLO model can be very efficient in detecting the required objects and also can make accurate predictions.

R. R.V.e Silva et.al., [9] described the process of classification and descriptors are used to detect the vehiclesand then detect the persons with 2 wheelers and detect if they are wearing the helmet or not..L. Allamki et. al., [10] using machine learning and Automatic Number Plate recognition".This paper does the process of extracting the objects from the image using YOLO object detection and has 2 segments in the entire process. F. W. Sieberta et. Al., [11] There are 3 divisions in this project in which the data is collected in the form of videos, pre-processed and used in detecting the riders of motorcycle with and without helmets.M. Swapnaet. Al., [12] In this model various previous methods related to automatic helmet detection has been taken into consideration and the new model has been given. This is a technique of automatic helmet detection, where the input is of either the video which has been recorded or it might be a video through a web camera.

3. Proposed Work

In order to overcome the problem of fatal accidents caused by lack of helmets we have come up with a solution which has OPEN CV tools and Machine Learning algorithm which detect whether the motorcycle rider is wearing a helmet or not, by which this can prevent these fatal accidents. This software can be integrated with CC cameras which are present and then it can automatically detect whether the drivers are wearing or not and can penalize them. The architecture diagram of the proposed method is shown in Figure 1 and the details of the components in the architecture diagram are discussed in the following sections.

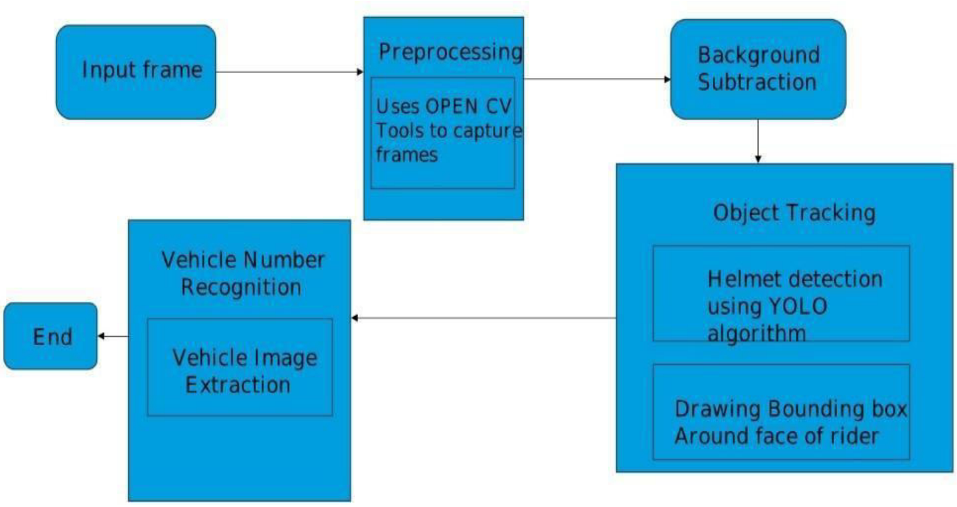

Figure.1. System block diagram

YOLO Algorithm

A real-time object identification system that formulates detection as a single regression issue is called the YOLO (You Only Look Once) algorithm. Because YOLO predicts bounding boxes and class probabilities from an image in a single assessment, it is much more efficient and appropriate for real-time applications than standard approaches that use area proposal networks and separate classification phases.

4. Dataset Description

Robo flow is a website in which we find data sets, but as there is no proper pre-processing on our data set, we had to take various data sets. Combine them label them and then had to create our own data set within the website itself. It provides us with options to do so.

Figure 2. Dataset description

In YOLO v8 model, the dataset has been split into training, validation and testing datasets separately. The validation images have been randomly selected from training sample based

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on the size of validation. The testing images are used to predict the result based on training datasets.

Performance Evaluation Metrics

We have evaluated the performance of a proposed model by using various performance metrics such as Precision, Recall, Accuracy, F1-measure and Mean Square Error (MSE). The confusion matrix is a two dimensional table, which is used to calculate the above mentioned metrics. In this matrix actual classifications are in column side and predicted values are in row side. The Figure 3. shows the confusion matrix table.

		Actual	
		Positive	Negative
Predicted	Positive	TP	TN
	Negative	FP	FN

Figure 3. Confusion matrix

Let TP, TN, FP and FN denote the number of true positive, number of true negative, number of false positive and false negative respectively. The true positive is an outcome, where the models correctly predict the positive class. The true negative is an outcome, where the models correctly predict the negative class. The false positive is an outcome, where the models incorrectly predict the positive class. The false negative is an outcome, where the models incorrectly predict the negative class.

i. Precision

The precision measure can be calculated by number of true positive results divided by the number of positive results predicted by the classifier.

$$\mathrm{PRE} = \frac{\text{True Positive}}{(\text{True Positive} + \text{False Positive})} \qquad (1)$$

ii. Recall

The recall measure can be calculating the number of correct positive results divided by the number of all relevant samples.

$$\mathrm{REC} = \frac{\text{True Positive}}{(\text{True Positive} + \text{False Negative})} \qquad (2)$$

iii. Accuracy

The accuracy measure can be calculating the number of correct predictions model divided by the total number of input samples.

$$\mathrm{Acc} = \frac{\mathrm{TP+TN}}{\mathrm{TP+FP+FN+TN}} \qquad (3)$$

iv. F1 -measure

The F1-measure (harmonic mean) is used to show the balance between the precision and recall measures. The F1- score measure can be calculated as follow:

$$\mathrm{F} = 2 * \frac{\text{Precision}*\text{Recall}}{(\text{Precision}+\text{Recall})} \qquad (4)$$

v. MSE

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The MSE value returns prediction error rate between the original and fused image. It is calculated by the equation below:

$$\mathrm{MSE} = \frac{\sum_{i=1}^{H}\sum_{j=1}^{W}(O(i,j) - \breve{O}(i,j))^2}{H \mathrm{x} W} \quad (5)$$

Where, O and Ŏ are represented as observed original image and feature fused image respectively and value of H and W represented as Height and Width of the images.

5. Experimental Results and Analysis

Using the YOLO v8 model based on deep learning and OpenCV for image processing, we assessed a helmet detecting system. To make the input photos compatible with the CNN model, they were pre-processed and scaled to 224 × 224 pixels. When utilizing a pre-trained model, like VGG-16, the system demonstrated higher performance. Figure 4 determines the training and number of epochs for the model.

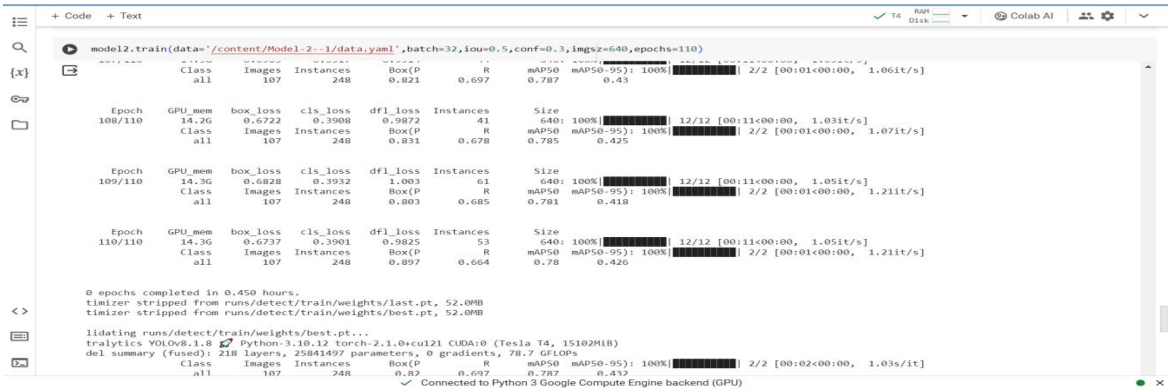

Figure 4. Model training

We have contrasted two popular deep learning models, YOLO and VGG-16, with our suggested helmet detection technique. The suggested approach showed a decreased Mean Squared Error (MSE) but a classification accuracy that was on par with VGG-16. The suggested model has an MSE of 0.76 and VGG-16 has an MSE of 0.91. Table 1 provides a summary of the performance comparison of helmet detection using several pre-trained models.

Table 1. Comparative analysis of proposed model performance

S. No.	ML/DL Model	Accuracy (Acc)	Precision (Pre)	Recall (Rec)	F1-Score (F1)	Mean Squared Error (MSE)
1	YOLO	0.9	0.89	0.88	0.88	1.5
2	VGG-16	0.94	0.94	0.94	0.94	0.91
3	AFF Method	0.95	0.95	0.94	0.94	0.76

Conclusion

In this study, we suggested a helmet detection system that uses a deep learning-based approach to improve classification accuracy and performance. Initially, we trained two popular models, YOLO and VGG-16, for helmet recognition, with accuracies of 90% and 94%. To improve detection performance, we used a fusion strategy that combined the capabilities of both models. The proposed technique obtained 95% accuracy and reduced Mean Squared Error (MSE) to 0.76. Based on a comparison of the various models, the suggested fusion method beats the others, resulting in greater classification accuracy for helmet identification.

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