Two-Wheeler Helmet Detection System Using Object Detection

Prof. Vikas Nandeshwar[a], Harshad Sheelwant[b], Nishit Shelar[c], Bhavesh Shelke[d], Shashank Patil[e], Abdul Sheikh[f]

a,b,c,d,e,f*Department of Engineering, Sciences and Humanities*, Vishwakarma Institute of Technology, Pune, India

[a] vikas.nandeshwar1@vit.edu, [b]harshad.sheelwant23@vit.edu, [c] nishit.shelar23@vit.edu, [d] bhavesh.shelke23@vit.edu, [e] shashank.patil23@vit.edu, [f] abdul.sheikh23@vit.edu

***Abstract* — A "helmet" is a protective cover worn while riding a two-wheeler, which is a safety measure for the rider and for the pillion. However, due to the negligence of people, helmets are not worn by most riders. According to the latest report of the National Crime Records Bureau (NCRB), as many as 1,55,622 people lost their lives due to road accidents in 2021, out of which around 70,000 people lost their lives in two-wheeler accidents.**

Our study is the perfect solution for this problem. We have made a smart machine learning based system integrated in a two-wheeler that makes wearing a helmet mandatory as it monitors every second of the ride. The moment the rider removes the helmet, the vehicle is supposed to turn off and make the rider wear a helmet. There are some existing studies that cover different parts of helmet detection techniques but almost each of the studies are usable and limited to that helmet however this study focuses on how the system can be integrated into the two-wheeler itself to generalize the detection of helmets. The perfect implementation of this study can help bring the accident rate from a large number to as little as nothing.

Keywords— Artificial-intelligence; Automobile; Helmet; Image-processing;

I. Introduction

A survey revealed that in countries like Thailand, Vietnam, Malaysia and India more than 50% of the households own a two-wheeler, i.e. a motorcycle or a scooter. A two-wheeler on a road is more exposed to a potential accident than other vehicles. In India as of 2022, two-wheeler fatalities make up 44% of total road accidents. Two-wheeler riders by law are required to wear a helmet while riding, however most of the riders neglect this law and that might result in amplified damage through an accident.

To avoid this, governments have implemented fines and even human monitored systems to charge some breaking the law, however this being manual there are chances of error.

Surveillance cameras on roads have been evolving every day in India. The cameras use an object detection system that identifies every vehicle on road and its registration number to cite fines and also control traffic. To safely and smoothly execute this system of controlling the traffic flow, real-time monitoring and machine learning based on pre-existing data is required. By implementing object detection and automation in traffic regulation, the efficiency and flow of traffic is seen to be more controlled and coordinated than earlier when manual techniques were used to do the same. Better accuracy and efficient processing is what we thrive for in all the processes. There is also some part of manual execution in such a technology which again opens us to errors.

To minimize the error we have used a smart and highly accurate object-detection program which detects a helmet through a live feed. The device will monitor the live feed each second frame by frame and analyze whether a helmet is worn by the rider or not. The program is set in such a way that at any point the rider is not wearing a helmet the two-wheeler turns off the ignition. This being a more accurate method and a more efficient method to eliminate road accident fatalities can be a great feature to implement in bikes and scooters.

II. Literature Review

[1] **S. Cui et al.,** *"An Effective Motorcycle Helmet Object Detection Framework for Intelligent Traffic Safety,",* in this study a standard computer vision model "Detectron2" which is a Facebook AI research library that provides advanced object detection and segmentation algorithms. They carried out multiple test runs on different data sets and have built a study using these tests on just the detection and methods that can improve detection.

[2] **S. Anjum et al,** *"Artificial Intelligence-based Safety Helmet Recognition on Embedded Devices to Enhance Safety Monitoring Process,"* this study focuses on safety

helmets at construction sites, not completely related to our methodology but uses a similar detection idea. They have used tensorflowlite libraries to make the detections effective and lighter on the devices. They have built an IOT system where if a construction worker is not wearing an appropriate helmet, the supervisor will receive a notification.

[3] **M. Uniyal et al,** *"IOT based Smart Helmet System with Data Log System,"* this study uses a raspberry pi 3 board connected GPS module and RF receivers that work on IOT system which conveys a message when a helmet is not worn on the head. This paper was important to us because the idea of turning the ignition on and off comes through this study.

[4] **K. C. D. Raj et al,** *"Helmet violation processing using deep learning"*, they used a CNN to classify a rider into “helmet” and “no helmet” with an additional license plate recognition system using a HOG descriptor with an accuracy of 90%.

[5] **B. R. Chandra et al,** *"Internet of Things (IoT) based Digital Helmet Design and Deployment"*, they used a CNN to classify a rider into “helmet” and “no helmet” with an additional license plate recognition system using a HOG descriptor with an accuracy of 90%.

[6] **Nandu R et al,** *"Smart Helmet for Two-Wheelers"*, this study is a “Smart Helmet” that when not worn denies ignition and when worn allows ignition. They have used a proximity sensor and a LED and placed them on the opposite sides inside a Helmet, that is when the glowing LED sheds light on the proximity sensor the circuit is completed sending signals to the further circuit that the helmet is not worn as nothing is blocking the light.

[7] **Keesari et al,** *"Smart helmet for safe driving"*, this study is not only a helmet identification model but works as an accident detection and an alcohol detection system as well. They’ve used multiple sensors to achieve the results, for the helmet a RF sensor is utilized.

III. METHODOLOGY

In this study, a custom dataset was constructed by incorporating annotations, “helmet” and “no_helmet” through the LabelImg tool.

In the early stages of the model, the study utilized a dataset available on Kaggle, a free for all dataset, which contained of images of all kinds of helmets, pre-annotated. The dataset had construction site helmets, helmets used by cyclists and other kinds of helmets which cluttered the model and the results weren’t as expected. While finding more datasets we landed on a custom dataset that consisted of around 60-80 images of the authors with helmet and also some images extracted from another free for all dataset of images with faces of people to make the model learn the difference between “helmet” and “no_helmet”.

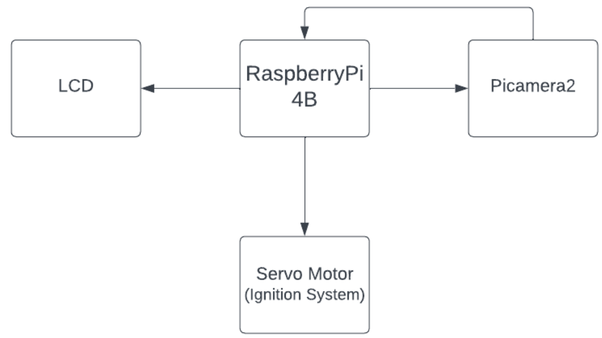

Fig. 1. Block Diagram

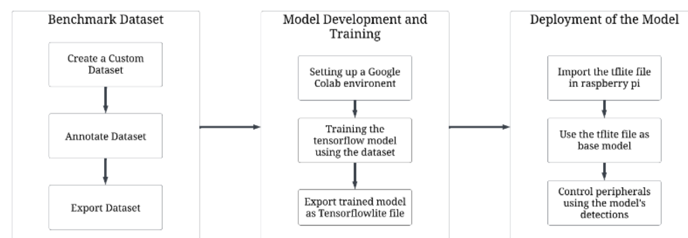

Fig. 2. Process Flow of the proposed method

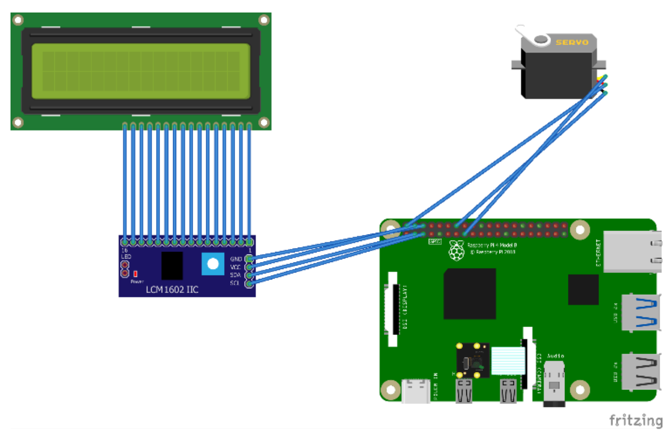

Fig. 3. Circuit

The circuit as shown in Fig. 3 includes a Raspberry Pi Model 4B, a 16x2 LCD, servo-motor as a prototype for the ignition of the two wheeler and a Picamera 2 as a camera module. However this being a prototype of the main idea, better components with more accuracy and better results can be used such as ‘ESP32’, which is a wireless camera module more apt to the study as we need a camera module that can be easily placed at a position on the dashboard of the two-wheeler from where the rider is clearly visible at every second of the ride.

To make use of a successful model we need a strong machine learning technology and TensorFlow was the best option because it utilizes CNN (Convolutional Neural Networking) technologies to develop a model that can be used in Google Colab to deploy in a working environment. As shown in fig. 2, the annotated dataset was utilized within the Google Colab environment to develop a tflite (TensorflowLite) model as raspberry pi is more efficient with Tflite files than Tensorflow files. The resulting tflite file contains the essential data required for accurate helmet detection. The tflite file being associated with custom images is more accurate and appropriate with the detections.

Following model creation, we exported the tflite file and integrated it into Raspberry-Pi 4B. Wherein we utilized OpenCV-python library for developing a system where we used an if-else statement to operate the ignition system which here is a servo motor and also a display. This methodology ensures a comprehensive and effective approach to enhancing safety through intelligent helmet detection systems.

IV. Results and Discussions

The prototype of the main study gives us a brief idea of how this Helmet Detection System can be implemented in an actual two-wheeler, as it benefits the rider and also other traffic on the road. We've reached at a level where the detection system is 85-90% accurate whether the rider is wearing a helmet or not. The whole system works in a way that if the rider is wearing a helmet the ignition i.e. the servo motor will operate and an LCD will display "Ride Safely" and if the rider is not wearing a helmet the motor will not work with the LCD saying "Please Wear A Helmet". This can be situated in the dashboard i.e. around the speedometer of a two-wheeler.

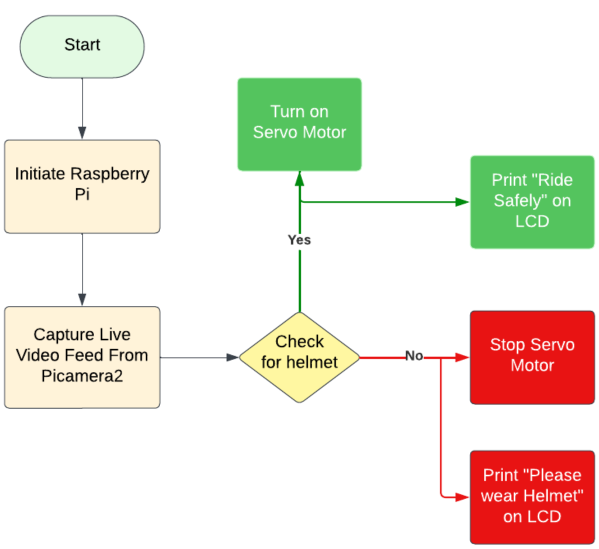

Fig. 4. Flowchart

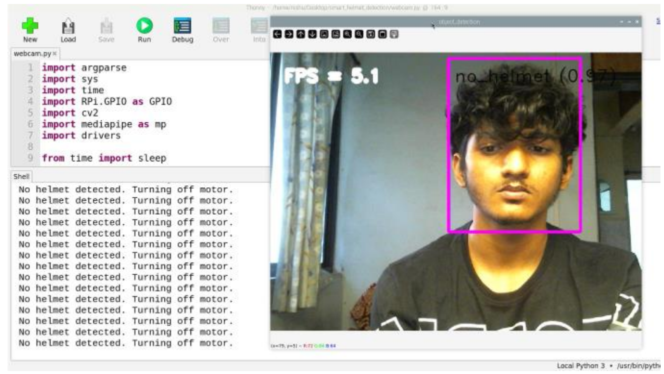

Fig. 5. Printing in the Terminal of the IDE on Raspberry Pi OS "No helmet detected. Turning off motor."

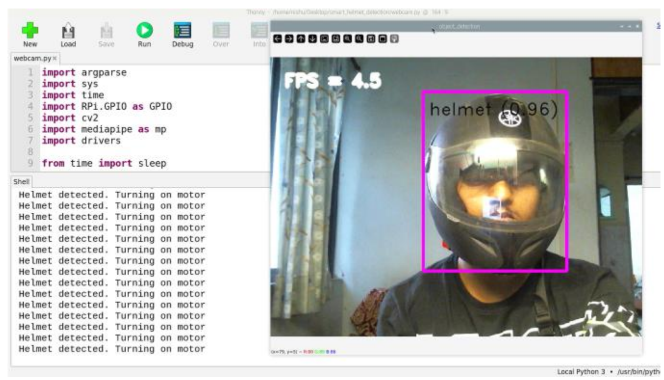

Fig. 6. Printing in the Terminal of the IDE on Raspberry Pi OS "Helmet detected. Turning on motor."

Fig. 5 and Fig. 6 shows a model that detects whether a helmet is worn and not, and annotates the same with the accuracy from 0 to 1 along with the label "Helmet" and "No Helmet".

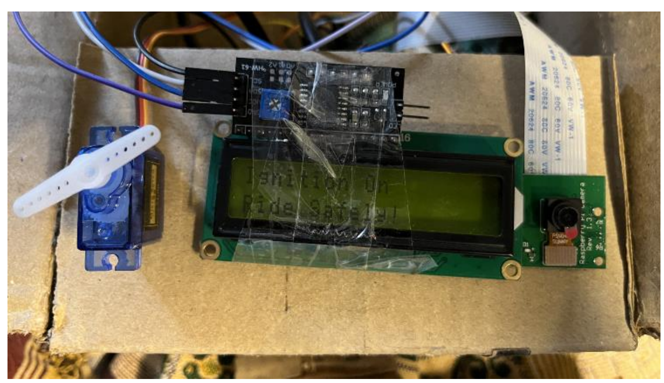

Fig. 7. LCD when helmet is worn

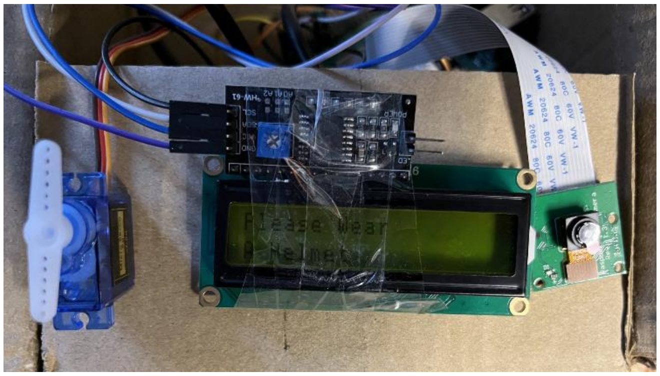

Fig. 8. LCD when helmet is not worn

In Fig. 6 and Fig. 7, the final result is visible on the LCD, that is, if the rider is wearing a helmet the system successfully detects the helmet and while turning the servo motor on it prints “Ignition On” on line 1 and “Ride Safely!” on line 2 while when the rider is not wearing a helmet the LCD prints “Please Wear” on line 1 and “A Helmet” on line 2.

From testing the model in low-light conditions and in camera angles that would simulate as in the camera is placed in the dashboard of a two-wheeler, it was found that there is scope for improvement in low-light conditions as the dataset used for training the model mostly contained images taken in good lighting. The results can be improved to higher levels if a camera of better clarity can be used in place of the existing camera.

The following table shows the accuracy measurements obtained by testing the model in various lighting conditions and camera angles.

TABLE I

Accuracy Measurements

Accuracy Measures	**Values**
Precision	93%
Average Accuracy Score (from 0 to 1)	0.93

[a] These values are calculated by testing of the model in various conditions.

V. Conclusion

The study ensures the critical assessment of the methodology proposed all along and contains the following points:

1) Road-safety and awareness about helmet compulsion while commutating via a two-wheeler.
2) Utilizing a non-biased system of recognition of helmet violations.
3) Successful implementation of a small size prototype of the proposed methodology, using similar electronic components to an actual vehicle.
4) Rigorous testing and improvement of the results of helmet-detection python module.
5) Using the methodology in an actual vehicle may it be an electrical or a fuel based two-wheeler.

VI. Future Scope

In further studies in the same enhancing the smart helmet in the future by adding innovative safety features like alarms, enhancing its helmet detection capabilities, and adapting it to a variety of helmet types seems like an easier job using better technologies. We may utilize cloud computing, interface it with additional safety sensors, and link it to the internet for remote control. Collaborate with two-wheeler manufacturers, obtain certifications, and solicit user input. By taking these steps, we intend to increase the usefulness and appeal of our smart helmet to a global audience.

VII. Acknowledgment

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