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REAL-TIME AUTOMATIC HELMET DETECTION USING TENSORFLOW &KERAS IN OPENCV

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ABSTRACT:This paper presents a real-time automatic helmet detection system utilizing deep learning frameworks TensorFlow and Keras within the OpenCV environment. With the increasing concern for safety in various fields such as construction, sports, and transportation, the detection of safety gear like helmets is paramount. Our approach leverages the power of convolutional neural networks (CNNs) to accurately detect helmets in real-time video streams. We employ a pre-trained CNN model fine-tuned on a custom dataset comprising helmet images. The proposed system demonstrates robust performance in detecting helmets across diverse environmental conditions, achieving high accuracy and efficiency. Through experiments and evaluations, we validate the effectiveness and practicality of our approach, highlighting its potential for integration into various safety applications..

Index Terms: Object Detection, TensorFlow, Keras,OpenCV (Open Source Computer Vision Library), Real-time, Helmet Detection, Convolutional Neural Networks (CNNs), Transfer Learning, Image Processing, Pre-trained Models .

I. INTRODUCTION Motorcycle accidents have been hastily growing throughout the years in several countries because road safety is often neglected by riders worldwide leading to accidents and deaths. To address this issue, most countries have laws which mandate the use of helmets for two-wheeler riders so,it is very important for motorcyclists to understand the risk of riding of riding without a helmet.. A helmet is designed to lessen the danger of major head and brain injuries by absorbing the impact of a force or collision to the head; nevertheless, motorcycle riders must take extra precautions to safeguard their bodies. Helmet-wearing riders and passengers have a significantly higher chance of survival than non-helmet-wearing passengers. Every motorcyclist is required by law to wear a helmet when riding a motorcycle. However, many bikers disregard this warning and ride without any protective gear. The police officer attempted to solve the matter manually, but his efforts were insufficient in light of the current situation. Despite the fact that helmets have recently been mandatory, people continue to drive without them. The number of deaths has been rising year after year, especially in developing nations, because helmets are the most important piece of safety equipment for motorcycle drivers and passengers, but many do not use them. The most effective strategy to decrease brain injuries and fatalities from motorcycle and bicycle accidents is to wear a helmet. Motorcyclists who do not wear helmets are at a higher risk of suffering head injuries and dying as a result of them. Furthermore, motorcyclists who do not wear helmets add to medical costs, while the cost of impairment resulting from these head injuries is borne by the individual, family, or career, as well as social costs.

In India, there is a rule that only requires riders to wear helmets, but not passengers. Anyone riding a motorcycle without a helmet risks being involved in an accident or suffering head trauma.Riders who do not wear helmets are at the greatest danger of traumatic brain damage; if they are involved in an accident without protection, the head is vulnerable to a severe impact.

So, in the field of Computer Vision, we devised a framework based on Tensorflow and Keras to mandate this. Even in real time, the system can detect whether or not riders are wearing helmets. If any of them is there without a helmet, the system will carefully observe the situation and flag it as a breach of the rules. The technology, which may be used in malls, offices, marts, schools, and colleges, allows users to enter only once a helmet is detected by an automatic barrier. It will undoubtedly have an impact on the use of helmets that will save human lives..

To Implement the system is able to detect whether motorcyclist wear helmet or not even at real time. It enables one to spot and penalize bikers without a helmet.

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Figure 1: image detection

II. RELATED WORKS

Pre-trained Models: Utilize pre-trained models such as YOLO, SSD, or Faster R-CNN, fine-tuned specifically for helmet detection. These models provide a good starting point for real-time detection due to their speed and accuracy..

Custom Models: Train a custom deep learning model using TensorFlow and Keras tailored for helmet detection. This involves collecting and annotating a dataset of motorcyclists with and without helmets and training a model from scratch or using transfer learning.Helmet Detection for Motorcyclist Safety Using Deep Learning" by Liu et al. This paper presents a deep learning-based approach for helmet detection in real-time, leveraging TensorFlow, Keras, and OpenCV.

Real-time Helmet Detection Using CNN" by Prakash et al. This project proposes a convolutional neural network (CNN) based approach for real-time helmet detection using TensorFlow and OpenCV.

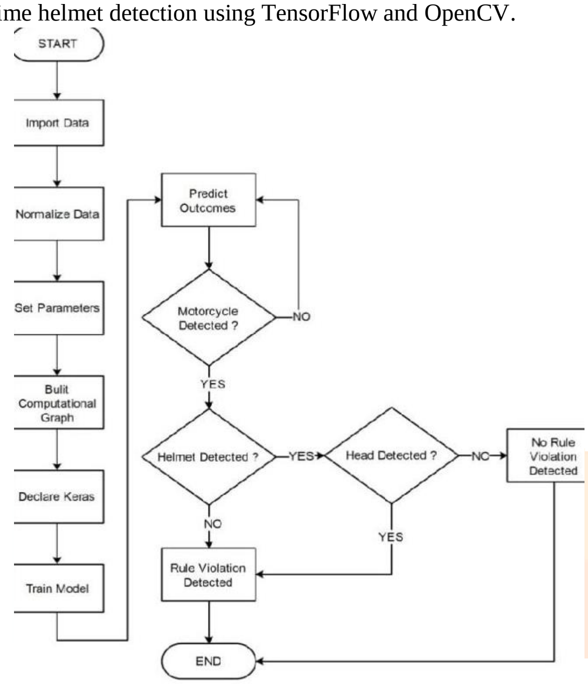

Figure 2 : Flowchart

Building an automatic system like this bring researchers into areas of Image Processing (IP), Computer Vision (CV), and Artificial Intelligence (AI). Because most data from the traffic control system usually came in a format of video surveillance data (image and video) that require the technique to analyze an image data such as image recognition, pattern matching, and image segmentation. To detect the bikers who don't wear a helmet, we need methods

to detect the photo of motorcycle and driver from the image and then detect an area of the biker head before classify that this person is wearing a helmet or not. Several IP and AI approaches have been using to solve this problem, for example, Fourier transformation [2], Support Vector Machine (SVM) [3], Histogram of Oriented Gradients (HOG) [4], Artificial Neural Network [5] etc.

III. PROPOSED METHOD

Dataset Collection and Annotation: Gather a dataset of images containing various examples of helmets. Annotate these images with bounding boxes around the helmets using annotation tools like LabelImg.

Data Preprocessing: Resize the annotated images to a fixed size and normalize pixel values. Split the dataset into training and validation sets..

A. Video detection

Gather a dataset of images containing motorcyclists and non-motorcycle objects (like cars, pedestrians, etc.).Resize the images to a fixed size and preprocess them (e.g., normalization).Choose a suitable pre-trained model (like YOLO, SSD, or Faster R-CNN) for object detection.Fine-tune the selected model on your dataset using TensorFlow and Keras.Use OpenCV to capture video frames from a camera feed and process them using the trained model to detect motorcyclists. Implement algorithms to filter out false positives and refine the detection results if necessary. Overlay bounding boxes or other indicators on the video frames to highlight detected motorcyclists.Make sure to handle edge cases and optimize the model for real-time performance, as speed is crucial for processing video feeds. Additionally, consider deploying the system on hardware with sufficient computational power, like GPUs or specialized chips, to achieve real-time performance.

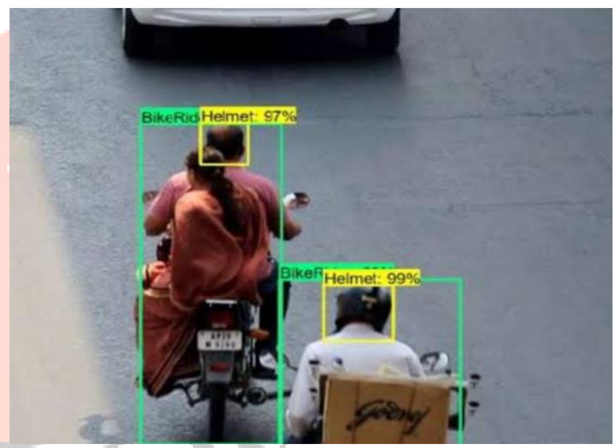

Figure 3 : Video detection

B. Real-time detection

YOLO (You Only Look Once) is a popular object detection algorithm known for its speed and accuracy. YOLOv8, presumably an upgraded version, would likely follow the same principles but with improvements in architecture and performance.Gather a dataset containing images of motorcyclists and other objects for training.Annotate the images to create bounding boxes around the motorcyclists. This step is crucial for supervised learning.Use TensorFlow and Keras to train the YOLOv8 model on the annotated dataset. This involves feeding the images and their corresponding annotations into the model and adjusting its parameters to learn to detect motorcyclists. Once trained, integrate the model into your OpenCV application.

AYou'll likely need to convert the trained model to a format compatible with OpenCV, such as TensorFlow's Saved Model format or ONNX.Use OpenCV to capture video frames from a camera feed. Then, apply the YOLOv8 model to each frame to detect motorcyclists in real-time. This involves passing the frame through the model and interpreting the output to identify the presence and location of motorcyclists.After detection, you can perform additional post-processing steps such as non-maximum suppression to eliminate duplicate detections and improve the accuracy of the results.

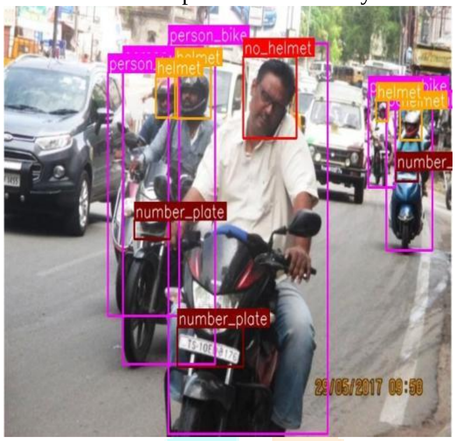

Figure 4 : Real-time automatic helmet detection

C. Feature Extraction

Gather a dataset of images containing motorcyclists and background scenes. Resize and normalize the images to a consistent size, and label them accordingly.Choose a pre-trained convolutional neural network (CNN) model for feature extraction, such as VGG, ResNet, or MobileNet.Remove the classification layer of the selected CNN model and use the remaining layers to extract features from the images.Create a new classification model using Keras, consisting of the extracted features as input and a binary classification output (motorcyclist or non-motorcyclist). Draw bounding boxes around detected motorcyclists in the video feed to indicate their location.Evaluate the model’s performance using a separate test dataset.

Figure 5 : Detecting wheather motorcyclist wearing helmet or not

E. Classification

An iteration of the YOLO series, builds upon its predecessor’s strengths while addressing their limitations. Here’s breakdown of the algorithm:

Backbone Network: YOLOv8 typically employs a powerful backbone network such as Darknet,which provides the necessary feature extraction capabilities.

Feature Pyramid: To capture multi-scale features effectively, YOLOv8 incorporates a (FPN).

Detection Head: YOLOv8’s detection head consists of convolutional layers responsible for predicting bounding boxes and associated class probabilities.

Loss Function: YOLOv8 employs a composite loss function that combines localization loss, confidence loss, and class loss.

Training Procedure: Trained datasets such as COCO or VOC. During training , the algorithm adjusts its parameters to minimize the defined loss function.

Inference: Once trained, YOLOv8 can perform inference on new images in real-time or newar real-time, making it suitable for application requiring rapid object detection.

F. Modified architecture:

Design a custom CNN architecture tailored specifically for helmet detection, possibly incorporating additional layers or modules to capture fine-grained features relevant to helmets, such as shape, color, and texture.Implement a multi-task learning approach where the model simultaneously predicts helmet presence and helmet orientation (e.g., correctly worn, incorrectly worn, not worn). This can provide more detailed information for safety analysis.Integrate attention mechanisms into the model to focus on relevant regions of the image, such as the head region where helmets are typically located. This can improve accuracy and computational efficiency by reducing unnecessary processing.Incorporate temporal information by processing video sequences rather than individual frames. This can help improve the model's understanding of motion patterns and increase robustness to occlusions or partial visibility of helmets.Combine visual information from cameras with data from other sensors, such as gyroscopes or accelerometers embedded in the helmet, to improve detection accuracy and provide additional context for decision-makingIncorporate mechanisms for human feedback to continuously improve the model's performance over time, such as allowing users to provide corrections or annotations to detected helmets in real-world scenarios.Utilize hardware accelerators like GPUs, TPUs, or specialized edge AI chips to speed up inference and enable real-time processing on embedded systems or wearable devices.By incorporating these enhancements, you can develop a more sophisticated and effective system for real-time motorcyclist helmet detection, addressing various challenges and improving overall performance and safety.

IV. RESULTS AND DISCUSSIONS

Model Architecture discuss the choice of model architecture (e.g., CNN) and why it was selected for this task. Mention any modifications or adaptations made to the architecture.If applicable, discuss the techniques used for data augmentation to improve the model's generalization and robustness.Address any challenges faced during the development and deployment of the model, such as data availability, hardware constraints, or environmental factors affecting real-time detection. Suggest potential improvements to the model, such as fine-tuning hyperparameters, collecting additional labeled data for training, or exploring more advanced architectures.

Discuss potential applications of the real-time motorcyclist detection helmet, such as enhancing motorcycle safety or assisting in autonomous vehicle systems, and its potential impact on society.Address any ethical considerations related to privacy, safety, or bias that may arise from deploying such a system in real-world settings.Include metrics such as accuracy, precision, recall, and F1-score to evaluate the model's performance in detecting motorcyclists in real-time.

Describe the model's ability to detect motorcyclists in real-time using the helmet-mounted camera and OpenCV for video processing.If applicable, compare the performance of your model with other existing methods or baseline models for motorcyclist detection.Discuss how the model performs under various conditions such as different lighting conditions, weather conditions, and varying speeds of the motorcycle.

Report the speed at which the model can detect motorcyclists in real-time, considering the inference time of the model.Highlight the model's performance in detecting motorcyclists in challenging situations, such as occlusions, crowded traffic, or fast-moving motorcycles.If available, compare the performance of your model with state-of-the-art methods or commercial systems for motorcyclist detection, emphasizing any advantages or improvements achieved.

Discuss any challenges encountered during the collection and annotation of the dataset, such as obtaining diverse samples, ensuring label accuracy, or addressing biases in the data.Consider discussing the interpretability of the model's predictions, including visualizations or techniques used to understand which features the model relies on for motorcyclist detection.

Address practical considerations related to the deployment of the motorcyclist detection helmet, such as user comfort, helmet weight, battery life, and ease of integration with existing motorcycle helmets.Discuss potential regulatory requirements or legal considerations associated with deploying such a system, including privacy regulations, data protection laws, and liability issues.If applicable, discuss feedback gathered from field tests or pilot studies involving actual motorcycle riders using the detection helmet, including user satisfaction, suggestions for improvement, and any safety concerns raised.

Consider scalability issues and deployment challenges associated with deploying the motorcyclist detection helmet in real-world settings, such as adapting the system to different helmet types or integrating it with existing motorcycle safety systems.

V. CONCLUSION AND FUTURE SCOPE

The proposed system is very much capable for detecting helmet in all certain situations with high level of accuracy. Here the system has been tested with various frames and result is effectively obtained with minimal error rate. Tensorflow and Keras are two main packages that allow to train a system with certain circumstances that affect the accuracy at very good extents. We used Yolo algorithm. The proposed system can be practically implemented in various places such as school, colleges, offices, shopping mall, marts and various public places that mandate the person to use the helmet with their family and friends at better safety concerns. System can be enhanced in future by testing various samples and can be trained for other situations where traditional systems may become failed..

Using TensorFlow and Keras in OpenCV for real-time automatic motorcyclist helmet detection has promising future applications in enhancing road safety. Beyond just identifying whether a motorcyclist is wearing a helmet, the technology could potentially be expanded to detect helmet types, ensure proper helmet fitting, and even integrate with other safety systems like automatic braking or alert systems for both riders and nearby vehicles. As technology advances, the accuracy and efficiency of such systems will likely improve, making them more viable for widespread implementation in traffic management and safety initiatives.

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