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Leveraging Intelligent Vision Systems for Multi-Feature Helmet Detection in Safety Applications

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ABSTRACT: Riding motorcycles without helmet wearing is one of the violations of important traffic rules ‘Mandatory Wearing of Helmet by motorcyclists’. The mortality/death rate is higher in bike accidents when compared to that of other types. The current methods include conventional methods which involve traffic officers who observe traffic rule violators by patrolling roads or traffic surveillance CCTVs. This requires more time and also manpower. It is tough to find and impose fines on each violator by using these approaches. This project includes a method to detect helmet wearing or not and also license number plate recognition for detecting and identifying two-wheeler riders with or without helmet and thereby penalizing them who do not wear helmets. Object detection using YOLO (You only learn only) is the main method to detect human and helmet presence in the given image. Object detection is carried out at various levels to find the helmet rule violators and their license plate number. The dataset is collected with both helmet and non-helmet wearing bike riders images. The image data are converted into grayscale data and stored in csv files. During the test image data checking, the images are converted into grayscale values and checked with available training data set images grayscale values. In addition, bike riders without helmet are found, then an email alert is sent to traffic department mail id. In addition, this project develops a new CNN architecture to classify helmet types and checks whether the image is having helmet or not. With i) good execution speed and ii) good generalization capability, this newly developed CNN architecture is used as an effective decision support method to detect rule violators for traffic department. Python 3.11 is used for development of the project.

KEYWORDS: Intelligent Vision Systems, Helmet Detection, Multi-Feature Detection, Convolutional Neural Networks (CNN), Real-Time Object Detection.

I. INTRODUCTION

The project is used for helmet wearing detection/classification. Here, the gray scale image is taken. The RGB image if taken, is converted into gray scale image first. Then all the images are resized into same size. Then the training data set images with helmet presence ‘yes’ are taken along with ‘no’. For each image, all the pixels’ grayscale value are found out and written in a row. So the total number of rows is equal to total number of images. The number of columns is the number of pixels in the image. These data is saved in comma separated file. For testing data, all these operations are carried out and saved in another comma separated value file. Then Convolutional neural network is applied to train the model with test data. The accuracy is found out and displayed. From the given test image, it can be found out as helmet present or not by checking with training data images. In addition, a test image is given and using image processing, checking for helmet is present or not.

II. LITERATURE REVIEW

AUTOMATIC DETECTION OF BIKE-RIDERS WITHOUT HELMET USING SURVEILLANCE VIDEOS IN REAL-TIME

In this paper [1], the authors proposed an approach for automatic detection of bike-riders without helmet using surveillance videos in real time. The proposed approach first detects bike riders from surveillance video using background subtraction and object segmentation. Then it determines whether bike-rider is using a helmet or not using visual features and binary classifier. Also, they presented a consolidation approach for violation reporting which helps in improving reliability of the proposed approach. In order to evaluate our approach, we have provided a performance comparison of three widely used feature representations namely histogram of oriented gradients (HOG), scale-invariant

feature transform (SIFT), and local binary patterns (LBP) for classification. The experimental results show detection accuracy of 93.80% on the real world surveillance data. It has also been shown that proposed approach is computationally less expensive and performs in real-time with a processing time of 11.58 ms per frame. Two-wheeler is a very popular mode of transportation in almost every country. However, there is a high risk involved because of less protection. To reduce the involved risk, it is highly desirable for bike-riders to use helmet. Observing the usefulness of helmet, Governments have made it a punishable offense to ride a bike without helmet and have adopted manual strategies to catch the violators.

SAFETY HELMET WEARING DETECTION BASED ON IMAGE PROCESSING AND MACHINE LEARNING

In this paper [2] the authors stated that safety helmet wearing detection is very essential in power substation. This paper proposed an innovative and practical safety helmet wearing detection method based on image processing and machine learning. At first, the Vibe background modelling algorithm is exploited to detect motion object under a view of fix surveillant camera in power substation. After obtaining the motion region of interest, the Histogram of Oriented Gradient (HOG) feature is extracted to describe inner human. And then, based on the result of HOG feature extraction, the Support Vector Machine (SVM) is trained to classify pedestrians. Finally, the safety helmet detection will be implemented by color feature recognition. Compelling experimental results demonstrated the correctness and effectiveness of our proposed method. Over the past decades, increasing accidents in power substation has raised many attentions for safety monitor. In order to ensure the safe operation of power equipments, more and more intelligent surveillance systems had been developed based on computer vision or image processing.

III. RELATED WORK

The integration of intelligent vision systems in personal protective equipment (PPE) monitoring, particularly helmet detection, has seen significant progress in recent years. Early approaches focused primarily on binary helmet detection—identifying whether a person is wearing a helmet or not—using hand-crafted features. However, with the advent of more robust and scalable solutions have emerged.

1. Traditional Image Processing Techniques:

Initial studies employed techniques such as color segmentation, edge detection, and feature extraction using Histogram of Oriented Gradients (HOG) or Scale-Invariant Feature Transform (SIFT) for helmet detection. For example, [Zhou et al., 2014] used background subtraction and color analysis to detect safety helmets in construction sites, but the method was limited by lighting conditions and background complexity.

2. Deep Learning-Based Object Detection:

The emergence of convolutional neural networks (CNNs) significantly improved detection accuracy. Models like YOLO (You Only Look Once), SSD (Single Shot Multibox Detector), and Faster R-CNN have been adapted for helmet detection tasks. [Wang et al., 2019] demonstrated the effectiveness of YOLOv3 in real-time helmet detection on construction sites, achieving high accuracy and low latency. Similarly, [Li et al., 2020] combined Faster R-CNN with ResNet backbones to improve feature extraction and address occlusion challenges.

3. Multi-Feature Helmet Detection

Recent research has extended beyond binary detection to multi-feature helmet classification, where systems detect various helmet types, colors, and additional safety compliance attributes (e.g., chin straps, reflective tapes). [Chen et al., 2021] introduced a multi-attribute learning model that jointly predicts helmet presence, type, and compliance level using a multitask CNN architecture.

4. Integration with Surveillance and IoT

Vision systems are increasingly being embedded into smart surveillance and IoT infrastructures. [Kumar et al., 2022] developed an edge-AI powered helmet detection system that integrates CCTV feeds with real-time processing capabilities on edge devices, enabling scalable deployment in industrial environments.

5. Dataset and Benchmark Challenges

The development of public datasets tailored for helmet detection has facilitated benchmarking and model development. Datasets like SHWD (Safety Helmet Wearing Dataset) and custom-labeled surveillance footage are commonly used. Nonetheless, variations in angle, occlusion, and environmental conditions remain significant challenges, prompting research into domain adaptation and data augmentation.

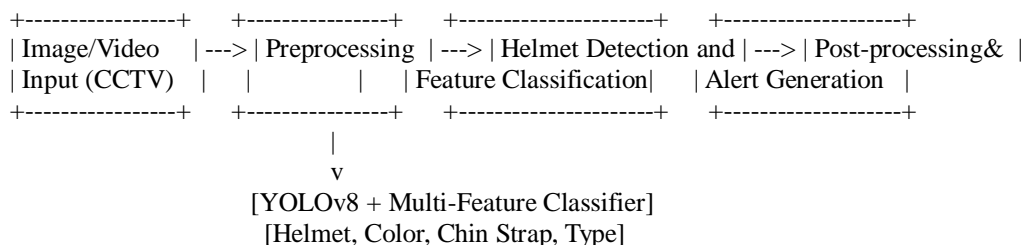
6. Cross-Application Insights

Helmet detection shares methodological overlap with other PPE detection tasks, such as vest or mask detection. Techniques from these domains, including attention mechanisms, semantic segmentation, and transformer-based models, are increasingly being applied to enhance helmet detection performance.

IV. PROPOSED SYSTEM AND DIAGRAM

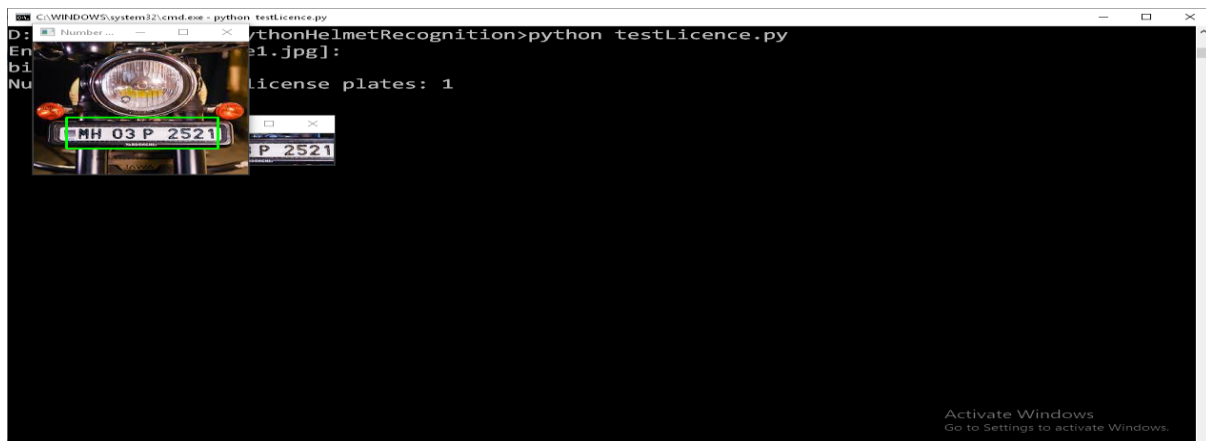
In proposed system, all the existing system process is carried out. Then a set of images with and without helmet wearing bike (two wheelers) riders are collected. Then, the gray scale image is taken. The RGB image if taken, is converted into gray scale image first. Then all the images are resized into same size. Then the training data set image with helmet class factor 'yes' are taken along with 'no'. For each image, all the pixels' grayscale value are found out and written in a row. So the total number of rows is equal to total number of images. The number of columns is the number of pixels in the image.

These data is saved in comma separated file. For testing data, all these operations are carried out and saved in another comma separated value file. Then Convolutional neural network is applied to train the model with test data. The accuracy is found out and displayed. From the given test image, it can be found out as helmet present or not by checking with training data images. Then the number data is parsed from the image and thus the vehicle registration number is found out. License Plate identification module is also added. If a bike rider image is found out from the video without helmet, then an email alert is sent to traffic department mail id.



V. EXPERIMENTAL RESULT

HIGHLIGHTING NUMBER PLATE





DETECTING LICENCE PLATE

```
C:\WINDOWS\system32\cmd.exe - python testLicence.py
D:\PythonProjects\PythonHelmetRecognition>
D:\PythonProjects\PythonHelmetRecognition>python testLicence.py
Enter filename [bike1.jpg]:
bike1.jpg
Number of detected license plates: 1
```

VI. CONCLUSION

This project develops a new CNN architecture to classify people with and without helmet and checks whether the image is having helmet or not. With i) good generalization capability and ii) good execution speed, newly developed CNN architecture is being used as an effective decision-support tool for admin to detect the presence of helmet in images. Python is used for development of the project. Bike Rider bounding box is plotted if he is not wearing Helmet. Also license plate extraction is also processed.

If the application is designed as web service, it can be integrated in many network applications. The application is developed such that above said enhancements can be integrated with current modules.

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