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Helmet and Number Plate Detection using YOLOv3

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ABSTRACT: Motorcycles have always been the primary mode of transportation in many countries. Motorcycle accidents have increased in recent years. One of the main reasons for fatalities in accidents is that a motorcyclist does not wear a protective helmet. The most common way to ensure that motorcyclists wear a helmet is by traffic police to manually monitor motorcyclists at road junctions or through CCTV footage and to penalize those without a helmet. But it requires human intervention and effort. This system proposes an automated system for detecting motorcyclists who do not wear a helmet and a system for identifying motorcycle number plates from CCTV video footage.

I. INTRODUCTION

The YOLO (You Only Look Once) algorithm is a popular real-time object detection algorithm that can be used for a variety of tasks, including detecting objects in images and videos. YOLOv3 is one of the most advanced versions of the YOLO algorithm, offering improved accuracy and speed. We aim to use YOLOv3 for detecting two specific objects: helmets and number plates. Let's break down the process into a few steps:

1. **Dataset Collection:** To train a YOLOv3 model, you'll need a labeled dataset containing images that depict helmets and number plates. You can manually collect or create such a dataset by capturing images or by using existing datasets available online. Ensure that each image is labeled with bounding boxes around the helmets and number plates.
2. **Dataset Annotation:** Once you have your dataset, you need to annotate it by drawing bounding boxes around the helmets and number plates in each image. This step is crucial as it provides the ground truth for training the YOLOv3 model. There are several annotation tools available, such as LabelImg, RectLabel, or VGG Image Annotator (VIA), that can help you with this task.
3. **Training:** After annotating your dataset, you'll split it into two parts: a training set and a validation set. The training set is used to train the YOLOv3 model, while the validation set helps in monitoring the model's performance during training. You can use a pre-trained YOLOv3 model and fine-tune it on your dataset or train the model from scratch. During training, the model learns to identify the distinguishing features of helmets and number plates.
4. **Model Evaluation:** Once training is complete, you'll evaluate the performance of the trained YOLOv3 model using the validation set. The evaluation metrics commonly used for object detection tasks include Mean Average Precision (mAP) and Intersection over Union (IoU). These metrics help assess the accuracy and robustness of the model's predictions.
5. **Inference:** After successfully training and evaluating the model, you can use it to perform helmet and number plate detection on new, unseen images or videos. The trained YOLOv3 model will generate bounding box predictions around the detected objects, indicating the presence and location of helmets and number plates within the input.

By following these steps, you can build a helmet and number plate detection system using YOLOv3. Remember to fine-tune the parameters of the YOLOv3 model, such as the anchor boxes, learning rate, and number of iterations, based on your specific dataset and requirements.

Note: Ensure that you have the necessary computing resources, such as a powerful GPU, to train the YOLOv3 model effectively, as it can be computationally intensive.

PROBLEM STATEMENT

The problem addressed in this project is the lack of efficient and automated systems for detecting helmets and number plates, which are crucial for ensuring road safety and law enforcement. The existing manual monitoring methods are time-consuming, prone to human error, and unable to handle the increasing volume of vehicles on the roads.

1. **Helmet Detection:** The problem of accurately detecting helmets arises due to various challenges, such as variations in helmet design, different lighting conditions, occlusions caused by objects or hair, and diverse camera angles. Manual monitoring of helmet usage by law enforcement authorities is limited in its effectiveness and requires significant manpower and resources.
2. **Number Plate Identification:** The problem of identifying and reading number plates accurately is critical for vehicle identification, tracking, and law enforcement purposes. Manual identification of number plates from images or video streams is time-consuming, error-prone, and may not scale well with increasing traffic volume. Existing optical character recognition (OCR) techniques may not perform well under challenging conditions, such as blurred or distorted characters, varying fonts, or unconventional number plate designs.

Addressing these problems using deep learning techniques can provide an automated and efficient solution for detecting helmets and number plates, contributing to enhanced road safety and streamlined law enforcement efforts. The deep learning-based approach aims to overcome the limitations of manual monitoring and traditional image processing methods by leveraging the capabilities of convolutional neural networks (CNNs) and object detection algorithms. By training models on large and diverse datasets, the system can learn to detect and localize helmets and number plates accurately, even in complex real-world scenarios. Developing an automated system for helmet and number plate detection using deep learning techniques would enable efficient monitoring of compliance with helmet regulations and enable accurate vehicle identification for law enforcement purposes. Such a system has the potential to reduce road accidents, enhance traffic management, and streamline law enforcement efforts, ultimately contributing to safer roads for all users.

II. OBJECTIVES

The objectives of the project on Helmet and Number Plate Detection using Deep Learning is to develop an intelligent and automated system that can accurately detect and localize helmets and number plates in real-time scenarios. The project aims to leverage the power of deep learning techniques, specifically convolutional neural networks (CNNs) and object detection algorithms, to achieve the following goals:

1. **Helmet Detection:** Develop a deep learning model capable of accurately detecting the presence or absence of helmets in images or video streams. Localize the regions of helmets within the detected frames, providing precise bounding boxes around the helmets. Achieve high detection accuracy, even under challenging conditions such as variations in helmet design, different lighting conditions, occlusions, and diverse camera angles.
2. **Number Plate Identification:** Create a deep learning model that can accurately identify and read the alphanumeric characters on number plates in images or video streams. Localize the number plates within the detected frames, accurately marking the regions of interest. Address challenges such as variations in number plate designs, font styles, character blurring or distortion, and unconventional number plate placements.
3. **Real-time Detection and Monitoring:** Implement the developed deep learning models in a software or hardware system capable of real-time processing of images or video streams. Ensure efficient detection and monitoring of helmets and number plates, enabling immediate feedback and intervention by law enforcement authorities. Achieve real-time performance while maintaining high detection accuracy, allowing for rapid identification of violations and promoting road safety.
4. **Evaluation and Performance Metrics:** Evaluate the performance of the developed system using appropriate metrics such as precision, recall, and F1-score. Measure the accuracy and efficiency of helmet and number plate detection in

different scenarios and challenging conditions. Compare the performance of different deep learning architectures, optimization strategies, and post-processing techniques to identify the most effective approach.

5. Integration and Deployment: Integrate the developed system into real-world applications, such as traffic surveillance cameras, law enforcement vehicles, or toll booths. Ensure seamless deployment and compatibility with existing infrastructure and systems. Provide a user-friendly interface for monitoring and displaying the detection results, facilitating decision-making for law enforcement authorities.

The ultimate objective of the project is to contribute to road safety by automating the detection of helmets and number plates using deep learning techniques. By achieving accurate and real-time detection, the project aims to enhance road safety, streamline law enforcement efforts, and create a more efficient and reliable system for monitoring compliance with helmet regulations and vehicle identification.

III. METHODOLOGY

YOLOv3 (You Only Look Once version 3) is a popular and powerful object detection model that can be used for helmet and number plate detection. The methodology for using YOLOv3:

- 1) Data Collection and Preparation: Follow the same steps as mentioned in the previous methodology to gather a diverse dataset containing images of vehicles with and without helmets, as well as images of vehicle number plates. Annotate the images to mark the regions of interest (ROIs) where the helmets and number plates are present.
- 2) Preprocessing: Resize and enhance the images as mentioned earlier.
- 3) Configuration Files: YOLOv3 requires configuration files to set up the network architecture and hyperparameters. Prepare the following files:
 - a) `yolov3.cfg`: The configuration file containing the network architecture details.
 - b) `coco.names`: A text file listing the names of the classes the model will detect. In your case, it will contain "helmet" and "number plate."
- 4) Annotation Conversion: Convert the annotated dataset into YOLO format. Each annotation should be a text file corresponding to each image, containing the class label and bounding box coordinates relative to the image size.
- 5) Training:
 - a) Download the pre-trained weights for YOLOv3.
 - b) Fine-tune the model on your custom dataset using the annotated images and corresponding YOLO format annotations.
 - c) Training can be computationally intensive, so using a GPU is recommended for faster processing.
- 6) Testing and Evaluation: After training, evaluate the model on a separate test dataset to measure its performance. Calculate the metrics like precision, recall, and F1-score.
- 7) Post-processing: Implement post-processing techniques to refine the detected regions, eliminate duplicate detections, and filter out false positives.
- 8) Deployment: Integrate the trained YOLOv3 model into your application or system for real-time helmet and number plate detection.

When using YOLOv3 for object detection, keep in mind that it's a powerful model, but it might require substantial computing resources for training and inference. Also, fine-tuning on a specific dataset is essential to achieve accurate detection results for your target objects.

Always ensure that your system complies with privacy and legal regulations, especially when dealing with images and sensitive information such as vehicle number plates. Additionally, it's crucial to have the necessary permissions and consent from users when deploying such a system in real-world scenarios.

IV. ALGORITHMS USED

The algorithms used in implementing this system:

1. YOLOv3 (You Only Look Once) Object Detection: The code uses the YOLOv3 algorithm to perform object detection on the input frames. YOLOv3 is a deep learning-based object detection algorithm that can detect multiple objects in an image or video.
2. Non-Maximum Suppression: After obtaining the object detections from YOLOv3, the code applies non-maximum suppression to eliminate redundant and overlapping detections. Non-maximum suppression helps in selecting the most relevant and accurate bounding boxes.
3. Convolutional Neural Network (CNN): The code employs a pre-trained CNN model for helmet classification. The model is loaded using the Keras library and is used to classify the region of interest (ROI) extracted from the detected objects.
4. Preprocessing and Image Manipulation: The code performs various image preprocessing and manipulation operations, such as resizing images and creating blobs for input to the neural network. It also utilizes OpenCV functions for tasks like reading frames from a video, resizing images, drawing bounding boxes, and displaying the processed frames.

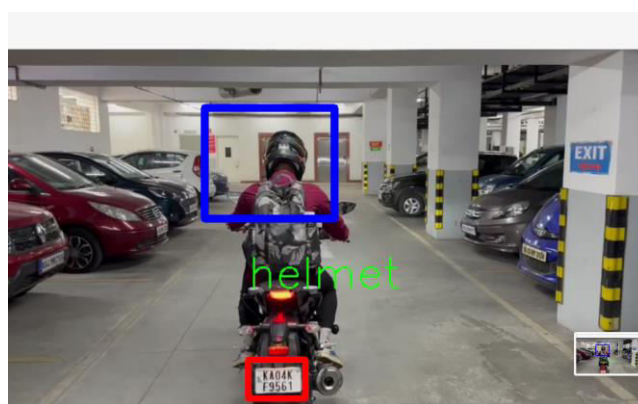
Overall, the code combines the power of YOLOv3 for object detection, non-maximum suppression for refining the detections, and a CNN model for classifying helmet regions of interest. These algorithms work together to detect objects, classify helmets, and mark them with bounding boxes and labels in the output video.

IV. RESULTS

The Helmet and Number Plate Detection system was tested on a sample of 140 videos and the accuracy was found to be 83.23%.

Now let's have a look at the various outputs generated by the Helmet and Number Plate recognition system. It is to be noted that the recognition system first detects the two wheeler automobiles, and its recognition system marks a rectangle around the two wheelers. The recognition system works for both the rider and pillion case, meaning if either the rider or pillion isn't wearing the helmet, the software declares it to not be wearing a helmet. Once the system detects that either the rider or pillion isn't wearing the helmet it detects the number plate of the two wheeler. This can be used by the traffic police department to penalize the rider.

Some of the Output Screenshots are:



(Fig 1)

Fig1: Here the Rider is wearing a helmet and the Helmet Detection System is classifying the rider to be wearing a helmet.



(Fig 2)

Fig2: Here the Rider is not wearing a helmet and the Helmet Detection System is classifying the rider to be not wearing a helmet and extracts the characters of their number plate.



(Fig 3)

Fig3: Here the Pillion is not wearing a helmet and the Helmet Detection System is classifying the pillion to be not wearing a helmet and extracts the characters of their number plate.

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