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Identify images of car collisions on the road using Deep Learning

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***Abstract**. An intelligent transportation system aims to steer vehicles without encountering accidents on the way to the destination. Autonomous vehicles greatly rely on cameras for perceiving their dynamically changing surroundings. Deep learning solutions to vision data is driving the research on collision mitigation systems for selfdriving cars or automobiles with a higher level of autonomy. This paper presents a three-class vehicular collision image classification dataset created from crowd-sourced dashboard camera videos containing on-road vehicular collisions. An image classification deep learning model is developed using teachable machine by transfer learning on the proposed dataset. The ability of the developed model to classify vehicular collision images based on the spatial aspect of the crash is evaluated and presented.*

Keywords: *Image classification, Deep learning, Accident classification*

1. Introduction

The development of smart cities demands an intelligent transportation system, the ultimate purpose of which is to reach the destination safer. Technology advancements have helped in safer navigation through several means, like improved road features, vehicular design, functionality, etc. Various Advanced Driver Assistance System (ADAS) features, such as automatic brake assist, forward collision warning, parking assist, surround view, etc., are already available in commercial vehicles, supporting enhanced driving. Newer versions of cars introduced by leading manufacturers come with more ADAS features or a higher level of autonomy, as framed by the Society of Automotive Engineering (SAE) International.

Road accidents are a major concern in India, with a total number of 4,12,432 reported in the country during the year 2021, causing 1,53,972 deaths and injuries to 3,84,448 persons, as per the Road Accidents in India 2021 report [1]. Technology-aided solutions to collision mitigation are the need of the hour. Various modalities are involved in detecting vehicular collisions, like smart road infrastructure [2, 3], wireless communication technology, and Internet of Things [4], etc. Risk prediction of road accidents using neural networks considering various features, including geographical characteristics, road, vehicle, and driverrelated characteristics, and temporal and weather conditions, etc, are presented in [5]. Unlike the abovementioned modalities camera provides rich vision data about the road environment from which various information can be extracted that can also be augmented with other sensory data like GPS, RADAR, LIDAR, etc. Deep learning algorithms are extensively used on computer vision data for their generalization and higher accuracy, and they demand lots of data for their development.

This paper presents the classification of images obtained from dashboard camera videos containing vehicular collision using Teachable Machine , a web-based tool with a MobileNet backbone. Dashboard camera view gives nearly the same viewpoint as a driver's perspective. Hence compared to CCTV video, dashboard camera video is more intuitive and reasonable to use in autonomous vehicle experiments, giving an ego-centric view of the road environment.

2. Methodology

This section presents the methodology carried out in collecting and preparing the dataset, the processing involved, the implementation of the image classification deep learning model, and the performance metrics used for evaluating the model's behavior. The dataset is prepared using crowd-sourced videos. Development of the image classification deep learning model is done using Teachable Machine. MoviePy, cv2, Keras, NumPy, matplotlib, Seaborn, and scikit-learn are some of the libraries and packages used in preprocessing of dataset and implementation of the work in the

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Anaconda integrated development environment (IDE).

2.1. Vehicular collision image classification dataset

The vehicular collision image classification dataset is created from crowd-sourced dashboard camera videos containing vehicular collisions available freely on YouTube. Crowd-sourced data will have wide variations in the specifications of the acquisition device, leading to varying resolutions, varying fields of view, etc., captured under different environmental conditions involving daylight, night-time, rainy weather, snowy weather, etc.

2.2. Model development

The teachable machine is an interactive web-based interface built with MobileNet backbone for creating image classification deep learning models. It basically performs transfer learning by training the top layers of a pre-trained network with the user's data to provide the classification model. The input to the image classification model is RGB images of size 224 × 224. So, the actual images in the dataset, which were of size 1280 × 720, are resized to 224 × 224 to be fed to the model. Options for hyperparameter tuning include variations in learning rate, batch size, and the number of training epochs.

2.3. Performance metrics

The efficiency of the developed image classification model is evaluated by computing certain standard performance metrics meant for the classification algorithm. The confusion matrix is a performance measure of a classification algorithm that represents the number of correct and incorrect predictions made by the model on the given test data in a matrix form. For the three-class classification problem in this work, the confusion matrix will be of size 3 × 3, and important metrics like accuracy, precision or positive predictive value (PPV), recall or sensitivity, specificity, negative predictive value (NPV), and F1.

$$Accuracy = \frac{TN + TP}{TN + FN + TP + FP} \tag{1}$$

$$PPV = \frac{TP}{TP + FP} \tag{2}$$

$$\mathrm{Re}call = \frac{TN}{TP + FN} \tag{3}$$

$$Specificity = \frac{TN}{TP + FP} \tag{4}$$

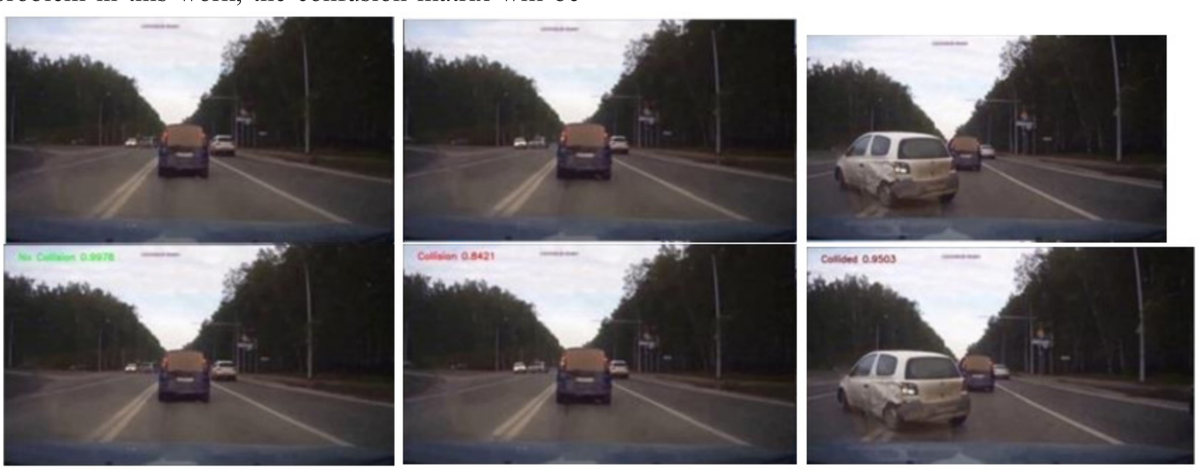
$$NPV = \frac{TN}{TN + FN} \tag{5}$$

$$F_1\ Score = \frac{2xPrecisionxRecall}{Precision + Recall} \tag{6}$$

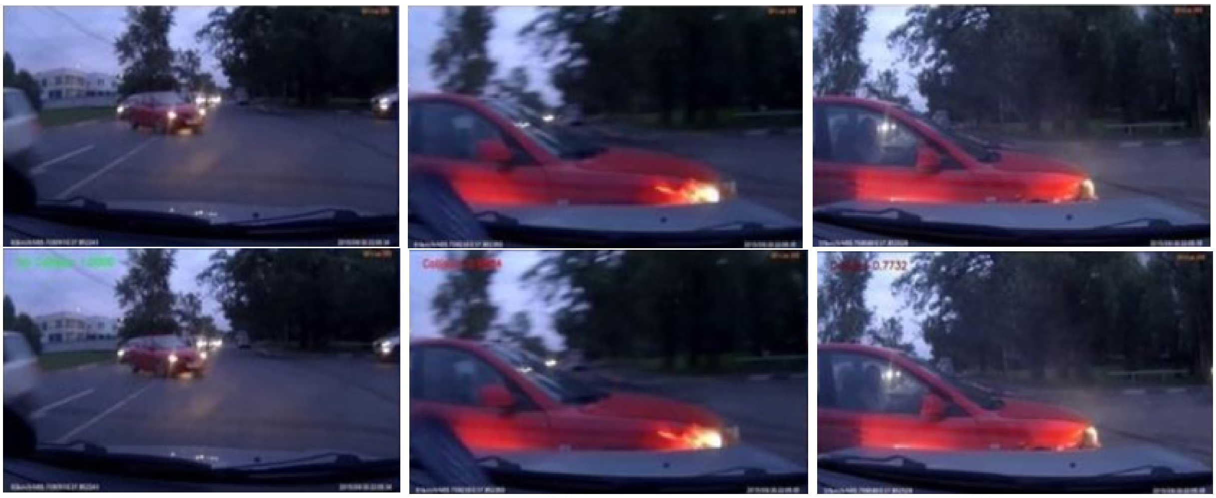
3. Results and Discussion

This section presents the outcomes of experimentation to get a satisfactory vehicle collision image classification deep learning model. Multiple experiments were conducted by tuning hyperparameters like learning rate and batch size to obtain better validation results.

The three-class image classification model, developed in the teachable machine at 0.0001 learning rate with a batch size of 16 and trained for 100 epochs, gave an accuracy of 73.13 %, 73.13 %, and 78.75 % for No Collision, Collision, and Collided classes, respectively. Figure 2.1 shows the image samples of model's inference on the test data. The original image and the prediction class with confidence score overlaid on the image are shown.



(i) (ii) (iii)



(i) (ii) (iii)

Figure 2.1. Samples of model's inference. The original input test image and the predicted class by the model with confidence score overlaid on the image for (i) no collision class, (ii) collision class, and (iii) collided class, respectively

4. Conclusion

A vehicular collision is an unfortunate event in transportation, taking a toll on human lives. As autonomy in vehicles is increasing and self-driving cars are soon to get operational, techniques to understand vehicular collision becomes more critical. As an incremental step towards it, a vehicular collision image classification dataset is presented in this paper. As the dataset is formed from dashboard camera videos of vehicles that recorded vehicular collisions, it is considered more representative of the fundamental nature of vehicular collisions and dynamic road conditions. An image classification deep learning model is obtained from the teachable machine by transfer learning approach using the proposed dataset. Vehicular collision, which results from a sequence of events happening across time, can be classified with only spatial information. From the results, it is understood that a deep learning image classification network can extract features from spatial data and relate the frames temporally apart in a video by classifying them as before or no collision, during a collision, and after collision with no explicit temporal information being provided. The model's performance from transfer learning on a custom-made vehicular collision classification dataset is evaluated. Future work can be in the direction of providing spatiotemporal information to deep learning architectures for vehicular collision action detection for spatially and temporally locating vehicular collisions in videos..

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