Explainable Real Time Vehicle Make Model Recognition Using Bag of Expressions Features

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Abstract:

Vehicle Make and Model Recognition (VMMR) has been an area of research in last few years. research in this topic will improve transportation systems. This has application or can be applied in traffic surveillance and traffic management. There is also increasing demand for traffic monitoring solutions. Many of the vehicle identification techniques are based on manual observation, license plate recognition. These system does not perform up to satisfactory level in the abnormal weather conditions. This faces problem in low light , occlusion, camera position with respect to vehicle, motion blur, and poor image quality. [1]

This review paper presents a comprehensive study of existing Vehicle Make and Model Recognition approaches, datasets, feature extraction methods, and classification techniques. The paper discusses traditional machine learning methods and deep neural network learning approaches, including Convolutional Neural Networks (CNNs), transfer learning, attention mechanisms, and hybrid frameworks. [1]

The study of the recently published papers shows that deep learning particularly CNN, transformer based architectures, provide better accuracy compared to conventional techniques. Integration of VMMR with edge computing and intelligent surveillance systems enables faster and more scalable deployment.

This topic has many of the applications like traffic monitoring, toll collection, law enforcement, stolen vehicle detection, surveillance, etc. Once a better model is developed many new applications can be identified in coming years. It has difficulty of Introduction of new models, Improvement of existing models. Which make an big hurdle. Weather conditions and Terrin are not stable in india there is need for consistent improvement.

Keywords: vehicle make and model recognition, large scale vehicle dataset, Intelligent transportation system (ITS), vehicle attribute recognition, vehicle type classification

Introduction

VMMR refers to the automatic identification of a vehicle's manufacturer (make) and its specific product variant (model) from digital images or video streams. Accurate recognition of vehicle make and model is essential for various real time applications such as traffic surveillance, traffic management, law enforcement, parking automation, toll collection, border security, etc.[2], [3], [4]

In the earlier phase of research the vehicle identification methods were focused on license plate recognition systems. These concepts and applications had limitations of poor image quality captured from camera. In addition to it had occlusion, damaged number plates, and day light, night light. In some cases, it was found that license plates missing, modified licence plate, not clearly visible from camera. research scholar applied the another concept of identifying visual appearance features of vehicles such as shape, headlights, grille patterns, logos, textures, and body structures. [5], [6]

The difficulty in identification is the similarity between different vehicle models. With the different angles or view point classes of Vehical classes do not respond. Factors that affect is the light conditions, blur image, image with motion, angle of camera, image angle of vehicle and quality of the image. A text based research work done which is a different approach visual to text conversion used. [7]

Author L. Lu and H. Huang worked on the extracting features from vehicle and Applying machine learning algorithms to detect the Vehical. They applied algorithms and methods of Scale Invariant Feature Transform (SIFT), Histogram of Oriented Gradients (HOG), Local Binary Patterns (LBP) and Support Vector Machines (SVM) for vehicle classification tasks. Results of the above methods were at moderate level , performance was low in difficult weather conditions, concept and model was not able to extract all features under all conditions.[8], [9]

Author W. Puismlee and R. Chawuthai worked on CNN models, deep Learning with front images of the vehicles. he used CNN models and deep learning to extract features from large datasets. They reduced the image size but increased layers. They claimed to get accuracy of 99% to recognize model of car. Author also tesed the model of typical conditions like blur , angles etc and he was satisfied with the results. [1]
Author compared with the deep learning architectures ResNet, VGGNet and found that results were comparable.

Related work

Author A. Nazemi, Z. Azimifar , Alexder Wong worked on this topic and their research paper applied the unsupervised feature learning on the real time framework. They proposed a system called ORV-MMR (On Road Vehicle Make and Model Recognition). They addressed fine grained vehicle classification in real traffic environments. They proposed and worked on two unknown class named as “Unknown Heavy” and “Unknown Light” where all undetected vehicles were categorized. They compare their work with other CNN architectures ResNet-50 and AlexNet. This research work was on Iranian “On-Road Vehicle (IORV)” dataset and the “CompuCar” data set . The framework is designed to recognize 50 predefined vehicle classes and two known category.[2] Authors introduce a multi stage classification model using SVM and a Multi-Layer Perceptron (MLP) network to calculate classification confidence. This research paper claims that the ORV-MMR framework provides an effective balance between accuracy, robustness, and computational efficiency for vehicle recognition applications. [2]

Author Michał Bularz , Karol Przystalski, worked in this research problem using the Tail Light of the vehicle. Their work is for passenger car. They used CNN approach to implement it. their concept was to detect rear light object and then crop the image to 64x64 pixels, they used object extraction and image binarization methods. [10]

A summary can be understood as this research has class similarity, viewing angle, low quality pictures and many more. So results of researchers are dependent on specific Terrin and Specific Vehical manufacturer.

Literature Survey

Vehical identification research have been done through multiple approach. Majority is based on Image processing through a deep neural network. each has own set of limitations. It is observed that it fails due to multiple reasons. Recently researchers are focused using specific features of the vehicle for example visual appearance, headlights, grills, bumpers, and body structures for recognition tasks.[4]

With the advancement of deep learning technologies, Convolutional Neural Networks (CNNs) became the dominant approach for vehicle recognition tasks. [11] Deep learning methods automatically learn hierarchical and discriminative features from large datasets, thereby significantly improving recognition accuracy. Several CNN architectures such as ResNet, VGGNet, Xception, DenseNet, and EfficientNet have been widely applied in VMMR systems. Researchers observed that deep learning approaches outperform traditional handcrafted methods, especially in vehicle classification problems where subtle visual differences exist among vehicle models.

Auther Author Amirkhani and Barshooi proposed the “DeepCar 5.0” framework for vehicle make and model recognition under challenging conditions. They introduced a multi agent and ensemble based deep learning framework. The authors worked on extracting some less known features from front view. they focused on front grill shape , headlight curve. Other front image component like fog studies were also studied. In this work they extracted multiple “Regions of Interest (ROIs)” on the image and assigned dedicated CNN architectures to each region.[12]

In the “DeepCar 5.0” framework project feature extraction applied on the specific parts.

In this work edge detection applied for extracting headlight and grill structures. Gabor filters were used to analyze bumper structure.

After extracting features from image regions using agents. It combined using an ensemble voting mechanism based on the blackboard system.

Author claims that experimental results showed that the proposed approach achieved classification accuracies of 96.72% in manual detection mode and 92.14% in automatic detection mode, outperforming several existing methods. [12]

Dataset for the research work is available in the public domain . Datasets such as “CompCars”, “VeRi-776”, “VehicleID”, “CityFlow”, “PKU-Vehicle”, and “BoxCars116k” are providing images of the vehicals with annotations , they have multiple angles and in some of the case weather conditions also included in the images. Dataset such as “DeepCar 5.0” had large scale dataset containing more than 40,000 images from 480 vehicle classes produced by 50 international automakers between 1999 and 2022. This dataset includes manually labelled bounding boxes for vehicle components. It also has technical specifications which supports fine grained vehicle analysis.[12]

Key Contribution

Research work have been done on Vehical using CNN, Deep car 5 framework, using deep learning architectures such as VGGNet, ResNet, EfficientNet, and transformer learning based models for VMMR tasks.

Discussions

Research in the VMMR has many constraints which are specific to the geographical location. Vehical types and their category is changing with time , Features are changing and many of the features are similar in nature. Many of the research work done but majority from USA , Europe etc. The real time scenario in the Indian road conditions are not same as USA and Europe. so there is lot of scope to work on this topic. The road and weather conditions make it difficult to identify the Vehical. In this research a large number of scenarios need to be considered before deciding the Make and Brand.

Conclusions

On successful implementation under the real time conditions this open new applications. This is applicable on Law Enforcement, Traffic monitoring etc. this is ever challenging field since the road conditions, traffic conditions and weather changes. so it needs consistent improvement.

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