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VEHICLE MODEL PREDICTION USING MACHINE AND DEEP LEARNING TECHNIQUES

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Abstract--- *Vehicle model recognition is a vital task for various applications, particularly in the context of Intelligent Transport Systems (ITS) and transportation management such as traffic monitoring and surveillance, toll collection, parking management, vehicle tracking and logistics, and law enforcement. The traditional method for identifying vehicles involves officers visually inspecting the footage and identifying the vehicle based on its appearance. While this approach can yield accurate results, it is also prone to errors due to human fatigue when dealing with long videos. Additionally, hiring employees to perform this task can be costly. Therefore, an alternative method may be needed to address these challenges. To overcome these issues, a vehicle model detection system is implemented which uses machine and deep learning techniques such as linear regression, support vector machines (SVM), K-Nearest neighbors (KNN), and Convolutional neural networks (CNN). The proposed approach yielded an average accuracy of 98.5%, signifying remarkable progress.*

Keywords--- vehicle model recognition, deep learning, linear regression, support vector machines, K-nearest neighbors, convolutional neural networks.

I. INTRODUCTION

Vehicle model recognition is a vital research area in the field of Intelligent Transport Systems (ITS) and transportation management, as the identification of the make, model, and year of a vehicle based on its visual appearance has several important applications [1].

Firstly, vehicle model detection can be used for traffic monitoring and surveillance, which enables authorities to analyze traffic patterns in real time, manage congestion, and improve public safety. Additionally, toll collection systems can use vehicle model detection to charge appropriate toll fees, and parking facilities can optimize space allocation and reduce congestion with real-time monitoring. Companies can also utilize real-time vehicle model detection to track the locations and movements of their fleets, reducing fuel consumption, improving delivery times, and enhancing overall fleet efficiency. Lastly, law enforcement agencies can employ vehicle model detection to identify and locate suspect vehicles involved in crimes and accidents.

Deep neural networks have recently gained popularity in the field of vehicle model recognition due to their remarkable performance in various computer vision tasks [2].

The main objective of this paper is to create a predictive model that accurately predicts the vehicle model based on several features, including make, model, and year. We will be working with a dataset containing these features and will explore different machine learning algorithms such as linear regression, SVM, KNN, and CNN to identify the most suitable one for this task. Additionally, we have also created a graphical user interface (GUI) that is user-friendly.

These networks have shown remarkable performance in a range of computer vision tasks, including segmentation, image classification, and object detection. However, there are still some challenges that need to be addressed in the context of vehicle model recognition, such as handling occlusion, variability in lighting and viewpoint, and dealing with large-scale datasets. In this paper, we present an evaluation of the performance of the machine and deep learning techniques for identifying the model of a vehicle.

The outline of this paper is organized as follows: Section II presents the appropriate literature required for

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vehicle classification. Section III describes the methodology in depth. The details of the results and analysis are discussed in section IV. Finally, section V concludes the purpose of this paper.

II. LITERATURE REVIEW

Hashir Yaqoob et al. [5], developed a system in which a vehicle's make and model are recognized using two different approaches. The first approach involved using the Bag-of-Features (BOF) model, where feature extraction was done using the Speeded Up Robust Feature (SURF) method, and classification was performed using the Multi-class Support Vector Machine (SVM) classifier. For the second approach, they used a Convolutional Neural Network (CNN) to extract and classify features. They also used a pre-trained neural network, AlexNet, and utilized Transfer Learning to train it on their dataset for vehicle classification in the VMMR system.

Zhou et al. [8] introduced a deep learning approach for detecting and classifying vehicles, using YOLO as the detection model to identify the vehicles. For classification purposes, they employed Alexnet and built four separate classifiers, including passenger vs. other, cars vs. vans, sedans vs. taxis, and sedans vs. vans vs. taxis. They fine-tuned the structures to fit a publicly available dataset and achieved an accuracy of more than 90% in their experiments.

Saripan et al. [9] presented a system for vehicle classification using surveillance video and vehicle characteristics as inputs. The system uses a tree-based approach and consists of three main modules: feature extraction, classification, and search manager. To extract features, the system crops vehicle images systematically from the surveillance video input. The feature data extracted is then passed to the classification module, and the results are sent to the search manager module, which stores and filters the outcomes based on the query commands provided.

Hsieh et al. [10] proposed the use of the Speeded Up Robust Feature (SURF) technique for detecting and recognizing vehicles. They utilized the front or rear views of the vehicle for their study, as these regions contain distinctive features that can be efficiently computed. Petrovic and Cootes are the first authors who suggested vehicle model recognition providing the foundation and methodology for subsequent research in this area.

III. METHODOLOGY

A. Dataset Explanation

To build machine learning models for vehicle model detection using linear regression, SVM, KNN, and CNN algorithms, a dataset of labeled images is required. The dataset should contain images of different vehicles, including various makes and models. Each image should be labeled with its corresponding make and model, which will serve as the ground truth labels for training the models.

To implement this project, we have used a car images dataset from Kaggle which contains 4165 images of different car models. Once the dataset is prepared, it can be partitioned into training and test sets. The models are trained using the training set, while the test set is utilized to assess the effectiveness of the trained models on new, unseen data.

B. Data Pre-processing

The images in the dataset should be pre-processed to ensure uniformity and compatibility for use with the machine learning algorithms. This may involve resizing, normalization, and filtering. Relevant features are extracted from the pre-processed images. This can be done using techniques such as Principal Component Analysis (PCA). For CNN, the features can be learned automatically using convolutional layers.

Figure.1 Sample car images data

C. Proposed Architecture

The proposed architecture model aims to compare linear regression with KNN, SVM with CNN, KNN with SVM, and KNN with CNN. Using these results, the model of the car is predicted. Correspondingly, accuracy comparison graphs are generated. The following figure shows the workflow of the proposed architecture.

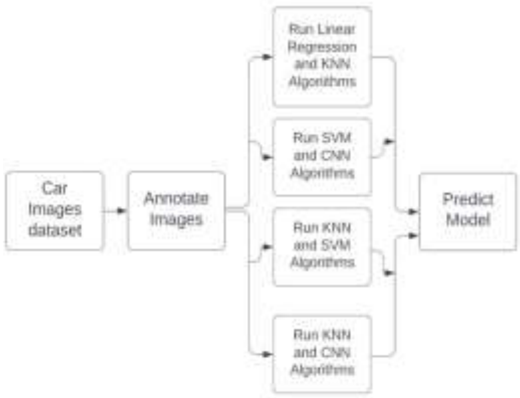

Figure.2 Workflow

D. Implementation Techniques

a) Linear Regression

Linear regression analysis is a statistical technique used to estimate and predict the value of a variable based on the value of another variable. The variable that we aim to predict is known as the dependent variable, whereas the variable used to make predictions is known as the independent variable. The relationship between these two variables is assumed to be linear, and the primary goal of linear regression is to determine the line of best fit that minimizes the difference between the actual and predicted values of the dependent variable based on the independent variable [4].

Linear regression proves to be a valuable tool in vehicle model detection due to its simplicity and speed. It can be trained using a relatively small dataset, and it also provides insights into the significance of each input feature in predicting the vehicle model. However, its effectiveness may be limited if the connection between the input features and the output variable is non-linear or if there are complex interactions between the features. In such cases, other machine learning models like SVM, KNN, or CNN may be more useful.

b) Support Vector Machine

Support Vector Machine (SVM) is a machine learning algorithm used for both classification and regression tasks. It works by identifying the hyperplane that separates the data points into their respective classes. It aims to find the optimal hyperplane that maximally separates data points of different classes in each dataset [11].

In the context of vehicle model detection, SVM can be used to classify a vehicle image into one of several pre-defined make and model categories. Initially, the algorithm is trained on a set of labeled images, where each image is associated with a specific make and model. The features extracted from the input image serve as input variables, while the vehicle makes and the model serves as the output variable.

SVM is helpful in vehicle model detection because it can handle non-linear relationships between the input features and output variables. It also works well with high-dimensional data, making it suitable for image-based classification problems. Additionally, SVM has been shown to outperform other machine learning algorithms in several image recognition tasks. However, the performance of SVM may depend on the choice of kernel function and hyperparameters, which need to be carefully tuned for optimal results.

c) K-Nearest Neighbors

K-nearest neighbors (KNN), a commonly used machine learning algorithm is used in classification and regression tasks. It works by identifying the K closest data points in feature space to a given input and utilizing most of their labels to predict the label of the input [6].

In the field of vehicle model detection, KNN can be employed to detect the make and model of a vehicle from an image. This requires training the algorithm on a dataset of labeled images where each image is labeled with a corresponding make and model. When a new image is presented, KNN searches through the dataset to locate the K nearest images that are similar in terms of their features. The algorithm predicts the make and model label of the input based on the majority label of the K closest images.

d) Convolutional Neural Networks

Convolutional neural networks (CNN) are a type of deep learning algorithm used for image processing and pattern recognition. CNNs work by processing input data through multiple layers of convolutional and pooling operations to extract high-level features that are then used for classification or regression tasks [7].

In summary, CNNs are a powerful tool for vehicle model detection due to their ability to learn and extract relevant features from images, which can accurately classify the type and make of a vehicle.

In the domain of vehicle model detection, CNNs can be utilized to detect the make and model of a vehicle from an image. This involves training the network on a

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dataset of labeled images, where each image is associated with a make and model label. The network learns to extract relevant features from the images that are useful for identifying the make and model of the vehicle. When presented with a new image, the trained network applies the learned features to classify the make and model labels of the input image.

CNNs are particularly useful for vehicle model detection because of their ability to learn complex features and patterns from images. This allows them to detect subtle differences between vehicles that may be difficult for other algorithms to identify.

IV. RESULTS AND ANALYSIS

The comparisons of various machine learning techniques for the vehicle make and model recognition indicates that the accuracy varies significantly across different methods evaluated.

Linear regression and KNN show the lowest accuracy of 29% and 20%, respectively, indicating that they may not be suitable for complex classification tasks like vehicle makes and model recognition.

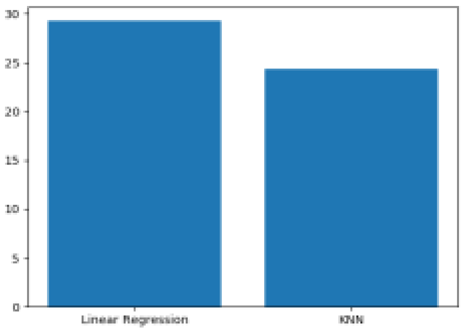

Figure.3 Accuracy comparison graph for linear regression and KNN

On the other hand, SVM and CNN show much higher accuracy of 30% and 98.5%, respectively, with CNN outperforming all other techniques. The data suggest that CNN is particularly effective for image-based recognition tasks like vehicle make and model recognition.

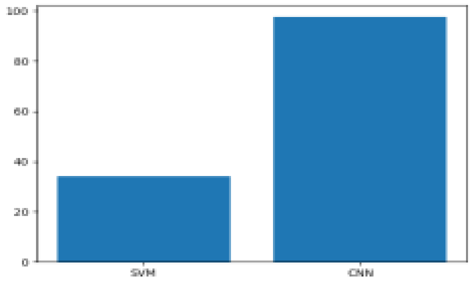

Figure.4 Accuracy comparison graph for SVM and CNN

Comparing SVM and KNN, SVM shows better accuracy than KNN with an accuracy of 37% compared to 30%. However, both methods have relatively low accuracy compared to CNN.

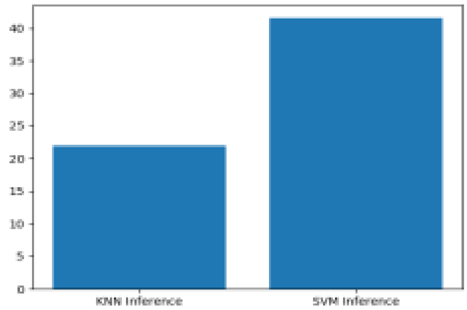

Figure.5 Accuracy comparison graph for KNN and SVM

Furthermore, the comparison of KNN and CNN shows that CNN outperforms KNN, with an accuracy of 94.4% compared to 12%. These results highlight the effectiveness of CNN in recognizing vehicle make and model, although it requires significant amounts of training data and computational resources.

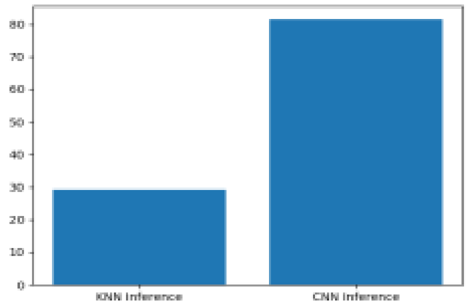

Figure.6 Accuracy comparison graph for KNN and CNN

In conclusion, selecting the appropriate machine learning technique for vehicle makes and model recognition is crucial for achieving high accuracy. The data suggest that CNN is the most effective technique for this task, while hybrid approaches that combine multiple techniques could be explored in future studies to improve accuracy and efficiency. The results also emphasize the importance of collecting and preparing large datasets for training machine learning models.

V. CONCLUSION AND FUTURE SCOPE

In conclusion, the use of machine learning models such as linear regression, SVM, KNN, and CNN have shown effective results in predicting the model of the vehicle. Each approach has its strengths and weaknesses in terms of computational complexity, accuracy, and training requirements.

Although linear regression is a quick and effective technique for predicting continuous variables, it might not be appropriate for challenging classification issues like distinguishing between different vehicle models. SVM and KNN are popular classification methods that can handle complex problems and are relatively easy to implement, but they may suffer from overfitting or poor performance on imbalanced datasets. CNN is a powerful technique for feature extraction and classification, particularly for image-based recognition tasks, but it requires large amounts of training data and computational resources.

Future research could explore hybrid approaches that combine multiple machine-learning techniques to improve accuracy and efficiency. Additionally, incorporating other sources of data, such as GPS or sensor data, could enhance the performance of vehicle make and model recognition systems. Finally, improving the robustness and reliability of these systems for real-world applications, such as autonomous vehicles or traffic monitoring, remains an important area for further study.

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