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Article Title: Vehicle Model Classification Using Deep Learning

Vehicle Model Classification Using Deep Learning

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ABSTRACT

One of the most significant issues in modern road safety and intelligent transportation systems is the automation of vehicle detection and identification. Many challenges have been solved in the advancement of image processing, pattern recognition, and deep learning technology in order to accomplish this goal. Vehicle Type Classification is a difficult task since the dataset has a large class imbalance, and several view- points for different cars can be identical. The proposed framework employs a shallow Convolutional Neural Networks (CNN) architecture to prevent overfitting and ensure that the correct features are learned, and we use an augmentation technique to produce synthetic images using the image data generation model in Keras due to class imbalance. The shallow CNN is used to extract features from the generated images, and then Softmax activation is used to classify them. Finally, the proposed system will achieves the classification of vehicle type i.e. classify the different car models with efficiently by novel methodology. The findings of the experiments demonstrate that shallow CNN can do well in real-world situations.

Keywords: Deep Learning, Shallow Convolutional Neural Networks (CNN), Car Models Classification, Vehicle Classification, Image Augmentation.

1 Introduction

Surveillance cameras can be seen nearly anywhere in cities. The key goals of security systems installation are real-time tracking and incident searching. The authors of this paper concentrate solely on activity finding. Police officers may use the camera technology to accomplish their search goal i.e. to locate a particular car. In general, officers need details about the vehicle's features, like the color and model of the vehicle, as an initial clue for vehicle identification. Officers also waste a significant amount of time alone watching captured recordings. Typically, the time spent searching exceeds the length of the video, and they must repeat the search many times.

In order to solve above problems, there have been numerous vehicle classification systems built. Recent advancements in sensing, machine learning, and wireless networking technology, in particular, have spawned a slew of novel vehicle classification systems.

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Various machine learning models are presented in recently for vehicle type classification. For instance, [1] built a system that can monitor vehicles in surveillance videos. They suggested Motion let as a new classifier. The classifier is an Adaboost learning-based detector [2]. Motion let's key objective was to categorize twelve separate vehicle directions. As a result, they were able to reach an accuracy rate of 87 percent.

In [3], artificial neural network was used as a classifier to divide vehicles into two different categories: large and small. The accuracy of their analyses was greater than 90%.

In [4], contrasted the classification efficiency of different classifiers, such as regression tree, bagging, and random forest. In their trial, both approaches produced findings that were comparable. Random tree, on the other hand, was selected for two reasons: it took less time to learn than other techniques and had no instruction.

In recent times, a new method known as Deep Learning [7] has emerged that can also be used in classification tasks. A neural network having more than two hidden layers is known as deep learning. The following are some of the stages of neural network evolution:

- There are more neurons in this network than in previous networks.
- In neural networks, there are more complex ways to link layers/neurons.
- A significant increase in the amount of computing resources required for training.
- Feature extraction that is automated.

Unsupervised and Pretrained networks, convolution neural networks (CNN), recurrent neural networks, recursive neural networks, and other forms of deep learning exist. Convolutional neural networks (CNNs) are the most widely used deep learning neural network. Convolution is the key function of these networks, which is programmed to learn rich features from the data set. The networks have been well to image object recognition and it regularly rank first in image classification competitions.

This paper presents the vehicle type classification (car models) using novel methodology of deep learning shallow convolutional neural networks. By using shallow CNN, overfitting problem will be overcome and class imbalance problem solve by image augmentation.

2 Related Works

Several studies [9]-[11] have used CNN as classifier in vehicle color recognition. Chen et al. [12] suggested using feature background to identify the vehicle's colour. They used their dataset, which included 15,601 vehicle images divided into eight color groups, to perform the classification. They were able to classify with a precision of 90.68 percent.

The authors used CNN with Chen's dataset [12] in [9], [11]. Their accuracy rates were 94.47 percent and 94.6 percent, respectively. In [10], they suggested Colornet, a novel CNN structure that achieved 95.74 percent accuracy in their vehicle color classification trial. Alexnet [8] and GoogleNet [13] were outperformed by the framework.

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Zhou et al. [14] suggested deep neural network or deep learning methods for vehicle recognition and classification. They used the YOLO [15] detector paradigm for detection. As classification approaches, Alexnet [8] was used. There are four types of classification with respect to classification modules: passenger vs other, cars vs vans, sedans vs taxis, and sedans vs vans vs taxis. Following the application of both structures, they were fine-tuned to work with the public dataset given in [16]. The accuracy of the experimental findings was greater than 90%.

The proposed method's key goal in this paper is to increase the accuracy of the previously described vehicle model and vehicle classification. In this study, a convolutional neural network with two convolution layers was chosen as the classifier. The CNN was selected due to its image recognition capabilities. The vehicle images from the dataset are fed into shallow CNN. In the following part, we'll go over it in more depth.

Table 1: *Output Classes in Car Model Classification*

No of Classes	**Output Classes**
1	Acura
2	Aston Martin
3	Audi
4	Bentley
5	BMW
6	Buick
7	Cadillac
8	Chevrolet
9	Chrysler
10	Dodge
11	Ferrari
12	Ford
13	GMC
14	Honda
15	Hyundai
16	Jeep
17	Lamborghini
18	Mercedes Benz
19	Nissan
20	Rolls Royce
21	Suzuki
22	Toyota
23	Volkswagen
24	Volvo

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3 Proposed Methodology

This system consists of shallow CNN structures that are used as classifiers in car model classification. The proposed method uses an input image, which is a car image, fed into the system. The classifications' output is identical to those listed in Table 1. The proposed system mainly consists of two process one is image augmentation technique which is used to expand the dataset by generating of new images which is implemented by image data generator model in keras; another one is shallow
CNN for extract the rich features for accurate classification which done by following layers such as,

- Convolution layer with 5x5 Kernal
- Max pooling layer
- Convolution layer with 3x3 Kernal
- Max pooling layer
- Fully connected layer
- SoftMax classification

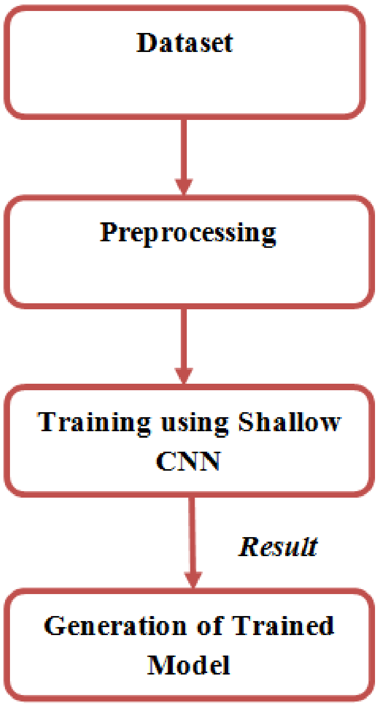

Figure 1: *Training Process of Proposed Method*

3.1 Training Process

In training process (Fig.1), first load the dataset then do the pre-processing which includes the image resizing process. Finally pre-processed dataset images are trained in the form of feature maps based on shallow CNN.

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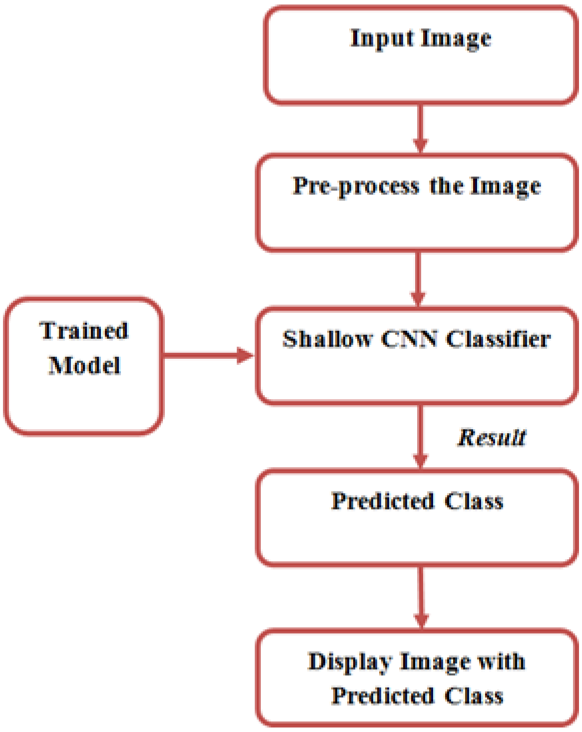

Figure 2: *Testing Process of Proposed Method*

3.2 Testing Process

Once the training is done, the model will be loaded and then input query image is given, the image will be pre-processed and will be passed to the classifier to predict the class for the particular car present in the image. Testing process is illustrated in Fig.2.

3.3 Models

The proposed system achieves the high accuracy by solving of two problems such as overfitting and class imbalance problems. Our light weight model of shallow CNN is used for overcome the overfitting problem and image augmentation technique is used for rectify the class imbalance problem.

3.3.1 Image Augmentation

Image augmentation is an effective technique for artificially creating differences in original images in order to extend the data set of an individual image. This generates new and exclusive images from an established image data set that contains a wide range of potential images. This is accomplished by using various transformation techniques such as zooming an actual image, rotating it by a few degrees, shearing or cropping an existing group of images, and so on. This is implemented by image data generator model in Keras. Deep learning Convolutional Neural Networks (CNN) require a large number of images to be efficiently equipped. This improves

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the model's efficiency by allowing it to generalize further and thereby reduce overfitting. Image augmentation used as a pre-processing phase before training the model or in real time.
Some Techniques for Image Augmentation

- Rotation: rotates the image by a given degree.
- Flipping: flips the image vertically or horizontally.
- Shearing: like a parallelogram, it moves one part of the graphic.
- Cropping: objects appear in various places in the scene in different proportions.
- Zooming in and out.
- Adjusting contrast

3.3.2 Shallow CNN

Convolutional Neural Networks are a form of feed forward artificial neural network that is somewhat identical to traditional neural networks. The weights and biases of the neurons in the network can be learned. Every neuron receives information and executes certain tasks. The convolution layer, pooling layer, and fully connected layer are the three main layers in CNN. The contribution of neurons bound to local regions within the input given will be calculated by the convolution layer, which computes the dot product between the weights and biases. To minimize the scale of the feature maps, a pooling layers used. As a result, the parameter will be reduced, and the computation time will be reduced. In general, CNN employs max pooling. Each neuron in the fully connected layer is linked to neurons in the previous CNN layer. The layers are fully connected, much as in a traditional neural network.
The convolutional and max-pooling layers derive high-level features from images, and the input images are classified using a fully connected layer. The network was trained using a cross-entropy cost function and the stochastic gradient descent algorithm.

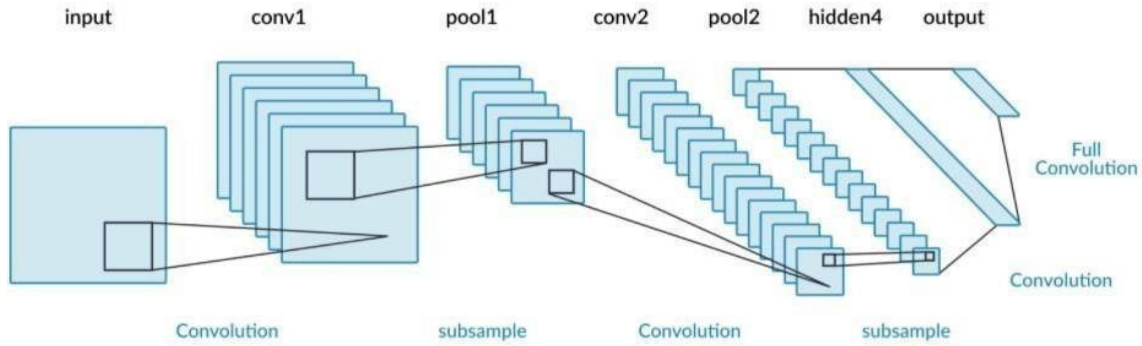

Figure 3: *Shallow CNN Architecture*

4 Experimental Results

The proposed system uses the approach of deep learning shallow CNN model to classify the 24 car models which are given in Table 1. The proposed system uses the Standford Car Dataset for car model classification. Sample images of car dataset are shown in Fig.4. The dataset is

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categorized into two parts: training and testing, which accounts for 75% and 25% of the total dataset, respectively.

Table 2: *Accuracy Analysis*

Models	Accuracy (%)
Decision Tree [5]	79.380
Random Forest [6]	79.821
Shallow CNN	93.341

Figure 4: *Dataset Sample Images*

Table 2 is shown the accuracy analysis with different models. In that, our proposed method shallow CNN based car model classification achieve the accuracy is 93.341 % and other models are DT is 79.380 % and RF 79.821 % of accuracy

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Figure 5: *Car Models Classification Results by Proposed Method*

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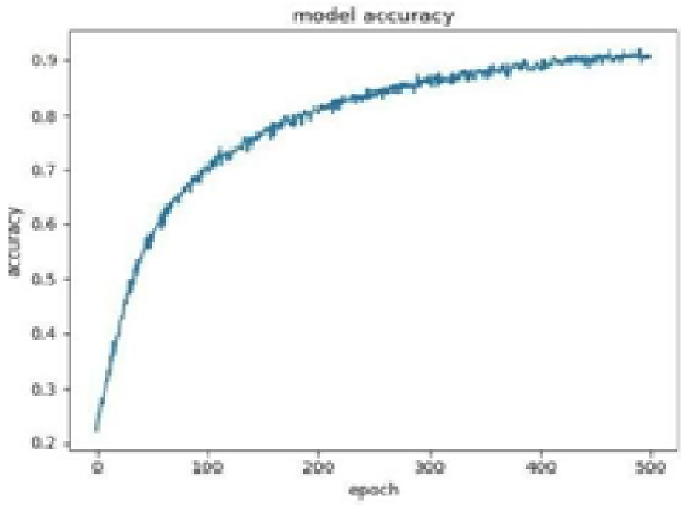

Figure 6: *Accuracy Analysis by Proposed Method*

5 Conclusion

The light weight shallow CNN model is proposed as a type of CNN and classifiers to classify car models in this paper. The proposed method effectively overcomes the two problems such as overfitting and class imbalance. Using of image data generator in Keras, image augmentation would implemented which used to expanding dataset to rectify the class imbalance problem; and overfitting solved by shallow CNN. We conducted several tests on our dataset, with the findings demonstrating that our classification scheme has a high accuracy rate.

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