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A Survey on CNN: Vehicle Classification and Number Plate Detection

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ABSTRACT: Intelligent transportation system takes the information from the sensors and the CC-TV camera. Video surveillance is the important feature of the intelligent transportation system. From this video, the detection of the vehicle and its number plate can be done. Detecting the vehicle type and its number plate is still the area of research, because of the various issues like brightness, uneven illumination and low contrast. Various image processing techniques like Haar-like features, Region of Interest (RoI) are used where features are needed to be provided manually. Here the convolutional neural network is used, where features are not provided manually. It also gives the high detection rate and low false positive rate. This convoultional neural network along with optical character recognition helps in recognizing the vehicle's number plate, also the classification of the vehicle is done by the help of the convolutional neural network.

KEYWORDS: Classification, CNN, Machine learning, Number Plate Detection, OCR, Vehicle detection.

I. INTRODUCTION

Vehicles are the integral part of our day to day life. As prices are getting down, anyone can afford more vehicles. Each and every day thousand of vehicles run on the roads due to which the accidents are increasing. The cases of the hit and run happening on the highway. Also there is increase in the number of the vehicle stealing. Hence, there must be a system to tackle these problem. The intelligent transportation system is the solution. Intelligent transportation system important for modeling and tracking traffic flow. Intelligent transportation system is becoming more important as the volume of the traffic is growing. Vehicle detection is the main aspect of the intelligent transportation system. Every vehicle has its own number plate and it is unique. Once a number is allocated, it can't be changed. Every number plate is having the particular model of the vehicle associated with it.

There are different types of vehicles. Vehicle classification in different group is required and it can be done like bus, sedan, truck, SUV, minivan. So far, numerous image-based methods have been proposed, and they roughly fall into two categories: model-based methods and appearance-based methods. Model based methods compute the vehicle's 3D parameters such as length, width, and height to recover the 3D model of the vehicle. Appearance-based methods extract appearance features (e.g., SIFT, Sobel edges) to represent the vehicle for classification. Most of these methods are based on vehicle side view images. Appearance-based methods extract appearance features (e.g. SIFT, Sobel edges) from either vehicle frontal or side view image to classify vehicle types. In real applications, more and more vehicle frontal view images are captured by traffic surveillance cameras.

II. RELATED WORK

License plate recognition, an image processing technology to identify vehicles by their license plates. Hui WU and Bing Li proposed an approach to detect the license plate by selecting the optimal frame. For extraction of the vehicle number plate the characteristics of the plate are noted like color[3]. By projecting the binary difference horizontally and vertically accurate rectangle is found. Finally the characters are isolated by peak to valleys method and identified. The main drawback of this method is that the features have to be identified manually.

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Tarak Gandhi and Mohan Trivedi showed the issues regarding the system which records the images from vehicle mounted camera, detects the vehicles, extracts their shape and appearance properties to classify the vehicles[18]. The overall structure is shown in the below figure.

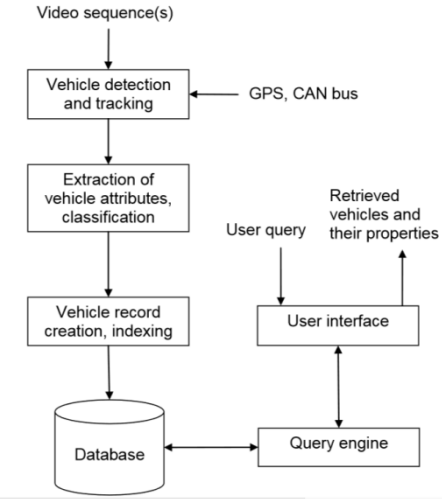

Fig1. Surround vehicle classification, logging and retrieval system [18].

For tracking the vehicles from the video the Kalman filter is used. To differentiate the various kind of objects size, shape and appearance cues are used. These characteristic features are extracted and a trained classifier is used for the classification of the objects. The histogram of oriented gradients(HOG) is used as a texture descriptors and SVM as classifiers. These histogram are used as feature vectors for the SVM. The HOG approach is good in detecting the vehicle but less reliable in discriminating between different types of vehicles. In order to remove this drawback SIFT features are used which has good classification performance [19]. Here the main part is to extract the features of the vehicle without which the accuracy cannot be achieved.

In order to remove the drawback of the normal image processing techniques Yongbin proposed vehicle detection based on the CNN. The important characteristic of the CNN is that, we don't have to provide the features manually. Here, first vehicle is localized by frame difference to detect the front of the vehicle by symmetry filter, which is then used to train the CNN. Frame difference is useful in detection of the vehicle in real time. Symmetric filter is used because frontal view of the vehicle is similar. The results show that proposed CNN is better than LBP, LGBP, SIFT[5].

Mennoti proposed license plate recognition with random CNN. The filter weights are set at random and normalized to zero mean and unit norm. With the help of the resulting CNN features the support vector machine (SVM) is trained to give better results[9].

Han used the pyramid-based localization techniques to identify the region of license plates. Here CNN is used, and the convolution and sub-sampling layers performed the feature extraction without any preprocessing. An input image is sub sampled by factor of 1.2 and CNN-based verifier operated on each pyramid image[12]. Two geometric constraints were designed to remove the false alarms as

C1: The ratio of width over height had to be larger than a fixed value.
C2: The size of the license plate had to be larger than a predefined size.

A single CNN gives better results but takes lots of computation for the detection. So a multi-CNN approach is used to detect number plate for mobile devices. First a supervised CNN is used to verify car and then the output is provided

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to the next supervised CNN for number plate detection. Finally the number is detected with help of optical character recognition by another CNN verifier. Here, as the multi-CNN is used, it results in the less computation of the neurons. As compared to the single CNN which takes about 93500 neurons for the number plate detection, the multi-CNN takes only 35230 neurons. Hence the computation time is very less in multi-CNN. The vehicle detection is unaffected by the variation in brightness, low contrast and uneven illumination. However the cars that partly occluded were not detected[1].

Chen proposed an integrated approach for vehicle detection and type detection. Here the three frame detection is used which detect the contour information of moving object. This approach detects the on road moving vehicle in real time. Deep learning is on getting wide attention due to its superb results on the image recognition. The DCNN is used to recognize and classify different vehicles. It gives good results because of the combination of moving object detection and DCNN. CNN requires no manual features extractor like other image process method. With the increase in the increase in the number of the training data the accuracy of the CNN improves[6].

An appearance-based vehicle type classification method from vehicle frontal view images is used instead of hand hand-crafted visual features. Convolutional neural network is used which learns the feature automatically. Once the features are obtained, the softmax regression is used to classify vehicle types. Model which is pre-trained by the sparse filtering can automatically learn discriminative and reliable features for vehicle type classification[10].

A vehicle type classification method using a semi supervised convolutional neural network from vehicle frontal-view images. Sparse Laplacian filter learning is used to obtain the filters of the network with large amounts of unlabeled data. The network takes the vehicle image as the input and outputs the probability of each type to which the vehicle belongs [7].

Classification of vehicle using feature encoding combined with CNN for learning high level features is proposed by Shuang Wang. Here local texture or color features are extracted to get high-dimensional fixed length vector. PCA is used to reduce the high dimensionality. SIFT feature descriptor is used for local features description.

The classification of the vehicle is done by using machine learning algorithm with 3-D object model fitting. A background mask and line analysis algorithm based on statistical measures to Hough Transform is applied, in order to remove noise and false positive road lanes [11] .

III. PROPOSED APPROACH

Methodology for the vehicle number plate detection and classification

A. Proposed System Architecture

The input is given in the format of the video. Some pre-processing is required before directly feeding it into the Convolutional neural network. This pre-processing is required in order to get the clear view of the vehicle. After pre-processing the images, it is fed to the convolutional neural network. The CNN then detect the vehicle number plate and its class.

B. Pre-processing

Some pre-processing is required before applying the CNN. This includes the removal of noise, blurring effect. This simplifies the detection process, as we get the less noisy view of the vehicle.

1. Gaussian blur

In image processing, a Gaussian blur is the result of blurring an image by a Gaussian function. It is a typically used to reduce image noise and reduce detail. The visual effect of this blurring technique is a smooth blur resembling that of viewing the image through a translucent screen, distinctly different from the bokeh effect produced by an out-of-focus lens or the shadow of an object under usual illumination. Gaussian smoothing is also used as a pre-processing stage in

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computer vision algorithms in order to enhance image structures at different scales. The Gaussian blur is a type of image-blurring filter that uses a Gaussian function for calculating the transformation to apply to each pixel in the image. The equation of a Gaussian function in one dimension is

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} - \frac{x^2}{2\sigma^2}$$

in two dimensions, it is the product of two such Gaussians, one in each dimension:

$$G(x,y) = \frac{1}{\sqrt{2\pi\sigma^2}} - \frac{x^2 + y^2}{2\sigma^2}$$

where x is the distance from the origin in the horizontal axis, y is the distance from the origin in the vertical axis, and σ is the standard deviation of the Gaussian distribution.

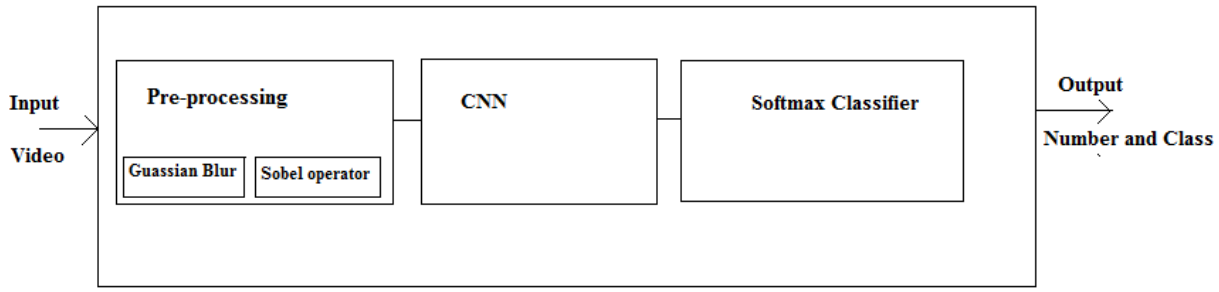

Fig 2. : Overview of the system

2. Sobel Operator

The Sobel operator or Sobel filter, is used in image processing and computer vision, particularly within edge detection algorithms where it creates an image emphasising edges. The Sobel operator is based on convolving the image with a small, separable, and integer-valued filter in the horizontal and vertical directions and is therefore relatively inexpensive in terms of computations. The gradient approximation that it produces is relatively crude, in particular for high-frequency variations in the image.

C. CNN

A convolutional neural network (CNN, or ConvNet) is a type of feed-forward artificial neural network in which the connectivity pattern between its neurons is inspired by the organization of the animal visual cortex, unlike other vision methods using handcrafted features. ConvNets are able to automatically learn multiple stages of invariant features for the specific task. ConvNets have been utilized in a great deal of applications such as hand tracking, face detection, facial point detection, and image classification. Convolutional Neural Networks are very similar to ordinary Neural Networks, they are made up of neurons that have learnable weights and biases. Each neuron receives some inputs, performs a dot product and optionally follows it with a non-linearity.

Layers used to build ConvNets a simple ConvNet is a sequence of layers, and every layer of a ConvNet transforms one volume of activations to another through a differentiable function. We use three main types of layers to build ConvNet architectures: Convolutional Layer, Pooling Layer, and Fully-Connected Layer

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INPUT [32x32x3] will hold the raw pixel values of the image, in this case an image of width 32, height 32, and with three colour channels R,G,B.
CONV layer will compute the output of neurons that are connected to local regions in the input, each computing a dot product between their weights and a small region they are connected to in the input volume. This may result in volume such as [32x32x12] if 12 filters are used.
RELU layer will apply an element wise activation function, such as the max(0,x)max(0,x) thresholding at zero. This leaves the size of the volume unchanged ([32x32x12]).
POOL layer will perform a down sampling operation along the spatial dimensions (width, height), resulting in volume such as [16x16x12].
FC (i.e. fully-connected) layer will compute the class scores, resulting in volume of size [1x1x10], where each of the 10 numbers correspond to a class score [16].

D. Softmax Classifier

Softmax regression is a generalization of logistic regression to the case where multiple classes can be handled. In order to calculate the probability of each vehicle type, the softmax classifier is employed as the output layer of the convolutional neural network. the input of the softmax classifier layer is the feature vector learned by previous layers, and the output is the type probability vector. A linear function is applied to model the relationship between the feature and the probability distribution of the vehicle type

$$v = W^T x + b$$

where $x \in R^{D1}$ represents the input feature, $v \in R^{C1}$ is a intermediate variable for describing the distribution, and C is the number of vehicle types

IV. CONCLUSION AND FUTURE WORK

By using the neural network approach the vehicle number plate can be detected and also the classification of the vehicle can be done. CNN is self learner and performed feature extraction giving high accuracy. It has been found from the survey of the previous work that instead of using single CNN for number plate detection if multi-CNN is used, the computation can be decreased significantly. So multi-CNN approach is better solution.

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