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Predicting speed of driverless cars according to different weather conditions

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Abstract

Convolutional neural networks (CNNs) are widely accepted and acknowledged in the fields of image analysis, image recognition, video recognition, face recognition, image classification and activity detection. CNNs have images as their input; process those images; assign adaptive weights and biases to many features of the image; and then classify them into various categories.

The intent of this paper is to establish a model to classify outdoor images to different weather classes and then using this classification as basis of many actions that can be provided to driverless cars. While performing the literature survey about field related to weather prediction we found out that the best results for weather classification are obtained while using the CNN models. This paper proposes a method of implementing convolutional neural networks to get the desired result of classifying separate weather conditions into four classes, namely foggy, rainy, sunny and snowy. And according to the weather condition predicted, the project will provide the necessary actions that need to be taken by the driverless cars.

Keywords: *Convolutional neural networks, sequential model, model layers, image classification*

1. Introduction

Currently, in the field of weather detection, many expensive and complex sensors are used; which are not even obtainable by all. As opposed to using these inaccessible hardware devices; surveillance cameras or even smartphones' cameras can be used to detect the weather conditions. And hence the project proposed, can be easily incorporated in driverless cars, without increasing its cost of production. The model we are proposing will take input in the form of an image and then classify that particular image to one of the four classes: foggy (figure 1), rainy (figure 2), sunny (figure 3) and snowy (figure 4). Many factors of the image like color brightness, haze and contrast are considered for the analysis of these conditions.

Figure 1: Foggy

Figure 2: Rainy

Figure 3: Sunny

Figure 4: Snowy

Weather detection can be utilized in many research fields and can provide inputs to many higher level processes. It can be used in driver-less vehicles for regulating the speed of the vehicle, setting the vehicle's speed according to the speed associated with weather condition at that particular time[13]. This method can also be applied to the speed limit sign boards; making those sign boards more robust according to the real-time weather surroundings[9].

This classification can even be utilized as a separate filter in various applications or even in the photo gallery of every individual. The same classification can also be exercised as a search tool in smartphones to find images with a certain weather surroundings.

The proposed model can also be used for local hazard warning[13]. The Local Hazard Warning tries to countervail hazardous situations by using information from vehicles that are present on the road at the moment and then provide a warning to others who are heading towards those locations. A vehicle that is in a situation with dense fog can detect and send the related information to the authority in charge; hence warning others to use alternate resources.

2. Related work

There are numerous works done related to weather prediction systems using many advanced algorithms and techniques:

2.1 H. Kurihata, T. Takahashi, I. Ide, H. Murase and Y. Mekada (Graduate School of Information Science, Nagoya University, Japan) Y. Tamatsu and T. Miyahara (Denso Corporation, Japan) proposed Rainy Weather Recognition from In-Vehicle Camera Images for Driver Assistance[2]; they developed a weather recognition method from in-vehicle camera images that uses a subspace approach to predict rainy weather. They had used the methodology of judging rainy weather by detecting raindrops on the windshield of the car. They used a subspace method that extracted features using principal component analysis (PCA) from images that have common features.

2.2 Uthai Phommasak, Shinya Watanabe and Hiroyuki Shioya (Department of Information and Electronic Engineering, Muroran Institute of Technology, Japan) Jun Mao (College of Computer Science and Technology, Henan Polytechnic University, China) presented Detecting Foggy Images and Estimating the Haze Degree Factor[5]; they introduced a numerical foggy image detecting method by using the atmospheric scattering model analysis and statistics of various outdoor images. Because the model's complexity is linear, it can be applied as an initial classification step of de-hazing processing and does not exhaust processing resources.

2.3 Wei-Ta Chu, Xiang-You Zheng and Ding-Shiuan Ding (National Chung Cheng University, Minxiong, Chiayi, Taiwan) brought forward Image2Weather: A Large-Scale Image Dataset for Weather Property Estimation[6]; they have presented a large-scale dataset of images where they captured images from all around the world. Their images contain rich weather information which they had obtained from a forecast website. This information rich dataset thus brings many research potentials in the computer vision society. They used KNN classifier and random forest classifier and found that random forest classifier outperforms the KNN classifier.

2.4 Cewu Lu and Chi-Keung Tang (The Hong Kong University of Science and Technology) Di Lin and Jiaya Jia (The Chinese University of Hong Kong) suggested Two-Class Weather Classification[8]; in which they had initiated a learning-based approach to classify two weather types: rainy and sunny. This straightforward two class weather classification problem was not very useful as a great variety of outdoor images are available. The key to their computational framework is a collaborative learning strategy with the SVM model, where only voters closer to the testing image information/structure are given more weight in classification.

3. Methodology and Approach

As mentioned in the abstract, the aim is to develop a model that can predict weather conditions from the image and then suggest some actions that the driverless cars can follow. At the beginning; we have researched and analyzed many related works and papers[2][5][6][8]. We collected useful information regarding image recognition and image classification. Also, we found that convolutional neural network outperforms all other machine learning algorithms when it comes to image classification. Accordingly we have used convolutional neural networks for our model.

3.1 Dataset and organizing the data

The dataset we used incorporate a total of 4830 images in jpeg format[6][8][14]. These 4830 images are divided into four classes: foggy, rainy, sunny and snowy (As shown in table 1)

Class	Train	Validation set	Test set	Total
Foggy	421	100	100	**621**
Rainy	1034	210	210	**1454**
Sunny	1006	253	244	**1503**
Snowy	832	210	210	**1252**
Total	**3293**	**773**	**764**	**4830**

Table 1: Distribution of dataset used

Resizing images: All pictures that were used, were first resized to a uniform size of 224x224 pixels, before performing any function on the images; and then were arranged in different folders for each class (foggy, rainy, sunny and snowy) and for every set (train, validation and test).

3.2 Convolutional neural networks

CNNs are widely popular among classification algorithms. They are one of the advanced algorithms of machine learning field. Currently, there are many libraries that can implement CNNs. Keras library which uses Tensorflow back end is one of the most popular library of the field. We have used the sequential model of the Keras for our project.[16] We have done lots of experiment on them to get better and an efficient model.

A CNN is made up of multiple layers of neurons, each of which performs operation, which is nonlinear in nature, on the outputs received from the preceding layer. The layers mainly include convolutional layers, pooling layers, a flatten layer and some dense layers.

3.2.1 Convolution layer: A convolutional layer is made up of many filters whose parameters are to be learned. The height and weight of the kernel are smaller than the input image. After computing all the kernels, an activation map is made[16].

3.2.2 Pooling layer: A pooling layer is typically placed between two convolution layers so as to reduce the number of parameters by down-sampling the representation. The pooling function can be either average function or max function. Max pooling is used more as compared to the average as the former works better[15].

3.2.3 Dropout layer: Dropout layer is used to randomly ignore some number of layer output to prevent overfitting of the model. This layer can be used in between different layers or even in the input layer; but it can never be used as the output layer[14].

3.2.4 Flatten layer: The flatten layer is used between the convolutional layer and the fully connected layers. Flattening transforms a two-dimensional matrix of features into a vector that can be fed into the fully connected final classifier model[15].

3.2.5 Dense layer: The dense layer is a deeply connected neural network layer, meaning all the neurons in a layer are connected to those in the next layer. It acts mostly as the output layer of the classifier model[14].

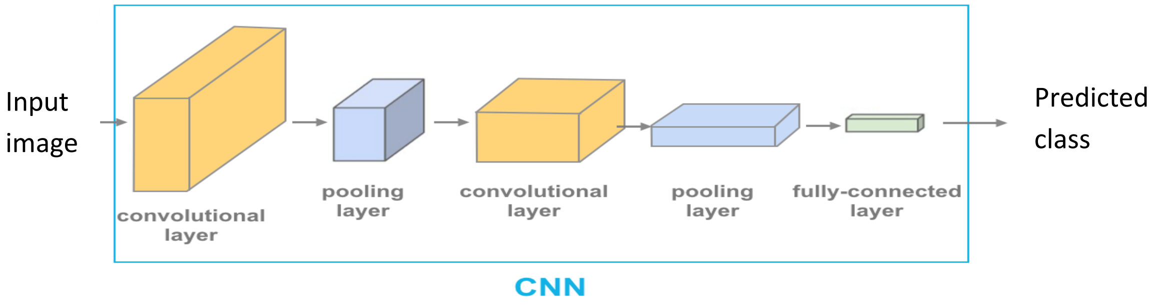

Figure 7: CNN architecture

4. Experimental results

We tried CNN model to develop a solution to this image classification problem. General accuracy of model used was around 75% Following table show the information regarding the model developed along with the respective result:

4.1 Model with accuracy 73.4%

Layers	**Parameters**
Conv2D	filters=32, kernel_size=(3, 3), activation='relu', padding = 'same', input_shape=(224,224,3)
MaxPool2D	pool_size=(2, 2), strides=2
Conv2D	filters=64, kernel_size=(3, 3), activation='relu', padding = 'same'
MaxPool2D	pool_size=(2, 2), strides=2
Flatten	none
Dense	units=4, activation='softmax'

Table 2: CNN model architecture

5. Conclusion

In this paper, we used convolutional neural networks for classifying images according to the weather conditions. And using this classification, we were able to suggest some actions to the driverless cars according to different conditions. We were able to get accuracy of up to 73.4%. The hardest part was to decide on the CNN architecture; the model takes a lot of time to train. Also, the dataset we used was too small to rely upon to solve real time problems. If we had strong GPUs, we could try a much larger dataset and find better solutions.

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