A New Framework for Weather Detection using Image Cues

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Abstract

At present, weather identification from outdoor image is an emerging experimental area and a lot of researchers are working on it to treasure trove information for discovering new ideas. Even though human eyes are the prime way to identify weather condition, more artificial methods are introduced nowadays for making the machine learning techniques efficient in recognizing weather situations. The main target of this framework is to point out the correct weather condition by extracting features from each outdoor input image. Each exterior image used as input is effectively processed and categorized into one of the six weather group: sunny, rainy, haze, cloudy and thunder on the basis of Inception v3 model. This model also ensure to follow the procedures in a manner to avoid difficulties faced by various existing techniques which uses high-cost sensors, which have computational troubles and some other methods with less classification accuracy. The output is verified and compared with that of other similar methods; from where the efficiency of this model is clearly understood.

Keywords: *Convolutional Neural Network, Transfer Learning, Inception v3*

1. Introduction

Weather is the way through which nature expresses its current condition and so, for getting an idea about the behaviour of the atmosphere, we have to understand the present weather condition as a sample weather state shown in Fig. 1. Weather has great impact on human, crops, animals, even on each and every tiny substance in the atmosphere. As a result of balancing the energy reside in sun rays, different weather conditions such as snow, rain, foggy, sunny, etc appears on the surface of nature. Good weather situations are very pleasing and highly usable for growth of variety of crop and fields. But when weather become too bad, it causes adverse effects on both agriculture and the life of every living thing.

A wide variety of weather measuring instruments, that consider every important parameters of weather are quite common in current world. Many advanced laboratories demanding high accuracy with less cost are also available for such identification procedure around different parts of the world. Since such phenomenon of the atmosphere varies due to lot of parameters, large data to be collected for clear understanding of the conditions. Recognizing weather from images is also a large research field and by now a number of methods are proposed in this area. From each unique weather features visible to eyes shown in Fig. 2, human beings can simply understand weather.

Figure 1. Sample Weather Image

This idea of training with weather clues is taken for machines to make them efficient to recognize exact weather. Weather forecasting is very much needed for getting the changes happened for weather by time and place in the future. For that, theories of science and machinery are used, but some limitations are still affecting the researchers.

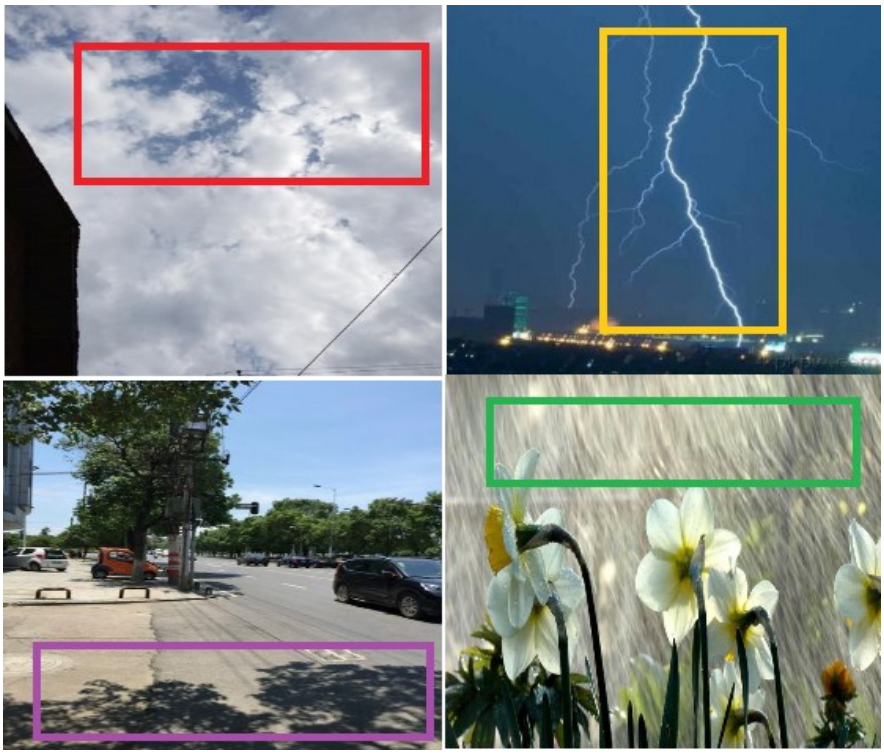

Figure 2. Some Common Weather Cues

In this paper work, quite new approach is introduced by putting forward the procedure of Inception v3 model for easily understanding that, out of six categories to which class does the outdoor pictures taken as input belongs to. This pretrained model bring about more accuracy in recognizing objects from images. Learning method called transfer learning take advantage of such models for accurate prediction to satisfy the goal. Section 2 gives an overview of various techniques introduced for understanding image through images. Section 3 explains about the proposed model and the steps followed by the system in detail. In section 4, some validation methods of result and their results can be viewed. And finally, a brief conclusion is given in section 5 to analyse the performance of the new method.

2. Literature Survey

Hiroyuki et al. put forward particular technique for the identification of weather condition using subspace method [1], to make decisions about rainfall by extracting features related to raindrops. This approach results a better and favourable output, but is affected by certain drawbacks, since it fails to consider other possible weather situations. Another method introduced by Martin and Frank [2] is to classify weather type by considering key components taken from input images with no supposition. The analysis results show that the weather classification is done with a high validity and effectiveness with the use of SVM [2] to evaluate the weather causes. Due to inefficiency in system learning and an increase in computational difficulty, this task has some restriction in many areas.

Zichong et al. developed a new system to tag the given image with suitable weather type spontaneously without much man work. They have taken sky features and used MKL [3] method for selecting necessary features. Since this approach is more practical in case of some fixed clip, for different sites, it requires distinct classification techniques. A new idea is recommended by Qian et al. for weather recognition depending on open air images. As a primary step, weather related key components are taken separately and after that, creation of decision tree [4] is done based on weather features. Since there is a situation when many water features may present all together, very smooth classification is not enough for understanding weather in this case.

An influential study of weather classification was done by Cewu et al. to categorize sample weather images as sunny or cloudy [5]. In order to perform this recognition and grouping in a better way, the authors adopted a collaborative learning approach using homogeneous voters [5]. The researchers also have an idea to extend this concept due to its disadvantage in giving entitle for only two classes. Zheng and Huadong utilized multiple kernel learning [6] to carry out numerous categorization for the weather type of images; aimed to beat up problem loading recent techniques that depends only on fixed clips. After the feature extraction step, all the dissimilar features are integrated using MKL [6] technique. Because of the complications with certain features in terms of classification, the research workers of this paper also reviewed about making a better number of weather features.

Mohammed et al. implemented a new idea for weather classification by utilizing Convolutional Neural Networks (CNNs) [7] to make the execution process easier and also to beat the challenges of previous works. In order to achieve the task, a vast analysis about the layers of CNN is performed using activation [7] of layers. Certain faults of the model are visible in some cases and so the system fails to bring a successful output over many different weather conditions. Zheng et al. employed on scene-free multi-class weather classification [8] to introduce more profitable technique and also to stay away from certain complications such as absence of various distinguished weather features and also due to the heterogeneous conditions of weather, faced by existing approaches. In some cases, this model is unsuccessful

since it mostly takes advantage of certain type of weather features for understanding the weather.

An advanced method for identifying weather condition is proposed by Caixia et al. using discriminative dictionary learning [9] to overcome the drawbacks of earlier models. To achieve this task with a precise completion result, the work incorporates both sky and non-sky [9] features obtained from images. Apart from that, the active learning method is fused with the above steps to prevent complications while doing the training stage. From the observation and contrast result, the active working and accurate throughput of the model is thus proved, whereas, the framework has disadvantage since the number of weather class is minimum. Xuelong et al. established a technique using CNN [10] to avoid problems of previous approaches due to insufficiency in features associated with weather and to find out weather in a desirable way. For performing the work, the researchers combined the method for grouping weather types and the step for performing division of weather features. After evaluating the approach, the capability to provide the desired outcome, even if there is a presence of a number of weather features at a time is demonstrated.

3. Weather Recognition Model

This section briefly describes about the newly introduced technique for recognizing weather and before that, a review on Convolutional Neural Network and Transfer Learning is also given. Step wise process of Inception v3 model is also illustrated below with major components in its architecture.

3.1. Convolutional Neural Network

Convolutional Neural Network always smoothen the path of learning object features and capture different feature representations using the layers present in the model. But one important thing is that CNNs are not as able as human to come to realize details of the given image. Their main applications are in categorizing images, grouping each of the images on the basis of likeness and also in identifying required objects from an image. The main working procedure of CNN is illustrated in Fig. 3.

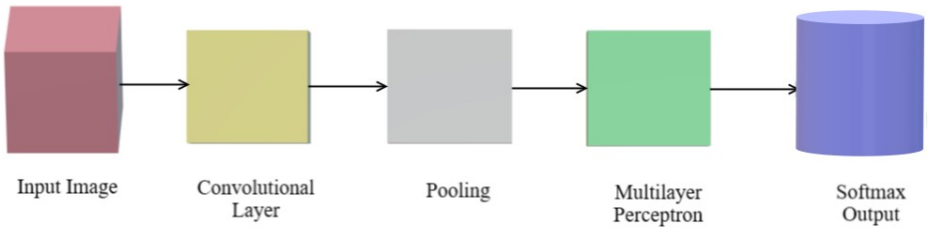

Figure 3. Basic CNN Procedure

While doing max pooling, creating another matrix is done by taking largest of the values from each section of given image and excluding other values. Pooling is important for getting sufficiently great features from images, so that it makes the classification process and result more accurate.

3.2. Transfer Learning

The internal action which is happening while doing transfer learning [12] is that, the step for feature extraction is used again and another training is needed to do for image classification step by using the dataset which is created recently for the proposed model. By doing this, a good result can be obtained without training the tough part, from where the required features are selected and taken.

3.3. Proposed Model

This portion keeps attention on how to recognize weather using Inception v3 model [11] and the basic functions of each component of this architecture. The two basic working steps are: selection of required features and categorizing images using two layers, one is fully-connected layer and the other one is softmax layer. In pre-processing task, the major focusing is done to polish up the image details and also for further improvement of specific features for doing the next step. Even though this step do not lead to enlarge the number of data resides in an image, it makes use of similar appearances found in images. Here, large number of weather features are available from a single input picture and they are the main part which gives way for resulting accurate result. The basic block diagram of the newly introduced system is presented in Fig. 4.

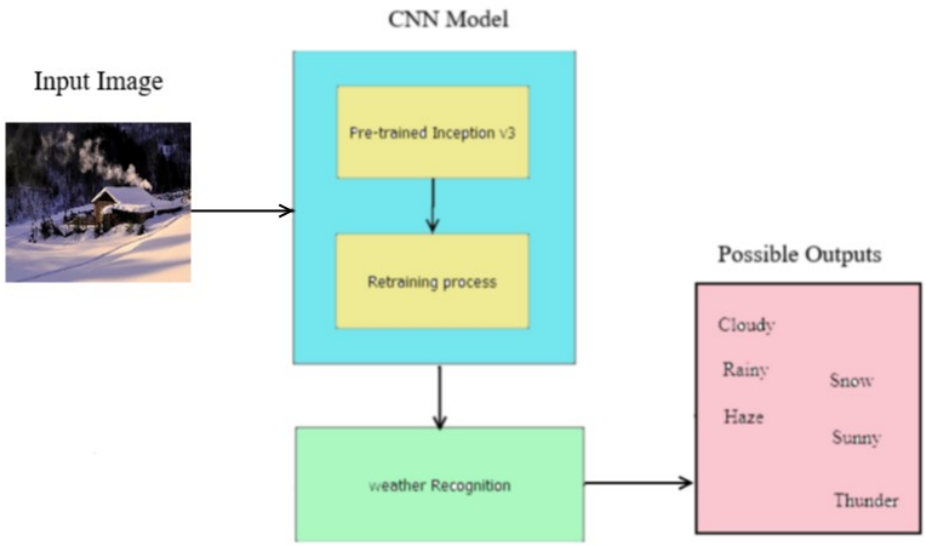

Figure 4. Architecture of Weather Recognition System

Training is done with about 3000 images, 1000 each from given six weather classes, ie, cloudy, rainy, haze, snow, sunny and thunder. It is needed to take more time for classifying each image categories by extracting specific image data; which is done internally in the system with layers of the model. Weather category was identified by finding the match between features already stored and with those information that are freshly taken. The inception v3 model shows top performance as compared to Inception v1 and Inception v2; as because it consists of advanced convolution part, superior

classifier and also with specific module for inception. Consider the basic architecture of inception v3 model [12] given below in Fig. 5.

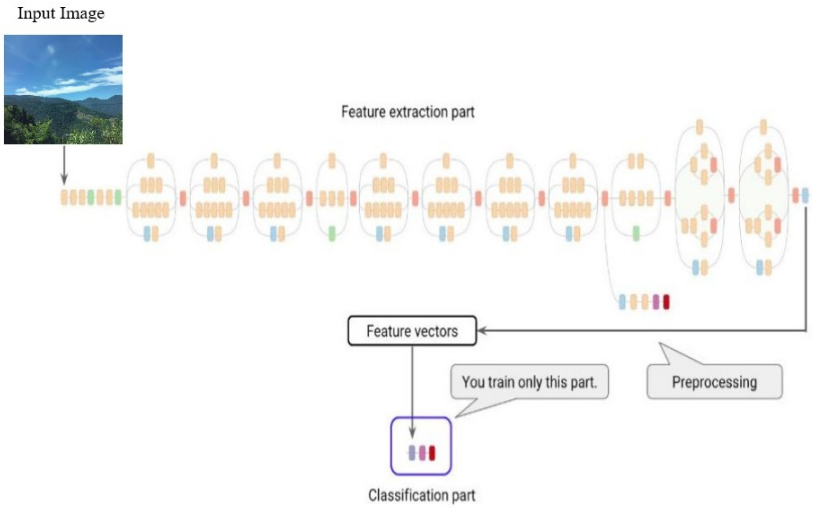

Figure 5. Inception v3 Model

By performing testing operation, checking whether output is correct or not is easily obtained and proper evaluation is also achieved by considering different situation along with possible cases. Correctly validating the nature of the system and the way it acts in adverse conditions are also important. For doing this, an input picture is given to the system in which it do various process internally and check for corresponding match. Defect is calculated by testing with various kinds of weather images that lack some major weather cues. The system is tested over many cases to make sure that no misbehaving will happen within a range of bad conditions so that a clear idea on system accuracy can be obtained. Inception v3 model [13] differ from other models in case of increased speed of training and decreased number of channels.

4. Experiments

4.1. Result Analysis

Dataset consists of a large number of images with different weather conditions and is categorized into six classes. Shadow, cloud, snow, rain drops, thunder, etc helps in recognizing and distinguishing each image from one another, so we can easily group images on the basis of this unique condition. If exact pattern is captured from each image, smooth processing can be performed. Sample images in each class are shown in Fig. 6. There were rare cases when certain images were misclassified into wrong group, but also the possibility in correct prediction is validated successfully. As output of the system, when a raw image is given, the class with highest priority value is resulted along with the confidence value and also, all other classes are sorted by highest next value.

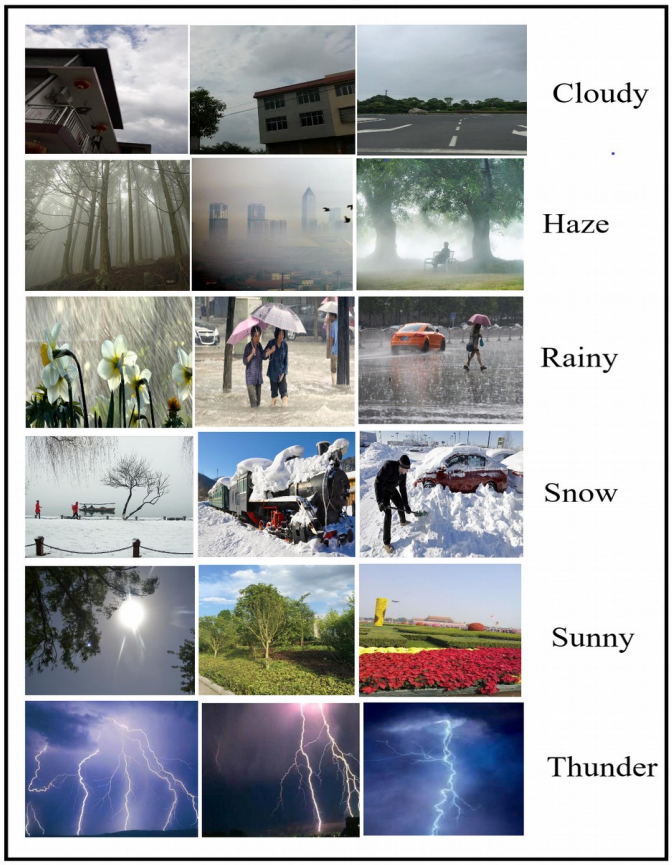

Figure 6. Sample Weather Classes

4.2. Comparison with Other Methods

In Table 1, comparison of our technique with some other approaches on the basis of accuracy is shown. One of the method uses in-vehicle cameras to get weather images and it takes histogram features along with the captured data related to road. They introduced an algorithm related to Real AdaBoost[1] for doing exact classification. Even though the analyzed result gives good output, accuracy is quite poor when compared to our approach.

Another model which uses the advantage of SVM [2] for classifying weather states ensures better output to make the system work efficiently in bad weather state. Features such as saturation, brightness, hue, sharpness, etc. were taken for categorizing weather. This system gives a less error rate, but not as versatile as our model. A certain group of researchers puts forward a new collaborative learning approach using homogeneous voters [3] by taking sky feature, shadow, haze, etc. as required weather features. It is achieved by evaluating the closeness of voter opinion to the particular weather class; but it also fails in some cases because of certain limitations.

Table 1. Comparison with Other Methods

Methods	Accuracy(%)
Using Real AdaBoost Based Algorithm	24.6%
Method with SVM for Classification	26.2%
Using Collaborative Learning Approach	53.1%
Our Method	85.7%

5. Conclusion

The proposed weather recognition system relies on Inception v3 model and uses transfer learning for training weather recognition model. The accuracy is 85.7% after training with samples images taken from weather dataset and is an improved value when compared to some other methods. There are a wide range of weather recognition methods existing in this field, but facing lot of limitations and bad circumstances. From the accuracy and validation output, it is clear that the system will give a better performance and throughput.

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