Weather Classification using Convolutional Neural Networks

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***Abstract*— Deep learning is one of the most popular fields in recent years and is applicable to many fields, such as computer vision and image processing. In this paper, we describe a new weather image classification technique using Alexnet and Resnet convolutional neural networks (CNN) combined with a multi-class Support Vector Machine (SVM). Experimental results in weather database, desnownet, and d-hazy datasets demonstrate that the proposed method achieves good performance in weather classification.**

Keywords—vision, convolutional neural networks, deep learning, image classification

I. INTRODUCTION

Image classification is used in many computer vision fields, such as ADAS, drone applications, image retrieval, and object recognition. In this paper, we describe a new multi-class classification scheme developed by using CNN combined with multi-class SVM [3]. For training and testing, we used the weather database [5], desnownet [6], and d-hazy dataset [4].

II. CNN ARCHITECTURE AND MULTI-CLASS SVM

A. CNN

In this paper, we adopt two CNN architectures, Alexnet [1] and Resnet [2] for feature extraction, respectively. Then, we use multi-class SVM [3] instead of existing SVM to classify images of various classes. Alexnet [1] uses ReLU (Rectified Linear Unit) activation function after convolution in the input image with 25 layers in total. Resnet [2] uses a total of 347 layers and 379 connections. The following sections describe details of Alexnet [1], Resnet [2], and multi-class SVM [3] used in this paper.

B. Alexnet

Alexnet [1] consists of a total of 5 convolutional layers and

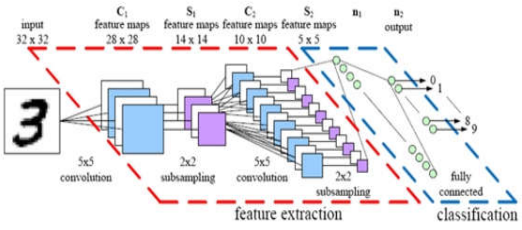

Fig. 1. CNN architecture

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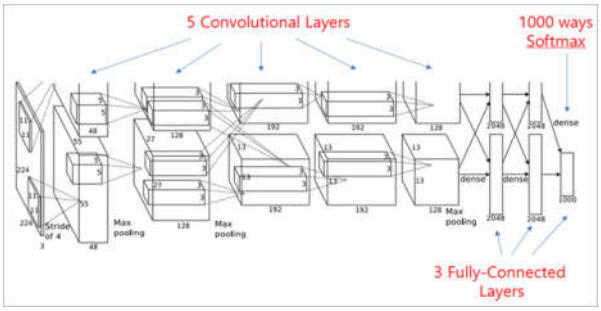

Fig. 2. Alexnet architecture

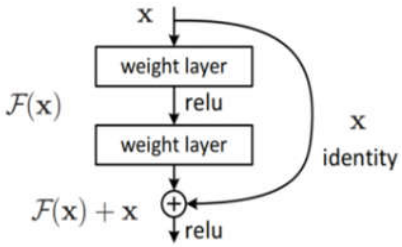

Fig. 3. Resnet architecture

3 fully connected layers and uses softmax for classification of 1000 categories. When designing CNN structure, the calculation problem is solved by using GPU. Alexnet [1] is the cornerstone of utilizing Deep Learning architecture. Fig. 2 shows Alexnet[1] architecture.

C. Resnet

The core idea of Resnet [2] is the residual block, which is shown in Fig. 3. It is a technique to combine input and output. The dimensions of input and output must be equal. By learning the difference between input and output, the middle layer can easily be optimized for deep neural networks, and the accuracy is improved due to the increased depth.

D. Multi-class SVM

A multi-class SVM [3] was used to classify images combined with CNN structures. SVM is one of the linear classifiers such as logistic regression, neural network, and Bayes classifier. The SVM algorithm is based on statistical learning theory and shows excellent generalization performance. It can be applied to various pattern recognition problems. It is also one of the popularized techniques because it can be used simultaneously with classification problems and

prediction problems and has a high accuracy of prediction. However, the binary classifier has a disadvantage that it cannot be directly applied to the general multi-class problem. Therefore, in this paper, multi-class SVM [3] is used instead of existing SVM to enable classification in various classes. As the complexity of multi-class SVM increases, the SVM also increases proportionally.

III. DATASETS

The experimental datasets are weather database [5] (sunny, cloudy), desnownet: Context-Aware Deep Network for Snow Removal [6] (snowy), and d-hazy dataset [4]. The weather database is used for two-class weather classification and the number of images of two classes is sunny 5000, cloudy 5000, and total 10000. Desnownet dataset [6] is created by desnownet [6]. This dataset consists of training, test, and realistic 3 subsets, and only 1329 realistic images are used. D-hazy dataset [4] is created in d-hazy and only 1500 NYU_Hazy out of 4 classes of middlebury_GT, muddlebury_Hazy, NYU_GT, and NYU_Hazy are used.

IV. EXPERIMENTAL RESULTS

In Weather database [5], 5,000 images out of two classes were applied, and 70 % of the 5,000 images were used for training and the other 30 % were used for testing. As shown in Table 1, Image classification accuracy using Alexnet combined with multi-class SVM (Alexnet-MCSVM) obtained 86 % sunny and 75 % cloudy. The accuracy of Resnet combined with multi-class SVM (Resnet-MCSVM) is sunny 92%, cloudy 88%.

DesnowNet [6] and D-Hazy dataset [5] are combined with weather database [5] for 4 classes (snowy, sunny, cloudy, and hazy) classification. Each class has 1,000 images, of which 700 images were used for training and 300 images were used for testing. As shown in Table 2, the image classification accuracy is 97 % sunny, 100 % cloudy, 96 % hazy, and 95 % snowy.

Fig. 4 and Fig. 5 show the correct and incorrect classification results, respectively.

Experimental results show that our method works well on weather classification. We believe that our work will make a valuable contribution to the area of weather classification.

TABLE I. CLASSIFICATION ACCURACY COMPARISION OF ALEXNET [1] AND RESNET [2] IN WEATHER DATABASE [5]

Methods	Alexnet-MCSVM	Resnet-MCSVM
Sunny	86	92
Cloudy	75	88

TABLE II. 4 CLASS WEATHER CLASSFIATION ACCURACY

Methods	Sunny	Cloudy	Hazy	Snowy
CNN-MCSVM	97	100	96	95

Fig. 4. Example of correct classification results

Fig. 5. Example of incorrect classification results

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