Multi-type Image Noise Classification by Using Deep Learning

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Summary
Image noise classification is a classical problem in the field of image processing, machine learning, deep learning and computer vision. In this paper, image noise classification is performed using deep learning. Keras deep learning library of TensorFlow is used for this purpose. 6900 images images are selected from the Kaggle database for the classification purpose. Dataset for labeled noisy images of multiple type was generated with the help of Matlab from a dataset of non-noisy images. Labeled dataset comprised of Salt & Pepper, Gaussian and Sinusoidal noise. Different training and tests sets were partitioned to train and test the model for image classification. In deep neural networks CNN (Convolutional Neural Network) is used due to its in-depth and hidden patterns and features learning in the images to be classified. This deep learning of features and patterns in images make CNN outperform the other classical methods in many classification problems.

Keywords:
Convolutional Neural Networks, Keras, Deep Learning, Image Noise Classification, Machine Learning.

1. Introduction

Image processing is widely used almost everywhere with so many interesting applications such as photogrammetry, aerospace, particle physics, geology, medical science and science of material[1]. Most of the image processing algorithms apply preprocessing steps that include finding distinguishing details [2-6], applying image enhancement prior to feature extraction [7-8], or application of deep learning before diagnosing and locating the lesions in human body[9].

Image denoising is a hot topic of interest for researchers working in the field of image processing. Noise in images is a common problem in this digital era. Usually, images are corrupted by noise during the transmission of images from one source to another. There could be many reasons for having noise in the images like, faulty memory location, post-filtering, compression, atmospheric conditions or devices from which images are captured[10]. Noise can be of different types according to the pdf that they are represented with. There are various types of noises that are encountered in images includes Salt and Pepper, Gaussian, Sinusoidal, Poisson noise and many other to name a few [11, 12, 13]. Noise can be of additive or multiplicative nature.

Conventionally, researchers that are working in the area of image denoising[14-15], work on assumption that the type of noise is known in advance. They work on the denoising of a specific type of noise without workin on the prediction of the type of noise. The type of noise, however, cannot be known in advance for many cases. Therefore, it is necessary to predict the type of noise before application of spatial domain or frequency domain filters to the corrupted image.

The area of noise prediction as a preprocessing step of image denoising is the topic that is touched by a few researchers. The simplest method to predict the type of noise added by a channel is to transmit a frame that is known to receiver in advance. The analysis of histogram of difference image will give an idea of the type of noise. However, this can provide information of the noise added by a channel during specific conditions such as weather or interference of electronic devices. It will not help in predicting the type of noise when images are transmitted in the presence of changing weather conditions or interference of other type of electronic devices. Also, noise added during the acquisition process cannot be predicted as well when images transmitted are not from the same camera. Such problems leads to adapt any other methods that uses image classification.

In some recent years, researchers are focusing on Convolutional Neural Networks (CNN) which has outperformed the many basic methods and techniques in many image processing and image recognition related problems. Deep learning has got attention by many researchers due to its outperforming performance over other existing classical methods. In specially image classification problems, deep leaning has played a vital role in learning the features and patterns in images to be classified. In many tasks such as face recognition, object detection and many other images recognition problems,

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deep learning has outperformed the other classical techniques.

This paper propose an image noise prediction technique that is based on convolutional neural network(CNN). CNN is hierarchal neural network, which takes digital images as input, extract the features from the given dataset of images via intermediate convolutional layers followed to the last output layer. And when model is trained, it is ready to predict any new input image.

The rest of the paper is organized as follows: Section 2 discusses the literature review relevant to image denoising and classification. Section 4 describes the proposed methodology, dataset acquisition and creation and tools used for the implementation. Section 4 also discusses the design and training of the network for the prediction of noise type. Section 5 discusses the limitations that acted as hurdles in the progress of this project. Section 5 is the Conclusion and future work.

2. Literature Review

Noise classification problem has become easy and interesting as deep learning has come to play its role. Many researchers are now adopting this technology to address almost every kind of problem. Whether it is related to natural language processing, computer vision, image processing and specially image classification. Major fields in which it is being used are object detection, face recognition, animal classification, medical image classification to detect disease from patient's data. It is also being used in self-driving cars, driving posture recognition, human activity recognition, number plate recognition for security systems and many more. CNN is also being used in image denoising and noise type classification as in our case.

As Khaw, Hui Ying and other co-researchers proposed this CNN based method for classification of different noisy images [18]. The authors' experiments have proven the reliability of the proposed noise types recognition model by having achieved an overall average accuracy of 99.3% while recognizing eight classes of noise.

In another paper by Sudpita Singh Roy [19] have proposed a deep leaning based approach for noisy image classification. In this paper first, they reconstructed the noisy images using autoencoders, classified the reconstructed the images. Also, in the denoising step, a variety of existing AEs, named denoising autoencoder (DAE), convolutional denoising autoencoder (CDAE) and denoising variational autoencoder (DVAE) as well as two hybrid AEs (DAE-CDAE and DVAE-CDAE) were used. Therefore, this study considered five hybrid models for noisy image classification termed as: DAE-CNN, CDAE-CNN, DVAE-CNN, DAE-CDAE-CNN and DVAE-CDAE-CNN. They used the famous and well-known MNIST and CIFAR-10 datasets in their study.

Gorkem and Ilkay [20], conducted a survey in which different algorithms are discussed. This paper has categorized the algorithms study in two parts; noise model free and noise model- based methods. Their key points of the study are deep learning, label noise, classification with noise, noise robust and noise tolerant. Different algorithms for noisy image classification are discussed with their pros and cons.

Michal Koziarski and Boguslaw Cyganek [21] in his paper on Image recognition with deep neural networks in presence of noise – Dealing with and taking advantage of distortions. This paper's aim towards the image denoising using deep learning and analyze the affect of different type of noises present in the images. investigation of a deep network training with noise contaminated patterns, and finally an analysis of noise addition during the training process of a deep network as a form of regularization.

3. Methodology

As the task is well defined in above sections is of image noise classification using convolutional neural network. For implementing this the steps taken from collecting dataset, adding different type of noises, model building, training and the other workflow are defined below.

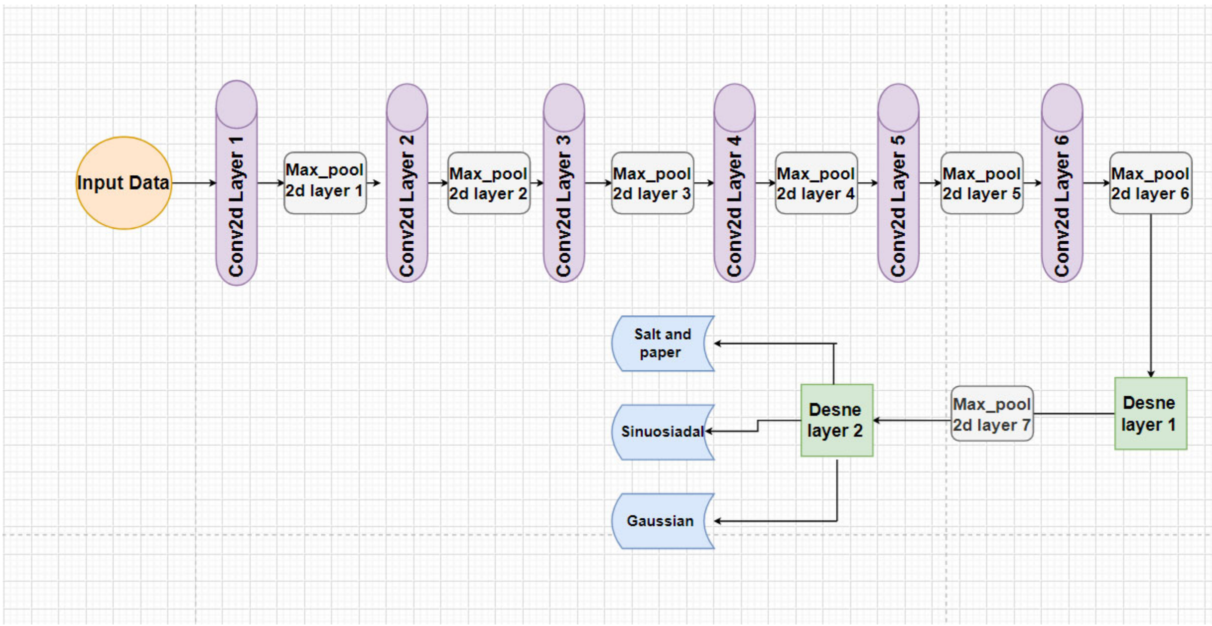

Fig. 1 Diagram of the designed CNN architecture

3.1 Dataset of ordinary images

The dataset used for image noise classification was taken from Kaggle website which included 6900 natural images [22]. Images were random and unlabeled belonging to no class as there was no need in this type of task where noise type will be used as a class. However, any other image dataset can also be used to this task.

3.2 Dataset creation for noise classification

Apart from this part, all other work is done using Python language. Reason for choosing MATLAB to perform this task was availability of built-in functions to add different kinds of noise to images [23]. Three most general types of noises mentioned below has been added to the images generating total images of 20,700 in which each noise/class has 6900 images. The noises include Salt and Pepper, Gaussian and Sinusoidal Noise.

3.3 Preprocessing the data

First step was to create categorical labels from the data to three classes as the network is designed to classify three noise types. This is necessary because CNN model needs to be informed the data is categorical. Images from the directory were resized, converted to Python arrays, shuffled and stored in Numpy arrays for training data and testing data.

3.4 TensorFlow and Keras for implementing CNN

For implementing a convolutional neural network, we will have to use Keras, TFLearn or directly TensorFlow. At the backend of neural networks TensorFlow is used but to use it directly is a difficult work to do. For the easiness for the researchers and practitioners, the developers have made high level libraries such as Keras and TFLearn to implement deep learning models easily. Remember, at its backend of these high-level libraries, TensorFlow works. The library used in this task is Keras for its simple to use style.

Building model and Implementing CNN layers - Five 2-dimmensional convolutional layers with ‘relu’ activation function were used to learn the patterns and features from the input given images which in the end will be used to classify the noise type. And each CNN layer is followed with 2-dimmensional max pooling layer to reduce the number of parameters and computation of the network. The hyper parameters of the layers were tuned with the respect to the accuracy and size of network in the mind to build an affective and low size model. The model is illustrated in Fig. 1.

Last two layers are dense (fully connected) layers. First dense layer was followed with a dropout layer to avoid overfitting and to increase generalization of our model. The nodes of Last layer's output were kept 3 because network had three 3 number of classes with 'softmax' activation function due to having a categorical classification. Finally, the model was trained on training dataset using just 4 epochs which gave 96.5% training accuracy, model was also tested on 900 images from each class and gave test accuracy of 99.8%. Training accuracy at each epoch can be visualized in Fig. 2.

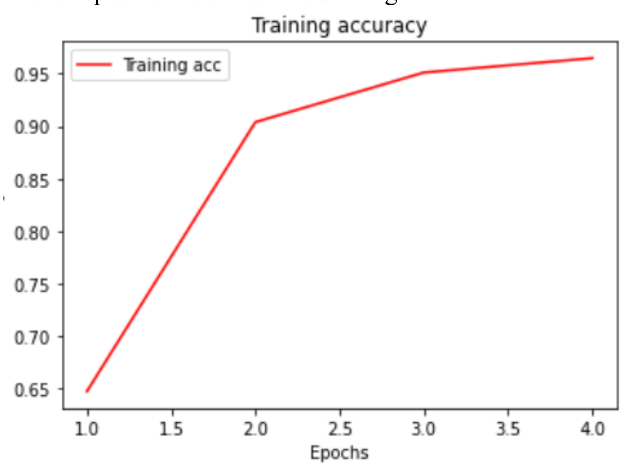

Fig. 2 Training status of the designed network at each epoch.

4. Limitations

The size of images for training was resized much low only size of 100 * 100 pixels due to not having proper TPU or proper GPU, and due to this some accuracy was compromised. If size would had increased, the experiment setup was not capable to process the images through CNN layers. Due to the limitations of availability of a good GPU, the image size was bounded to only 100*100 pixels to process the images quickly and reduce the model size. Accuracy further can be increased in the future work if good GPU are to be used which will allow us to increase the size of images resulting in having more details to be learned by the CNN layers.

5. Conclusion and Future work

Image Noise classification model is implemented using CNN layers. Three types of noises were added to 20,700 images of our dataset including Salt and Pepper, Gaussian and Sinusoidal Noise. 6900 images per class were distributed. Noise was added using MATLAB. After adding the Noise, the images were preprocessed in order to fed into CNN network. To implement CNN this Keras a TensorFlow high-level library was used. Model was trained with 4 epochs and got 98% training accuracy and validation accuracy of 96.5%. Model is completely ready to predict the type of noise available in image and giving testing accuracy of noise with 99.8% accuracy.

As the model was trained with 96.5% accuracy, along with classification of different kind of noises in images model can be extended to develop a system or web application which can automatically remove noise from the image by using pre-defined filters or any other technique. Future aim is to work on development of efficient algorithms for the removal of three to five type of noise from the image, merge the proposed network with the image denoising algorithms.

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