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Medical Image Denoising using Deep Learning

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***Abstract*: In medical field, image denoising is must for analysis of images, diagnosis and treatment of diseases. Now a day, image denoising methods based on deep learning are effective. We determine the quality of the denoised image, peak signal to noise ratio (PSNR), Mean Square Error(MSE) and compare with training data set. An experimental result shows that our approach has better performance than some other techniques. In this paper, we present a new image denoising techniques for removing salt and paper noise from corrupted image by using deep learning.**

***Keywords*: CNN DAE, Deep learning, Image denoising , Medical image ,MSE, PSNR, Salt and paper**

1. Introduction

Medical images such as MRI, Mammograms, CT and ultrasound are constitute various types and degrees of noise, due to corruption in its acquisition and transmission by many different effects. The presence of noise in the medical images has direct or indirect consequence that complicates the diagnosis, analysis and treatment process timely [1]. The quality of the original image is affecting which produce poor decisions either by humans or machines in image denoising process. A very common type of image noise is the so called salt and pepper noise, which is scattered throughout the image and consists of only the maximum or minimum intensity values (i.e.,0 or 255) in the dynamic range. Generally, the removal of salt and pepper noise consists of two problems: (1) how to detect the noisy pixels and (2) how to repair them. Therefore, the aim of noise removal or reduction is improve the quality and accuracy in the medical image as much as possible.

Researchers study vastly on image denoising which is a main problem in the field of computer vision. Most popularly studied and conventional medical image denoising techniques are transform based, like discrete wavelet (DW) [2], Shearlet [5], curvelet [6], discrete cosine (DC) [7], isotropic diffusion filtering [8], bilateral filters [9]. y is a noisy image generated as a combination of image x and some noise v, all having image units. The objective of image denoising is to recover a clean image x from a noisy observation y which follows an image degradation model $y = x + v$. One common assumption is that v is paper and salt noise with standard deviation σ. Here we take σ equal to 0.01.

Large data size using deep learning methods, it has been explained that, deep architecture can offer competitive consequence if the model has ability to train with very big data size, which is a severe problem when it comes to medical images, where obviously limited datasets are available. Therefore, in addition to seeking for appropriate denoising techniques, exploiting the deep learning application to image processing problems (for example denoising) with small dataset, like medical image is still an open research area.

The sequence of the paper is organized as follows. In section II explain related work. The proposed denoising model, architecture and some explorative concepts, are detailed in Sect. III, Sect. IV gives experimental results. Conclusion of the paper explain in section V.

2. Related work

A. Auto encoder (single layered)

It takes the raw input, passes it through an unseen layer and tries to rebuild the same input at the output. So, fundamentally it works like a single layer neural network where predicting the input only at the output is preferred instead of predicting labels. Therefore, the loss you compute is between the raw input you have given and your predicted input at the output layer. More or less same input is the result of minimizing this loss which is predicted at the output as the one you are providing. A latent feature from the raw features is studied by using auto encoder while retaining the ability to manufacture the raw input back from the latent features. First of all, noise is added to the raw input purposely before providing it to the network. This is referred as denoising. Some noises are gaussian and masking noise. But it is necessary to keep in mind that when loss is computed, it will be between the predicted input and the original input only.

B. Deep Learning

Deep learning is a form of machine learning algorithms use multiple layers to increasingly extract higher level features from raw input based on artificial neural networks. For example, in image processing, lower layers may denote edges, while higher layer may determine human-meaningful items such as digits/letters or faces.

In deep learning, a set of data used which is generally obtained even in large quantities, and that thus can supply a big number of “bits” of information for algorithms to learn from.

Machine learning method are change towards innovation of many levels of representation which is planned in recent years and moved by deep learning which is improving approach between the machine learning research community. Learning of useful representations of data are focused in learning algorithm for deep architecture, which are proper to the task at hand, and are arranged in a hierarchy with multiple levels. There are many psychological features for deep architectures: Brain idea (as a deep architecture organized by several areas of the brain); Cognitive statement and engineering statement (organize ideas and concepts in a modernized way and at multiple levels by humans) Sharing of statistical capability for multi-task learning; Procedure complexity.

Learning can be supervised, semi-supervised or unsupervised. Many modern deep learning models are based on an artificial neural network, generally, Convolutional Neural Networks (CNN), although they can also think propositional formulas or latent variables ordered layer-wise in deep generative models such as the nodes in deep belief networks and deep Boltzmann machines.

3. The proposed denoising model

Our proposed medical image denoising model is shown in Fig. 1.

The involvement of our work can be summarized as follows:

1. We develop medical image denoising model using Deep Learning.
2. To reduce complication of diagnosis, analysis and treatment process timely.
3. To calculate PSNR and MSE.

A. Denoising Model

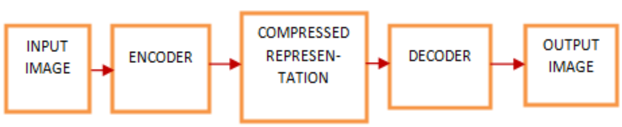


Fig. 1. Denoising Model

First original image given to the encoder. An encoder is a device, circuit, transducer, software program or algorithm that converts information from one format or code to another, for the aim of normalization, speed or compression. A compressor enrolls data (e.g., audio/video/images) into a littler form. Image compression is the art and science of reducing the amount of data required to represent an image. Compression can reduce the transmission time. Image compression system is composed of 2 distinct functional components: an encoder and decoder. Encoder performs Compression while decoder performs Decompression.

Input image f(x) is fed into the encoder, which creates a compressed representation of input. When a compressed image is given to decoder, a reconstructed output image f '(x) is generated. In still image application, the encoded input and decoder output are f(x, y) and f '(x, y). Finally, achieve output image.

B. Deep learning for Image Denoising

It is an auto encoder which has multiple layers except that it's training is not same as a multi layered NN. The process, in short, is carried out as follows:

Provide noise to the input. It passes through the hidden layer. Output is generated and loss is calculated between the output (which is the predicted input) and the original input. continue until convergence when the loss is minimized. Then finally pass the full data through this network and collect the data present in the hidden layer. This forms new input. Take this (collected) input and pass noise to it and follow the same procedure thereafter. Ultimately after done with the last layer, the data collected in this last hidden layer is now its form new data.

Original image x is added with noise to create noisy image x~. Then it is passes through layer1 Encoder and Layer2 Encoder. After that Layer3 Decoder and Layer4 Decoder passes to get final output denoise image.

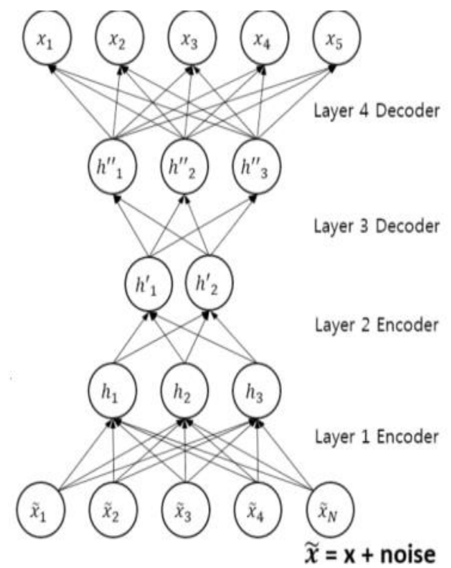


Fig. 2. Stacked denoising auto encoder

4. Experimental results

A. Training and Testing Data

For salt and paper denoising with known noise level = 0.01. We follow to use 150 images of size 512X512 for training data set. Image normalized into a scale of (0, 1) because we use grayscale image. For colour image use scale (0, 3). Out of 150 images in training data, we use (80% data) 120 images as training data & (20%data) 30 images for validation. Adam is used for optimization. We use 128 filters. Here batch size is 20 and epoch is equal to 200.Loss are minimized because we use double derivative. Take σ =0.01

In testing part, again use another 150 images of size 512 X 512 with normalized scale (0, 1). Give a noisy image from testing data and obtain a denoised image optimized to input.

Here we performed our proposed methodology on trained database. The performance of proposed method is found out by

Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR). MSE and PSNR are the two error metrics used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, PSNR represents a measure of the peak error. The result shows image before denoising and after denoising. For normal denoising σ =0.01 is shown in below figure with before and after denoising.

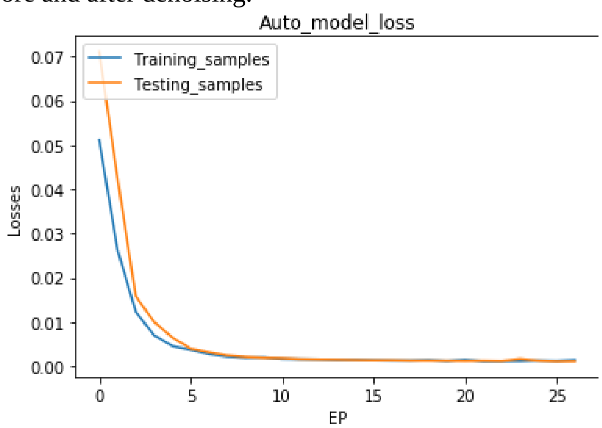
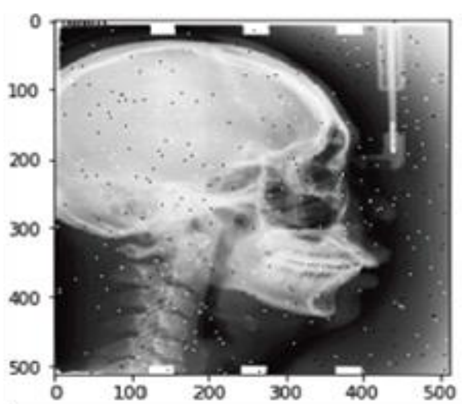
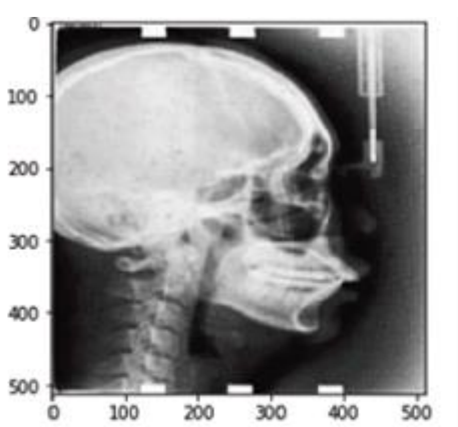


Fig. 3. The paper and salt denoising results



a) Before denoising



b) After denoising

Fig. 4. Image before and after denoising

```
before denoising
MSE 208.54024207026717
PSNR 24.938904875410451
after denoising
MSE 59.95307657408802
PSNR 30.352680864461186
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The table1 shows various images randomly taken and their observed results before and after denoising with parameter as MSE and PSNR.

Table 1
The average result of our medical image denoising model before and after denoising

	Before Denoising		After Denoising	
Image	MSE	PSNR	MSE	PSNR
1	222.65	24.65	57.21	30.55
2	227.54	24.56	44.99	31.59
3	211.48	24.87	56.5	30.6
4	216.07	24.78	36.62	32.49
5	218.08	24.74	42.62	31.83

From above table shows PSNR is increased and MSE is decreased & give noise free image.

5. Conclusion

Deep Learning is the common method to filter salt-and pepper noise plays a very important role in medical image preprocessing. It can improve the image quality of reconstruction, and this is significant in practice. In this paper, a deep learning was proposed for image denoising to remove noise from noisy observation. The proposed method shows that after denoising with deep learning method MSE decreases whereas PSNR increases which indicates that the reconstruction is of higher quality.

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