Graduate Project,2022

Project Title: Image Denoising Using Wavelet Transform and Convolution Neural Network

In the field of image processing, image naturally corrupted by noise is a common problem. Images are corrupted by various types of noises. In this project, gaussian, speckle, and Poisson noises are considered. For noise removal, I have used wavelet transform and convolutional neural networks. The typical discrete wavelet transform's wavelet coefficients are threshold by the wavelet de-noising technique. On the other hand, the convolutional neural network in image denoising has some importance. It has different layers that can use corrupt data as input and output units to enforce the data set to have a better representation of feature data. The performance is measured by PSNR.

Wavelet-Based Image Denoising:

All images have some noise and the denoising algorithm tries to minimize the noise from the image to have a better representation. The methodology used for wavelet transform is given below:

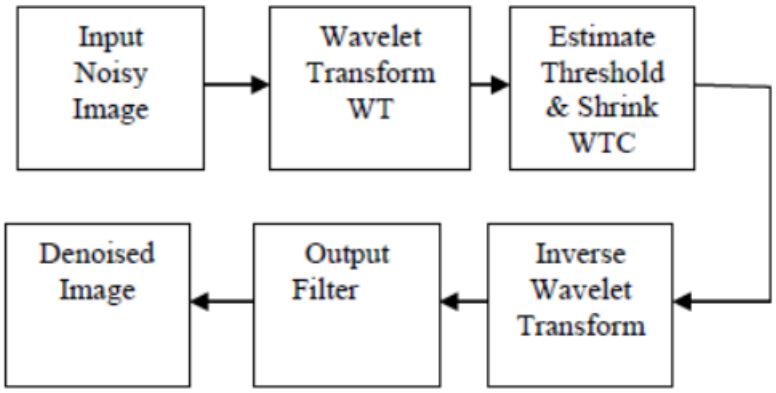

Figure 1: Wavelet Transform Block Diagram

Gaussian Noise Remove:

In MATLAB, gaussian noise is added to the original image and then using a threshold to optimize the noise and retrieve the image. The SNR value of the original vs noisy image is 17.7548 and the SNR value of the original vs denoised Image is 18.6138. The figure shows the original, gaussian noisy, and denoised image.

Figure 2: Image Corrupted by Gaussian Noise

Speckle Noise Remove:

In MATLAB, speckle noise is added to the original image, and then using a threshold to optimize the noise and retrieve the image. The SNR value of the original vs noisy image is 13.0592 and the SNR value of the original vs denoised Image is 17.5209. The figure shows the original, speckle noisy, and denoised image.

Figure 3: Image Corrupted by Speckle Noise

Poisson Noise Remove:

In MATLAB, Poisson noise is added to the original image and then using a threshold to optimize the noise and retrieve the image. The SNR value of the original vs noisy image is 21.8049 and the SNR value of the original vs denoised Image is 20.5045. The figure shows the original, Poisson noisy, and denoised image.

Figure 4: Image Corrupted by Poisson Noise

Convolutional Neural Network Image Denoising:

In the area of noise removal, the convolutional neural network plays a significant role. I have built a neural network from scratch. I have trained the model considering Gaussian noise. The network model I have built is called “SdnNet”. The convolution layer is doing the computing part. The regression layer is used for image restoration of the noisy pixels that it received from the classifier network. Classifier network involves the convolution and Relu layer. The CNN architecture is given below:

```
%CNN Layers
layers = [ ...
    imageInputLayer([50 50 1])

    convolution2dLayer(3,64,'Stride',1,'Padding',[1 1 1 1])
    reluLayer

    convolution2dLayer(3,64,'Stride',1,'Padding',[2 2 2 2])
    reluLayer
    convolution2dLayer(3,64,'Stride',1,'Padding',[1 1 1 1])
    reluLayer

    convolution2dLayer(3,1)
    regressionLayer];
```

Then I create a denoising data store that takes images in the data store, makes several patches from it, and adds Gaussian noise to the patches. The denoising data store has Patches Per Image, Patch Size, Gaussian Noise Level, and Channel Format properties. All color images in the denoising image data store are converted to grayscale when the Channel Format property is set to "grayscale." The data store properties are given below:

```
imds = imageDatastore(fullfile(rootFolder), ...
    'LabelSource', 'foldernames');
dnds = denoisingImageDatastore(imds,...
    'PatchesPerImage',512,...
    'PatchSize',50,...
    'GaussianNoiseLevel',[0.01 0.1],...
    'ChannelFormat','grayscale');
```

There are some training parameters as well. I have used the ADAM optimizer. The maximum epoch was 10. This training took a long time which is why I choose this number of epochs.

Gaussian Noise Remove:

The original, noisy, and denoised image is given below. The SNR value of the original vs noisy image is 17.7208 and the SNR value of the original vs denoised Image is 17.7208.

Figure 5: Image Corrupted by Gaussian Noise

Speckle Noise Remove:

With this network, I tried to remove speckle noise. The figure below shows the results. This model performs well in removing speckle noise. The SNR value of the original vs noisy image is 21.8111 and the SNR value of the original vs denoised Image is 21.8111. The figure shows the original, speckle noisy, and denoised image.

Figure 6: Image Corrupted by Speckle Noise

Poisson Noise Remove:

With this network, I tried to remove Poisson noise. The figure below shows the results. This model also performs well in removing Poisson noise. The SNR value of the original vs noisy image is 13.0586 and the SNR value of the original vs denoised Image is 13.0586.

Figure 7: Image Corrupted by Poisson Noise

Conclusion and Future Work:

I have tried to increase the number of layers in my network, but it took many hours to complete an epoch. The denoising was not effective as well. In the future, I will try to work on this. I will also work on other noise removal techniques such as using filters and try to differentiate among them with respect to performance.

Learning from the project:

1. What is denoising and why it is important in digital image processing?
2. How wavelet works in denoising?
3. How to build a CNN layer?
4. What is the use of layers?
5. How to compute effectively?
6. How to use the saved network and use it later?