Modern Deep CNN Based Median Filter Method for Salt and Pepper Noise Elimination: A Survey

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Abstract—. Images of faces are employed in a wide number of applications in digital image processing, including the identification and authentication of individuals, the recognition and classification of various expressions of emotion, and a great deal of work linked to matters of security. Within the scope of this study is an investigation of noise reduction filters that work very well to get rid of salt and pepper noise, mostly in the spatial domain. In the field of image processing, one of the most interesting topics of research is isolating or reducing salt and pepper noise. Eliminating impulse noise is seen as extremely important in the realm of picture extrapolation, despite the fact that doing so is a more challenging endeavour than extracting basic noise from images. As a direct consequence of this, there have been less studies conducted in this area. This research did really present a CNN-based new technique for minimising salt and pepper noise with high density impulsive noisy images. The strategy in question uses an Advanced Convolutional Neural Network centred Unsymmetric Trimmed Median Filter. If there is more than 75 percent noise density, the current iteration of the MDBUTMF will not be able to reconstruct the original picture from the noisy photos. A number of different metrics, including as Mean Square Error (MSE) and Peak Signal to Noise ratio, are utilised in the process of determining the performance of the innovative technology (PSNR). When compared to MDBUTMF, the results of the simulation consistently indicate that the novel technique performed the best in terms of both qualitative and quantitative integrity criteria.
Keywords—image processing, Denoising, salt & pepper noise, trimmed median filter, MSE, PSNR

I. INTRODUCTION

De-noising is one of the most fundamental challenges that might be encountered in image processing. Estimating the number of pixels in an image is one of the most fundamental challenges in image processing. The estimation method or scaling, for example, is used to compute appropriate pixel values among known ones, whilst de-blurring or de-noising is used to calculate clear picture pixels from damaged ones. Both of these methods are used to compute the values of pixels.
Three distinct areas of study, all of which are related to one another, examine the problem of completing an image by adding details that are absent from it in order to produce a result that is convincing to the human eye [1]. The de-noising process is an essential part of image processing and can be performed either as a stand-alone technique or as a component of other processes. There are a variety of approaches to removing noise from an image. The ability of a successful picture de-noising prototype to eliminate noise while preserving edges is the feature that is considered to be the most essential. In the past, linear prototypes were utilised quite frequently. A common technique involves the use of a Gaussian filter or the resolution of radiative heat transfer using input photographs as input data, which is an example of a nonlinear, second-order PDE prototype [2]. This particular method of noise reduction is effective enough to fulfil certain requirements. One of the most important advantages of using linear noise filtering models is their speed.

However, linear prototypes have the drawback of not being able to preserve edges very well. Edges, which are discerned as visual discontinuities, become smeared out. On the other hand, prototypes, in general, are significantly superior to linear programming when it comes to dealing with edges. One of the most well-known filters for de-noising linear images is called the Total Variation Filter (TVF), and it was invented by Rudin, Osher, and Fatemi. This filter performs a decent job of retaining edges, but in addition to that, it also converts smoothly variable elements of the input image into piecewise areas of the image [3].
When a noisy pixel needs to be replaced, the median value of the window or the values in its neighbourhood are used. It's likely that a replaced pixel (mean or median) is a chaotic pixel that doesn't help with noise reduction when you're dealing with salt and pepper noise in a high-density environment. In the Unsymmetric Modified Decision-Based Trimmed Filters, the noise pixel is replaced by the trim median value (not including either 0 or 255). The noisy pixel is replaced with the average value of all the elements in the window that was picked [4].
Denoising images is an essential step in the image processing workflow, and it can be performed either as a stand-alone technique or as a component of other operations. Denoising a picture or cleaning up some data can be done in a variety of different ways. The capacity to remove noise from an image while simultaneously preserving its edges is one of the most important requirements for a successful denoising model. In the past, linear models were utilised quite frequently. The application of a Gaussian filter is a common strategy that people use.

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In addition to the Gaussian filter, we utilised the box filter, the median filter, the adaptive median filter, and the Gabor filter. It is possible to create patterns such as "box" and "cross." Medical imaging refers to the processes and practises that are used to create images of the internal structures of the body for the purposes of clinical assessment and medical support. In addition to diagnosing and treating illness, the purpose of medical imaging is to uncover previously unknown internal structures concealed behind the skin and bones. In addition to this, the CT scan creates a database of normal anatomy and physiology, which makes it possible to identify any abnormalities.

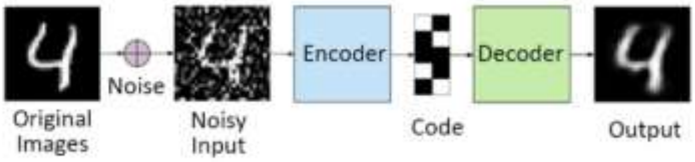

Figure 1: Denoising Model

II. DIFFERENT SORCES OF IMAGE NOISE

The introduction of noise into an image occurs whenever the image is being acquired or transferred. There are many different things that can go wrong that will lead to the appearance of noise in an image. The amount of corrupted pixels will serve as the basis for the quantification of the noise. The following is a list of the primary kinds of noise that can be found in digital images:

a) While the image is being taken, the imaging sensor could be affected by the surrounding environment.

b) Image noise may be introduced by inadequate levels of light and sensor heat.

c) Image corruption can also be caused by interference in the data transmission.

d) If there are dust on scan screen, they could cause noise from image.

DIFFERENT TYPES OF NOISE:-

The unfavourable effects that are created in an image are referred to as noise. During the process of capturing or transmitting a picture, the introduction of noise is influenced by a number of different elements. The degree to which noise detracts from an image is directly proportional to the nature of the disturbance that it is. The most important thing for us to do is get rid of a certain kind of noise. As a consequence of this, we are able to identify various types of noise and utilise a wide number of methods to eliminate it. There are many different types of image sound, including Impulse noise (also known as the salt-and-pepper sound), Amplification variation (also known as Gaussian noise), Shot noise, Quantization noise (also known as uniform noise), Film grit, on-isotropic loud sounds, Multiplicative noise (also known as speckle noise), and Cyclic noise.

Impulse Noise is a sort of noise that is also known as salt and pepper noise. Impulse noise is also known as random-valued impulse [5]. There are a few different names for the same phenomenon, including spike noise, random noise, and autonomous noise. Salt and pepper noise is the outcome of this sound's effect on the visual, which causes the formation of black and white dots [6]. The presence of this noise in the image is caused by abrupt and quick oscillations in the visual signal. It's possible that dusty grains in the image capture sources or overheated deficiencies components caused this form of noise. The image has some tiny irregularities as a result of the noise. Show how the actual image is affected by the noise that you found (figure 2).

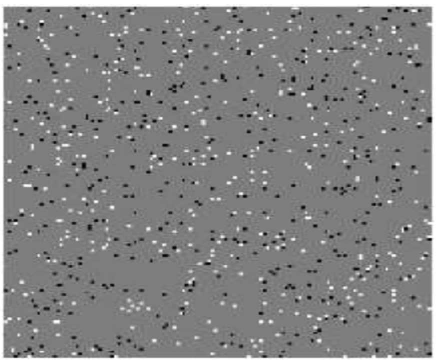

Figure 2: Salt and pepper noise

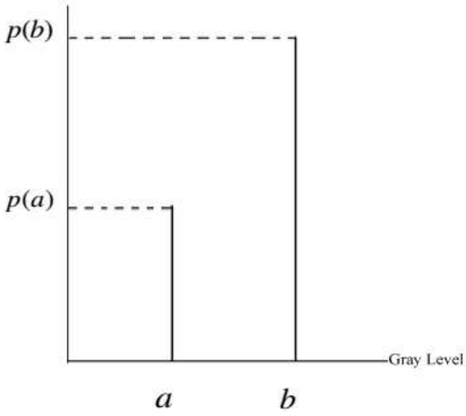

Figure 3: PDF of Salt and pepper noise

Gaussian Noise (Amplifier Noise): The terms normal noise prototype and Gaussian noise are interchangeable. This noise model follows a Distribution function and is likely to increase over time [7]. In the input images, each pixels is combination of true image pixel and a randomized, Gaussian dispersed noise component. The noise is unaffected by the pixel value's intensity at each position.

Gaussian distribution is another name for it. It has a normally distributed probability density (PDF). During images acquired, this noise is introduced to the image, such as sensor noise generated by poor light, high temperature, or transmission, such as circuitry noise. By smoothing the image (mean filtration, wiener filter, and gaussian flattening), this noise can be removed, however smoothing also distorts the perfectly alright image edges and details. It can also be removed by using discrete cosine transform to the noisy image, such as the wavelet. The following formula and graphic [1] show the PDF of Gaussian Filter:

$$p(z) = \frac{1}{\sqrt{2\pi\sigma}} e^{-(z-\mu)^2/2\sigma^2} \quad (1)$$

PDF of Gaussian noise [1] is depicted in Figure 3

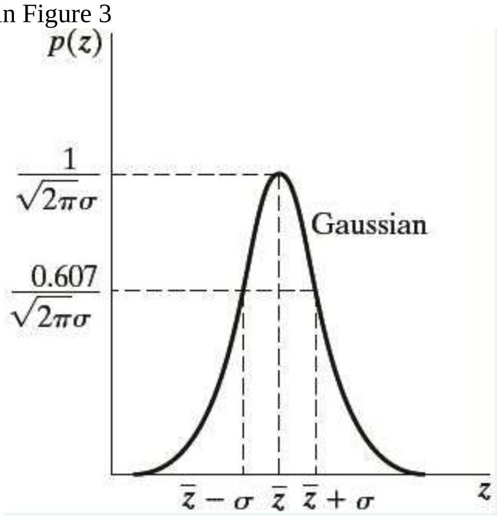

Figure 4: PDF of Gaussian Noise

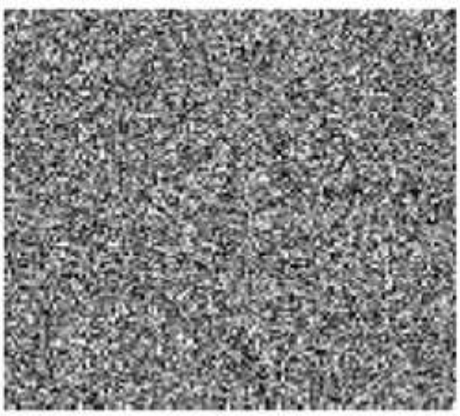

Figure 5: Gaussian Noise
(mean=0, variance=0.05)

Speckle Noise: This noise is caused by the processing of backscattered data from several distributed sites in a coherent manner. When the transmitted signal from an item with a size smaller than or equivalent to single image processing unit depicts abrupt oscillations in a traditional radar system, this form of noise is detected.

Figure 6: Speckle noise

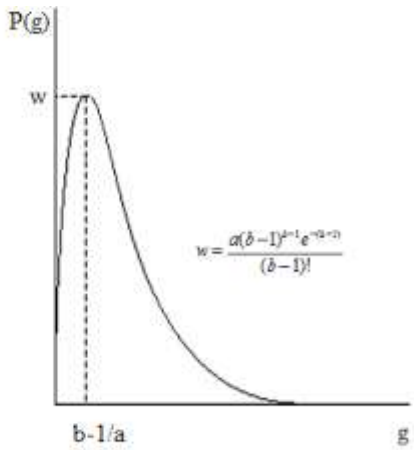

Figure 7: PDF of Speckle noise

III. DIFFERENT TYPES OF FILTERS

Image de-noising is an essential part of the image processing procedure that ultimately leads to image interpretation. The best picture de-noising technique should be able to get rid of all the noise in the image while keeping all of the information that it contains. There is a wide variety of these methods available for use. Techniques for de-noising might be either linear or non-linear in nature. Non-linear algorithms are able to preserve image details, in contrast to linear methods which preserve speed but not image quality. In a general sense, de-noising filters can be divided up into the following categories:

- Adaptive Filter
- Order Statistics Filter
- Mean Filter
- Averaging
- Median Filter

Adaptive Filter:- The behaviour of these filters is influenced in part by the empirical properties of the image region that is enclosed by the filter region. BM3D is a filter that modifies its settings depending on the surrounding environment. An approach to nonlocal picture modelling that makes use of adaptive, high-order group-wise models is what this is called. This approach of eliminating noise consists of three distinct processes [7-8]:
1. Examine. To begin, comparable image blocks are grouped together. Each group's pieces are stuffed to create 3-D data array, that are then de-correlated utilizing an integrable 3D transformation.
2. Preparation. Hard thresholding is used to filter the resultant 3-D group spectra.
Synthesis is the third step. Inverting the filtered spectra yields estimates for each block in the group. The final picture restoration is determined as weighted average of all collected block-wise estimations, and they are returns to its original **places**.

Order Statistics Filter:- Filters are non-linear filters, and the output of these filters is influenced by the order in which the pixels in the filter region are arranged. The name of the filter is referred to as a max-filter whenever the value in the centre of each pixel in an image region is changed to the value that corresponds to the 100th percentile. When the identical pixel value is replaced by zero percent, the filter is said to be operating at its most basic level and is referred to as a minimum filter. In this particular method of filtering, the pixel in question is replaced by the median of the pixels that are adjacent to it. A window is chosen, the characteristics of which vary according to whether the signal is 1D or i2D, and it is moved over each pixel value. One of the issues that arises with the use of a median filter is that the majority of the time and effort spent computing is directed toward computing the median of each window.

Mean Filter:-

A nonlinear averaging filter, the mean filter, can be found in [6]. This filter will calculate the average value of the distorted image over a certain predetermined area in this particular scenario. The value that represents the average is being used in place of the intensity value that represents the central pixel. The aforementioned technique is carried out for every single pixel value in the image.

Averaging Filter:-

In order to restore grayscale and colour photos that have been severely affected by salt and pepper noise while simultaneously attempting to overcome the drawbacks of the average filter, an averaging filter is applied. This filter is used to restore the images. Similar to how the mean filter works, the distorted pixel must first be identified before one of the following treatments may be applied to it:

Case 1: If a noisy pixel (255 or 0) is present in the specified window, and all of nearby pixel values are likewise noisy, the screen's median value would be noisy as well. To prevent this, mean of pixel in current window is calculated, and noisy pixel is substituted with that number.

Case 2: If a noisy pixel (255 or 0) is present in the specified frame, and several of nearby image pixels are also noisy, then their median price shall be noisy as well. To reduce noise from an image, a 1-D array of chosen image region is produced, with the 0/255 values removed, and the median of the residual values computed, with noisy pixel value substituted by this value.

Case 3: If none of noisy pixels are found in specified window, no adjustments are made and pixel value remains unchanged. This technique produces better outcomes than other filters, but it has the disadvantage of causing image blurring at larger noise concentrations.

Median Filter:-

The output of a non-linear, best-order static filtering technique known as the mean filter is decided by the ranking of pixel values contained within the filter zone. The median filter is an effective tool for reducing background noise in a variety of settings. The centre value of the pixel is replaced with the median of the picture pixels that fall under the filter region [9] [10]. The median filter is a type of non-linear filter that can be used to cut down on noise. Using this method of filtering, the pixel is replaced with the median of the pixels that are adjacent to it. A window is chosen, the characteristics of which vary according to whether the signal is 1D or i2D, and it is moved over each pixel value. One of the issues that arises with the use of the median filter is that it requires a significant amount of time and effort to be invested in computing the median of each frame. The efficiency of the median computation is key to demonstrating how quickly an algorithm can execute for enormous signals. This is because the filter needs to analyse each entry in the signal. In addition, the median filter performs admirably in conditions of low noise density but is ineffective under conditions of high noise density.

IV. MEDIAN FILTER

The algorithm known as Modified DecisioniBased Free - free Trimmed MedianiFilter (MDBUTMF) [6] first identifies the impulsive noise and then does an analysis of the distorted images. The pixel that is being processed is analysed to determine whether or not it contains noise. That is, if the processed pixel had grey level values that fell between the minimum and maximum levels, the image is free of noise and should not be altered in any way. If the processor pixel hits either the maximum or minimum grey level, then it is considered to be a noisy pixel, and MDBUTMF is responsible for handling it. The MDBUTMF can be viewed as consisting of the following stages.

Step 1: Put 0s in the picture's first-row, first-column, and last-row, last editorial.

Step 2: Choose a window with a size of 33 pixels and assume that processing pixel is pij in the frame.

Step 3: If the processed number of pixels is somewhere between 0 and Pij255, it is an uncorrupted pixels, and its meaning is left unaltered.

Step 4: Pij is a corrupted pixel if it equals 0 or 255. The following are examples of image processing scenarios:

Case (i): If the selected window contains all 0’s and 255’s, then P_{ij} is replaced with mean of the element of the window.

Case (ii): If all the elements in the selected window does not have 0’s and 225’s,

Remove the 0s and 255s, sort the attribute in increasing order, and find the median value. Pij should be replaced with the median value.

Step 5: Repeat steps 2–4 until every pixel in image has been processed.

Step 6: Steps 2 through 5 should be repeated.

Step 7: Step 1: Remove any extra inserted rows and columns of 0s.

V. IMAGE RECONSTRUCTION

Image reconstruction, or restoration, is the final and most important phase in the super resolution process. It removes the blurring effect as well as any noise in image. The general prototype or principle is as follows:

$$g(x, y) = h(x, y) * f(x, y) + n(x, y) \qquad (2)$$

Where g(x, y) denotes a reduced image, h(x, y) denotes a point spread function, f(x, y) denotes a high-resolution ideal image, and n(x, y) denotes image noise.

Equation 3's Fourier transformations (FT) are given by

$$G(u, v) = H(u, v)F(u, v) + N(u, v) \qquad (3)$$

The goal of super resolutions (SR) restoration is to use prior information and posterior processing techniques to F(u, v) to increase its supporting domain.

Get a new point up and share (PSF) called H' now (u, v). H(u, v) also has an expanded support domain, which improves the image's resolution. Due to the lack of prior information in an image and the difficulty in obtaining the image's point spread function, blind discrete wavelet transform is most likely utilised to rebuild the image.

There are two forms of blind franchised.

1) The recovery of the image is isolated from the recognition of the point spread function. After obtaining the cumulative distribution function (PSF), standard restoration techniques are employed to construct an estimate of the main image.

2) Because the identification of the PSF (point spread functional) and image restoration are done at same instant, this technique is somewhat complicated.

Aside from that, the Auto Regressive Becomes At and Priori Blur Identification methods are two other approaches that are commonly employed in blind wavelet decomposition.

Figure 8: Image after restoration

VI. CONCLUSION

In most cases, an algorithm is being developed. It has been recommended and put into practise that the CNN-AMDBUTMF (CNN-advance modification judgement asymmetric trim median filter) be used for various denoising techniques on images of various formats. On the other hand, the averaging and minimum filters did not perform very well. The median filter is the most effective tool for cutting down on the salt and pepper noises in an audio recording. My dissertation's future work will include modified thresholding, improved PSNR (peak signal-to-noise ratio), and reduced mean square error (MSE) for both grayscale and colour images. All of these improvements will be made.

The efficiency of the method is examined using grayscale photos with a variety of noise densities. The technique that has been proposed is superior in terms of its ability to reduce the effect of noise, particularly at high noise concentrations. This approach can also be applied to a wide variety of noises, including speckle, Gaussian, random, and others.

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