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Medical Imaging Processing

Noise in Image

By

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Noise Definition

Noise is any undesired information that contaminates an image. Noise appears in image from a variety of source. The digital image a acquisition process, which converts an optical image into a continuous electrical signal that is then sampled is the primary process by which noise appears in digital images. At every step in the process there are fluctuations caused by natural phenomena that add a random value to exact brightness value for a given pixel.

We may define noise to be any degradation in the image signal, caused by external disturbance. The errors will appear on the image output in different ways depending on the type of disturbance in the signal. Cleaning an image corrupted by noise is thus an important area of image restoration.

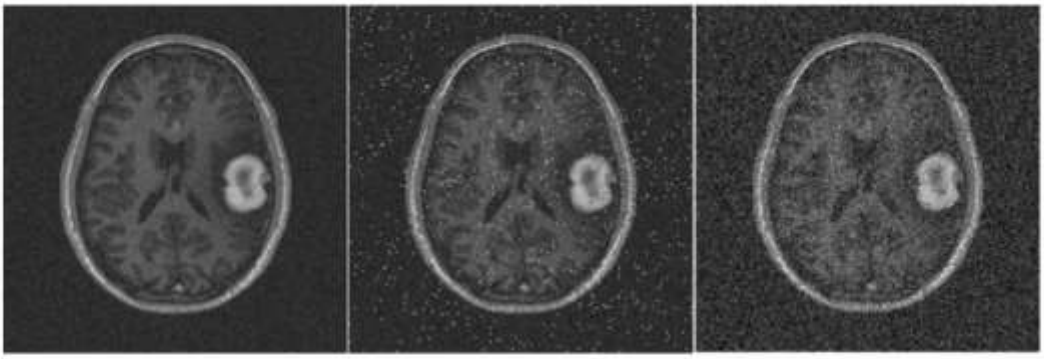
Types of noise:

There are four different noise types:

1-Salt and pepper noise:

Also called impulse noise, shot noise, or binary noise. This degradation can be caused by sharp, sudden disturbances in the image signal; its appearance is randomly scattered white or black (or both) pixels over the image. As shown in figures below:

(a) Original image (b) With added salt & pepper noise



2 –Gaussian noise:

Gaussian noise is an idealized form of white noise, which is caused by random fluctuations in the signal (white noise by watching a television) is normally distributed. we can model a noisy image by simply adding the image I and noise N: I+N. Assume that I is a matrix whose elements are the pixel values of our image, and N is a matrix whose elements are normally distributed. As shown in figure (a)

3- Speckle Noise:

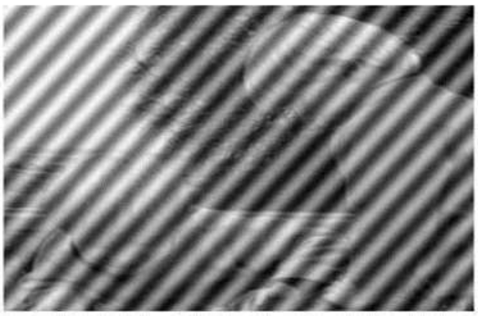
Whereas Gaussian noise can be modelled by random values added to an image; speckle noise (or more simply just speckle) can be modelled by random values multiplied by pixel values, hence it is also called multiplicative noise. Speckle noise is a major problem in some radar applications. As shown in figure (b)

(a) Gaussian noise (b) Speckle noise

Although Gaussian noise and speckle noise appear superficially similar, they are formed by two totally different methods.

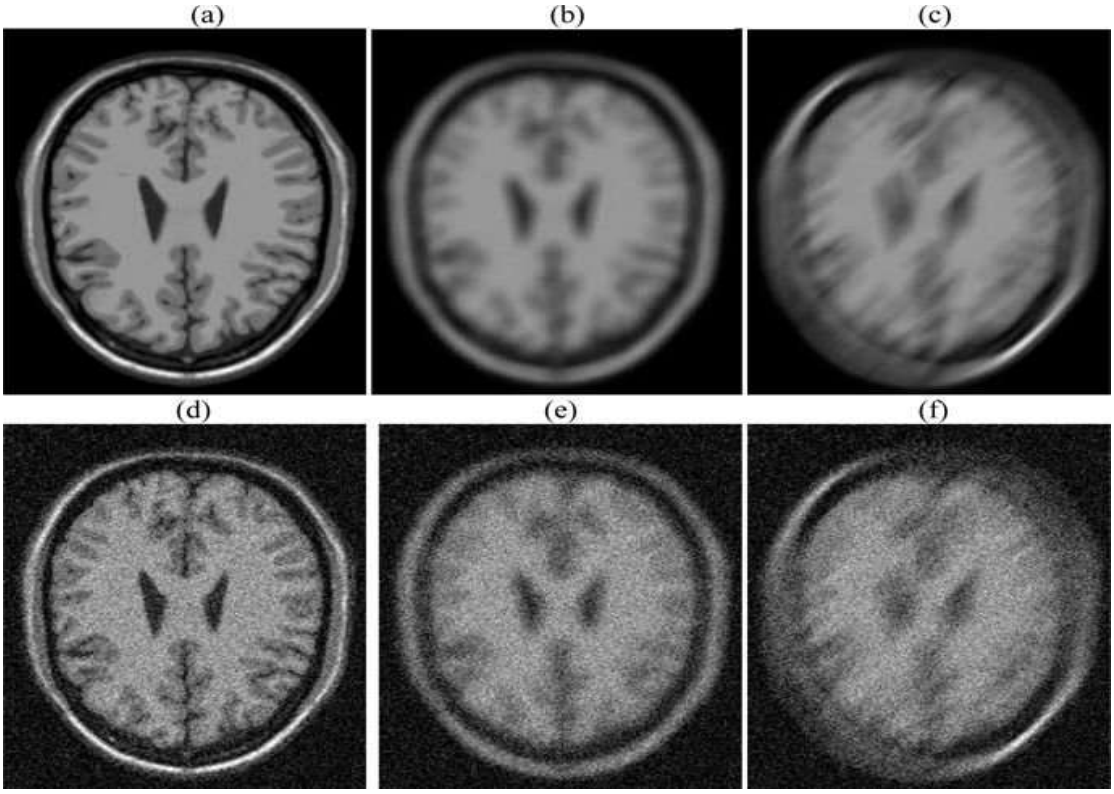
4- Periodic noise:

If the image signal is subject to a periodic, rather than a random disturbance, we might obtain an image corrupted by periodic noise. The effect is of bars over the image. As shown in figure below:



Salt and pepper noise, Gaussian noise and speckle noise can all be cleaned by using spatial filtering techniques. Periodic noise, however, requires image transforms for best results.

MRI brain image with blur and noise:



(a) Original image;

(b) Gaussian blur;

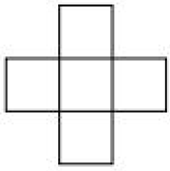
(c) Motion blur;

(d) Rician noise only;

(e) Guassian blur plus Rician noise;

(f) Motion blur plus Rician noise.

3-Rank-order filter: Median filtering is a special case of a more general process called rank-order filtering. Rather than take the median of a set, we order the set and take the nth value, for some predetermined value of n. Thus median filtering using a 3x3 mask is equivalent to rank-order filtering with n=5. Similarly, median filtering using a 5x5 mask is equivalent to rank-order filtering with n=13. There is only one reason for using rank-order filtering instead of median filtering, and that is that it allows us to choose the median of non-rectangular masks. For example, if we decided to use as a mask a 3x3 cross shape.



Example01 :

The 5x5 is a standard rank order filter which works in a 5 by 5 environment. When 25 pixel values encountered in the input map are:

2	**4**	**10**	**3**	**21**
14	**1**	**119**	**12**	**9**
112	**7**	**5**	**118**	**13**
8	**8**	**132**	**15**	**6**
113	**2**	**5**	**10**	**12**

Then the median filter orders these 25 values as:

1,2,2,3,4,5,5,6,7,8,8,8,9,9,10,10,11,12,12,12,13,13,14,15,21

The value at rank order 13 is assigned to the pixel in the output map: 9.

Input pixel value 5 is smaller than the value of surrounding pixels in this example, while the output pixel value 9 is the median value of the 25 pixels examined.

Example 02:

The MED3x3 filter is a standard rank order filter which works in a 3 by 3 environment.

When 9 pixel values encountered in the input map are:

9	12	9
11	5	7
8	8	13

Then the median filter orders these 9 values as:

5, 7, 8, 8, 9, 9, 11, 12, 13

The value at rank order 5 is assigned to the pixel in the output map: 9.

Input pixel value 5 is smaller than the value of surrounding pixels in this example, while the output pixel value 9 is the median value of the 9 pixels examined.

4−An outlier method:

Applying the median filter can in general be a slow operation: each pixel requires the sorting of at least nine values. To overcome this difficulty. We use of cleaning salt and pepper noise by treating noisy pixels as outliers. The following approach for noise cleaning:

Choose a threshold value D.

For a given pixel, compare its value p with the mean m of the values of its eight neighbors.

If |p−m|>D then classify the pixel as noisy, otherwise not.

If the pixel is noisy, replace its value with m; otherwise leave its value unchanged.

Cleaning Gaussian noise:

Average filtering: If the Gaussian noise has mean 0, then we would expect that an average filter would average the noise to 0. The larger the size of the filter mask, the closer to zero. Unfortunately, averaging tends to blur an image, as we have seen in chapter 3. However, if we are prepared to trade off blurring for noise reduction, then we can reduce noise significantly by this method. Suppose we take the and averaging filters, and apply them to the noisy image t. The results are shown in figure (6) The results are not really particularly pleasing; although there has been some noise reduction.

```
>> a3=fspecial('average');
>> a5=fspecial('average',[5,5]);
>> tg3=filter2(a3,t_ga);
>> tg5=filter2(a5,t_ga);
```


(a) 10 images (b) 100 images

Figure (6): Image averaging to remove Gaussian noise.

Exercises

1. The arrays below represent small greyscale images. Compute the 4×4 image that would result in each case if the middle 16 pixels were transformed using a 3×3 median filter:

8	17	4	10	15	12
10	12	15	7	3	10
15	10	50	5	3	12
4	8	11	4	1	8
16	7	4	3	0	7
16	24	19	3	20	10

1	1	2	5	3	1
3	20	5	6	4	6
4	6	4	20	2	2
4	3	3	5	1	5
6	5	20	2	20	2
6	3	1	4	1	2

7	8	11	12	13	9
8	14	0	9	7	10
11	23	10	14	1	8
14	7	11	8	9	11
13	13	18	10	7	12
9	11	14	12	13	10

2. Using the same images as in question 1, transform them by using a 3×3 averaging filter.

Bubble Sheet Questions: Image Noise Removal:

Q1. What is the primary goal of image noise removal techniques?

a. To introduce noise to the image
b. To enhance the appearance of noise in the image
c. To reduce or eliminate the unwanted degradation in the image signal caused by external disturbance
d. To create artificial noise patterns in the image

Answer: c. To reduce or eliminate the unwanted degradation in the image signal caused by external disturbance

Q2. Which of the following is NOT one of the types of noise mentioned in the text?

a. Salt and pepper noise
b. Gaussian noise
c. Electrical noise
d. Speckle noise

Answer: c. Electrical noise

Q3. What type of noise appears as randomly scattered white or black pixels over the image?

a. Gaussian noise
b. Speckle noise
c. Salt and pepper noise
d. Periodic noise

Answer: c. Salt and pepper noise

Q4. Which filtering method is particularly suitable for removing salt and pepper noise?

a. Low pass filtering
b. Median filtering
c. Rank-order filtering
d. Outlier method

Answer: b. Median filtering