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SURVEY ON IMAGE PROCESSING IN THE FIELD OF DE-NOISING TECHNIQUES AND EDGE DETECTION TECHNIQUES ON RADIOGRAPHIC IMAGES

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ABSTRACT

Digital Image Processing is the processing on digital images by means of different algorithms. The important steps of image processing are de-noising and edge detection. Images captured by cameras /video cameras have noise due to the electromagnetic and other geographic ,atmospheric conditions, incorrect photo count. Hence removing noises from an image is a challenging task in image processing. Second, edge detection is one of the first steps of feature extraction. Edge detection characterizes the boundaries in the image and thus reduces the amount of data and also filters out the unnecessary information from the image and provides the structural properties of the image. There are many algorithms for both de-noising and edge detection on images. This paper discusses the mean and median filter for de-noising the radiographic images and the different edge detection techniques on radiographic de-noised images and compared them.

Keywords: C*old Trap, PSNR , MSE , Filters, De-noising Spatial and frequency domain,LoG Operator*

1. INTRODUCTION

The significance of digital images is increasing by the day and is being used in the medical and research areas. This paper presents review the concept of de-noising and edge detection on Radiographic images. Radiography, which is one of the processes to produce an image, has ample information; this property is exploited in the detection of elements and compounds in images. Detection of minerals based on images of satellite uses these images. This paper uses Radiographic images of Fast Breeder Reactor (FBR) in atomic field for maintaining the oxygen/hydrogen level in sodium within permissible limit.

The aim of de-noising technique is removal of noises from an image and thus becomes the first step in image processing. The technology for removal of noise should be applied carefully; otherwise noise removal introduces artifacts and which causes blurring of the image. The aim of edge detection is to provide the structural properties of the image. Important features can be extracted from the edges of an image and these features are used by higher-level computer vision algorithms.

These techniques are required because they stand as the basic process of image processing of the cold trap images to identify the sodium impurities in the internal structure of reactor. After performing de-noising and edge detection, we can use the edge detected image for segmentation to find the different threshold values of the image, by which we can identify the sodium impurities. Here, this paper discusses the mean and median filter for de-noising and some popular edge detection algorithms like Canny, Roberts, Sobel, Prewitt, LoG and their results are observed in the form of images.

2. DE-NOISING TECHNIQUES

De-noising technique is used to restore the image corrupted by noise as close as possible to the original image. This paper gives the results of de-noising techniques using PSNR values of each filter.

2.1. PSNR (PEAK SIGNAL TO NOISE RATIO)

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PSNR is the ratio of maximum possible power in the image to the noise quantity in the image. Mathematically represented as

$$PSNR=10.\log_{10}\left(\frac{MAX_I^2}{MSE}\right)=20.\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

Where MAX_I-maximum possible pixel value in the image,

MSE-mean-square error in the image.

The unit of PSNR is 'db' (decibel). If both images are identical then PSNR values becomes infinity because in such cases MSE will become zero.

2.2. CLASSIFICATION OF DE-NOISING TECHNIQUES

There are two basic approaches for image de-noising. They are spatial domain filtering and transform domain filtering. In this paper we discuss about spatial domain filters; which are further classified into linear filter (Mean filter) and non-linear filter(Median filter).

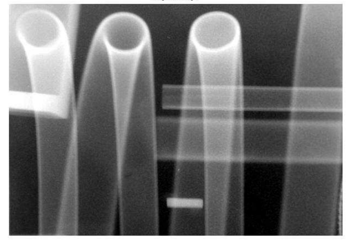
2.2.1. LINEAR FILTERS- MEAN FILTER

Mean filter is the optimal filter for removing grain noise in an image. It is the linear filter which uses a mask over each pixel in the image. The components of the image which fall under the mask are averaged together to form an output pixel. This filter is also called average filter and it becomes weak when the noise in the image is adaptive noise. Generally this filter is applied for noise suppression. Mathematically,

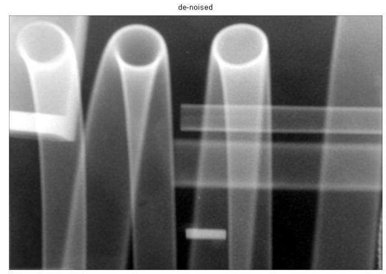
$$f(x, y)=\frac{1}{m*n}\sum_{i=0}^{i=m}\sum_{j=0}^{j=n} f(i,j)$$

where m, n-window size parameters,

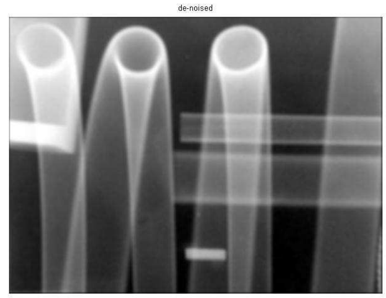
f(x, y)- represents the value of the central pixel of the image under the window,
f(i, j)-represents the pixel value of the image under the window co-ordinate(i,j).[2]



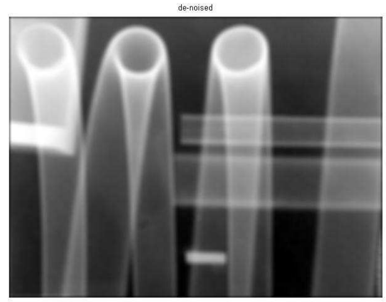
Original image



De-noised image of window [3 3]



De-noised image of window [6 6]



De-noised image of window [9 9]

PSNR values for the de-noised images for windows

[3 3]	35.7781
[6 6]	31.2646
[9 9]	29.0501

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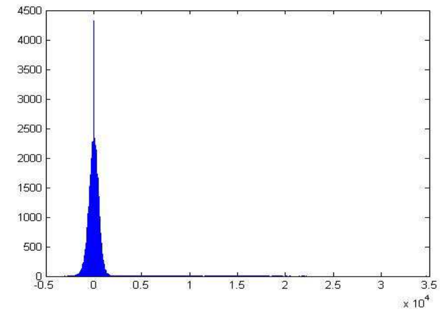
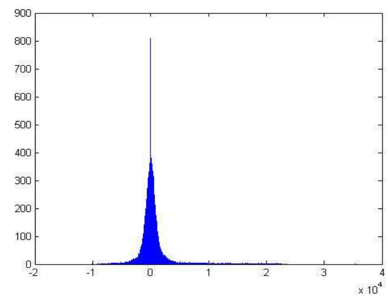
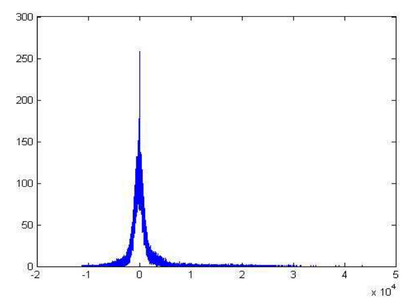


Pdf- mean filter of window [3 3]



Pdf-mean filter of window [6 6]



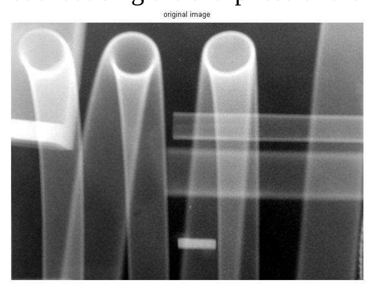
Pdf-mean filter of window [9 9]

Analysis:

1. On increasing Window size the PSNR will decrease in Mean filter.
2. Lower PSNR means more data change has been occurred (including noise, blurring).
3. Increasing the window size may blur the image.

2.2.2. NON-LINEAR FILTERS - MEDIAN FILTER

This is the most favorite filter in digital image processing. Unlike mean filter, it takes median of neighboring pixels. It is often used when the noise in image is of type 'salt and pepper'.[3] It is used to simultaneously reducing noise and preserving the edges. Median filtering is therefore better able to remove these outliers without reducing the sharpness of the Image[3].



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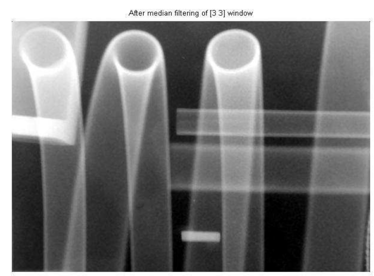
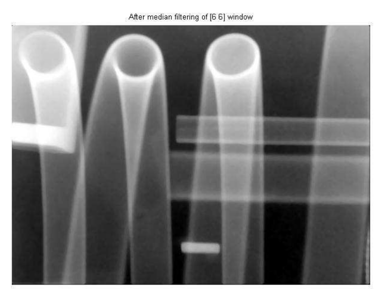
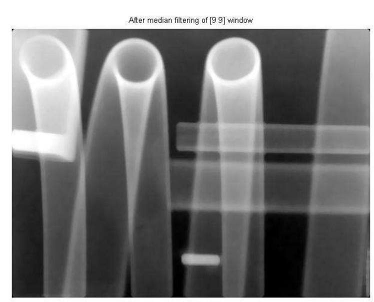
Original image



De-noised image of window [3 3]



De-noised image of window [6 6]



De-noised image of window [9 9]

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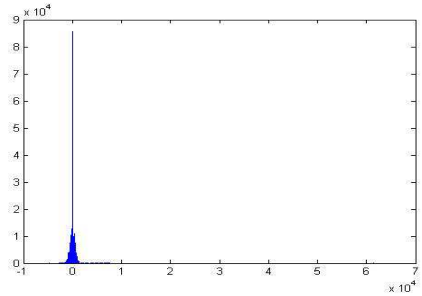
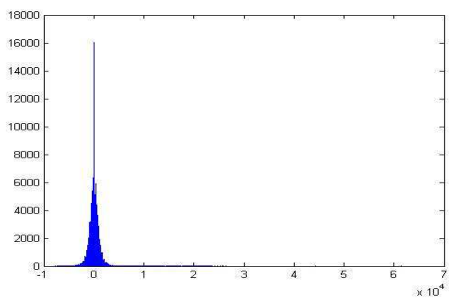
PSNR values for the de-noised images for windows.

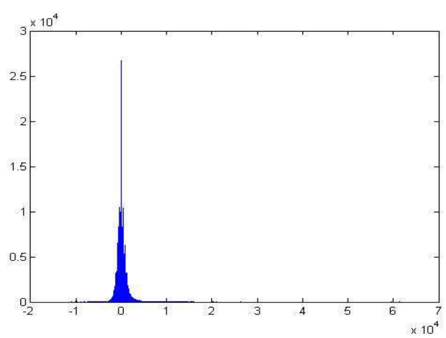
[3 3]	42.2295
[6 6]	33.3135
[9 9]	34.4992



Pdf- median filter of window [3 3]



Pdf-median filter of window [6 6]



Pdf-median filter of window [9 9]

Analysis:

1. By analyzing the above graphs it can be said that increasing the window size will not always decrease the PSNR.
2. If window size is increased the window size from odd to even, the PSNR will decrease and if window size is increased from even to odd, then will increase.
3. Hence, Median filter preserves edges when compared to Mean filters.

3. EDGE DETECTION

It is the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. It involves the convolving the image with an operator. There is large number of edge detection operators, where each operator is sensitive to certain types of edges. Edge detection is difficult in noisy images, since both the noise and the edges contain high frequency content. Attempts to reduce the noise result in blurred and distorted edges. Operators when used on noisy images are typically larger in scope and also results in less accurate localization of the detected edges. Not all edges involve a step change in intensity. Effects such as refraction or poor focus can result in objects with boundaries defined by a gradual change in intensity. The operator needs to be chosen to be responsive to such a gradual change in those cases. So, there are problems of false edge detection, missing true edges, edge localization, high computational time and problems due to noise etc[1].

3.1. STEPS IN EDGE DETECTION

The fundamental steps performed in edge detection:

1. Image smoothing for noise reduction- suppress as much noise as possible, without destroying the true edges.
2. Enhancement: apply a filter to enhance the quality of the edges in the image(sharpening).
3. Detection: determine which edge pixels should be discarded as noise and which should be retained (usually, thresholding provides the criterion used for detection).
4. Localization: determine the exact location of an edge (sub-pixel resolution might be required for some applications, that is, estimate the location of an edge to better than the spacing between pixels). Edge thinning and linking are usually required in this step[1].

3.2. EDGE DETECTION OPERATOR

Edge operator provides the edge magnitude, edge orientation, high detection rate and good localization. For edge detection, the

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gradient operator is used. The gradient is a vector which has certain magnitude and direction:

$$\nabla f = \begin{pmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{pmatrix}$$

$$\text{Magn}(\nabla f) = \sqrt{(\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial x}\right)^2)}$$

$$\text{Magn}(\nabla f) \approx |M_x^2| + |M_y^2|$$

$$\text{Dir}(\nabla f) = \tan^{-1}\frac{M_y}{M_x}$$

Properties of the gradient

1. The magnitude of gradient provides information about the strength of the edge.
2. The direction of gradient is always perpendicular to the direction of the edge (the edge direction is rotated with respect to the gradient direction by -90 degrees)[1].

3.3. EDGE DETECTION TECHNIQUES

This paper discusses five commonly used edge detection algorithms. They are Roberts, Prewitt, Sobel, LoG(Laplacian of Gaussian) and Canny edge detectors.

3.3.1. ROBERTS EDGE DETECTOR

The Roberts operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It highlights regions of high spatial gradient which often correspond to edges. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point[4].
In theory, the operator consists of a pair of 2×2 convolution masks. One mask is simply the other rotated by 90°.

+1	**0**
0	**-1**

0	**+1**
-1	**0**

G_x G_y

Roberts Cross convolution masks

These masks are designed to respond maximally to edges running at 45° to the pixel grid, one mask for each of the two perpendicular orientations. These can be combined together and be used to find the absolute magnitude of the gradient at each point and the orientation of that gradient.

The gradient magnitude is given by:

$$|G|=\sqrt{(G_x^2+G_y^2)}$$

The angle of orientation of the edge giving rise to the spatial gradient is given by:

$$\theta = \arctan\left(G_y / G_x\right) - \frac{3\pi}{4}.$$

3.3.2. PREWITT EDGE DETECTOR

It is a discrete differentiation operator, which is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations[4].

Mathematically, the operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical. If we define A as the source image, and Gx and Gy are two images which at each point contain the horizontal and vertical derivative approximations, the latter are computed as:

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} * A$$

$$G_y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} * A$$

where * here denotes the 2-dimensional convolution operation.
The *x*-coordinate is here defined as increasing in the "right"-direction, and the *y*-coordinate is defined as increasing in the "down"-direction. The gradient magnitude is given by:

$$|G|=\sqrt{(G_x^2+G_y^2)}$$

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Using this information, we can also calculate the gradient's direction:

$$\theta = \arctan\left({}^{G_y}/_{G_x} \right).$$

3.3.3. SOBEL EDGE DETECTOR

This operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial gradient that corresponds to edges. And also it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image[4].

In theory, the operator consists of a pair of 3×3 convolution masks. One mask is simply the other rotated by 90°.

This is very similar to the Roberts Cross operator.

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

$$G_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

Sobel operator convolution masks.

These masks are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one mask for each of the two perpendicular orientations.

The gradient magnitude is given by:

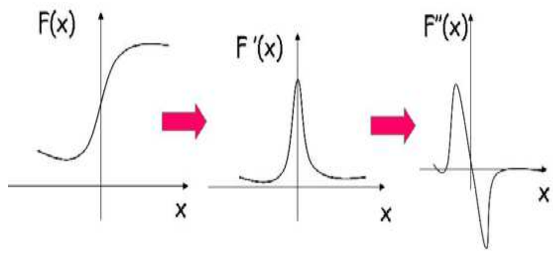
$$|G| = \sqrt{(G_x^2 + G_y^2)}$$

The angle of orientation of the edge giving rise to the spatial gradient is given by:

$$\theta = \arctan\left({}^{G_y}/_{G_x} \right) - \frac{3\pi}{4}.$$

3.3.4. LAPLACIAN OF GAUSSIAN DETECTOR (LoG OPERATOR)

It is also called zero crossing operator and Marr Hildreth edge detector. It is a gradient based operator which uses the Laplacian to take the second derivative of an image. The idea is that if there is a step difference in the intensity of the image, it will be represented by in the second derivative by a zero crossing.



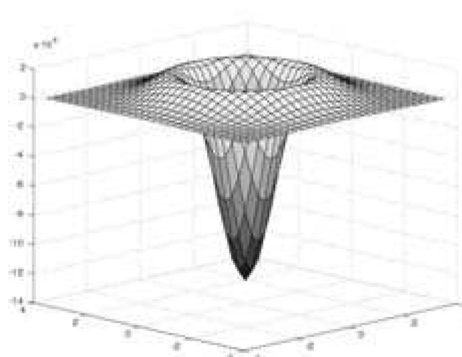
So the general algorithm for the Marr-Hildreth or LoG edge detector is as follows:

1. Smooth the image using a Gaussian. This smoothing reduces the amount of error found due to noise.

2. Apply a two dimensional Laplacian to the image:

$$r^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

This Laplacian will be rotation invariant and is often called the "Mexican Hat operator" because of its shape.



This operation is the equivalent of taking the second derivative of the image.

3. Loop through every pixel in the Laplacian of the smoothed image and look for sign changes. If there is a sign change and the slope across this sign change is greater than some threshold, mark this pixel as an edge[5].

3.3.5. CANNY EDGE DETECTOR

It is the optimal edge detector algorithm. Canny had a list of criterion for the improvement of edge detection. They are:

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1. Low error rate- no edge should be missed and non-edges shouldn’t have responses.
2. Edge points should be well localized.
3. There should be only one response for one edge.

Based on these criteria, the canny edge detector algorithm is given by:

The steps in the Canny edge detector are as follows:

1. Smooth the image with a two dimensional Gaussian.

2. Take the gradient of the image. This shows changes in intensity, which indicates the presence of edges. This actually gives two results, the gradient in the x direction and the gradient in the y direction.

$$|G| = |G_x| + |G_y|$$

3. The direction of the edge is computed using the gradient in the x and y directions.

$$\theta = \tan^{-1}\frac{G_y}{G_x}.$$

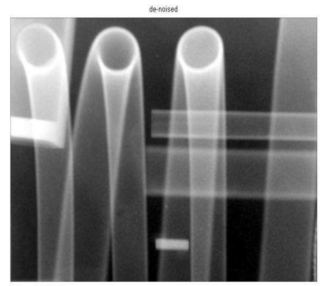
4. Once the edge direction is known, the next step is to relate the edge direction to a direction that can be traced in an image.

5. Non-maximal suppression. Edges will occur at points the where the gradient is at a maximum. Therefore, all points not at a maximum should be suppressed. Then for each pixel check if the magnitude of the gradient is greater at one pixel's distance away in either the positive or the negative direction perpendicular to the gradient. If the pixel is not greater than both, suppress it[5].

6. Edge Thresholding. The method of thresholding used by the Canny Edge Detector is referred to as "hysteresis". It makes use of both a high threshold and a low threshold. If a pixel has a value above the high threshold, it is set as an edge pixel. If a pixel has a value above the low threshold and is the neighbor of an edge pixel, it is set as an edge pixel as well. If a pixel has a value above the low threshold but is not the neighbor of an edge pixel, it is not set as an edge pixel. If a pixel has a value below the low threshold, it is never set as an edge pixel[5].

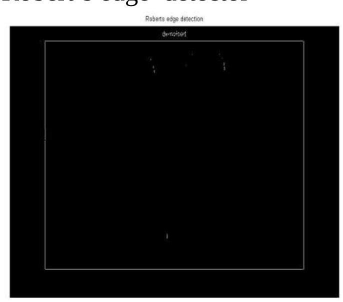
3.4. VISUALIZATION OF VARIOUS EDGE DETECTION ALGORITHMS

First edge detection is performed on the mean filtered image of window size [3 3].

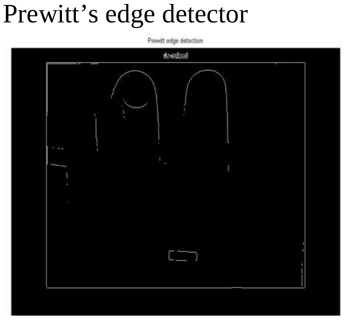


Let us apply the edge detection algorithms on the given image.

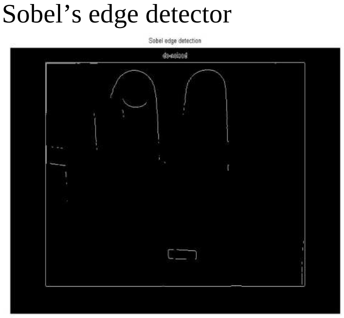
1. Robert’s edge detector



2. Prewitt’s edge detector



3. Sobel’s edge detector



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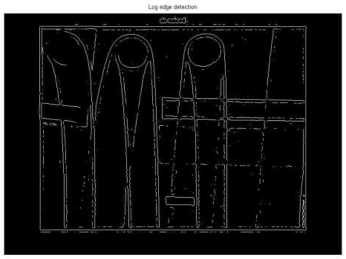
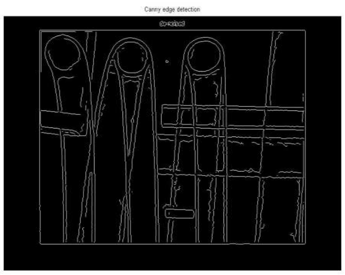
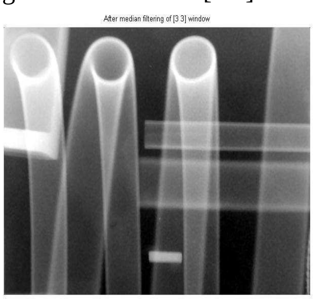
4. LoG edge detector



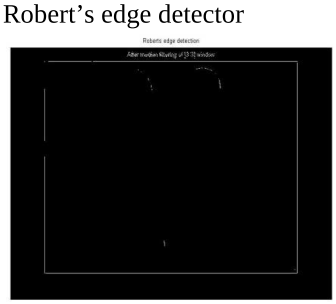
5. Canny edge detector



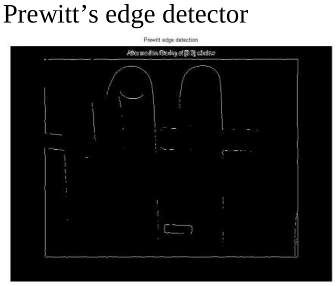
Now let us see edge detection for median filtered image of window size [3 3].



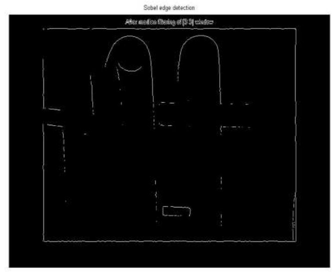
1. Robert's edge detector



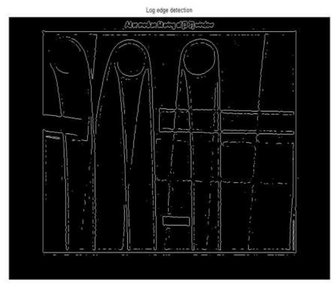
2. Prewitt's edge detector



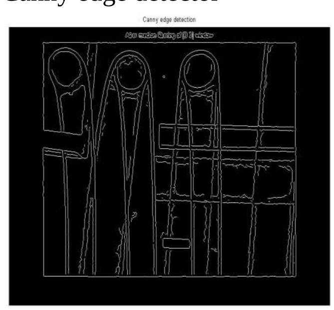
3. Sobel's edge detector



4. LoG edge detector



5. Canny edge detector



ANALYSIS:

From the above observation, the Robert's operator shows the edges where the pixel intensity is very high.

1. The Prewitt's operator works better than the Robert's since it can distinguish the intensities in a particular region and shows the edges having greater intensities.
2. Sobel operator works the same as the Prewitt's, but it uses Convolution masks rather than kernels.
3. LoG edge detector works well than the above three operators, since it can differentiate the step difference between the pixel intensities, hence the edges of different intensities are detected.

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4. Canny edge detector also works well, since it uses the threshold values to detect the edges, which give better description of the image.
5. Form the evaluation, LoG edge detector and Canny edge detector work well for both mean and median filtered radiographic images.

4. LIMITATIONS OF WORK AND FUTURE DIRECTIONS

The limitation of this paper stands to the radiographic image of the cold trap device, where the de-noising and edge detection techniques are applied. By using the output of the edge detected image the sodium impurities can be found as a future work using the different threshold values of the image, obtained from the segmentation process.

5. CONCLUSION

1. De-noising and edge detection are so essential for the processing of cold trap radiographic images.
2. From the analysis of de-noising techniques median filter works better than the mean filters.
3. In the edge detection techniques, Canny edge detector and LoG edge detector works well when compared to others.
4. As a whole of surveying de-noising and edge detection, 'Median filtering and Canny edge detection' and 'Median filtering and LoG edge detection' works better on radiographic images.

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