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A comparison Study of Image Edge Segmentation Methods using Prewitt, Sobel and Laplacian of Gaussian for Medical Images

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Abstract:
Image processing has an important and main role in several fields. It uses to understand and discover the image and its objects in efficiently and meaningful way. The understanding is a main step to extract information form image. The more realization has been established from different scientists in the field for image segmentation. The main segmentation purpose is to detect the edges information which available inside an image clearly. Edges are the important character for image and it has produced by summaries of the things. Mostly, Edge detection steps and its techniques have employed to evaluate and analysis of image characteristic. Many and several kinds of techniques for detecting the edges from any type of images. This paper has achieved the comprehensive analysis about the many edge detection techniques like Prewitt, Sobel and Laplacian of Gaussian. The comparisons are in terms PSNR (Peak signal to noise ratio), SNR (Signal to noise ratio) and Entropy. Finally, experimentally observed that Laplacian of Gaussian technique is working well and recorded better results than others techniques.

Keywords: *Image segmentation, Edge detection, Prewitt, Sobel, Laplacian of Gaussian, PSNR, SNR*

1. Introduction:

Digital image processing (DIP) is a technology and processes which have been achieved to increase image goodness and its recognition. This processes have used to improve the information and things that derives from the image [1]. Image consider a vital multimedia characters that has a necessary part as a method of visible information [2]. Image has features which are rich and several information and that not had in text way and based on its color has separated for gray and color scales. Image delivers extra features than information which offered in text figure [3].Image segmentation is a steps to simplify a digital image into segments or pixels that are easier to analyze and recognize the active edges in a difficult image. Familial image segmentation techniques that achieved a lot by the researchers are Edge Detection, Threshold, Histogram, Region based techniques, and Watershed Transformation. [4].

Hence, image segmentation of color images is completely unlike with gray scale images, e.g., content depended image recovery [5]. Any technique is strong and works fully is based on the kind of image. The image's pixel property with its information nearby to that pixel are two main factors for all techniques [6]. It showing as match of pixels in any region with gaps for edges in image. Edge depended segmentation is used to separate images based of their edges and using the threshold to insulate the background from an

image [7]. Neural network depended techniques work and help for convoying steps of segmentation by using learning techniques [8].

The image segmentation results are the major factors of additional studies and define the goodness for more image processing process [9]. Image segmentation techniques have a vital part in medical uses, i.e., diagnosis of diseases related to brain heart, knee, spine, pelvis, prostate and blood vessel, also pathology localization. Thus, it is still an important part for exploring in image processing uses. It is a significant key for researchers an inspiring mission and helps the developers to improve a common and more techniques in this filed [10].

The doctors using medical images in several and main uses such as anatomical structure study and treatment planning. A distinguishing of muscles with glands are consider from main medical images uses with its volume measurements. The medical imaging technology such as MRI, CT and US which consider the major product of medical images. In otherwise, it mostly complex in nature also noisy [11]. Medical images have a lot of noises such as salt and pepper noise, speckle and Gaussian noise echo disturbance etc. In, addition the noises must take off earlier the segmentation steps of the right results. The analysis step has achieved based on just Gaussian model [12].
The paper is organized as follows: In section 2, Image segmentation, in section 3, Edge Detection and its methods. Methodology will be showed in section 5 and finally, results and conclusion will be explained in section 5 and 6 respectively.

2. Edge Detection:

Edge detection techniques depend on segment shape, black, color of boundaries and based on discontinuities. It has an important part in image processing work and its applications [13]. It can be achieve edge detection techniques in several areas and scopes of industry, agriculture also image processing which use computational power for variety of applications. The main objective for edge detection is to indicate the changes and to recognize the physical existence that outputs them in image edges that have a many of information. Edge detection has to be suitable due to the strength, ability, and possibility of the achievement for sequent processing stage builds by these features [14].

The segment of the image into the background and object is an essential phase in the image interpretation. Edges are the boundary between different textures and it is the gaps which available in the image intensity for each pixels. Image edge detection using in many fields for data compression, data segmentation, and image recognition [15]. Edge detection is not easy for images which consider a noisy because of each of noise also edge include frequency with high contents.

The efforts for decreasing the noise outputs produces the image noisier and output for deformed image [16]. Filters are archived in the method for recognizing the images by forming and determining the gaps that takes the changes to pixel intensity are the border of an image. It must require a good edges for better level processing with precise and rapid edge detector will increasing the efficiency of whole processing system [17]. Several techniques for edge detection which existing and each one created beside a specific kind of sittings to identify information of edges. These techniques have an important role in many fields and studies. The most important and famous techniques are Roberts, Prewitt, Sobel, Laplacian of Gaussian and Canny.

A lot of studies were achieved depending on edge detection techniques to resolve several identification difficulties for images and exactly the Sobel technique have used to detect various characteristics for image. In addition, Prewitt with Roberts's edge detection have evaluated and calculated next compared with the Sobel technique [18]. Depended on the comparative evaluation which showed that the Sobel

techniques have batter results and less time when compared with other techniques. In addition, presenting an edge detection technique with a developed Sobel quantity technique and an importance on non-

maximum and dual threshold techniques to determine the new developed quantity technique. So a result, the proposed technique has achieved an important increase in edge information with circuit difficulty [19].

The following studying proposes an edge detection design using the Sobel filter on the Field Programmable Gate Array (FPGA) board. The Sobel technique has prepared using the Verilog lipoprotein utilization [20]. The suggested design descried the difficulty of power and has reduced retard and area when compared with another three designs which achieved by this study. The Sobel technique was selection since it have produced a rational scope of the parallel of the used programs. The results depending on tables have showed the Sobel technique produced improved and good results when compared with other techniques also generated many batter and clearly values [21].

2.1 Sobel Edge Detection:

Edge detection is a technique which finds the image edge essential in computing the estimate absolute gradient magnitude in each point for input image in its gray-scale. The matter for calculating appropriate absolute gradient magnitude for edges lines in the applied attitude [22]. The Sobel performs a two-dimensional spatial gradient measure on images. Also, it moves a two dimensional pixel array to statistically uncorrelated dataset to remove frequent data. The data amount must be reduced for explaining and identifing a digital image. This edge detector uses a pair of 3×3 involution masks, one to estimate gradients in the x-orientation and the additional one to guesses gradients in the y–orientation. Sobel detector consider a high sensitivity to noise which available in images and it effectively determines them as edges [23]. Thus, it is suggested within vast data connections which are detected in data transmitting. The figure 1 below shows Sobel masks [9]:

-1	-2	-1
0	0	0
1	2	1

G_x

-1	0	1
-2	0	2
-1	0	1

G_y

Figure 1: Sobel Operator

Each one of those masks is convolved with the image. At every pixel locations there are a couple of number: S1, S2 match to the output form a mask of row and column thereafter. These numbers are used of computing 2 matrices, the edge size and path.

Edge size = $\sqrt{S_1{}^2 + S_2{}^2}$ ..... (1)

Edge Path = $\tan^{-1}[\frac{S_1}{S_2}]$ ..... (2)

Equation 1 with Equation 2 above applying the Sobel two matrices

0	**-1**	**0**
-1	**4**	**-1**
0	**-1**	**0**

2.2 Prewitt Edge Detection

Several factor have been used for producing edge identification. Prewitt operator consider fully like with Sobel operator and the variance of the C value is 1. The involution mask has 1, -1, with 0 that is explain below in Figure 2. The major advantages for this technique is to supply an improved performance on horizontal with vertical edges in the images. Also, a second advantages for this is support advanced responses of noisy images [24]. This technique's mask must contain an opposite signs and operator should have the following properties:

1. Mask's sum must to be similar for zero.
2. Several edges detection because extra weight. The following Figure 2 has defined a masks.

1	1	1
0	0	0
-1	-1	-1

G_x

-1	0	1
-1	0	1
-1	0	1

G_y

Figure 2: Prewitt Operator

Any one of masks is involutedly by the image. Every pixel position have exist two numbers that were presented as P1, P2 which match for the results by row and column for masks respectively. The results were used to define two measurements which are the edge scale with alignment which shown below respectively equations (3) with (4) [25]:

Edge Scale = $\sqrt{P1^2 + P2^2}$ …….. (3)

Edge Alignment = $\tan -1 = \frac{P1}{P2}$ …… (4)

2.3 Laplacian of Gaussian:

This LOG operator smoothest the image with the Gaussian-shaped kernel through involution, followed by the Laplacian operator [13]. Gaussian edge-preserving mask Laplacian is [26]:

L2

-1	**-1**	**-1**

L1

-1	8	-1
-1	-1	-1

1	-2	1
-2	4	-2
1	-2	1

L3

Figure 3: Laplacian of Gaussian

Laplacian is a derived operator that is applied to detect edges which available inside image. There are several basic difference among Laplacian operators and other techniques operators such as Prewitt, Sobel, Robinson and Kirsch. The main differences are all these techniques have a first request derived masks. In other hand, Laplacian consider a second request derived mask. This mask has two more categories one is positive and other is negative Laplacian operator. It can't bring outer edges in every specific track and that is a second difference between Laplacian and rest operators. It bring outer edges from image for two main classification which are respectively inner and outer edges.

4. Methodology:

This paper have used 15 datasets of medical images by an image measure of almost 200x300 pixels have captured by digital camera from hospital. First of all Sobel, Prewitt and Laplacian of Gaussian techniques have applied to 15 medical images and by using MTALAB software to find for the results. Secondly, the value of PSNR, SNR and entropy are calculated among every input image and the resultant edge detected image. Finally, Sobel, Prewitt, and Laplacian of Gaussian techniques were compared to find a superior edge detection technique. Figure 4 below shows a samples on input images as datasets.

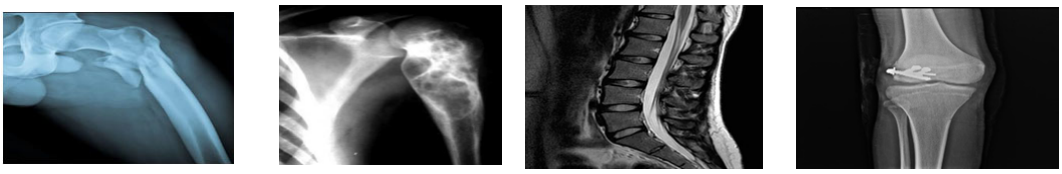

Figure 4: *Samples of dataset*

Therefore, Figure 5 has showed data collection step as a first step which achieved in paper. The medical images dataset have been divided for 15 images as dataset. The next step is executing the Prewitt, Sobel then Laplacian of Gaussian techniques for detection by MTALAB 2019a application. Finally, evaluating the results for indemnifying item's edges for all images by collect PSNR, SNR and Entropy for results. The ratio between the power for corrupting noise and the best likely power for a signal which effects the validity of its illustration is PSNR. In addition, PSNR mentions the ratio between the edges discovered images i.e. the expected output and the ground truth image that too supposed to be expected and possible image.

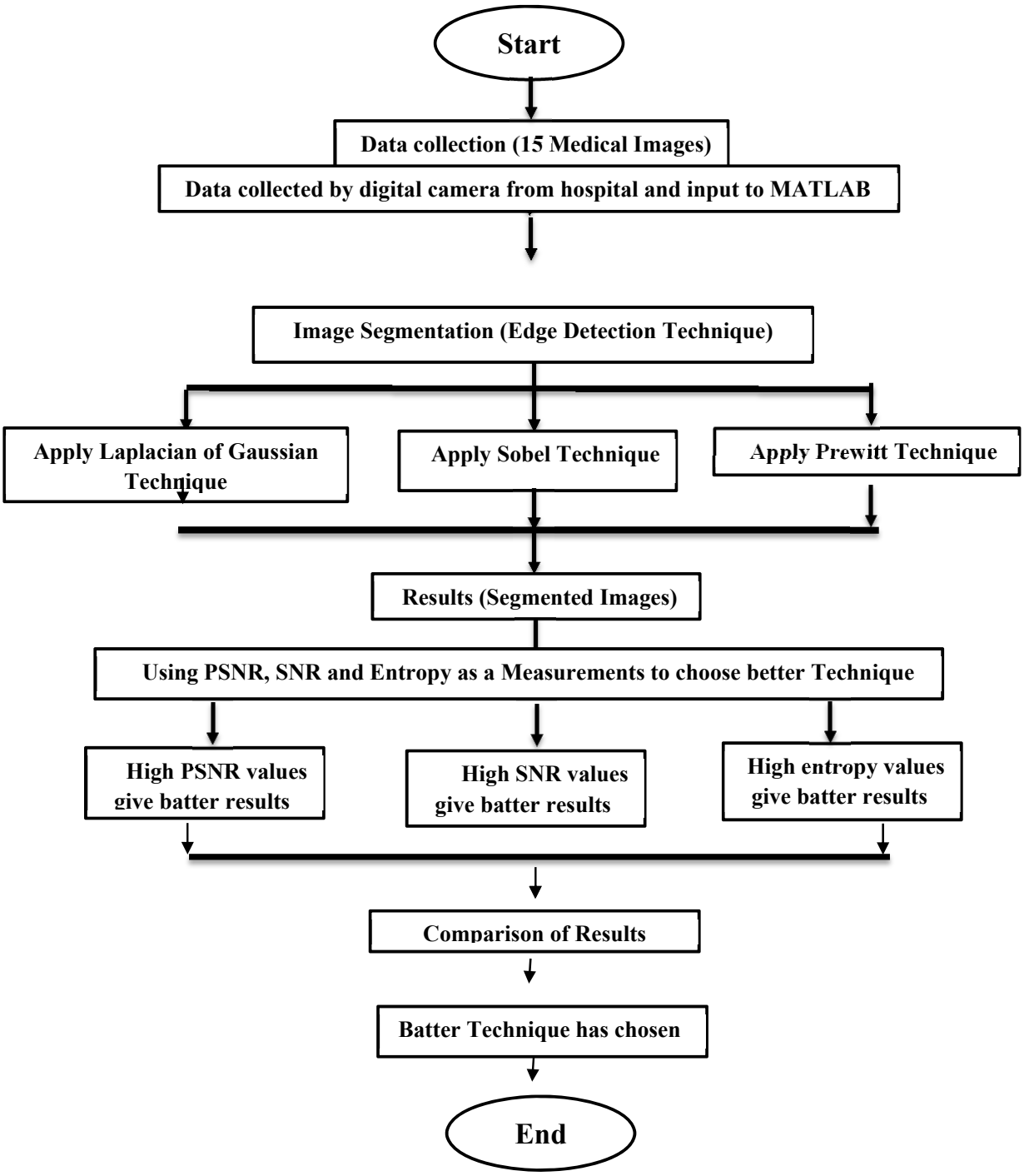

Figure 5*:* Paper Methodology

5. Results:

In this section, three different edge detection techniques Sobel, Prewitt and Laplacian of were compared for this experiment for medical images. Performance of three techniques is computed by determining different fidelity parameters like PNSR, SNR and Entropy given by table (1), table (2) and table (3) respectively. For making this comparison, techniques are achieved with MATLAB R2014a.The

comparison is done by computing PSNR, SNR and entropy measurements of each technique and medical images which have been taken for analysis. The high values of three measurements indicate that the segmented images have a good quality in objects detection. The numeric results shown in table 1 to table 3 are the outcomes from the MATLAB program which is achieved for all images. The Laplacian of Gaussian can bring its efficiency with high rate in PSNR. Prewitt technique provides least range of PSNR for the all 15 images. At the same time, Laplacian of Gaussian recorded highest values of SNR and Entropy when compared with Sobel and Prewitt techniques values on all medical images.

Table 1: PSNR Values of Techniques

Image	Prewitt	Sobel	Laplacian of Gaussian
1	20.0487	20.0374	20.0515
2	19.9853	20.0192	20.0985
3	20.057	20.072	20.0898
4	20.1024	20.0153	20.1221
5	20.0157	19.9703	20.0817
6	20.0164	20.0235	20.0599
7	20.0467	20.1004	20.2271
8	20.0343	20.0256	20.0473
9	19.9842	20.0101	20.072
10	19.9963	20.0286	20.0297
11	20.0137	20.0204	20.119
12	20.0046	20.1568	20.2575
13	20.2215	19.9962	20.3725
14	20.0175	20.0791	20.0982
15	20.0250	20.0340	20.0910

Table 2: SNR Values of Techniques

Image	Prewitt	Sobel	Laplacian of Gaussian
1	16.1434	16.1635	16.265
2	16.091	16.2041	16.4927
3	16.4661	16.6358	16.7256
4	16.3189	16.3035	16.4687
5	16.1661	16.1719	16.2761
6	16.196	16.2417	16.5065
7	16.3339	16.4974	17.0492
8	16.6732	16.813	17.2026
9	16.3234	16.4526	16.6277
10	16.1957	16.2954	16.566
11	16.2837	16.3581	16.557
12	16.2973	16.5553	16.7997
13	16.4322	16.3385	16.6215
14	16.289	16.4826	17.0601
15	16.2432	16.2769	16.4914

Table 3: Entropy Values of Techniques

Image	Prewitt	Sobel	Laplacian of Gaussian
1	1.4084	1.4699	2.2448
2	1.4476	1.574	2.1274
3	1.8308	1.9099	2.1261
4	1.5449	1.6188	1.8949
5	1.486	1.5382	1.9033
6	1.4552	1.5078	1.9084
7	1.7049	1.8139	2.2003
8	2.0431	2.1178	2.1464
9	1.7021	1.7608	1.8413

10	1.5229	1.5748	1.6942
11	1.6292	1.6872	1.8045
12	1.6474	1.7307	2.2613
13	1.9505	1.7604	2.1749
14	1.6943	1.8088	2.2408
15	1.5462	1.5799	1.6218

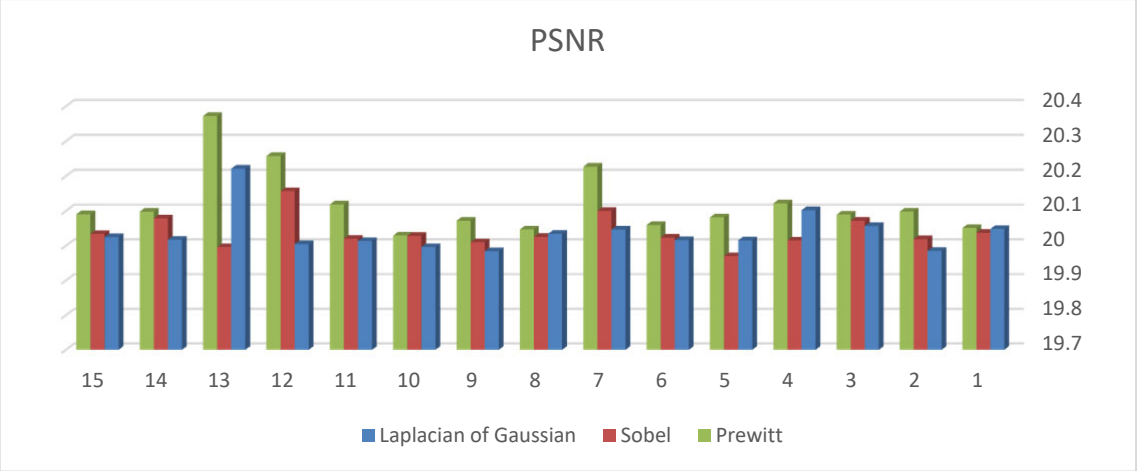

Figure 6: PSNR Values

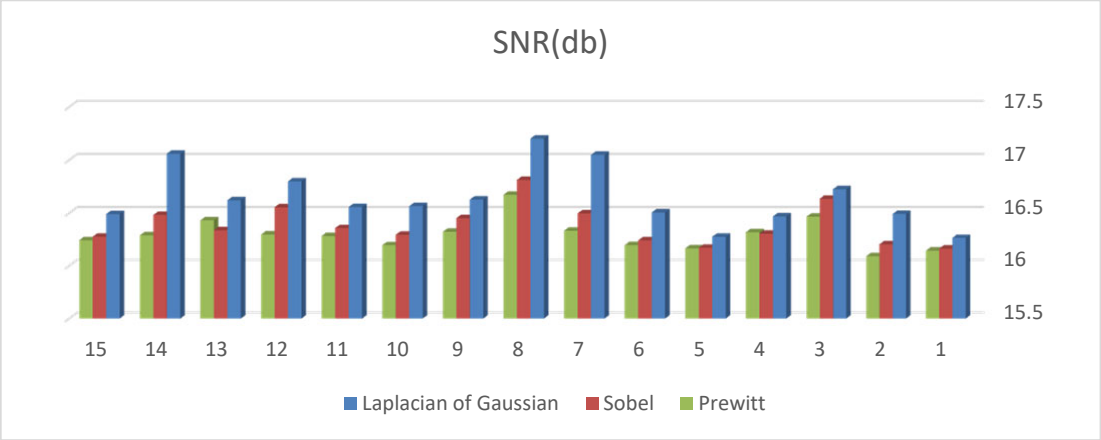

Figure 7: SNR Values

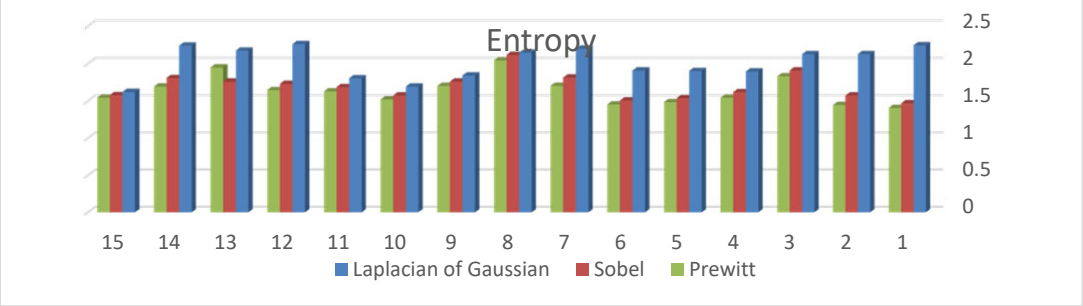

Figure 8*:* Entropy Values

Therefore, the graphs above show a comparison of PSNR, SNR and entropy of the three different techniques for 15 different medical images. As can be observed from the graphs the Laplacian of Gaussian technique show better values for three parameters as compared to Prewitt and Sobel. As shown in figure (6), the higher PSNR values ensure that the segmented images by Laplacian of Gaussian means the images have batter quality when compared to the other techniques. In addition, the figure (7) and figure (8) show that SNR and entropy values have recorded a higher values for Laplacian of Gaussian than other techniques. Under this experimental analysis, the operator by Laplacian of Gaussian technique has worked out well in all aspects. Figure 9 below shows results for three edge detection techniques of same medical image in dataset.

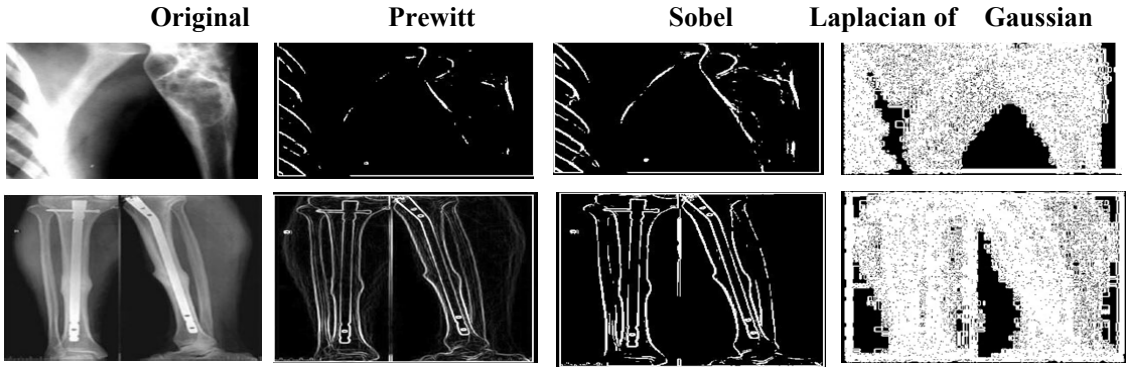

Figure 9*:* Results Samples

6. Conclusion:

To compare diverse edge detection techniques for the effective performance results that used for medical images. This paper compares and evaluate the performance for various edge detection techniques of last digital image segmentation such as Laplacian of Gaussian Prewitt, Sobel edge detection techniques. In the experiment results, it can be shown clearly a Laplacian of Gaussian technique was produced best and appropriate results when compared to other techniques. It has showed a high result of PSNR, SNR and Entropy than Prewitt, Sobel edge detection techniques which helps to identify and determine the effective edges. This paper will support the scholars in the image segmentation's field and its uses in all live scopes.

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