Comparison between Median, Unsharp and Wiener filter and its effect on ultrasound stomach tissue image segmentation for Pyloric Stenosis

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Abstract

Ultrasound is widely used in medical applications. However, the problem in ultrasound image is it contains many speckles, and this make a sonographer hard to interpret the ultrasound image. The idea to solve this problem is by make the pre-processing image before proceed with further image processing techniques. The filter is used to remove the speckles so that the area of the region needed is clearer. After that, the segmentation also can help sonographer to analyze the qualitative and quantitative of ultrasound images. Three types of filter are being use to compare the effect of the filters and choosing the best one to enhance the ultrasound images. Such filters are median filter, wiener filter and unsharp filter. Then, the morphological and segmentation process will enhance the shape of the region of interest. From the final images, the qualitative and quantitative dimensions are measured and presented.

Keywords: Median filter, wiener filter, unsharp filter, pyloric stenosis, ultrasound

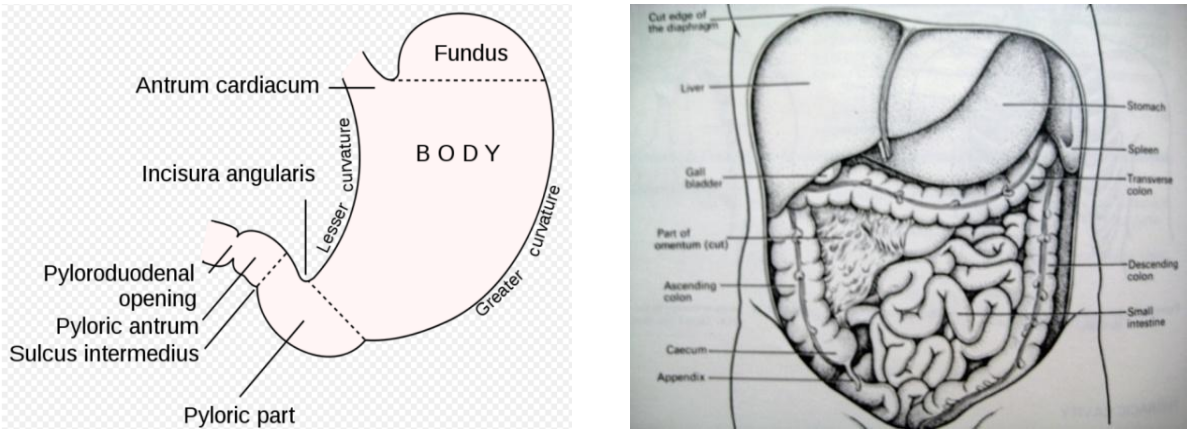
1. INTRODUCTION

Stomach is a place where work as temporarily reservoir food before the food being digestive by enzyme. Stomach also a place for protein to be digesting. The function of stomach muscular is to mix the food. Some of the suitable acidity and liquefaction at the pyloric end will give the pyloric antrum forces small jets of gastric contents through the pyloric sphincter into the duodenum. The shape of stomach is J-shaped. It contain cardio-esophageal junction and has two orifices. Those orifices are cardiac orifice, at the opening to esophagus and pyloric orifice, at the opening to duodenum. Stomach also has two curvatures which are lesser curvature and greater curvature. Before scanning using the ultrasound, the position of stomach need to identified. Physiologically the stomach is placed at left hypochondriac area. The position of the stomach can be simplified as in Table 1.

Table 1 : The position of stomach

Position of stomach	Organ
Interiorly	Left lobe of liver and anterior abdominal wall
Posterior	Abdominal aorta, pancreas, spleen, left kidney and adrenal gland
Superiorly	Diaphragm, esophagus and left lobe of liver
Inferiorly	Transverse colon and small intestine
To the left	Diaphragm and spleen
To the right	Liver and abdomen

Pyloric stenosis, also known as infantile hypertrophic pyloric stenosis (IHPS), is the most common cause of intestinal obstruction in infancy. IHPS occurs secondary to hypertrophy and hyperplasia of the muscular layers of the pylorus, causing a functional gastric outlet obstruction because of a narrowing of the pylorus, the opening from the stomach into the small intestine [1].



(a) (b)

Figure 1: (a) Stomach with anatomical landmarks including the pylorus and (b) Location of stomach from front

Normally, food passes easily from the stomach into the duodenum (the first part of the small intestine) through a valve called the pylorus. In pyloric stenosis, the muscles of the pylorus are thickened. This thickening prevents the stomach from emptying into the small intestine. The cause of the thickening is unknown and it can be from genetic factors. Children of parents who had pyloric stenosis are more likely to have this problem. Pyloric stenosis occurs more often in boys than in girls, and is rare in children older than 6 months. The condition is usually diagnosed by the time a child is 6 months old. Figure 2 shows the hypertrophic pyloric stenosis [1].

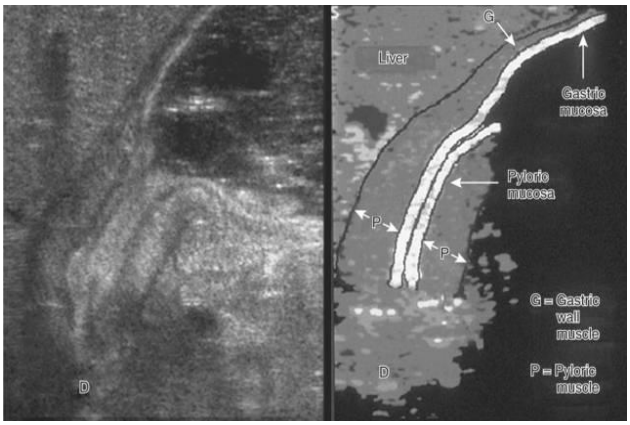
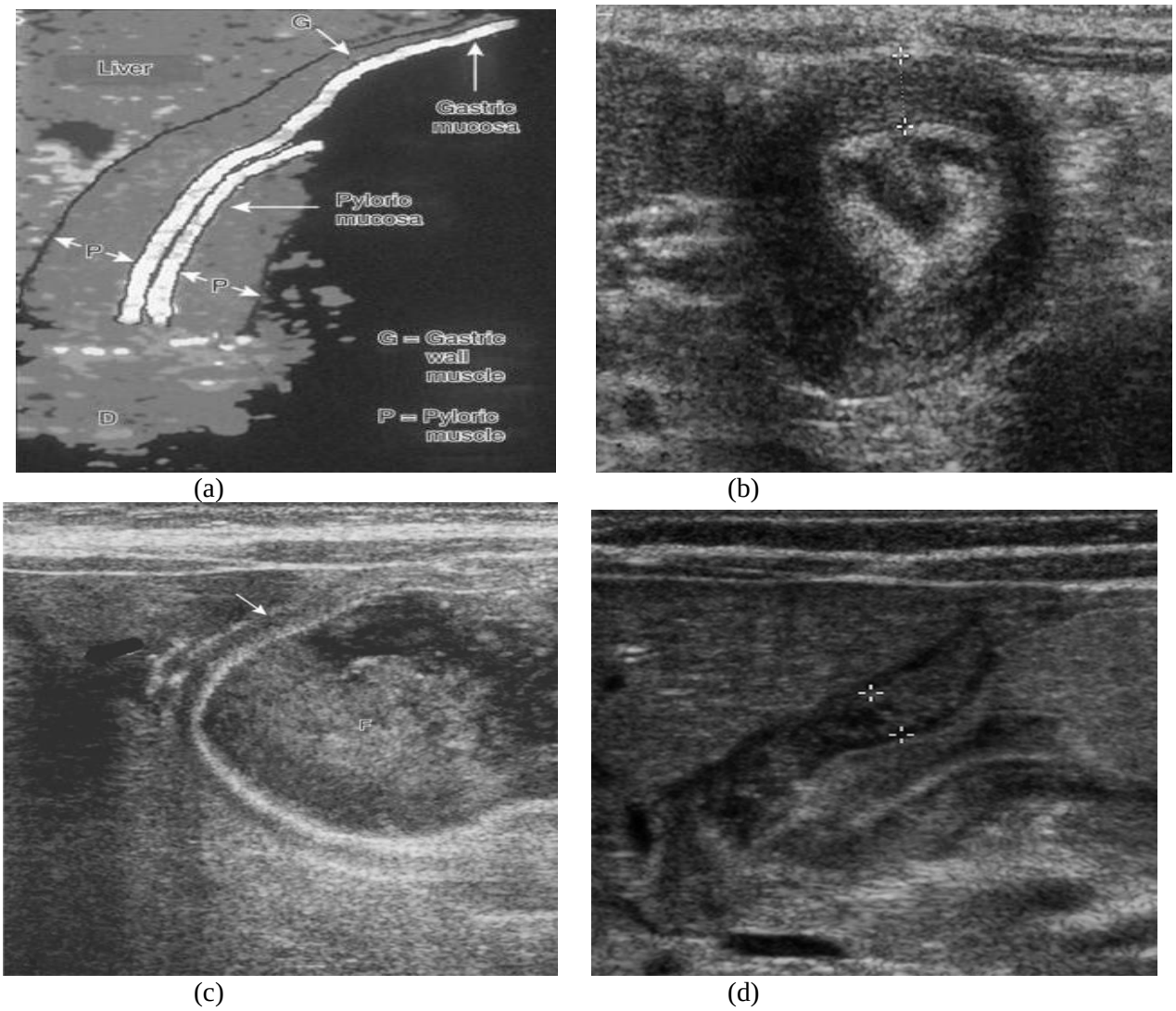


Figure 2**:** Hypertrophic pyloric stenosis. Ultrasonogram (left) and labeled ultrasound image (right) in a patient with HPS. The stomach was filled with retained fluid. The normal gastric wall (G) thickness was 2 mm or less. The pyloric muscle (P) thickening is well seen adjacent to the thickened mucosa. Note the difference in mucosal thickness from normal stomach in the antrum in comparison with the pylorus. D, duodenal cap. *(Courtesy of Omar Lababede, MD, Cleveland, Ohio)* The problem in medical images is there are many speckle and hard for a tomographer to interpret the image of ultrasound. The best way to solve the problem is by filtering and segmenting the images of ultrasound [4,5,8]. Image processing is used in a wide variety of applications such as image recovery applications, image enhancements and medical imaging applications. Image enhancement operations improve the qualities of an image. They can be used to improve an image's contrast and brightness characteristics, reduce its noise contents, or sharpen it details. Filtering is also useful for improving the visual appearance [2].There are several reasons for performing filtering. It may reduce the level of noise, help a segmentation algorithm extract finer details more robustly. It is empirically known that a certain filter works excellently for a certain type of original image or degradation while it may not be suitable for other images. It means there is no universally optimal filter. Therefore, the choice of the right filter is important as it will determine the final result of the images [3].

2. METHODS AND MATERIALS

Figure 3(a) to (d) are some ultrasound images of normal and abnormal condition in pylorus. It can be seen that from the figures, it is hard to interpret the ultrasound image because it contains many speckles.



(a) (b)

(c) (d)

Figure 3: (a)The normal gastric wall (G) thickness was 2 mm or less, (b) "Doughnut" signs of hypertrophic pyloric stenosis in an infant, (c) Sagittal ultrasound image through the pylorus reveals a thickened and elongated pylorus (asterisks) and (d) Hypertrophic pyloric stenosis (HPS).

Therefore, a special technique is proposed to analyze the ultrasound image. In this paper, three types of filters were used to see the differences effect between them. The process start with filtering the ultrasound image using different filters such as median, wiener and unsharp.

After filtering process, the images undergo the threshold using Otsu method [12]. From thresholding process, the picture was reprocessing using morphological technique and the final process was segmenting the images. The flowchart in Figure 4 summarized the methodology used in this work.

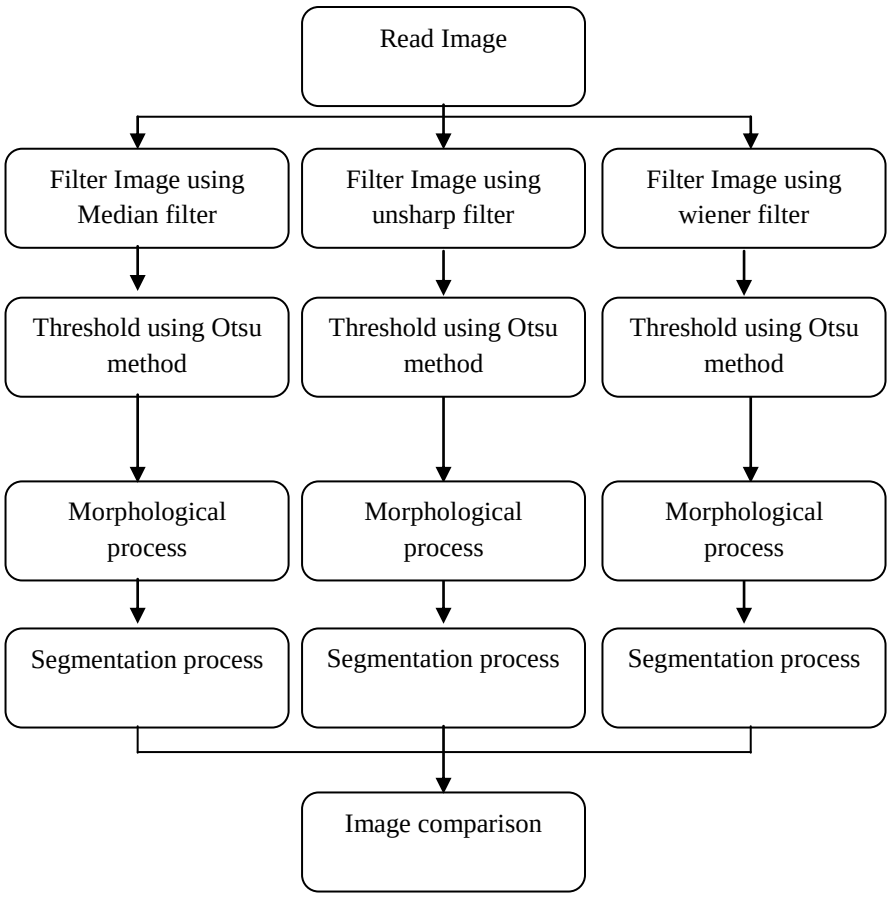


Figure 4: The methodology involved in image processing of ultrasound image used in this work.

2.1 Median filter

Median filter is a spatial filtering operation, so it uses a 2-D mask that is applied to each pixel in the input image. It is used to remove defects and noise from pictures. Median filter is much less sensitive than the mean to extreme values (called outliers), therefore it is better without reducing the sharpness of the image and edge preserving nature [4]. The algorithm for median filter is every pixel from the picture to be filtered is replaced by the median value of the neighbouring pixels [5]. The picture is thus transformed by the median filter by another picture that has exactly the same size. For every pixel P of the input picture we first create a list of the 9 (3x3) pixels surrounding P. The 9 pixels are then sorted. The median value is the value located at the centre of the sorted list. Figure 5 shows an example of median filter application.

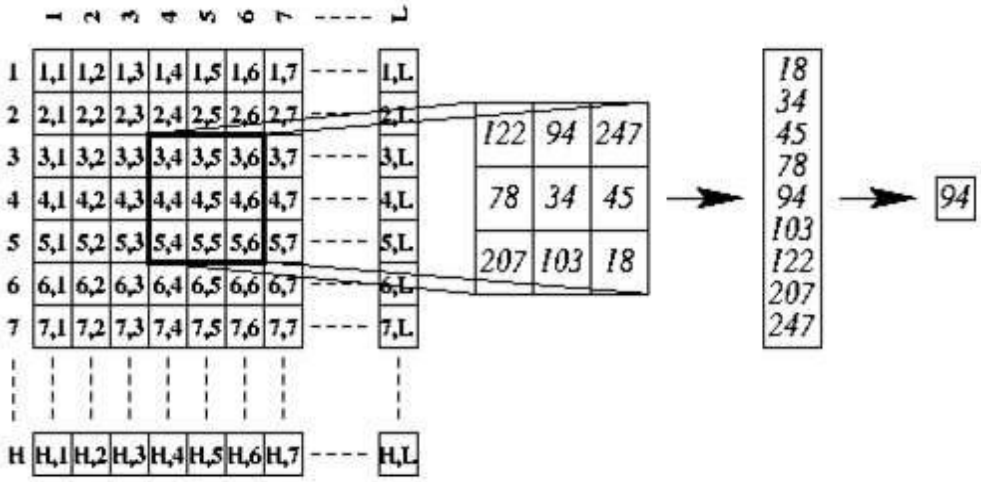


Figure 5: An example of median filters application. In this case, habitually a 3x3 median filter is used.

2.2 Unsharp filter

The classical unsharp masking is the method that using nonlinear Filter. The unsharp masking method operates by adding a fraction of the highpass filtrated version of the input image to the original one (see Fig. 1). This operator is sensitive to noise due to the presence of the linear highpass filter which cannot discriminate signal from noise. Moreover it perceptually enhances image more in dark areas than in lighter ones. Various schemes have therefore been proposed in order to improve the performances of the unsharp mask [9]. Figure 6 is the working process of unsharp filter.

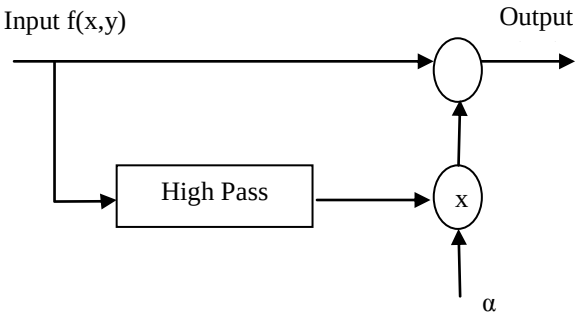


Figure 6: Working process of unsharp filter

2.3 Wiener filter

Powerful linear techniques, such as Wiener filtering, are meaningful only when additive noise is present [6,7]. Wiener uses a pixelwise adaptive Wiener technique based on statistics approximate from a local neighbourhood of every pixel. In this paper, we will propose a comparison between three filers, median, unsharp and wiener technique. The best method is capable of solving the noise problem in ultrasound image by show good image towards effects to ultrasound stomach tissue image segmentation for pyloric stenosis. This proposed method will help pathologists identify the characteristic of pyloric stenosis. For this reason, the paper is separately as follows. First, as mention in introduction, the brief review about medical image is guided and summary about filters technique. Second is methodology of doing the tasks. Third, the three example tests based on these techniques are tried. Meanwhile, we also made the comparisons with median filter, wiener filter, and unsharp filter. Finally, some conclusions are made and discussed.

2.4 Morphological

Morphological process is a process which deals with the shape of features in an image. Usually this method is use to eliminate imperfections occurred during segmentation. Dilation and erosion are the basic morphological operation. Basically dilation will expand the size of the structure and erosion will shrinks the size of the structure. The expanding and shrinking of the structure is depending on the size and shape of the structuring element used. There are many types of structuring element in morphological process. Such structuring elements are diamond, disk, line, octagon, pair, rectangle, square and many more. In Matlab code [12], these structuring elements can be written as:

SE = strel(shape, parameters) (1.1)

2.5 Edge enhancement

Generally the purpose of edge detection is to detect discontinuities in gray level. The edge represents the local change of intensity in an image. It occurs on the boundary between two different regions in an image. An ideal edge will give sharp transition in gray level. Basically, the principle of edge detection is the image will be convolved with the edge operator. The value from the convolution process will then replacing the centre of pixel value [11]

There are many types of edge detection. This paper use Laplace method to segment the image. The operator of Laplace is shown in Figure 7.

-1	-1	-1
-1	8	-1
-1	-1	-1

Figure 7: Laplace operator will convolve with the input image to enhance the edge of the image.

3. RESULT AND DISCUSSION

A comparison of the results in Figure 8, Figure 9 and Figure 10 show that the images were blurred after applying the Median and Wiener filtering techniques. The blurring in Median filtering reduces the speckle noise while keeping the image edges. However, the resulting blurring in wiener filtering is different from Median filtering. In the median filtering, the speckle noise reduced but the image edges were maintained. By using Wiener filtering, the speckle is reduced but the image edges are intact. Also, the images are sharper compared with Median filtering. Although speckle is reduced well and structures are enhanced using Wiener filter, however, some details are lost and some are over-enhanced.

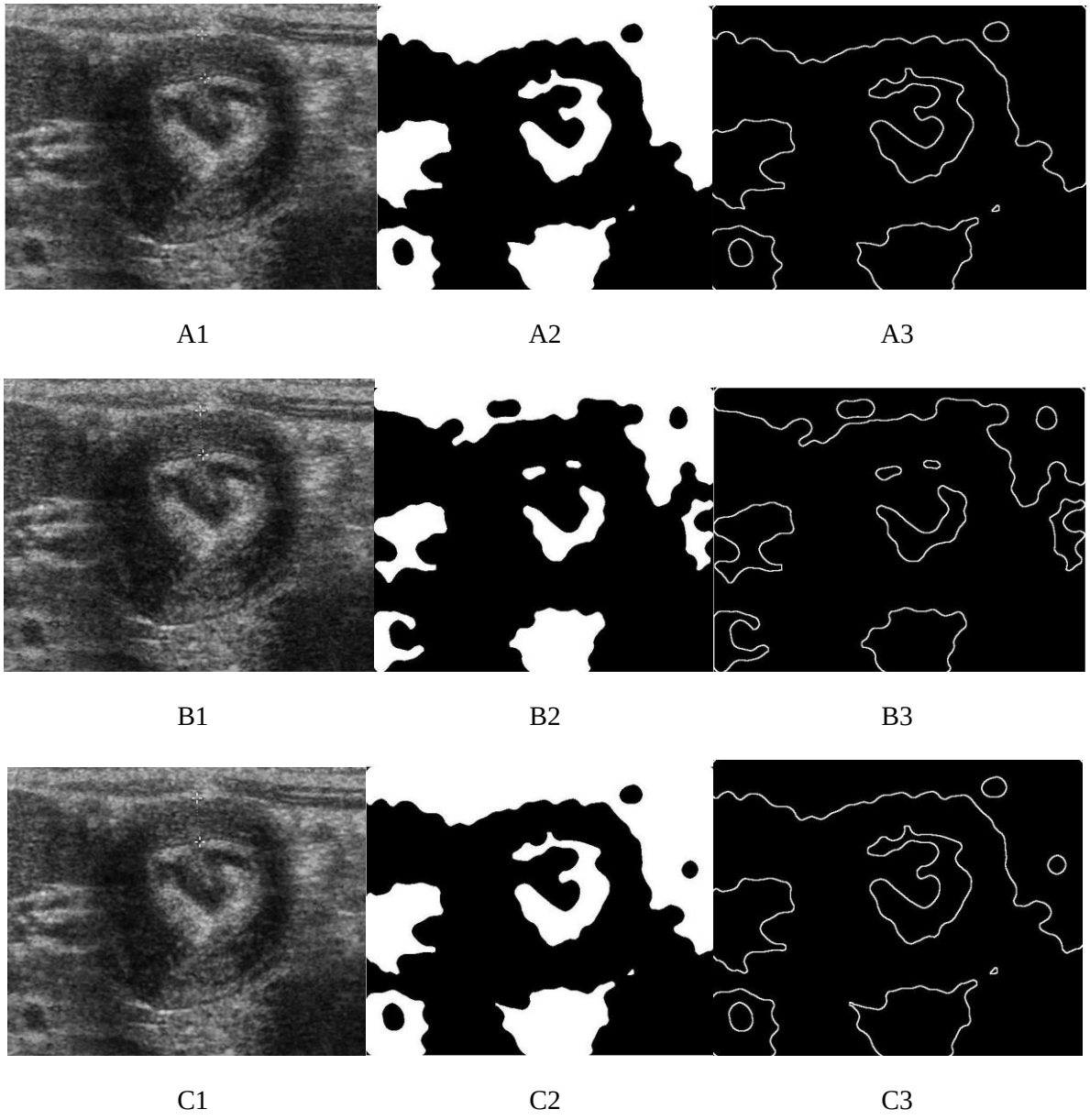


Figure 8: A1, A2, A3 – Effect of using median filter, morphological process, and edge enhancement of the Figure 3(b). B1, B2, B3 – Effect of using unsharp filter, morphological process, and edge enhancement of the Figure 3(b). C1, C2, C3 – Effect of using Wiener filter, morphological process, and edge enhancement of the Figure 3(b).

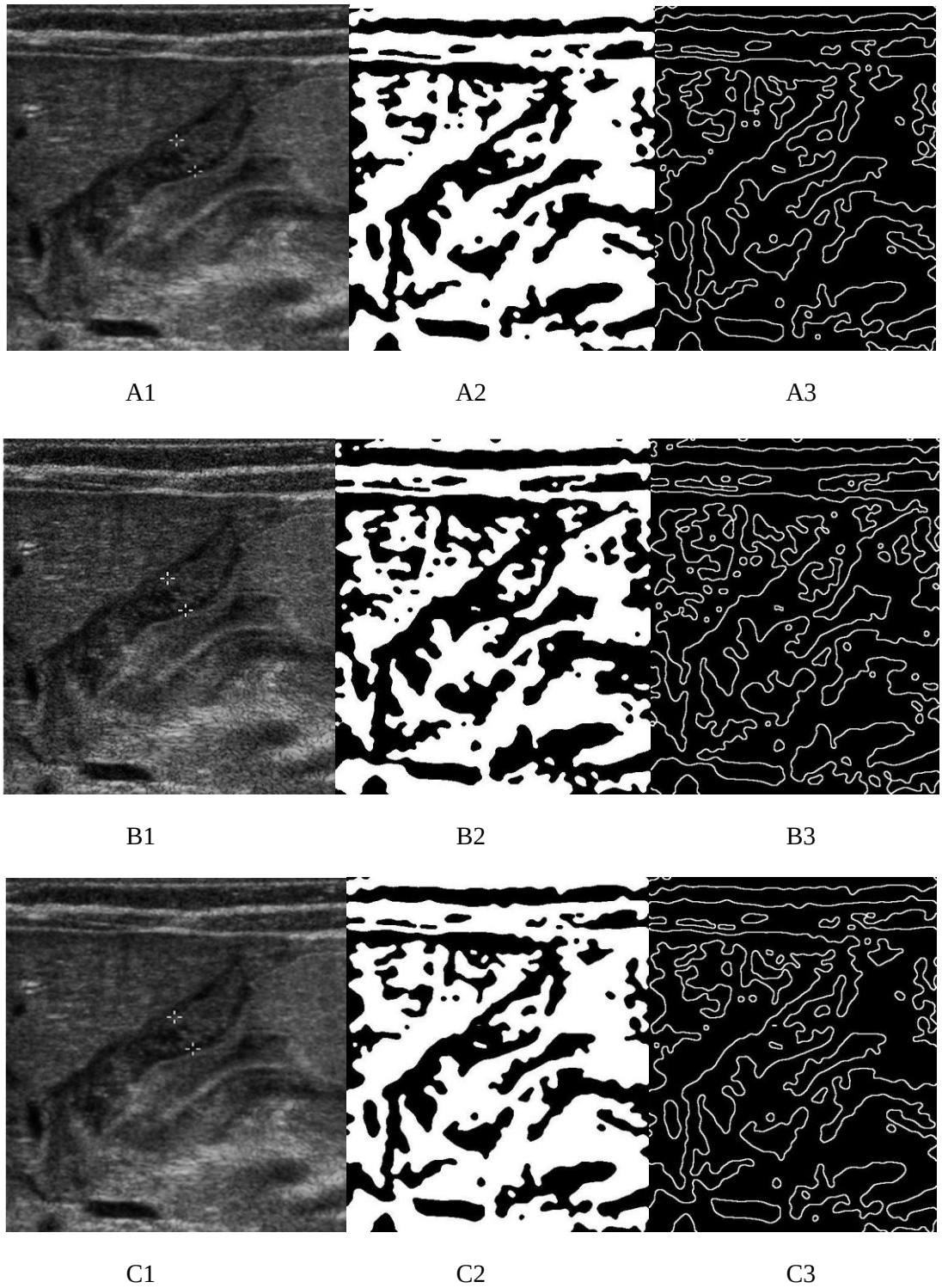
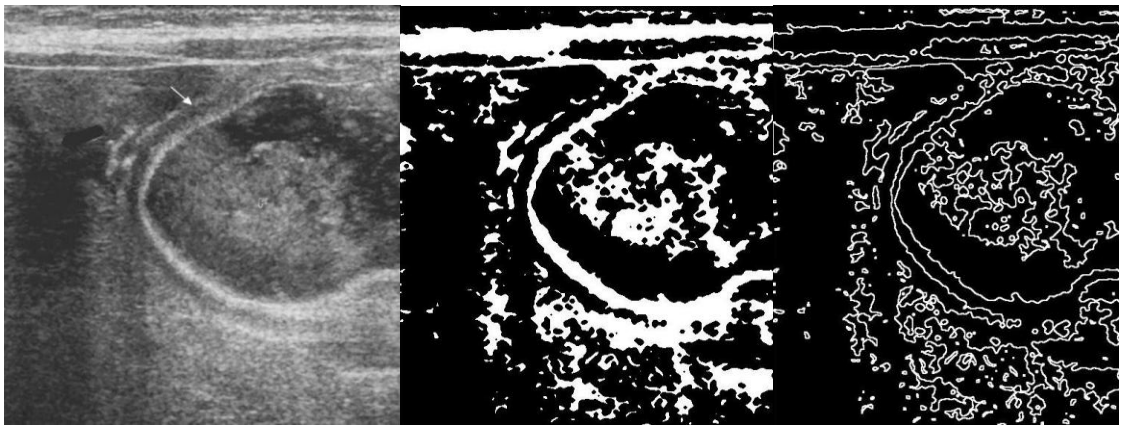
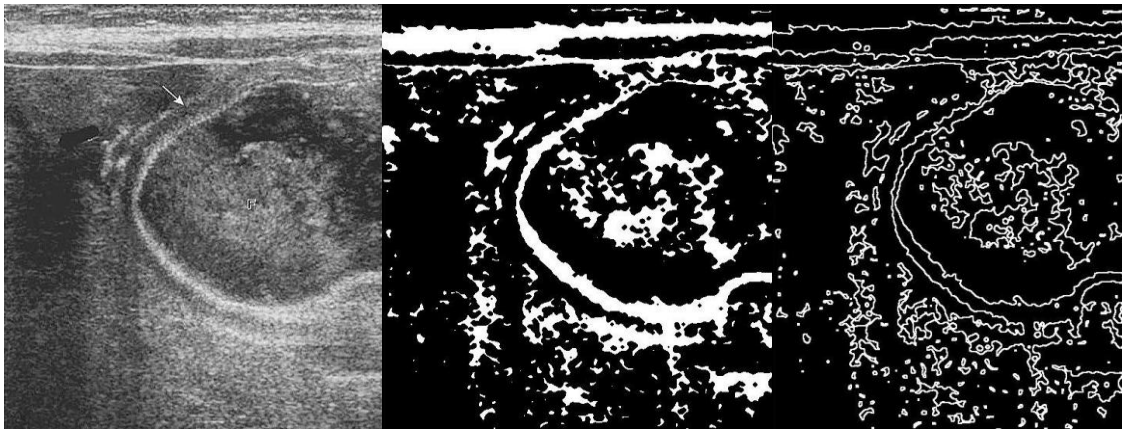


Figure 9: A1, A2, A3 – Effect of using median filter, morphological process, and edge enhancement of the Figure 3(d). B1, B2, B3 – Effect of using unsharp filter, morphological process, and edge enhancement of the Figure 3(d). C1, C2, C3 – Effect of using Wiener filter, morphological process, and edge enhancement of the Figure 3(d).



A1 A2 A3



B1 B2 B3

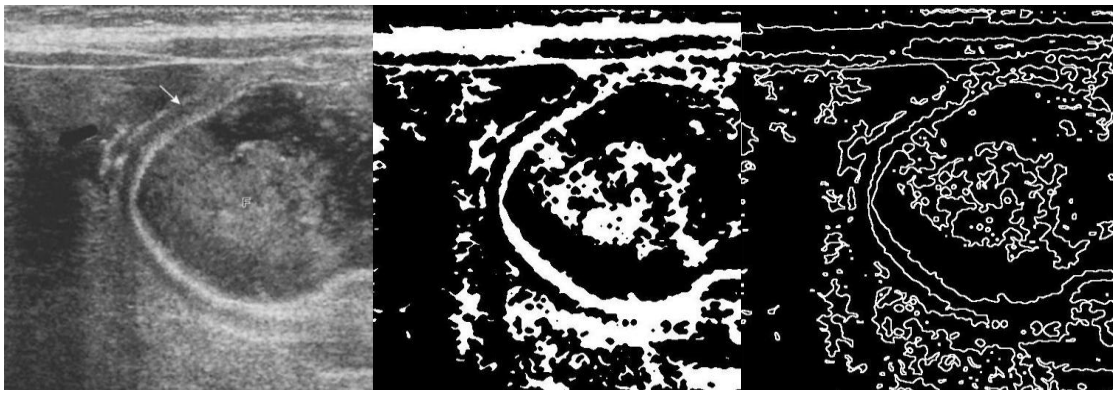


Figure 10: A1, A2, A3 – Effect of using median filter, morphological process, and edge enhancement of the Figure 3(c). B1, B2, B3 – Effect of using unsharp filter, morphological process, and edge enhancement of the Figure 3(c). C1, C2, C3 – Effect of using wiener filter, morphological process, and edge enhancement of the Figure 3(c).

3.1 Discussion

Median filtering was able to increase the intensity value at a certain point in the image. Wiener filtering was able to the increase the value of pixels and the intensity values. This result makes the images sharper. However, the unsharp filter is different. It increases the contrast of the image. If the noise can be distinguished from the blurred image in frequency space, then Fourier methods such as the Wiener filter are very effective.

Unfortunately this is rarely the case for tomograms, where the sources of blur are diverse [7]. The unsharp mask is one of the most popular tools for ultrasound image. It consists of three operations. First is it blurs the original image with a smoothing kernel, then calculate the mask by subtracting the blurred image from the original and finally add the mask, multiplied by a strength factor, to the original. The unsharp mask lacks in theoretical foundation but proven itself in practice to be highly effective at sharpening edges without overly exaggerating the noise [10]. As compared to Fourier methods such wiener, the unsharp mask has one special advantage. It does not preferentially amplify the highest frequency components, and therefore tends to be less noise-sensitive. So the image is sharper when using unsharp technique compare to other filtering techniques.

After filtering the images, the next step is the segmentation process. The segmentation consists of three processes which are converting the images into binary images, apply the morphological technique and edge enhancement. The images were converted into binary images using Otsu method and followed by morphological process, dilation and erosion. Finally, the edge detection was applied to the images using Laplace method. The segmentation process was applied to help the tomographer analyze the qualitative and quantitative images easily without speckles [8]. From the final images, we can see that there is a difference between those three images. The final images produced by unsharp filtering technique seem much more similar to the original images compare to other filtering techniques. Unsharp shown that not much edge in the final images lost. It can maintain most of the structure from the original image.

4. CONCLUSION

There are many ways to improve the ultrasound images. Some use filtering technique and segmentation to improve the image and reduce speckles. However, the choosing method is very important as it will determine the output of the images. Among three filtering techniques, which are median filter, wiener filter and unsharp filter, the unsharp filter gives the best result.From the segmented images, tomographers can obtain qualitative dimensions such as location of region of interest and also quantitative dimensions such as area, volume or the analysis of dynamic behaviour of anatomical structures over time. In future, it was suggested that image processing designer design the filter using unsharp filtering technique.

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