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Research Article

Effect of Enhancement Technique on Nonuniform and Uniform Ultrasound Images

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The absence of adequate scientific resources in the area of medical sciences sometimes leads to improper diagnosis of diseases and hence the treatments of such diseases are affected badly. However, with the advancement of technology, the complicacy of various malfunctions inside the human body reduces. Ultrasound imaging is one of the biomedical scanning techniques that let the pathologist make comment reasonably and accurately on the disease or irregularity seen in the scan while low imaging quality lets the diagnosis go wrong. Even a little distortion can route the pathologist away from the main cause of the disease. In this research work, the enhancement of dark ultrasound images has been done. An algorithm is developed using enhancement technique for nonuniform and uniform dark images. Finally, we compared the quality of the processed and unprocessed images. Both ETNUD and mean and median filtering techniques were used for image analysis.

1. Introduction

Digital image processing (DIP) is the broader and significant area of research and possess its application practically and virtually everywhere [1–4]. NASA's Mars Exploration Rover Project, surveillance, emotion recognition components, inspecting robotic eye, monitoring the sediments load in rivers, video editing, and many other fields are some major applications of digital image processing [5–11]. Applications related to human-machine interfaces like iris recognition and heart beat scan are emerging and are excellent applications of digital image processing [12–16]. Medical imaging is a science that depicts different human body parts under observation [17]. Images captured from different medical instruments like X rays, magnetic resonance imaging (MRI), computed tomography (CT) scans, and ultrasound are not always very clear [18–22]. Hence, some effective technique is needed to enhance the quality of the medical images. Among all medical imaging tests, ultrasound is considered as the safest till now and thus emerged as a major tool for the diagnosis of irregularity or malfunction inside human body [23]. Ultrasound uses the principle of SONAR in which the sound is reflected off the object and gives the size and distance of the object. The high frequency sound waves are transmitted into the human body with the help of ultrasound probe (transducer/electric instrument used for conversion of energy). These sound waves penetrate through the body and are reflected from inside the body parts with variable texture. The echoes of the sounds reflected off the different tissues are collected by the transducer probe [23]. The frequency of the reflected sound wave and the time it took to echo are forwarded to the computer software that converts the data to a two-dimensional image. The objects close to the transducer probe will appear bright, whereas the far away objects will appear darker on the image. Relatively higher frequencies are used for displaying the images of softer tissue and muscles, of tendons, testes, breasts, and neonatal brains, while lower frequencies are used for deeper objects like pancreas, liver, or gall bladder. Several image enhancement techniques have been purposed by different researchers to enhance the quality of ultrasound images specific to a particular disease [24–32].

In this paper, enhancement technique for nonuniform and uniform dark images (ETNUD) purposed by some researchers is applied for enhancement of dark portions

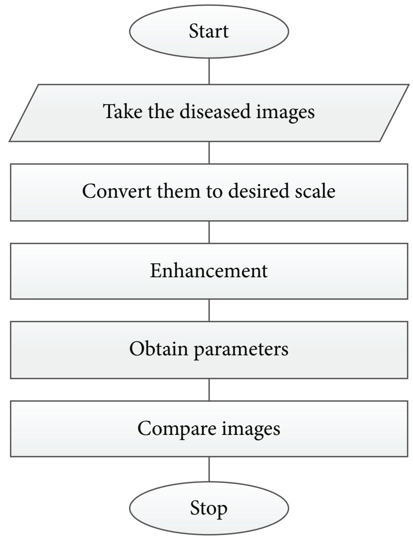


Figure 1: Flowchart showing the analysis of the enhancement and analysis of the image.

in ultrasound images as its use in ultrasound images for detection of irregularity has not been reported yet [33, 34]. This method relies on the information got from the image histogram. It adjusts the intensity of dark and bright regions. Since this technique provides a poor contrast, a pixel dependent contrast enhancement method is used here. Gaussian form is used to provide good dynamic range compression and the luminance information of surrounding pixels gathered by using 2D discrete spatial convolution with a Gaussian kernel. α and λ are the two main factors effecting the quality of image. α is an offset parameter which adjusts the brightness of the image and λ adjusts the color hue. Since most of the ultrasound images were dark, hence it was a little bit difficult to make diagnosis. ETNUD is analyzed to check whether it enhances the dark ultrasound images to an extent of clarity or not. Quality of the processed and unprocessed ultrasound image was calculated to check out the difference.

2. Methodology

Few arbitrary ultrasound images are taken as input from Internet source and are preprocessed. In preprocessing step, the ultrasound images were resized by taking random pixel points, covering whole image, and converted to grayscale to reduce computational load. Though we choose a standard reduction size in this experiment, it can be adjusted depending on the area selected by the operator to concentrate. During next steps, the qualities of preprocessed images were enhanced using ETNUD and mean and median filtering. Finally, the comparison of the quality of the processed and unprocessed images was drawn. $Q = 0.5\mu_n + 0.4\sigma_n + 0.1S$ is the modified form of the quality equation $Q = 0.5\mu_n + \sigma_n + 0.1S$ used for accessing the quality of images [30, 31]. Here, μ_n, σ_n, and S are the normalized brightness parameter, normalized contrast parameter, and sharpness (Figure 1).

The applied method, that is, ETNUD, is applied using the following selection method. Nonlinear dynamic range compression (DRC) is applied based on some information extracted from the image histogram. For this, the histogram of the intensity images is subdivided into four ranges:

$$\begin{aligned} r_1 &= 0\text{–}63, \\ r_2 &= 64\text{–}127, \\ r_3 &= 128\text{–}191, \\ r_4 &= 192\text{–}255. \end{aligned} \tag{1}$$

Thus, using DRC, intensity of image (I_n^{DRC}) is given by

$$I_n^{\mathrm{DRC}} = \begin{cases} (I_n)^x + \alpha & \text{for } 0 < x < 1, \\ \left(0.5 + (0.5 I_n)^x\right) + \alpha & \text{for } x \geq 1, \end{cases} \tag{2}$$

where I_n is the normalized version of image intensity and α is the offset parameter. Also, x signifies the range intensity in between 0 and 1.

The center-surround contrast enhancement $I_{\mathrm{en}}(m,n)$ is given as

$$I_{\mathrm{en}}(m,n) = 255\left(I_n^{\mathrm{DRC}}(m,n)\right)^{E(m,n)}. \tag{3}$$

$E(m,n)$ is the information contained in an image given by

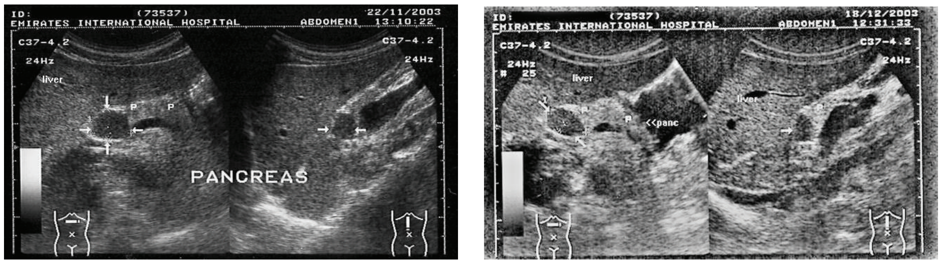
$$E(m,n) = \left[\frac{I_f(m,n)}{I(m,n)}\right]^S \tag{4}$$

and $I_f(m,n) = I(m,n) * G(m,n)$.

Also,

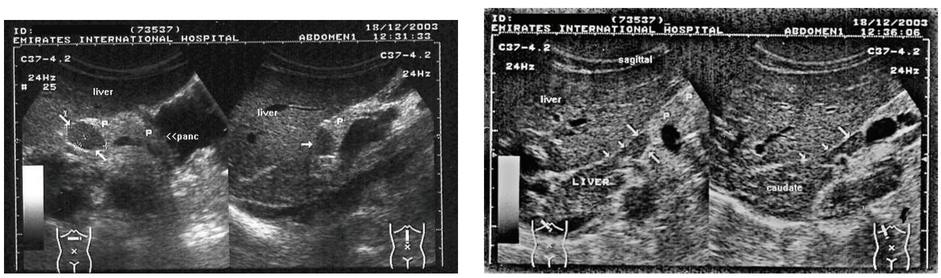
$$G(m,n) = K e^{(-(m^2+n^2)/\sigma_S^2)}, \tag{5}$$

where $G(m,n)$ is the Gaussian kernel, K is the proportionality constant and is usually equal to 1, S is the adaptive contrast enhancement parameter, and m and n are the row and column pixel locations of an image, respectively [34].



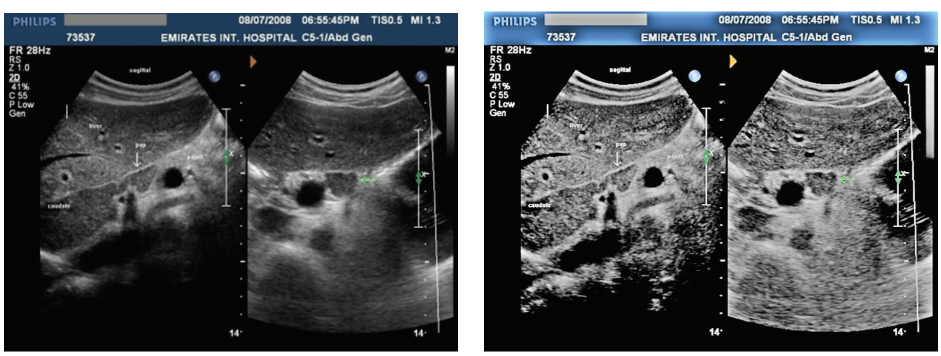
(a) (b)

Figure 2: (a) shows the pancreatic input ultrasound images and (b) shows their output.



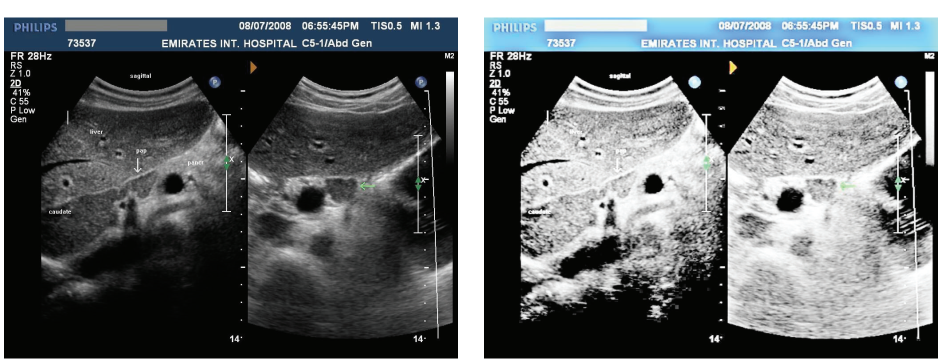
(a) (b)

Figure 3: (a) shows the pancreatic input ultrasound images and (b) shows their output.



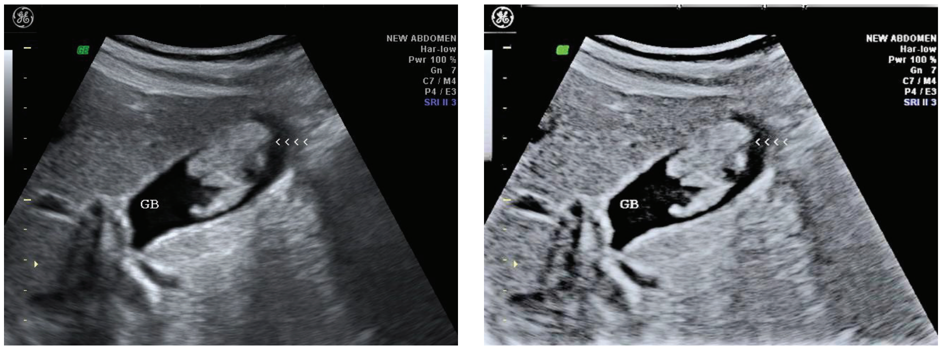
(a) (b)

Figure 4: (a) shows the pancreatic input ultrasound images and (b) shows their output.



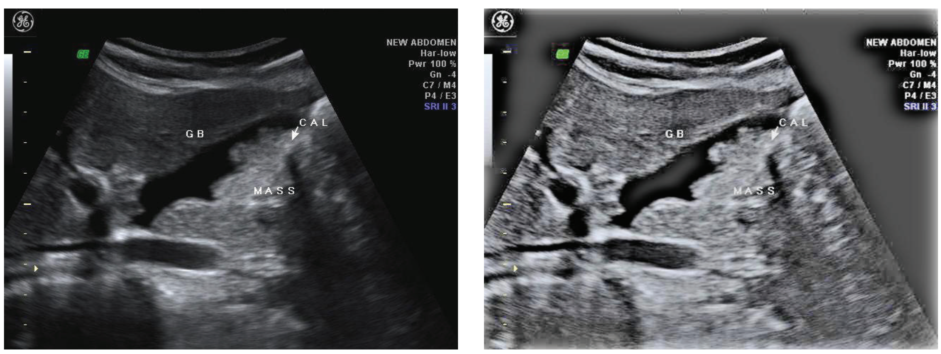
(a) (b)

Figure 5: (a) shows the pancreatic input ultrasound images and (b) shows their output.



(a) (b)

Figure 6: (a) shows input ultrasound images of gall bladder and (b) shows their output.



(a) (b)

Figure 7: (a) shows input ultrasound images of gall bladder and (b) shows their output.

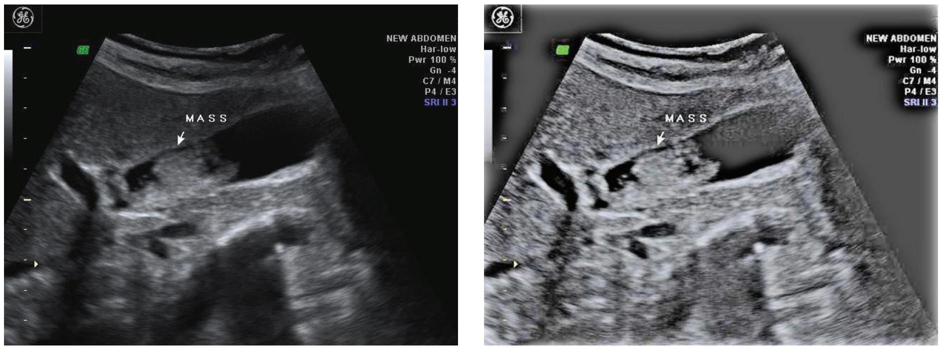
3. Results and Discussions

3.1. Results after ETNUD. From our previous study on the enhancement technique [30], it was concluded that for $\lambda = 1$ and $\alpha = 0.45, 0.05$ the images got enhanced and brightened in the dark area. So, the same values were applied on the diseased ultrasound images and the results were very refined and useful. Different diseased images ultrasound images were taken for the study and are shown in Figure 2.

Figures 2–5 show patient with diseased abdominal ultrasound images with a rounded mass in the region of pancreatic head and isthmus. This shows the possibility of a pancreatic cyst in Figures 2 and 3. However, images in Figures 4 and 5 reveal that possible "mass" appears to be an extension of the caudate lobe of the liver. These ultrasound images are diagnostic of "papillary process of the caudate lobe of liver." This normal variant mimics pancreatic or preaortic lymph node masses [33]. Figures 6, 7, 8, and 9 show ultrasound images of gall bladder having a semisolid biliary sludge ball. Figure 10 shows the faces of conjoined foetuses and Figure 11 shows a foetus inside womb. Corresponding to these original images, the processed images are shown in the lower rows. The output images were processed for $\lambda = 1$ and varying α, as $\lambda = 1$ gave much better effects as compared to other values as already discussed in [30]. The processed images appeared better than the original one. The details of the diseases were more clearly available to the operator or viewer. A comparison of quality of unprocessed and processed images was sought. Table 1 shows the quality and standard deviation of quality for original and the processed enhanced images.

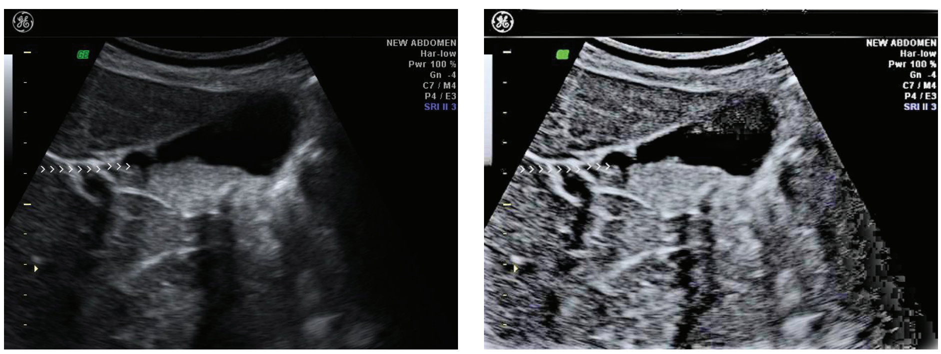
Table 1: Comparison showing quality and standard deviation for original and processed enhanced images.

Images	Original image		Enhanced image	
	Quality	STD	Quality	STD
1	0.2114	0.0002	0.4144	0.0020
2	0.2555	0.0003	0.3557	0.0023
3	0.2528	0.0004	0.2731	0.0052
4	0.2224	0.0015	0.2851	0.0067
5	0.3347	0.0033	0.4902	0.0050
6	0.3416	0.0036	0.3977	0.0022
7	0.3519	0.0033	0.3816	0.0031
8	0.3149	0.0035	0.4719	0.0040
9	0.2998	0.0035	0.4989	0.0025
10	0.2158	0.0021	0.2640	0.0004



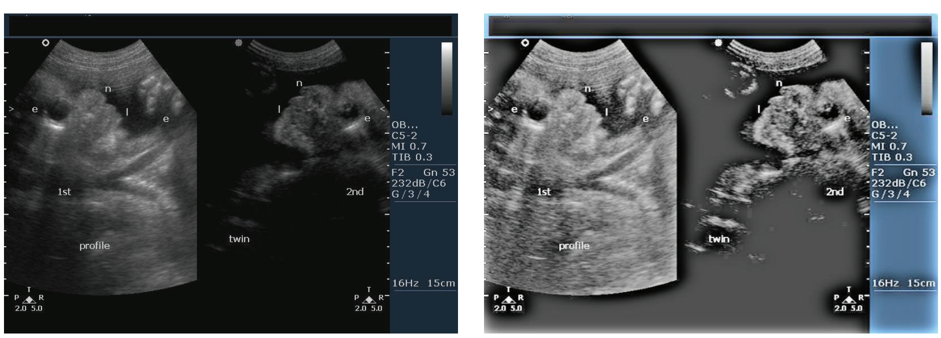
(a) (b)

Figure 8: (a) shows input ultrasound images of gall bladder and (b) shows their output.



(a) (b)

Figure 9: (a) shows input ultrasound images of gall bladder and (b) shows their output.

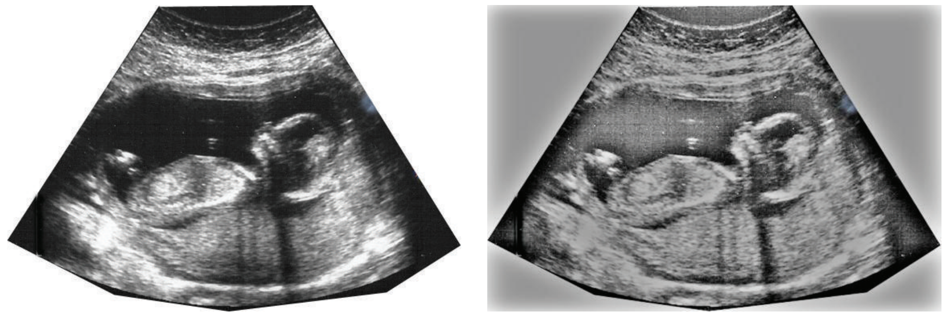


(a) (b)

Figure 10: (a) shows the input ultrasound images of foetus and (b) shows their output.

STD is the standard deviation of the quality. QORIM and QPRIM are the quality of the original unprocessed images and processed enhanced images, respectively. SORIM and SPIM are the standard deviation of the quality of the original and processed ones, respectively. As seen from the table the quality of the images shows a hike in the quality of images. Corresponding to the data in the table, the bar graphs are plotted as shown in Figure 12.

3.2. Results after Mean and Median Filtering. Digital images are prone to different types of noises which render the valuable data being lost. Noise is the result of the image acquisition process that results in pixel values that do not reflect the true intensities of the scene. Median filtering is similar to an averaging filter in the fact that each output pixel is set to an average of the pixel values in the neighbourhood of the corresponding input pixel. However, with median filtering, the value of an output pixel is determined by the median of the neighbourhood pixels, rather than the mean. The median is much less sensitive than the mean to extreme values (called outliers). Median filtering is therefore better able to remove these outliers without reducing the sharpness of the image.



(a) (b)

Figure 11: (a) shows the input ultrasound images of foetus and (b) shows their output.

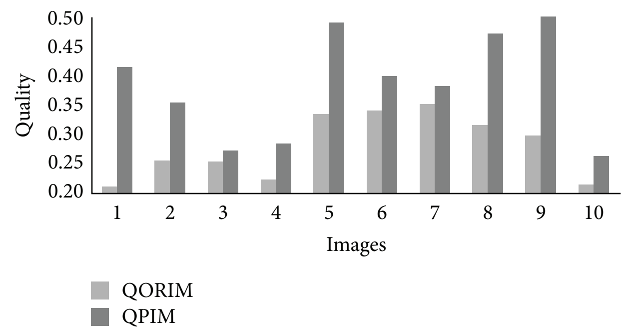
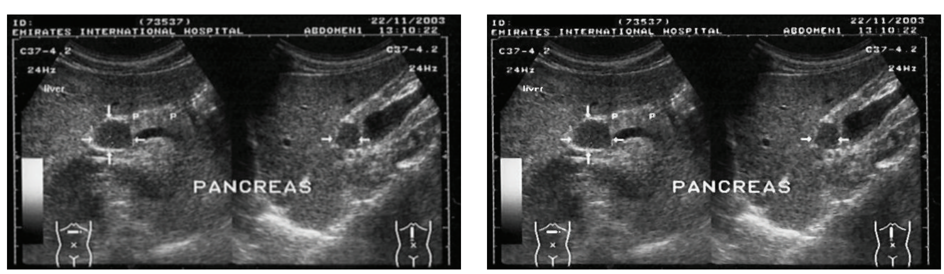
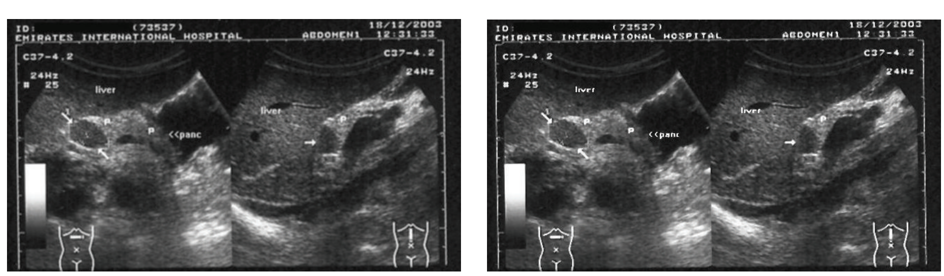


Figure 12: Bar graph showing quality analysis.



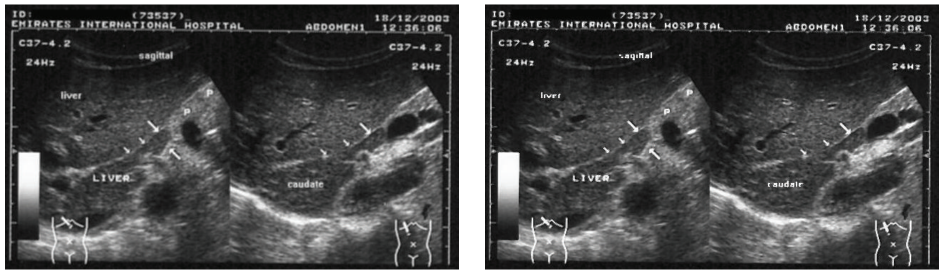
(a) (b)

Figure 13: (a) shows pancreatic images after mean filtering and (b) shows their output images after median filtering.



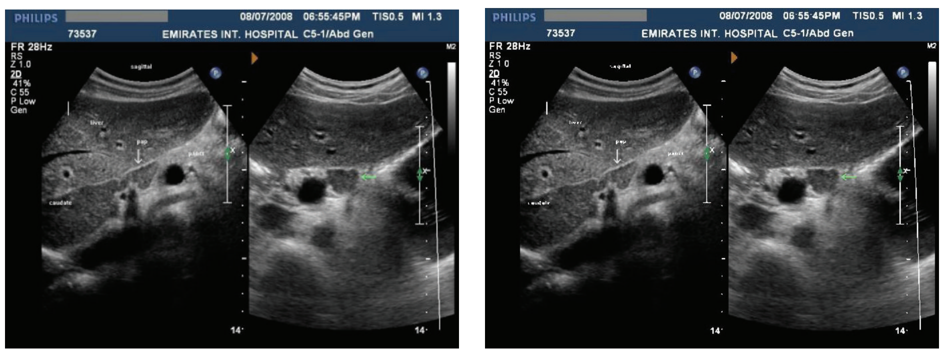
(a) (b)

Figure 14: (a) shows pancreatic images after mean filtering and (b) shows their output images after median filtering.



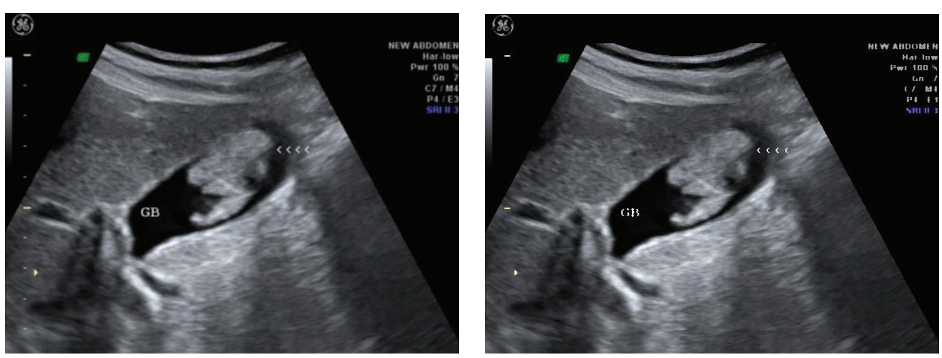
(a) (b)

Figure 15: (a) shows pancreatic images after mean filtering and (b) shows their output images after median filtering.



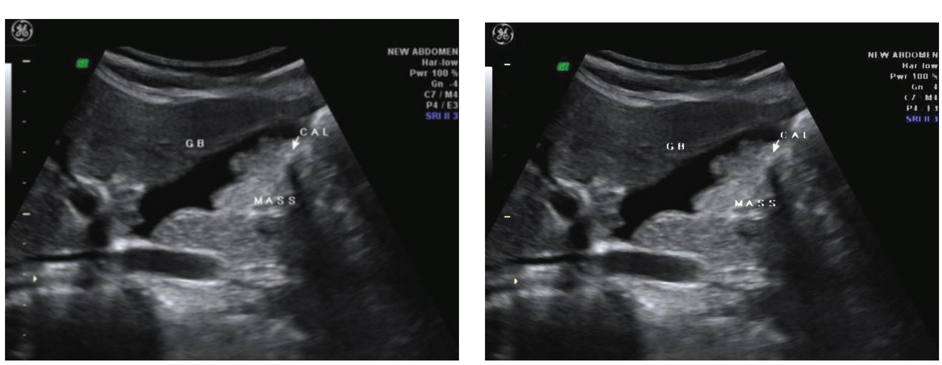
(a) (b)

Figure 16: (a) shows pancreatic images after mean filtering and (b) shows their output images after median filtering.



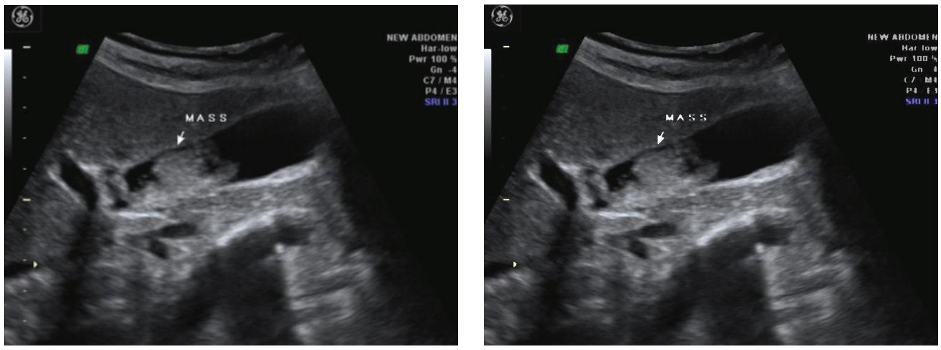
(a) (b)

Figure 17: (a) shows pancreatic images after mean filtering and (b) shows their output images after median filtering.



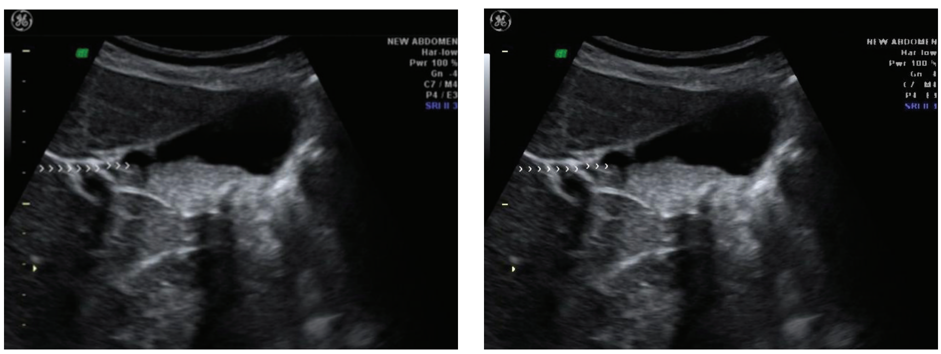
(a) (b)

Figure 18: (a) shows images of gall bladder after mean filtering and (b) shows their output images after median filtering.



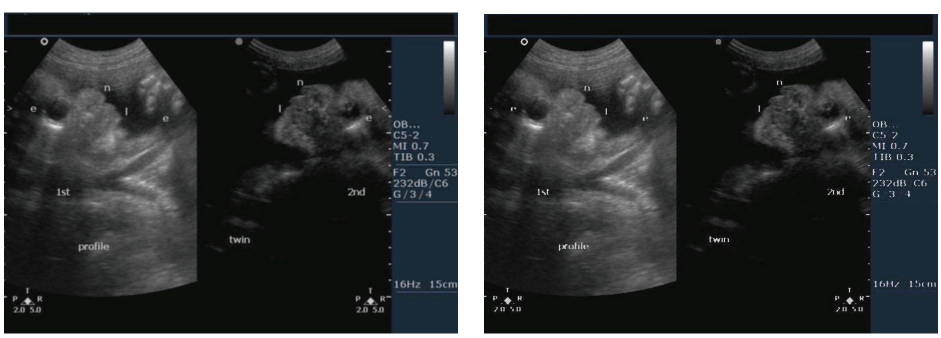
(a) (b)

Figure 19: (a) shows images of gall bladder after mean filtering and (b) shows their output images after median filtering.



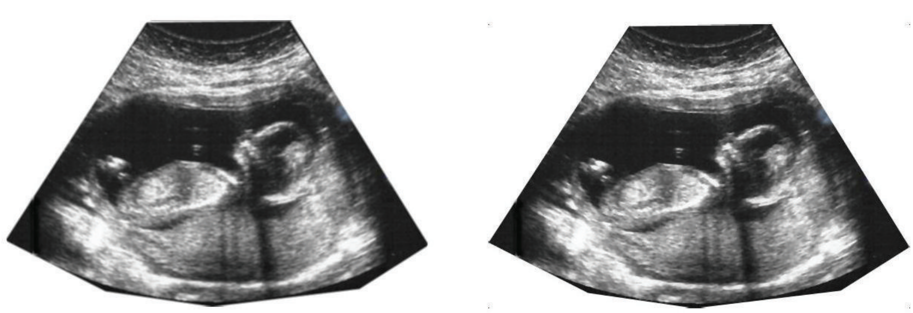
(a) (b)

Figure 20: (a) shows images of gall bladder after mean filtering and (b) shows their output images after median filtering.



(a) (b)

Figure 21: (a) shows the output images of foetus after mean filtering and (b) shows their output after median filtering.



(a) (b)

Figure 22: (a) shows the output images of foetus after mean filtering and (b) shows their output after median filtering.

If we compare the images processed by ETNUD and median and mean filtering, the results produced by ETNUD are clearer as compared to the other two. The images processed through mean and median filtering provide least information whereas the images those processed through ETNUD had information more visible in the dark part of regions also. Figures 13(a)–22(a) show the images processed through mean filtering and Figures 13(b)–22(b) are the images processed through median filtering.

4. Conclusions

In this paper, the objective of the study was to carry out the enhancement of the ultrasound images. The results showed that images were enhanced. The ETNUD technique is better than mean and median filtering as it provides a clearer and high quality ultrasound images which helps the operator in prediction of diseases more accurately. The enhanced ultrasound images help a lot in the assessment of the malfunction inside the body. Our next motto is to enhance the digital imaging by using genetic algorithm techniques and apply the same in the medical imaging.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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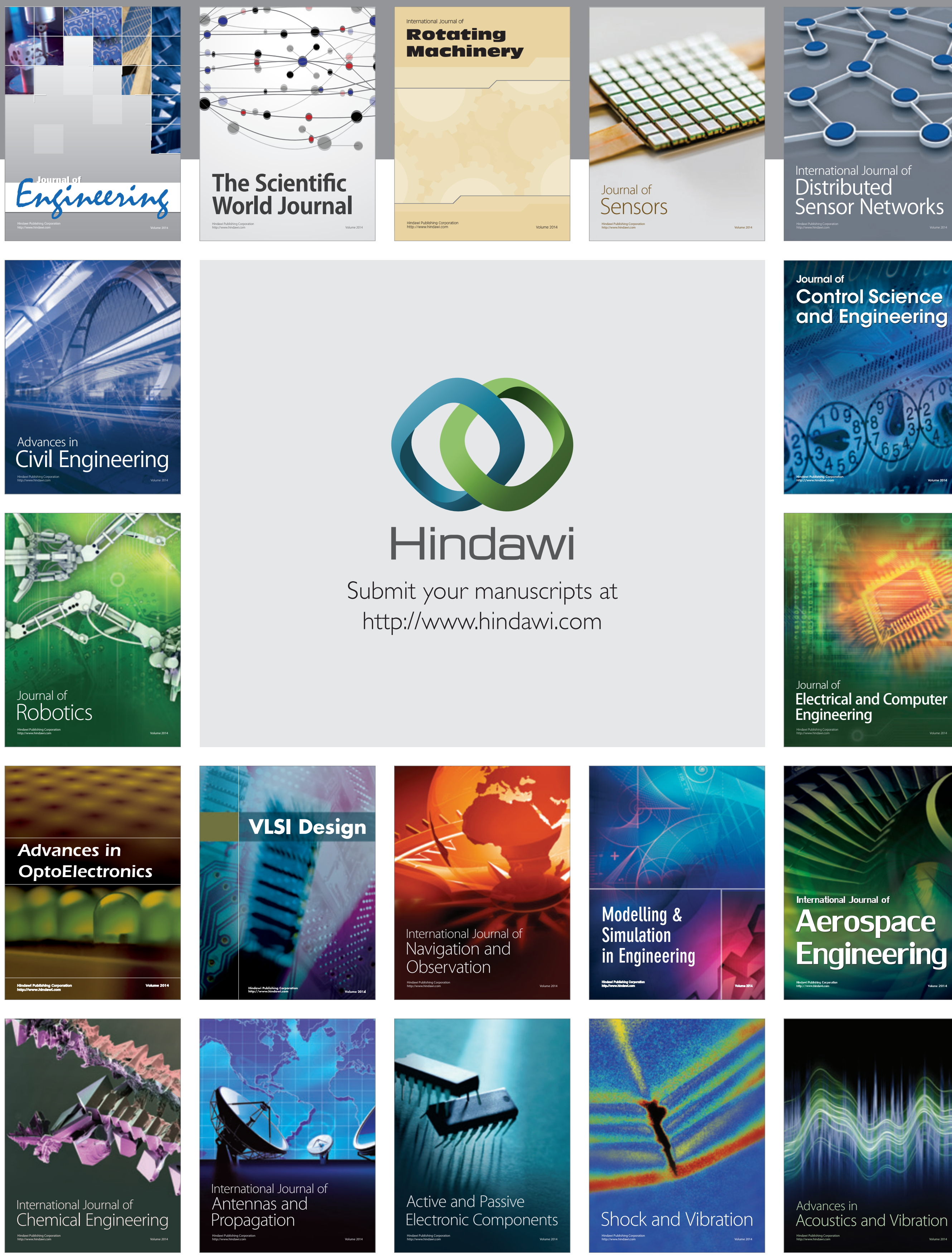

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