International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST2310134

An Image Segmentation for Different Medical Image Modalities using Wavelet Transform Technique

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Article Info

Publication Issue
Volume 10, Issue 1
January-February-2023

Page Number
292-307

Article History
Accepted: 15 Jan 2023
Published: 05 Feb 2023

ABSTRACT

Image Segmentation techniques are emerging every day in the medical environment. To retain the details of the medical images and obtain the suitable image segmentation method for considered medical image modalities, an image segmentation system based on the Wavelet Transform to decompose at an appropriate level is proposed in this paper. The detailed information of horizontal, vertical and diagonal direction was obtained with the decomposition of images based on the wavelet transform technique. The suggested technique has obvious benefits among the four image quality indexes: sensitivity to noise ratio, peak sensitivity to noise ratio, structure similarity, and entropy, especially for X-ray image segmentation. The method will provide a new ground for further scope in this research work to better understand the image segmentation techniques for medical images.

Keywords: Image Segmentation, Wavelet Transform, Image Quality Evaluation, Medical Image Modalities.

I. INTRODUCTION

Medical image processing helps in visual representations of a body's inner portion. It is the set of different image processing techniques that produce processed images for medical analysis of the body. Medical image processing is also used to visualize organs and tissues [1], [2]. It also supports maintaining a physiology and regular anatomy database for identifying disorders. Various medical applications such as identification of bone fracture, tumour detection etc., are present in human beings [3]. But two major problems arrived in medical images, the first is that a medical image is available in a lossy format, and the other is an erroneous diagnosis in its identification [4].

A method that can diagnose abnormalities with maximum accuracy and minimum database is hugely advantageous. Medical image processing is used to analyze and detect any infection, extracting features from the image by various preprocessing techniques

after removing noise. Segmentation has a critical job in the medical surroundings and has a remarkable impact as well as multiple applications [5], [6]. This method helps to segment the original image into valuable areas. It is found that the infected regions, according to the image's distinctiveness, like brightness level, gray level and texture, but it faces many difficulties [7]. Firstly, many medical images are tough to segment using the old traditional procedure. Second, it loses the local details of the image due to very low processing effect [8], [9]. So, the primary inspiration is to discover a versatile and effective segmentation method. Therefore, the suggested segmentation technique uses the wavelet transform, which decomposes the images into the detailed components of vertical, horizontal and diagonal [10], [11]. Experimental outcomes expressed that the suggested segmentation technique is better than the old ones [12]. It has advantages in terms of four image identifiers: sensitivity to noise ratio, peak sensitivity to noise ratio, structure similarity, and entropy in the segmentation of different image modalities.

The research work is structured as follows. Section 1 gives a small preface to the work associated with medical image processing. In Section 2, different medical image modalities have explained in detail. Section 3 describes a detailed explanation of the traditional segmentation methods used in health science. In Section 4, the suggested process explained the wavelet family and the images' decomposition. Section 5 describes the implementation, experimental analysis and discussions of the outcome. The conclusion of this work is explained in Section 6.

II. MEDICAL IMAGE MODALITIES

Medical imaging is one of the best approaches to accomplish the goal, to visualize the inside portion of the body without surgery or any invasive actions. This can be used for diagnosis and therapeutic purposes, creating one of the most powerful resources to care for patients effectively. Different medical imaging modalities are available for analyzing several problems or physiological disorders for diagnosis [13]. These modalities are also beneficial for patient records regarding the patient's follow-up process [14]. The major aim is to find efficient and accurate diagnoses.
The imaging techniques are used with recent scientific advances in medical sciences. The broad range of imaging modalities is ultrasound (US), computed tomography (CT), X-rays and magnetic resonance imaging (MRI). These approaches can be practical as non-invasive techniques to visualize the human's internal parts without any surgical intervention. Many medical imaging modalities use X-ray radiation projected onto the body, like CT scans and X-ray images. Other non-radioactive kinds are MRI and US.

A. X-rays

X-rays are high-energy waveforms or waves of electromagnetic radiation. Sometimes it is called X-radiation; its wavelength ranges occurs from 10 picometers to 10 nanometers. X-rays are very important in skeletal systems' pathology as these can identify bone structures. There is almost no danger in their examination. Radiology is a particular field of medical science that uses radiography and various procedures to obtain X-ray images.

However, through repeated tests, X-rays may damage certain cells in the body, leading to diseases in the future. The X-ray radiation is always kept on the expected basis to obtain a decent image of the specific part of the examined body. Similarly, radiographers who take images constantly wear lead shields or hide behind protective screens after X-rays are completed to avoid repeated exposures of X-rays. If possible, pregnant women should not undergo these tests, as it can cause changes in the normal conditions of the fetus, so there is a slight risk that is why women are

asked if they are pregnant or not pregnant before undergoing an X-ray.

B. Ultrasound

Ultrasound is also called sonography, a clinical test that utilizes high-frequency sound waves to record the body's live images and generate images of inner body organs and soft tissue. Not at all like X-rays; ultrasounds do not use any radiation. Ultrasound imaging helps to develop images of the inside part of the body. It helps to analyze the reasons for agony, swelling and contamination of inner organs and scan the growth of infants in pregnant women. It also aids to manage biopsies, examining heart problems, and observing the damage after a cardiovascular failure. The ultrasound is protected, non-obtrusive, and does not use ionizing radiation. There are two primary classifications of ultrasounds:

1) Pregnancy ultrasound: It helps to see an unborn child. The test can give information about an infant's development, improvement, and wellbeing.

2) Diagnostic ultrasound: To see and give information about other inside parts of the body. These incorporate the heart, veins, liver, bladder, kidneys, and female regenerative organs.

Ultrasound is the safest variety of imaging in the medical field and has many applications. It uses sound waves rather than ionizing waves. One more category of ultrasound generally uses the 'Doppler' – a vaguely unlike using sound waves that allow the blood flow through arteries and veins to see.

C. CT scan

A CT scanner is an uncommon X-ray machine that generates a 3D image of a subject for detailed identification. A CT scanner sends a few light emissions of X-rays from various edges to investigate all parts of the body. The CT scanner emits a narrow beam as it travels through a curve. The X-ray locator inside a CT scanner can see many various degrees of thickness inside the body's organs, including the tissues.

A computer utilizes this data to work on the thickness of the tissues and measures the outcomes showing them as a two-dimensional image on a screen. Pregnant ladies ought not to have a CT scan as there is a slight danger that radiation may make an anomaly for the unborn youngster. The different colour utilized in CT scans regularly contains iodine, which can cause an unfavourably susceptible response in individual patients. Additionally, the colour may cause some kidney harm to individuals who have kidney issues. The advantages of using CT scans far exceed the risks, like with X-rays, including cancer risk.

D. MRI

Magnetic resonance imaging uses hard magnetic fields. MRI is an analytic device used to record various portions of the body without X-rays. Dissimilar to X-rays and CT examines, which use radiation, an MRI utilizes incredible magnetic and radio waves. A radio wave receiving wire is used to impart signs to the body and afterwards get flags back. These returning signals are changed over into images by a computer to the scanner. MRI can utilize to analyze different orthopaedic conditions and other conditions. The MRI scans provide point-by-point images of the body portions, which help to treat patients better. MRI creates diagnostic images using no harmful radiation. It uses radio waves to produce images that cannot visualize using CT scans or X-rays. It enables to see within a joint or ligament from outside. MRI doesn't use ionizing radiation, so it can also be used for pregnant women with no side effects.

III. TRADITIONAL IMAGE SEGMENTATION METHODS

Segmentation is a processing of the images and is used to segment an image into different sections, repetitively reliant on the attributes of pixels in an image. This method reduces easy examination and is very helpful in the enhancement and compression of images. The motive of this approach is to distinguish the background and the object in the image. But, the segmented approach has developed into the latest challenge as of its complex surroundings and unstable brightness in images. The poor quality of the segmented image may guide to unsuccessful and inaccurate outcomes [15]. Some algorithms are explained below-

3.1 Segmentation based on Edge Detection (SED)

Edge Detection is a popular method for locating edges using first and second-order derivatives [16]. The first-order is the gradient used in the segmentation of the images. Various edge detectors are available; some are named Sobel, Canny, Prewitt, and Robert cross, giving unusual results. But some drawbacks are also present in this method: poor sensitivity to noise ratio, expensive computation, false detection, time-consuming and wrong zero crossings.

3.2 Segmentation based on Thresholding (ST)

The thresholding of an image represents its intensity histogram, created by light objects on a dark background. It is one of the applications of image segmentation [16]. Selecting the T threshold, which helps to recognize these modes, is an easy way to remove the object from a unique background. The random image part where the intensity is more than the threshold is termed the object part; the other is a background part. That means there are two pixels; the first is related to objects, and another is related to the background. When a whole image constantly compares to the threshold, the earlier situation is termed global thresholding. But the evaluation of threshold varies over an image, is termed variable thresholding.

It is used to specify regional thresholding where the threshold studies in the image rely on the property of a region of concern. So the most crucial shortcoming to this technique does not have specificity and sensitivity for exact classification.

3.3 Segmentation based on K-means Clustering (SKC)

SKC specified to classify the subjects using characteristics into K-number of groups. This method first changed the randomly used image, available in pixels, into an RGB (Red, Green, and Blue) space. The points that have similar colours are a group to make clusters. The execution of this approach involves two steps. It computes the k-centroid in the initial step and then selects each point to the cluster closest to the centroid in the next step. The centroid and its related data points show all clusters. In the centroid, each cluster describes the summation of all distances from the objects in that cluster. Therefore, it is an iterative way to decrease distances from all objects to the centroid of the cluster.

SKC is a simple method to perform, and it also has some limitations. Firstly, the superiority of the previous clustering result depends on the self-assertive purpose of the initial centroid. But the centroid at random choices will offer remarkable results, unlike early centres. Therefore, it will find out centroid cautiously for obtaining the preferred segmentation [17].

3.4 Segmentation based on Watershed (SW)

The catchment basins used as segments of the image. Here two ways are taken to execute the watershed technique for segmentation [17]. The first way is to

search a downstream path from all pixels to the local minima in image surface altitude. It describes the lay of pixels in the associated downstream paths at the same minimum altitude. On the other hand, all gray level minimum indicates a single catchment basin, so the method is to pack the catchment basins from the base. It is also used for complex segmentation as if it applies contour detection and simple thresholding. Still, it will not give an outstanding and precise outcome.

3.5 Segmentation based on Extracted Texture (SET)

It is the most eminent low-level image representation technique for computer vision applications like image collaboration, template matching and region detection. This method contrasts with the division and recognises the recorded images in Text, Graphics and Space. These recorded images were segmented into separate blocks, and for all blocks, five GLCM (Gray Level Co-event Matrix) highlights were used. Image segmentation was refined by performing a textured check, and the zone description was completed using heuristics from trial images.

Two major drawbacks in the analysis of images are present in this method which has several destructive impacts. Therefore, two phenomena are noisy image and rotation in the image. Hence, the images might vary in viewpoint, scale, or light intensity [17].

IV. PROPOSED SEGMENTATION APPROACH

The wavelet transform technique is proposed for this research work.

4.1 The principle of Wavelet Transform

The wavelets resemble oscillation, together with amplitude, starts at zero and return to zero [18]. The transform is a grouping of the “reverse, shift, multiply and integrate” process termed as convolution with segments of an identified object that aid to extract data from the unidentified object. This is a mathematical approach that conveys the image in frequency and spatial domains. Hence, this shows the images in multiple resolutions.

Wavelet families have proven to be very useful in image processing. Some wavelet families are named Haar, Daubechies, Coiflets, Biorthogonal, Symlets, Morlet, Meyer, Mexican Hat, Complex Wavelets, and other Real Wavelets.

4.2 Segmentation based on Wavelet Transform (SWT)

Wavelet transform is the handy tool that uses to extract significant information associated with the image successfully. In the multi-scale term, the wavelet transform is the common method with a histogram of an image. It can constructively stay away from the noise. Hence, the proposed approach is described as the image's histogram, which decomposes into dissimilar wavelet coefficients [19]. X-ray image processing by wavelet transform approach describes in a pointwise way-

i. Initialize images as input from the stored dataset.
ii. Select the appropriate mother wavelet.
iii. Choose the level of decomposition using quantitative values.
iv. Features are extracted from the selected detail component with measures of SNR, PSNR, SSIM and Entropy.

4.3 Selection of Wavelet

The selection of wavelet is based on the following criteria-

4.3.1. Criteria for selection of a wavelet-

Choose a low pass wavelet filter from the wavelet filter bank in its library. It is found from the literature that the cross-correlation coefficient is used to

observe which wavelet is well overlapped with the considered dataset. Hence, estimate the cross-correlation coefficient among the images and choose a wavelet filter. Determine the optimum wavelet filters that maximize the cross-correlation coefficient [20]. The cross-correlation coefficient is calculated between two images; assume the images are f(x) and g(x), which is shown in Eq. (1). It describes the degree of uniformity among the images [27]. Hence, it shows the 'Haar' wavelet is maximumly correlated to the considered medical image modalities.

$$r = \iint_{x,y} f(x)g(x)dx \qquad \text{Eq. (1)}$$

4.3.2. Criteria for selection of decomposition level-

After selecting the wavelet, estimate all detailed components to find the decomposition level. For the study of the detailed coefficients, determine energy or entropy. All of them are based on "entropy", which allows estimation of the informativeness of a set of coefficients. The optimal decomposition level as the level with minimal entropy. Entropy is a common indicator characterizing the degree of uncertainty. Larger entropy values correspond to the greater randomness of the system, and the smaller ones indicate the ordering of the system. Hence, detailed coefficients which show the minimum entropy for respective images are selected for level of decomposition [21], [22].

V. EXPERIMENTAL SETUP AND DATA ACQUISITION

5.1 Data Collection

Data have been acquired in two distinct ways, which are discussed as below-

i. **X-ray Machine**- Real-time data have been acquired by a portable digital X-ray machine available in the biomedical laboratory, Electrical Engineering Department, MITS, Gwalior. Forty images were taken in the laboratory by the research scholar, as shown in Figure 1(a), and out of a total of forty images, only two X-ray images are shown in Figure 1(b) (c).

Figure 1 (a) Taking X-ray images from X-ray machine (b) Normal arm bone X-ray image (c) Normal wrist bone image

ii. **Vidhya Imaging Centre-** Three hundred sixty medical images (60 X-ray images, 100 Ultrasound images, 100 CT Scan images and 100 MRI images) are obtained. Two images as samples are shown in Figure 2 (a) (b).

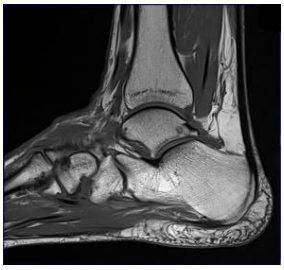
Figure 2 (a) Ultrasound image (b) Chest X-ray image

To check the ability of the wavelet transform in image segmentation, SWT and additional traditional segmentation techniques such as SED, ST, SKC, SW and SET, evaluate on the considered total of 400 medical images. Out of these 400 images, the result of only four samples (each medical modality) is shown in this paper. The considered sample images are shown in Figure 3 (A) X-ray, (B) Ultrasound, (C) CT Scan, (D) MRI.

(A) X-ray

(B) Ultrasound

(C) CT Scan



(D) MRI

Figure 3 Samples from the database of medical image modalities

5.2 Feature Extraction

The subsequent measures are significant in wavelet transform-

5.2.1 *Signal to Noise Ratio (SNR):* A noise is an irregularity shown in colour or brightness in images. The adaptive noise detector is used to distinguish the noise type. Image distortion is a considerable matter in the processing of an image. Images distorted due to noises such as Salt and Paper noise, Gaussian noise, Speckle noise, Poisson noise are types of noise in the advanced images. SNR explains the quality of the signal or an image [23], [24]. The higher values of SNR show the lesser noise and provide a better-featured image. Scientifically, it shows in Eq. (2)

$$\mathrm{SNR} = 10\log\frac{S_{\mathrm{original}}}{S_{\mathrm{noise}}} \qquad \text{Eq.(2)}$$

S_{original} – Original signal with no noise
S_{noise} – Noisy signal

5.2.2 *Peak Signal to Noise Ratio (PSNR):* An error between the original and processed image is the main coding degradation measure. Though, an evaluation of

it needs some reference images [23], [24]. It also has a few errors that indicate the difference between the restructured and source image shown by Eq. (3). The high values of PSNR indicate that they have very little distortion and have good segmentation effects.

$$\mathrm{PSNR} = 10\log_{10}\left(\frac{\mathrm{MAX}_1^2}{\mathrm{MSE}}\right) 20\log_{10}\left(\frac{\mathrm{MAX}_1}{\sqrt{\mathrm{MSE}}}\right) \qquad \text{Eq. (3)}$$

MAX_1 − Maximum value of image point colour
MSE − Mean square error

5.2.3 *Structure Similarity (SSIM):* The mean values are employed to compute the standard deviation, brightness as the covariance measurement, and contrast for estimating the SSIM values [25]. The scale of its index ranges from -1 to 1. The product is 1 for two identical images, and followed by the result of segmentation is superior.

It is used to approximate the similarity level between the original and segmented images. Its mathematical Eq. (4) is as follows:

$$\mathrm{SSIM}(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \qquad \text{Eq. (4)}$$

Here, $\mu_x$is the average of x, μ_y is the average of y, σ_x^2 is the variance of x, σ_y^2 is the variance of y, σ_{xy} is the covariance of x and y. $c_1 = (k_1 L)^2$ and $c_2 = (k_2 L)^2$ both constants specify maintaining stability, and L shows the dynamic range of pixel values. Take $k_1 = 0.01$ and $k_2 = 0.03$.

5.2.4 *Entropy:* It calculates randomness used to classify the input image's texture [26] and is shown in Eq. (5). The fewer the values of entropy, the fewer the counts of the histogram since pixel values turn into discrete and match up to a bin value. Hence, entropy must be the lowest.

$$E = -\sum p.* \log^2(p) \qquad \text{Eq. (5)}$$

Where p contains the normalized histogram count return.

5.3 Performance Analysis with Haar Wavelet

Different image segmentation techniques, as well as wavelet transform-based methods, are performed in MATLAB 2019 software. In this section, all 400 medical images are considered for the three levels of decomposition by using the proposed wavelet method, which is represented in Figure 3 (A-D). With the help of wavelet transform based image segmentation, each medical image was used to obtain the three-level decomposition. Their outcomes are represented in Figure 4, Figure 5, Figure 6 and Figure 7, respectively.

In decomposed medical images, there is (a) approximation; (b) vertical detail, (c) horizontal detail, and (d) diagonal detail for every level of decomposition and the wavelet transform based image segmentation technique can efficiently retain the detailed information of the original image. Merely high-frequency components, namely vertical, horizontal, and diagonal detail components, are only considered in this study to obtain good results and neglect the low-frequency component, i.e. approximations.

This analysis found that the third level of decomposition of the vertical component of an X-ray image is well performed and provides a good decomposed image. But for other medical images modalities, it is not as suitable. This method was also proved mathematically by using image indexes such as SNR, PSNR, SSIM and entropy.

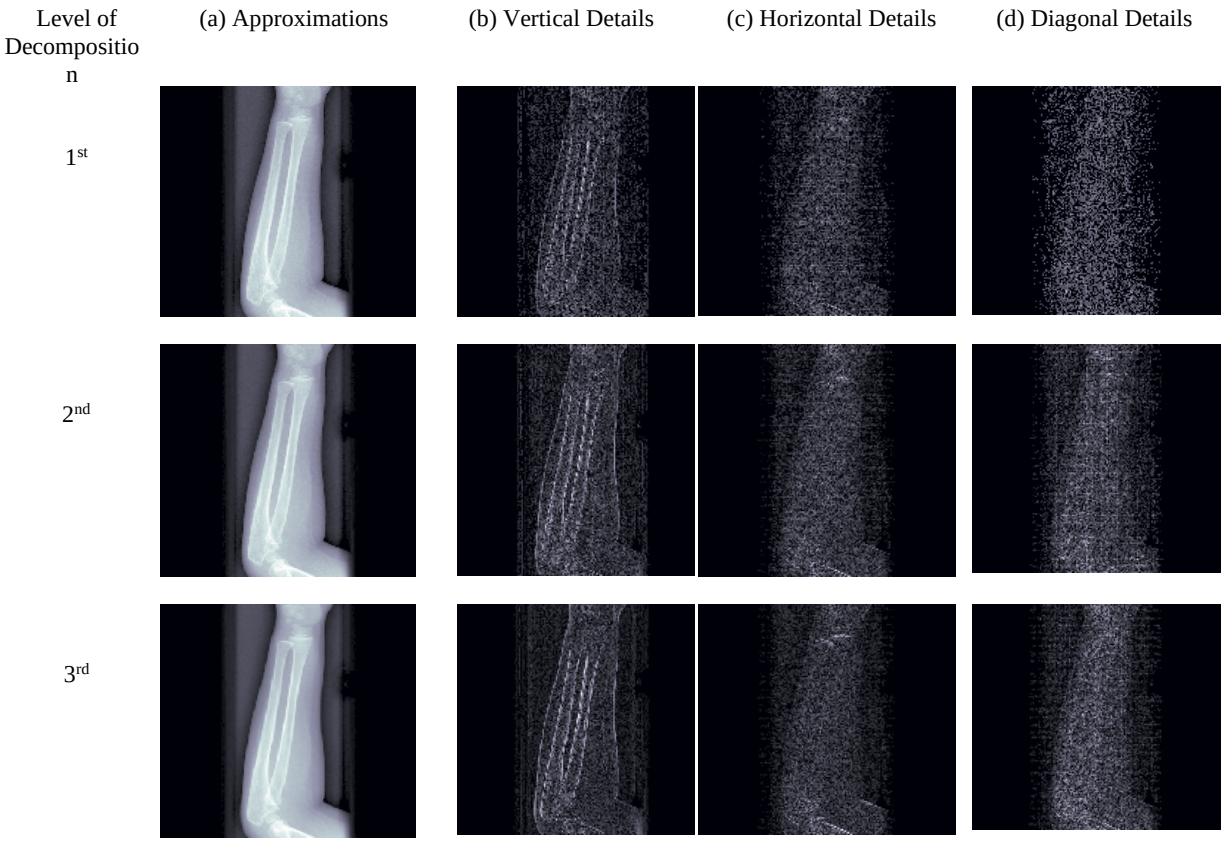


Figure 4 Three-levels of decomposition of X-ray image

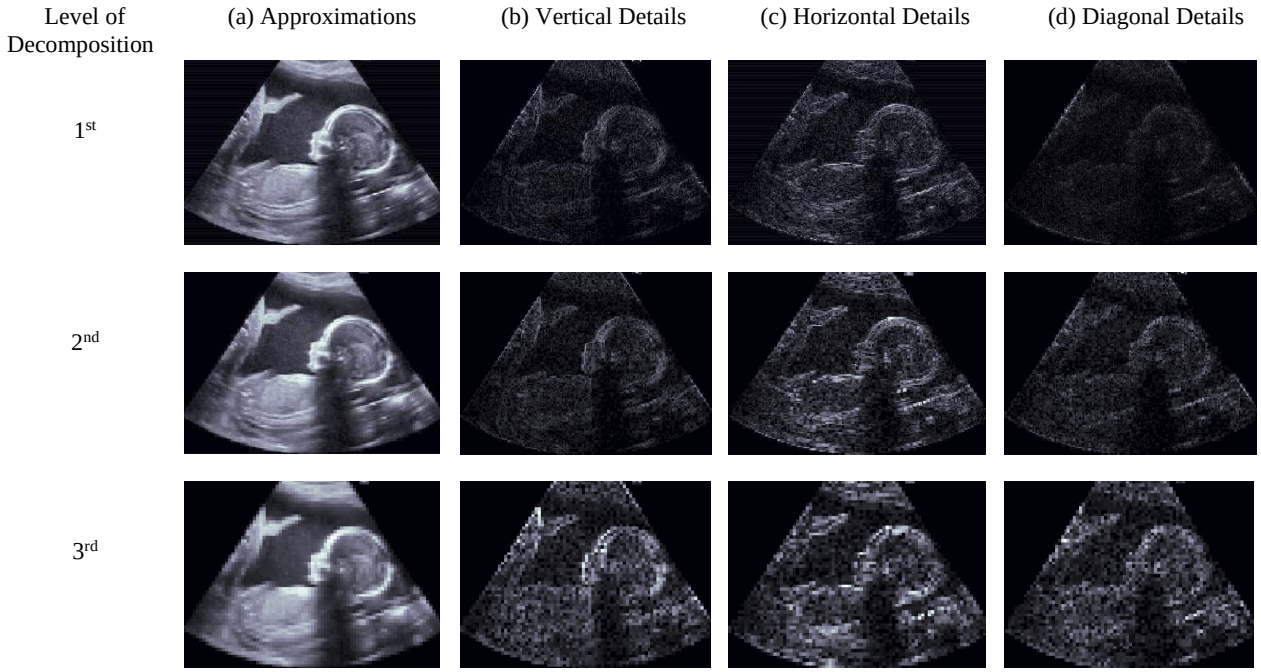


Figure 5 Three-levels of decomposition of ultrasound image

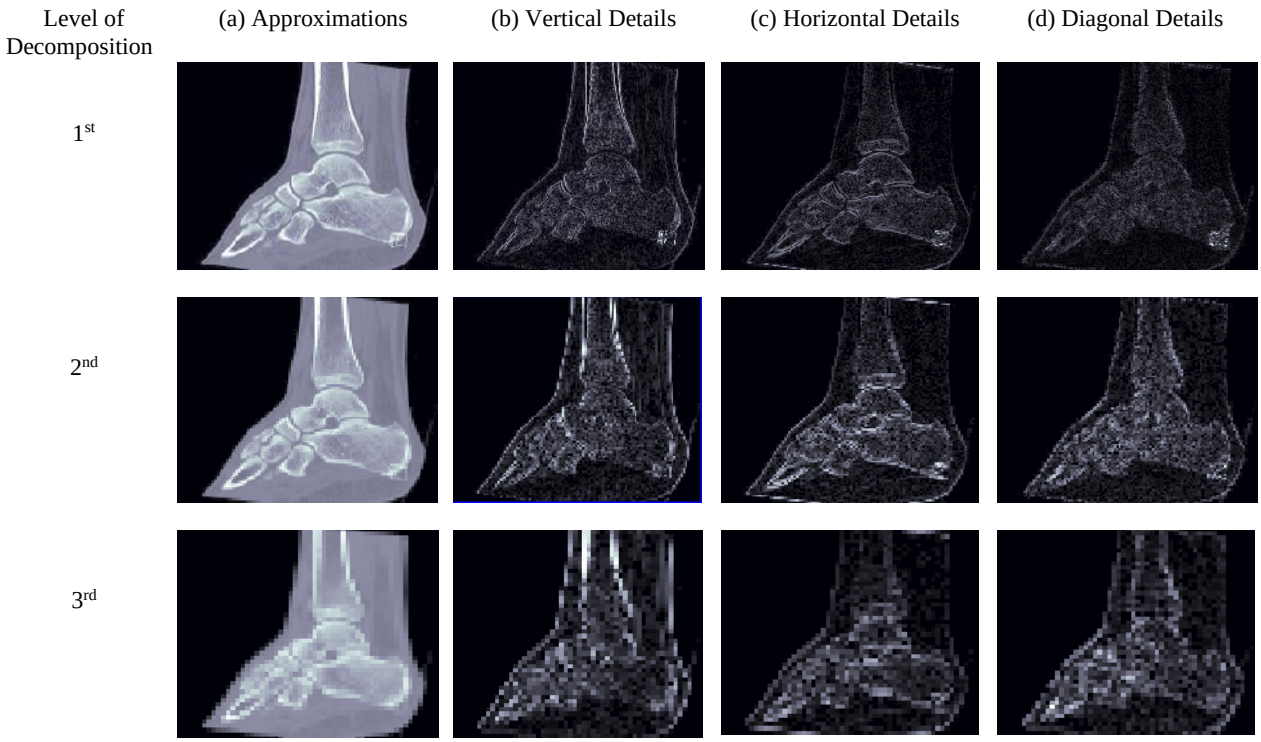


Figure 6 Three-levels of decomposition of CT Scan image

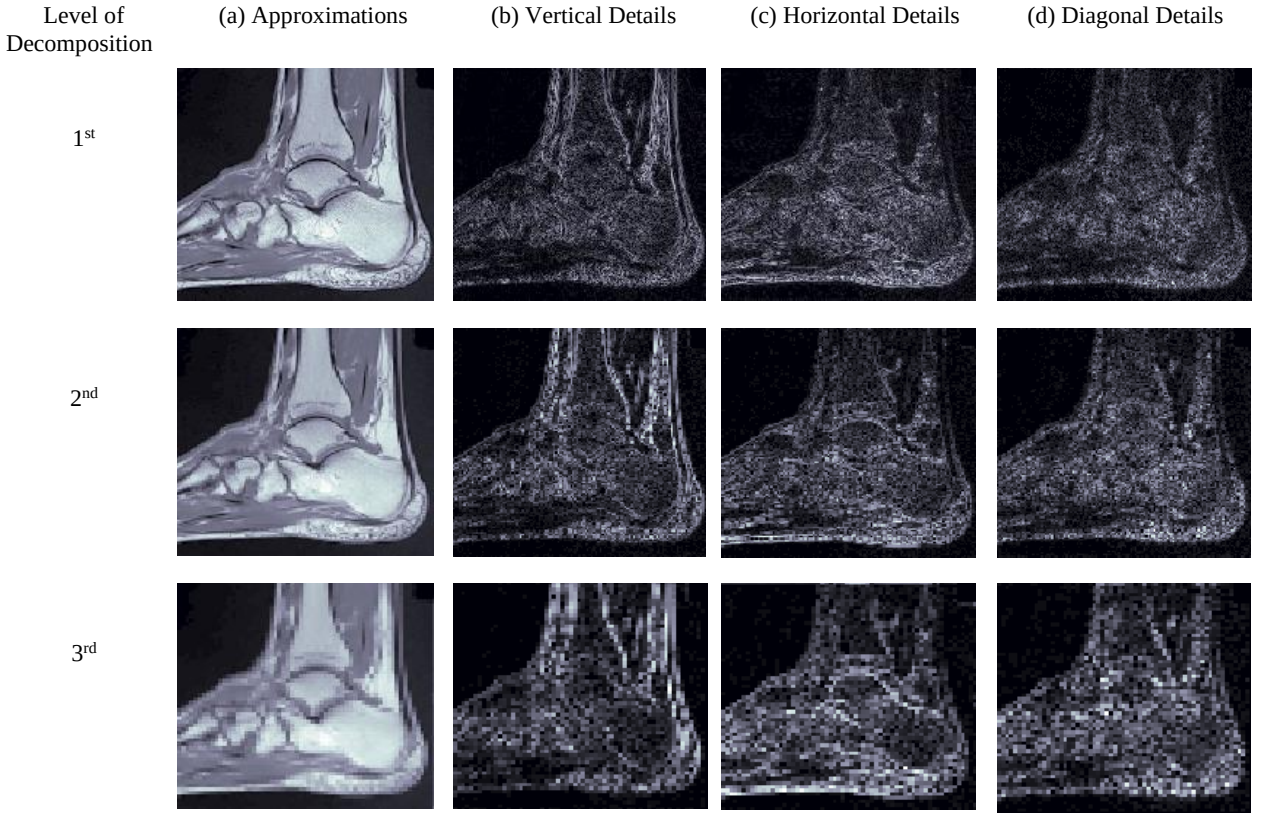


Figure 7 Three-level decomposition of MRI image

It is visualized from Table 1 that the third level of decomposition has the lowest Entropy values than other levels of decomposition for the considered data sets of (A) X-ray image and from Table 2, Table 3, Table 4, the first level of decomposition has minimum Entropy values for the (B) Ultrasound image, (C) CT scan image and (D) MRI image respectively. It is found that the third level of decomposition of X-ray image gives accurate outputs. But for the other three image modalities, the first level of decomposition gives good results. That means it is not required to decompose further the MRI, CT scan, Ultrasound images. Hence wavelet transform method gives better outcomes for X-ray images.

Table 1: The outcome of entropy values for the X-ray image

Level of Decomposition	(a) Approximations	(b) Vertical Details	(c) Horizontal Details	(d) Diagonal Details
1st	1.0925	0.8925	0.9995	1.2354
2nd	1.0582	0.9922	0.9233	0.9994
3rd	1.0512	**0.6251**	0.8510	0.9725

Table 2: The outcome of entropy values for the Ultrasound image

Level of Decomposition	(a) Approximations	(b) Vertical Details	(c) Horizontal Details	(d) Diagonal Details
1st	0.7603	**0.4752**	0.7354	0.7946
2nd	0.7798	0.4916	0.7981	0.8228
3rd	0.8104	0.6587	0.7480	0.8961

Table 3: The outcome of entropy values for the CT Scan Image

Level of Decomposition	(a) Approximations	(b) Vertical Details	(c) Horizontal Details	(d) Diagonal Details
1st	0.9568	**0.5656**	0.7581	0.7694
2nd	0.9880	0.6895	0.7345	0.7914
3rd	0.9825	0.6999	0.7794	0.8123

Table 4: The outcome of entropy values for the MRI Image

Level of Decomposition	(a) Approximations	(b) Vertical Details	(c) Horizontal Details	(d) Diagonal Details
1st	0.2351	**1.0031**	1.2751	1.2951
2nd	0.2635	1.0715	1.1231	1.2953
3rd	0.2225	1.1259	1.2359	1.3112

VI. RESULTS AND DISCUSSIONS

To examine the efficiency of the suggested technique, SNR, PSNR, SSIM and Entropy standards are used in support of their comparative study. The result shown in Table 5 presents the four statistical measures: SNR, PSNR, SSIM and Entropy. They are calculated using a few traditional segmentation approaches and the wavelet transform technique using dataset images of A, B, C and D from Figure 1. In favour of the wavelet transform based segmentation approach, the values of image identifiers have been estimated from the vertical component of the decomposed image. This is the only significant area to be selected, so ignore the extra three elements: approximation, horizontal detail and diagonal detail components for obtaining the outcome. With Table 5, it is evident that the

suggested SWT has better quality than additional traditional segmentation techniques in provisions of SNR, PSNR, SSIM and Entropy for considered X-ray image.

With the help of SNR, PSNR, SSIM and Entropy, it can say that SWT has better quality than other traditional segmentation approaches. For the Ultrasound image, it is clear that the proposed method is good in terms of SNR, PSNR, and SSIM but poor in terms of Entropy. For the CT scan image, it is seen that the proposed approach is better than other approaches in terms of SNR, PSNR, and Entropy and is inferior in terms of SSIM. For the MRI image, it is found that the proposed approach is superior to other techniques in provisions of PSNR and SSIM. It is inferior in terms of SNR, Entropy. With SNR, PSNR, SSIM and Entropy values, it can declare that the wavelet transform approach provides improved outcomes than other segmentation approaches, particularly for the X-ray image. Therefore, SWT can assist doctors in preparing and predicting, and it is favorable to handy application.

Table 5: The outcome of image identifiers using various segmentation approaches for four images

Data set	Techniques	SNR	PSNR	SSIM	Entropy
X-ray Image	SED	04.5745	07.9274	00.2465	01.7635
	ST	06.8532	09.5558	00.4984	01.3462
	SKC	11.9864	08.9124	00.2176	00.9300
	SW	20.6762	08.0092	00.3848	00.9934
	SET	10.4671	12.0161	00.2751	01.4833
	SWT	**21.4063**	**12.9653**	**00.5389**	**00.8987**
Ultrasound Image	SED	05.6212	06.5793	00.3745	01.8322
	ST	05.9263	09.8282	00.2684	01.7235
	SKC	12.3527	14.6840	00.2935	01.6662
	SW	12.8280	10.8201	00.7235	02.9746
	SET	08.3302	11.1663	00.3736	01.8835
	SWT	**18.6345**	**20.7243**	**00.8113**	02.6354
CT Scan Image	SED	04.7386	02.9752	00.0942	01.2734
	ST	05.9920	01.1742	00.0010	02.2412
	SKC	15.4979	01.9432	00.8131	02.0091
	SW	12.3881	01.3442	00.5028	01.9223
	SET	06.8311	01.9953	00.0592	02.0248
	SWT	**15.9903**	**02.9911**	00.8987	**01.0093**
MRI Image	SED	06.9212	01.1835	00.0926	01.3663
	ST	08.5752	01.0162	00.0107	01.8253
	SKC	26.3001	01.0072	01.0332	00.8256
	SW	12.6168	01.9953	01.4222	01.7756
	SET	20.7125	01.0376	00.1139	00.4123
	SWT	17.5211	**02.9610**	**01.8972**	00.9423

5.4 Comparison in all segmentation approaches

The comparison of the proposed method and other segmentation approaches shows in Figure 8. Figure 8 (A-D) represent the visual impact; with the help of this visualization, it can be found that the suggested SWT, and one of the other traditional methods, i.e. SET, are two methods that provide good outcomes on the four medical images. SWT also maintain character, extra background, and further details, with having more reference values. The output of all segmentation methods of four medical images as shown in Figure 8 and Table 5. With the numeric values, this was found that SNR, PSNR, SSIM are supposed to be maximum, and Entropy must be least for

improved image segmentation. Therefore, it is found that the wavelet transform shows the best outcomes for X-ray image segmentation. Also, the visual representation of Figure 8 describes that the recommended WT technique can attain a satisfactory outcome, especially X-rays, which is better than other methods. Hence, wavelet transform based image segmentation is considered the best method for X-ray image decompositions.

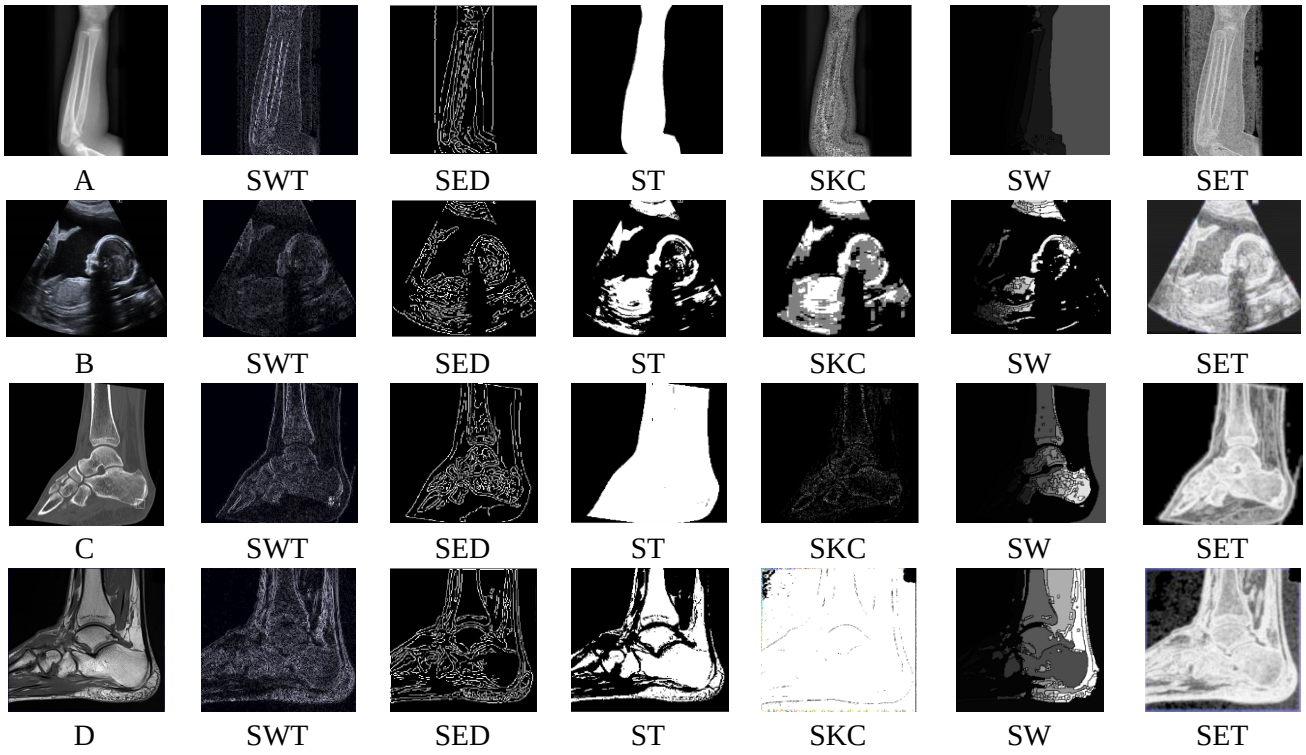


Figure 8 The outcomes of all considered image segmentation methods

VII. CONCLUSION

A single process to perform image segmentation for all kinds of medical images may be practically tough to obtain. The wavelet transform based segmentation approach for better segmentation of different medical image modalities is considered. All numeric measures are shown in Table 5, which concludes that in comparison to other traditional segmentation techniques, the segmentation technique based on wavelet transform can give the best outcome for X-ray image out of all medical images taken in the research work. Therefore, with Figure 8, it is found that the wavelet transform based image segmentation approach gives the proper segmented and critical area of interest and retain some important factors of the image modalities. Hence, the proposed method can be analysed with a few more segmentation methods for further research on fracture detection.

Acknowledgements

The authors are thankful to Dr Anil Kumar, working as a Radiologist in Vidhya Imaging Centre, Gwalior, for providing the database for research work. The whole work is performed in the research laboratory at MITS, Gwalior. Authors are also grateful to AICTE, New Delhi, for providing a research grant named NDF-RPS, Grant No. 8-10/RIFD/RPSNDF/Policy-1/2018-19 and 13 March 2019.

Contributors

The first author acted as a research coordinator, and is responsible for data collection with implementation and designing the models. All authors read and approved the final report. All authors reviewed the report and provided further contributions and suggestions.

Declaration of interests

Authors declare that they have no conflict of interest.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Conflict of Interest

All authors of this research paper have cooperated in the implementation and analysis of the study. The contents of this paper have not been published or copyrighted earlier. Also, this is not under consideration for publication somewhere else. I am one corresponding author signing on behalf of the other co-authors of this manuscript, and attesting to the above.

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Cite this article as :

Rinisha Bagaria, Sulochana Wadhwani, A. K. Wadhwani, "An Image Segmentation for Different Medical Image Modalities using Wavelet Transform Technique", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 10 Issue 1, pp. 292-307, January-February 2023. Available at doi :

https://doi.org/10.32628/IJSRST2310134

Journal URL : https://ijsrst.com/IJSRST2310134