ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

International Journal of Mechanical Engineering

DIGITAL X-RAY TIBIA BONE FRACTURE DETECTIONUSING BIFURCATE SEGMENTATION APPROACH

Abirami N

Part Time-Research Scholar (Bharathiar University),

Assistant professor, Department of Computer Application,

Sri Krishna Arts and Science College, Coimbatore

Dr.S.Gavaskar

Assistant Professor, Department of Computer Applications,

Bharathiar University, Coimbatore,

Abstract:

Image processing plays a vital role in medical disease diagnosis by using X-ray,MRI images, CT images, Mammography, Ultra Sound. But X-ray image is a very fast and cheaper than other imaging techniques. It is easy mechanism to predict the bone related diseases. It supports the doctors of physicians to easy diagnosis. In bone fracture prediction is the important task in medical image processing. Segmentation is the one of main process before classification. Segmentation is used to divide the image into sub image based on region, threshold values. The accuracy of classification depends on the accuracy of segmentation. Many researchers have worked on image segmentation but the performance is subjective to the type of body image under diagnoses. This research proposed an improved algorithm, which is called Bifurcate Segmentation(BIS). There are two stages in proposed segmentation approach. The performance of the proposed method is evaluated by the following metrics such as sensitivity, specificity, dice coefficient, Jaccard similarity. The proposed BIS algorithm achieved 98% of accuracy which performs better than other existing methods considered forstudy.

KEYWORDS: Image Processing, Segmentation, sensitivity, specificity, dice coefficient, Jaccard similarity

I INTRODUCTION

According to the study of biomedicine, the Software applications and Imaging processes are becoming more and more famous. Because they are applicable for diagnosis and treatment. So,these two fields became more beneficial for doctors, scientists, clinicians, and other users who use medical device. Software applications which are analysed naturally became the helpful tools to take out the details about the following subjects such as: organ damage, disease diagnosis, fracture detection, experimental studies, etc. In the field of biomedical, one among the project had attained the best detection method for bone fractures in any parts of the body. Later it will be informed to the physicians and radiotherapist. When the applications in this field are engaged in these operations, the required images are gained through the imaging devices in the biomedical field. The standard of images is very basic because the required details are extracted, and the features of high accuracy are also detected. Since bones are basically made using a material, which is called as matrix that helps the human to stand, gives the body shape, and it also can-do unlimited movements. So, bones are called as one of the topmost essential portions in skeletal system because it has an organic framework. It is a livingcreature which approximately contains 70% minerals, 22% proteins and 8% of water (Bayram and Çakıroğlu, 2016). Bones are said to be too hard and strong because they carry huge quantity of calcium. When the force come from outside of the body, it will be broken or cracked directly or indirectly due to the hardness present in the bone (Marolt et al., 2010) (Veysi, 2017). Fracture means the splitting or weakening of the bone's integrity. This happens in the bone because of the interior and exterior forces (Wang and Puram, 2014).

Nowadays, fractures in the bone is viewed using biomedical imaging devices like X-ray, MRI (Magnetic Resonance Imaging), Scintigraphy and CT (Computerized Tomography). Recently, in medical imaging systems, DICOM (Digital Imaging and Communication in Medicine) is mostly used because it consists of more details about the patients while compared to other image formats. Those formats include .jpg, .jpeg, .png, .tiff. Here, .tiff has also chosen in the digital images (Öztürk and Kutucu, 2017). Digital image processing approach focuses toexpose the wanted and researched details for the users by filtering the digital images.

II IMAGE SEGMENTATION AND ITS TYPES

The sole purpose of performing segmentation in the image is to extract the infected region from the original image of kidney. There are multiple ways to segment the infected portion from the infected region. The background images from the infected images can be removed by utilizing the background subtraction technique, which is one of the efficient methods in eliminating the background.

This section also discuss the segmentation and its types that used by various researcher to segment the image. Some of them are region based, thresholding based, clustering based, and classifier.

Region based

In this method based on the common property image is divided into various region. There are two logics: i. fusion the pixel based on their property like histogram, color, threshold value. ii. second one focused on non-uniform area are broken into smaller areas which may be identical. Assimilation starts from an identical region. Main drawback of this method is computation time will be long **(Maggie Moran, Melissa Myers(2022).**

Threshold based

This is exceptionally straightforward method. It is used to create a binary image. Binary image is created by using gray image thresholding. To split the image into smaller area or portion threshold value is used. Converting pixel to two or more classes from source imageis called segmentation. If more than two classes then the result will be several binary images.The binary images will help to reduce the complexity of data and processing time **Ram Kumar Madupu, et.al(2020).**

Classification based

It is based on supervised method. It classify the pixel based on predefined patterns. It segment the image based on predefined pattern. Nearest neighbor classifier is simple classifier. In which each pixel is classified based on closest intensity. K-nearest neighbor is acommon approach in the segmentation. But it needs training process. **Abbas et.al(2021).**

Clustering based

Clustering technique uses the region segmentation to arrive at sets or clusters of pixels having similarity in existence with respect to the feature space **(Ma, Y., & Luo, Y. (2021))**

There are two approaches used in Clustering-based techniques

i. K-means clustering-It is used to solve the low-level segmentation tasks. This algorithm is convergent and computationally efficient.

ii. Fuzzy Clustering-It is effectively used in image processing pattern recognition and fuzzy modelling.

III RELATED WORKS

Bagaria et.al(2021) deals with the process of detecting the fracture present in the human bone by applying image processing method i.e., with the help of X-ray images. Medical images particularly X-ray images are used to diagnose whether the bone has any fracture which is

defined using two methods. One is wavelet transform based segmentation and other is neural network-based classification method. In this study, there are various image segmentation methods are available, but while comparing the images with other conventional segmentation method, using Wavelet Transform based segmentation explicit specific meaning. Here are also some statistical image identifiers are present namely, Signal to Noise Ratio (SNR), Peak Signalto Noise Ratio (PSNR), Structural similarity (SSIM), and Entropy etc. The newly proposed techniques have notable benefits, especially in medical image segmentation. The Haar Wavelet demonstrated maximum correlation with the regarded images. So, based on the Wavelet Transform algorithm, the accurate vertical, horizontal and diagonal elements can break down the X-ray images. The vertical element in the Wavelet Transform has chosen the third level decomposition because it reveals less Entropy. The Error Backpropagation Neural Network (EBP-NN) allocated with the captured medical images from wavelet-based segmentation technique. Thus the neural network has been fitted with fractured and non-fractured images then it is checked and tested on different X-ray images. An EBP-NN classification system withthe structure of 1024–22-2 provides the maximum percent of accuracy. So, thus the newly proposed system helps for fracture detection in bone perfect quality of images.

Bekkanti et.al (2020) developed X-ray images for diagnosing bone fractures in the body. Dueto quick scan and lowest price most of them prefer X-Ray images when compared to MRI and CT scan. The main aim of this paper is to automate the detection of bone fracture. For the purpose of extracting the features, an efficient Computer-Aided Detection (CAD) has been proposed. The extracted features are used for diagnosing the edges, and fractures. And Graph cut Method is proposed for detecting the corners in the images. To make these algorithms, totally 500 bone X-ray images are collected from OMNI Hospitals located at Visakhapatnam. As the result, 94% of accuracy is obtained which is very much better when compared to any other automated fracture detection method. This will be helpful for the orthopaedics to detect the fractures in the beginning stage with a minimal error rate. And it also helps to take fast decisions in the need of surgery.

Tandeep Kaur .et.al(2016) proposed a new technique that automatically detects fracture in the bone whereas it is entitled as "Bone Fracture Detection using Image Segmentation". This

technique uses three algorithms, such as: segmentation, FRFuzzy c-means. An effective algorithm is described based on thresholding and morphological operators. As a result, 89.6% accuracy and 93.1% precision with the sensitivity of detecting fracture is attained which is equal to 95.5%.

San Myint et.al(2016) proposed to detect the fracture in the bone using image processing method. This system uses canny edge detection technique to detect the lines in the image using segmentation and Hough transform methods. In this system, three important steps are used, such as: pre-processing, segmentation, and fracture detection.

Luis Nascimento.et.al.(2015) explained about the new technique to find the lines present inthe bone with ultrasound images with the help of computer-aided identification. The proposed strategy contains noise reduction which is tracked using the bone line identification and lastly identification of available fractures on the bone line. As a result, 89% of fractures (within 44 images) were diagnosed perfectly.

Kamil Dimililer.et.al.(2017) introduced a brilliant classification system which is suitable for detecting fracture in the bone. This new method uses back propagation neural networks. This includes two stages: (1) image processing, (2) classification phase. This concludes using SIFT algorithm with 91.4% of accurately yielded images and using BPNN algorithm, the accuracyof 94.3% is attained.

Malashree.et.al.(2017) introduced a new algorithm to detect the radius of fracture in the bone using Automatic Hough transformation. This proposed system consists of three major steps, such as: image pre-processing, segmentation, feature extraction and detecting the radius of bone fracture. This paper used MATLAB 2018 for programming. This method results 90% accuracy (within 20 images).

4. PROPOSED METHOD

Segmentation plays a vital role in fracture detection in healthcare. Generally, the bone parts surrounding with tissues or flesh in x-ray of long bone image. Due to this reason segmentation of bone fracture is difficult. Intensity range of both flesh and bone region may overlap. This makes the inaccurate segmentation. So the extraction of bone from two different background elements. Generally, in X-ray images flesh are appeared as dark gray and bones are appeared as bright gray. After the denoising the fracture area separated by segmentation. This research work proposed two stages of segmentation. The first stage is Extrication Segmentation and second stage is Bone Boundary Segmentation. In the Extrication Segmentation method, initially a reasonable random threshold value is applied to the training set. Then the mean of the pixel values under and overhead this threshold is calculated. Finally, the mean of the two means is calculated and the value is used as the new threshold value. This process is continued until the difference between two consecutive threshold values is smaller than a preset minimum. In Bone Boundary Segmentation process, an edge prediction is done by using proposed crafty edge prediction method. In this research work, a total of 50 X-ray images were taken as training data for the proposed algorithm.

Stage 1: Extrication Segmentation

To separate the flesh and bone we have to separate the foreground and background. To separate the foreground and background Midpoint thresholding is proposed in this research work. Based on the intensity of the pixel gray area intensity values are organized into similar zones. The gray regions are separated from the black background to separate the flesh. The remaining area will be brighter area that is bone.. In this method initially apply reasonable random threshold value. Then calculate the mean of the pixel values under and overhead this threshold, respectively. Finally, compute the mean of the two means and use this value as the new threshold value. Continue until the difference between two consecutive threshold values is smaller than a preset minimum.

Stage 2: Bone Boundary segmentation

After the flesh and bone segmentation, the bone is separated, an edge prediction is done by using proposed crafty edge prediction method. In this method gradient operation has been done for both horizontal(x) and vertical(Y) directions and predict the magnitude of the edge and direction of the Gradient(G). The proposed method will predict the following types of edges such as: step, ramp, roof and ridge type edges in bone. it is shown in the figure 1.

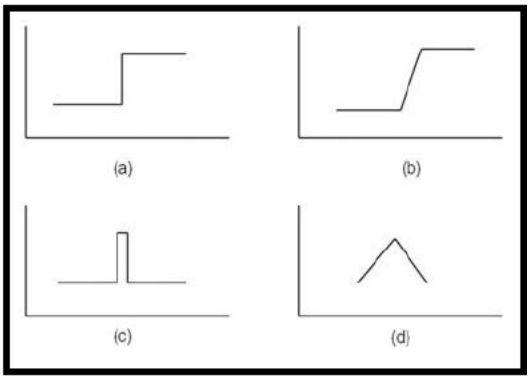

Fig. 1. Type of Edges (a) Step Edge (b) Ramp Edge (c) Line Edge (d) Roof Edge

If value of G continuously increased then edge will be RAMP if value of G equal to threshold (Th) then edge will be step, if G=distance then edge will be line, finally G=convex then edge will be Roof .So it will predict tiny cracks or fractures in bone. Figure 2 shows the implementation results of proposed work with input image after stage1 and stage 2 segmentation, the red color box shown the segmentation of fracture.

*Algorithm**: Bifurcate Segmentation***

Input *: Denoised Long bone X- Ray Image*(I_m)

Output: *Fracture Segmented*

Stage 1: Extrication Segmentation

Step1: Select an initial estimate for T

Step2: Segment image using T −→ Group G 1 (values > T) Group G 2 (values < T)

Step3: Compute mean intensity values for G 1, G 2 −→ m 1, m 2

Step4: Compute a new threshold value T = 1 2 (m 1 + m 2)

Step5: Repeat (2) through (4) until the difference in T in successive iterations is smaller than Δ T

Stage 2: Bone Boundary segmentation

Step 6: predict the magnitude of the edge and direction of the gradient by Eqn 1,2 and 3

Magnitude – both direction horizontal (G_x) and vertical directions (G_y)

$M= G_x+ G_y$ ->(1)

$G=\sqrt{Gx^2 + Gy^2}$ ->(2)

direction of the gradient $\alpha=tan^{-1}\frac{Gx}{Gy}$ ->(3)

Step7 : Compare the gradient value

- *(i) If G =increasing then → Edge prediction (RAMP)*
- *(ii) If G=Th then→ Edge prediction(STEP Edge)*
- *(iii) If G= Distance → Edge prediction(LINE)*
- *(iv) If G= convex→ edge prediction(ROOF)*

Step 8: Non-Maximum Suppression

Step 6: Hysteresis Thresholding

if $G < t_{low}$: discard the edge

if $G > t_{hign}$: discard the edge

else : keep the edge

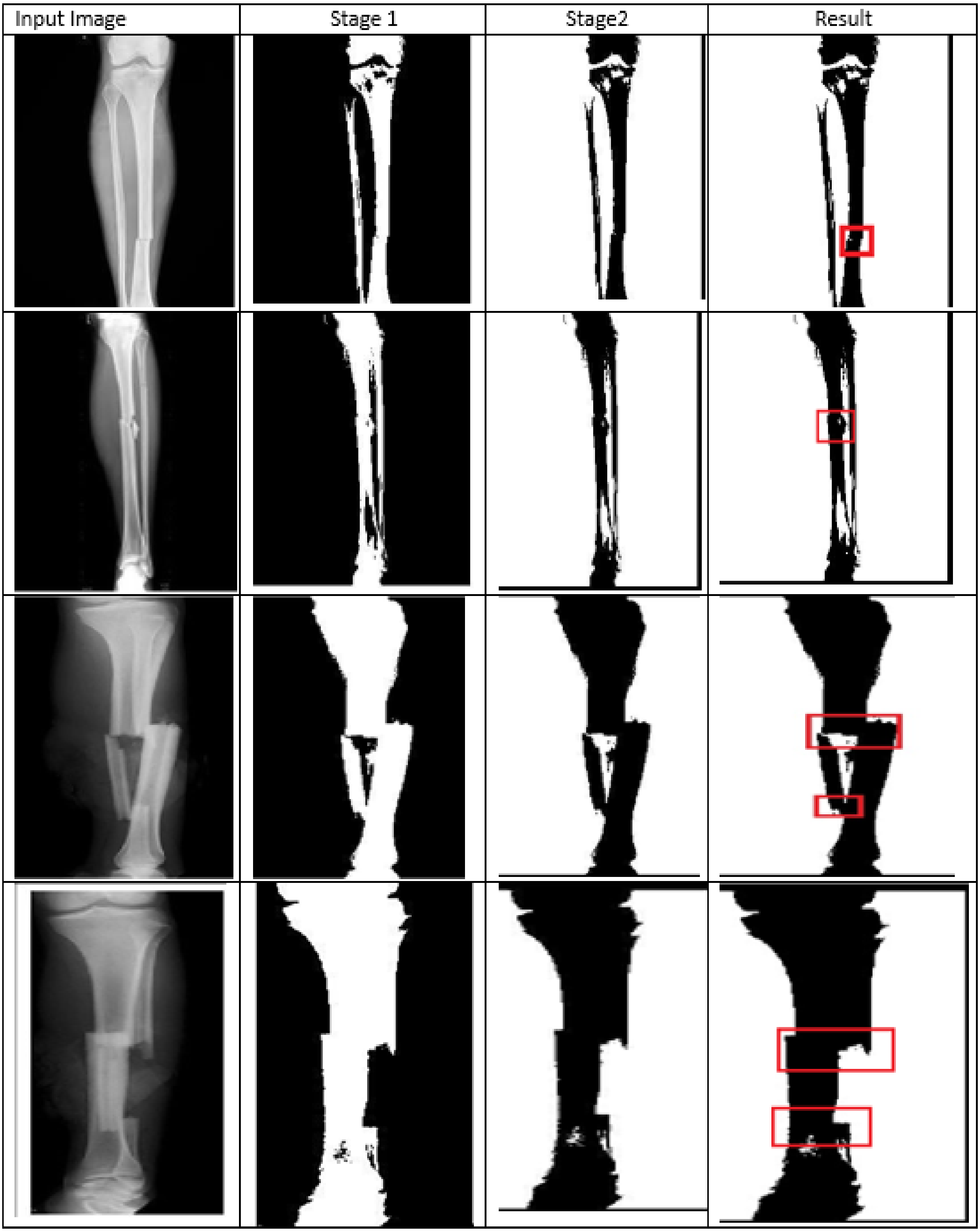

Figure 2 Result of Proposed Method

IV. PERFORMANCE EVALUATION METRICS

In order to signify the performance of the algorithm developed for segmentation, the performance is measured using the metrics — such as sensitivity, specificity, dice coefficient, jacquard similarity, accuracy and recall. The results obtained out of the proposed method is equated with the metrics measured with the existing method, such as Graph cut method and FRFCM.

A. Accuracy

The metric which defines how accurate a system can predict is measured by Accuracy. Higher the value of accuracy the model is said to be more robust and performs better. Accuracy can be obtained by using the following equation (4)

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (4)$$

Here True and negative is TN, True and positive is TP, False and negative FN and False and positive FP. The Hypothesis of the segmentation is to find the infected region from the fruit surface.

True Positive (TP) defines the ratio of Correctly recognized as Infected Region prediction ratio. **False Positive** (FP) is the ratio of incorrectly recognized as Infected Region. **True Negative (TN)** is the ratio of correctly recognized as uninfected region. **False Negative (FP)** is the ratio of incorrectly recognized as uninfected region.

$$FP = \frac{pixels\ falsely\ segmented\ as\ foreground}{Total\ number\ of\ pixels}$$

$$FN = \frac{pixels\ falsely\ segmented\ as\ background}{Total\ number\ of\ pixels}$$

$$\frac{pixels\ Correctly\ segmented\ as\ foreground}{} \quad (5)$$

□(6)

□(7)$TP =$

$Total\ number\ of$ pixels

□□□

A. Sensitivity and Specificity

Sensitivity and specificity are statistical metrics. They are denoted by the formulae in equation (9) and equation (10) respectively. Sensitivity measures the ratio on the number of the infected area, which was recognized adequately with a disease by the algorithm.

$$sensitivity = \frac{TP}{TP + FN} \rightarrow (8)$$

Specificity indicates the assessment, which is the number of uninfected areas whichwere adequately recognized as not having a disease by the algorithm.

$$\text{Specificity} == \frac{TN}{TP + FN} \rightarrow (9)$$

B. Dice Coefficient (DC)

A statistical method used to evaluate the similarity of two shapes is termed as the Dice coefficient. The accuracy of segmentation result between the proposed segmentation approach and the Existing segmentation approach is evaluated by the Dice Coefficient.

It is the ratio among double the intersection of the regions obtained by computerized segmentation X and Y to the Union of the Segmented X, Y region, and it is described as follows.

$$Dice = \frac{2|X \cap Y|}{|X| + |Y|} \quad □ (10)$$

C. Jaccard Similarity (JS)

A statistical formula to measure the difference of sample sets is termed as Jaccard similarity. The similarity among sample sets is evaluated by it. The ratio of intersection between the set A and B to Union of set A and B is termed as Jaccard Similarity as shownin the equation no. 12.

$$JS = \frac{A \cap B}{|A \cup B|} \quad (11)$$

V. RESULTS AND DISCUSSIONS

This section provides results obtained through experimenting 3 sample X-ray of long bone images which are denoised and fed as the input to the proposed method. Table 1 shows the values of parameters defining the performance metrics such as sensitivity, specificity, dice coefficient, Jaccard similarity is measured for existing segmentation methods such as Graph cut and FRFCM to the proposed **Bifurcate Segmentation(BIS)** method. Finally, the Accuracy value is generated for each model.

It is observed that Image-1 has 0.98 as sensitivity, 0.97 as specificity and .98 as Dice coefficient and .97 as Jaccard Similarity result and an accuracy of 98.73 for the proposed method which is relatively higher than Graph-cut with 78.47 and FRFCM with 78.27 as Accuracy. In Image-2 the sensitivity is 0.97, the specificity is 0.99, Dice coefficient is 0.95, Jaccard similarity is 0.96 and an accuracy of 98.68 which is relatively higher than Graph-cut with 73.43 and FRFCM with 74.21 as Accuracy.

In Image-3 the sensitivity is 0.98, the specificity is 0.97, Dice coefficient is 0.98, Jaccard similarity is 0.98 and an accuracy of 98.65 which is relatively higher than Graph- cut with 75.43 and FRFCM with 75.21 as Accuracy. In Image-4 the sensitivity is 0.98, the specificity is 0.97, Dice coefficient is 0.98, Jaccard similarity is 0.98 and an accuracy of 98.65 which is relatively higher than Graph- cut with 75.43 and FRFCM with 65.21 as Accuracy. In Image-5 the sensitivity is 0.98, the specificity is 0.97, Dice coefficient is 0.98, Jaccard similarity is 0.98 and an accuracy of 98.65 which is relatively higher than Graph- cut with 75.43 and FRFCM with 75.21 as Accuracy.

Table 1 Comparison of Metrics

Test Image	Method	Sensitivity	Specificity	DC	JS	Accuracy
Image1	**BIS**	**0.985**	**0.974**	**0.986**	**0.973**	**98.73**
	Graph-cut	0.773	0.755	0.784	0.784	74.47
	FRFCM	0.542	0.787	0.555	0.535	64.27
Image 2	**BIS**	**0.978**	**0.996**	**0.956**	**0.967**	**98.68**
	Graph-cut	0.723	0.731	0.776	0.744	73.43
	FRFCM	0.578	0.543	0.589	0.567	64.21
Image 3	**BIS**	**0.985**	**0.978**	**0.989**	**0.987**	**98.65**
	Graph-cut	0.783	0.679	0.756	0.687	74.43
	FRFCM	0.556	0.556	0.598	0.557	64.21
Image 4	**BIS**	**0.995**	**0.966**	**0.988**	**0.985**	**98.74**
	Graph-cut	0.773	0.689	0.766	0.677	74.53
	FRFCM	0.557	0.586	0.578	0.567	64.61
Image 5	**BIS**	**0.983**	**0.987**	**0.977**	**0.987**	**98.55**
	Graph-cut	0.763	0.669	0.756	0.697	74.43
	FRFCM	0.566	0.546	0.578	0.567	64.11

Comparison of sensitivity values obtained in segmenting the image by Graph-cut. FRFCM and **BIS** is graphically represented in Figure 3.Specificity is the measure on correctly recognizing the uninfected region in the fruit, Higher the specificity better the performance. Comparison of specificity values obtained in segmenting the image by Graph-cut. FRFCM and **BIS** is graphically represented in the figure 4 Similarly the Similarity measures Dice Coefficient and Jaccard Similarity Values are obtained and their value are graphically compared in Figure 5 and Figure 6 respectively.

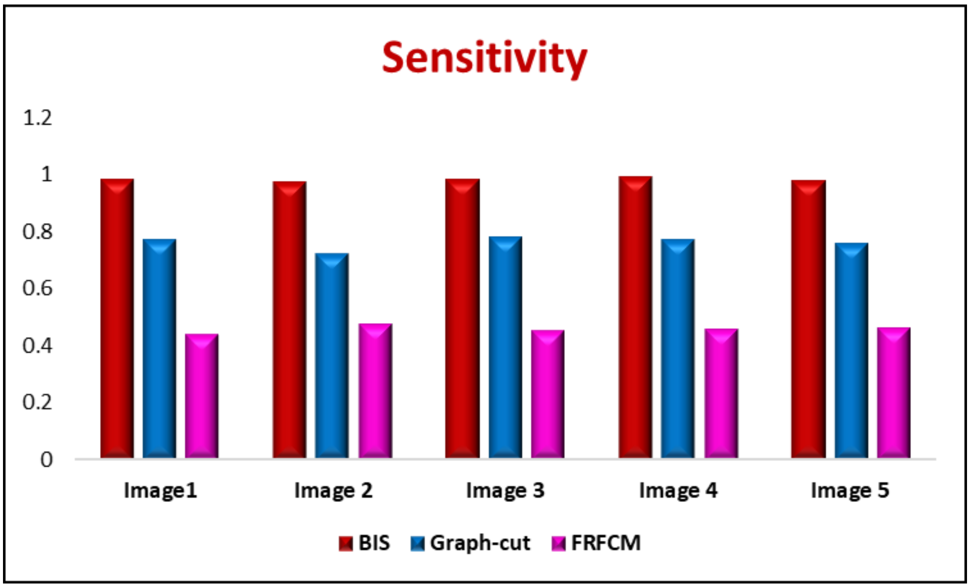

Figure 3: Comparison of Sensitivity of Segmentation Algorithms

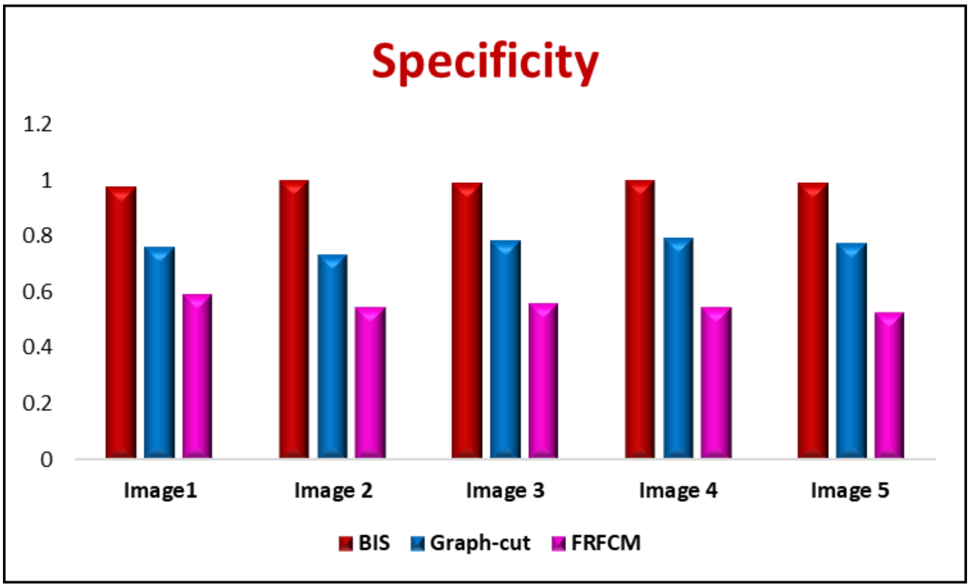

Figure 4: Comparison of Specificity of Segmentation Algorithms

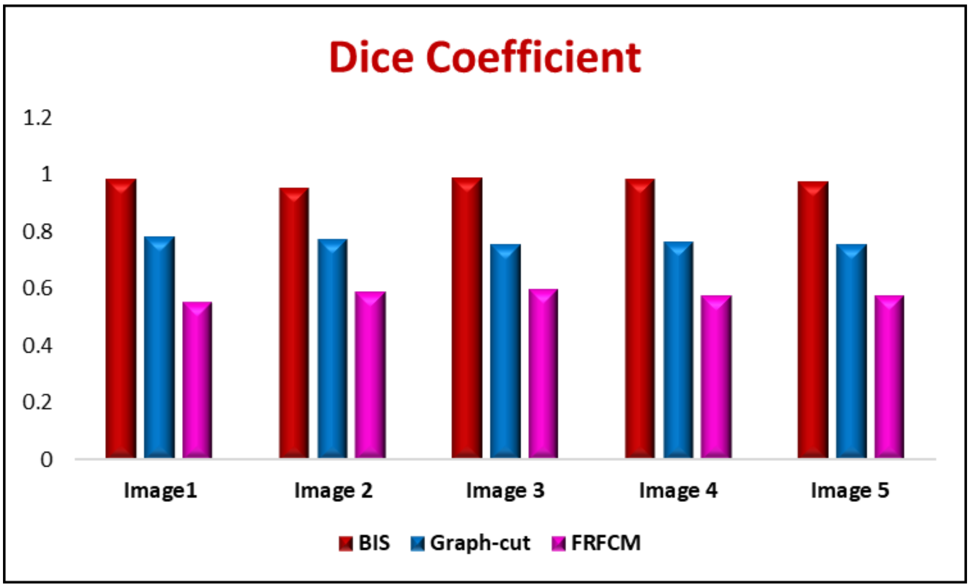

Figure 5: Comparison of Dice Coefficient of Segmentation Algorithms

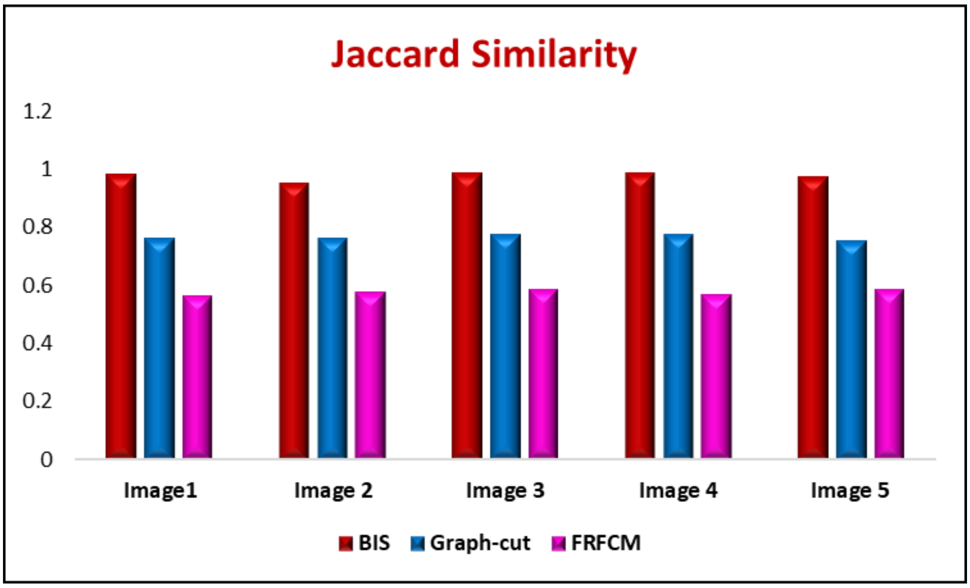

Figure 6: Comparison of Jaccard Similarity of Segmentation Algorithms

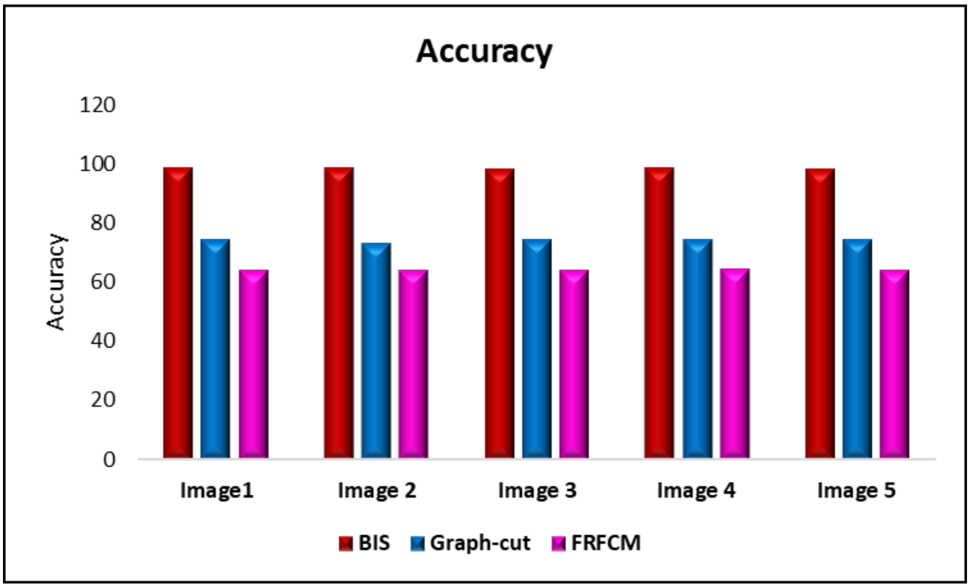

Figure 7: Comparison of Accuracy of Segmentation AlgorithmsVI.CONCLUSION

The proposed segmentation algorithm is based on threshold segmentation method, which helps the user to classify the visual difference of segmenting the infected region from the bone surface. Fractures are extracted from the image based on the density of the pixel. Five metrics, including the specificity, Accuracy, Dice Coefficient, Sensitivity and Jaccard Similarity, are used for evaluating the performance of the proposed BIS algorithm achieved 98% of accuracy which performs better than other existing methods considered for study.

References

[1] Bekkanti, A., Karimunnisa, S., Gogulamudi, S., Kumar, K. T. P. S., & Basha, C. Z. (2020, September). Enhanced computerized bone fracture detection using harris corner detection. In *2020 International Conference on Smart Electronics and Communication (ICOSEC)* (pp. 572-576). IEEE.

[2] Bagaria, R., Wadhwani, S., & Wadhwani, A. K. (2021). A wavelet transform and neural network based segmentation & classification system for bone fracture detection. *Optik*, *236*, 166687.

[3] Tandeep Kaur,Anupam Garg, “Bone Fracture Detection using Image Segmentation”, IJETT, June 2016, vol.36, pp 82-87

[4].San Myint, Aung Soe Khaing ,Hla Myo Tun, “Detecting Leg Bone Fracture in X-RayImages”, IJSTR, June 2016, vol.5,Issue 6, pp 140-144

[5].Luis Nascimento, M.Graca Ruana, “Computer-Aided Bone Fracture Identification basedon ultrasound images”, IEEE, February 2015

[6].Kamil Dimililer, “Intelligent Bone Fracture detection system”, ICSCCW, August 2017,vol.120, pp 260-267.

[7] Malashree,G.Narayana Swamy, “Automatic Detection of Radius of Bone Fracture”, IJRET, June 2017, vol.4, Issue 6, pp 1796-1799.

[8] Dhiraj B. Bhakare, Prajwal A.Jawalekar, Sumit D.Korde, “A Novel Approach for Bone Fracture Detection Using Image Processing”, IRJET, February 2018, vol. 5,Issue 2, pp 193- 195.

[9] Harmanpeet Kaur, Amit Jain, “Detection of Fractures in Orthopedic X-Ray Images”,

March 2017, vol. 8, pp 545-551

[10] Cephas Paul Edward .V, Hilda Hepzibah S, “A Robust Approach for Detection of the type of Fracture from X-Ray Images”, IJARCEE, March 2015, vol.4, Issue 3, pp 479-482

[11] Manjari, G.S.N.S.Ajay Kamal, U.N.Subhadra Devi, Dr.M.Satyanarayana, “Detection and classification of Bone Fractures Using GLC Features”, IJRASET, September 2017, vol.5,

Issue 9, pp 581-586

[12] Ozgur Ozturk, Hakan Kutucu, “Detection of bone fractures using image processing techniques and artificial networks”, IEEE, September 2017

[13] Irfan Karthik, “A study of Various Bone Fracture Detection Techniques”, IJECS, May 2017, vol. 6, Issue 5, pp 21418-21423

[14] Lu Ming, “Image Segmentation algorithm research and improvement”, IEEE, August 2010, vol.5, pp 211-214.

[15] Oishila Bandyopadhyay,Arindam Biswas, Bhargab B.Bhattacharya, “Long-Bone Fracture Detection in Digital X-ray Images Based on Concavity Index”, IWCIA 2014, vol.8466, pp 212-223

[16]A.Swarnalatha, Dr.M.Manikandan(2017), “Review of Segmentation Techniques for Intravascular Ultrasound (IVUS) Images”, ICSCN, March 2017.

[17] Ma, Y., & Luo, Y. (2021). Bone fracture detection through the two-stage system of crack-sensitive convolutional neural network. *Informatics in Medicine Unlocked, 22,* 100452.

[18] Abbas, W., Adnan, S. M., Javid, M. A., Ahmad, W., & Ali, F. (2021). Analysis of tibia-fibula bone fracture using deep learning technique from X-ray images. International Journal for Multiscale Computational Engineering, 19(1).

[19] Ram Kumar Madupu, et.al(2020)., “Detection of Bone Fractures Automatically with Enhanced Performance with Better Combination of Filtering and Neural Networks”, IEEE Xplore: 01 September 2020.

[20] Maggie Moran, Melissa Myers(2022), “Use of ultrasonography for identification of long bone fractures”, Visual Journal of Emergency Medicine, Volume 28, July 2022, 101381