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Research paper

Early detection of joint abnormalities from ultrasound images

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Abstract

Musculoskeletal ultrasound is effective for the early detection of joint abnormalities like erosion, effusion, synovitis and inflammation. Computer software is developed for segmentation of joint ultrasound image to diagnose the defect. The objective of developing this paper is to achieve early diagnosis of joint disorders by segmentation of ultrasound image with different algorithms. Ultrasound machine with high resolution probe can be used for development & findings of joints by the orthopaedician, rheumatologist and sports physician. These find-ings are done by processing the ultrasound images of patient joint using modern image processing techniques. Therefore algorithms has been designed and developed for analysis of medical images that is musculo ultrasound image based on optimization approach, using genet-ic algorithm and PSO algorithm. To improve the better quality of the image many improvisation techniques have been introduced. Hence, these algorithms perform better segmentation and identification of joint abnormalities. The analysis of ultrasound image is directly based on image segmentation steps, pre-processing, filtering, feature extraction and analysis of these extracted features by finding the output using different optimization techniques. In proposed method, efforts have been made to exhibit the procedure for finding and segmenting the mus-culoskeletal images of abnormal joints. The present approaches are segmentation operation on ultrasound images by applying genetic and PSO algorithm. The comparison between these algorithms is done, such that the algorithm itself analyses the whole image and perform the segmentation and detection of abnormalities perfectly

Keywords: *Ultrasound; Joint Abnormalities; Genetic Algorithm; Particle Swarm Optimization.*

1. Introduction

The term Image processing is a tool in which the data's from the image are converted into digital form and different types of mathematical operators are applied. This technique is mainly used for enhancing the image. This method is also known as picture processing [1].To capture the image of a joint, musculoskeletal ultrasound (MSUS) is used. Ultrasound imaging is more preferred for joint imaging other than X-ray, CT scan and MRI [2].The methods going to be applied in this process are image segmentation methods specifically genetic algorithm (GA) and PSO algorithm. These methods are used for detecting the joint abnormalities from an ultrasound image. Initially, the image obtained from the patient is preprocessed and the noises are removed. Segmentation is applied to the image which is partitioning the image into many segments for details [3].Two algorithms used with this segmentation is GA and PSO algorithms. Genetic algorithm is a search based optimization technique which is guided by principle of evolution and natural genetics. PSO algorithm refers to an optimal search technique based on behavior of bird flocks [4]. Before applying these algorithms, other segmentation steps like preprocessing, contour evaluation should be done [5]. Filters like bottom hat and top hat filters are used to remove noises and increase contrast. Finally, output is obtained for this segmentation of ultrasound images to find the defects in the joint.

2. Materials and methods

The techniques to be applied in this project are genetic algorithm, PSO algorithm along with other segmentation steps [6]. These algorithms are used for detecting the abnormalities better in an ultrasound image of joints [7]. First, the input joint US image is pre-processed, contour evaluated and noises has been removed [8]. Cropping can be done if needed, for concentrating on particular region of the joint. Watershed segmentation and disc based segmentation are applied for the segmentation of joint image for better division of segments. After this, the genetic or PSO algorithm is applied to the joint US separately. Size distribution is done for each image of normal and abnormal joint US. Finally, the segmented part is indicated in original image in each techniques and these techniques are compared with its output images.

3. Methodology

3.1. Spectral clustering

This model is prominently used for dividing the images based on Eigenvector values. The N cut method is mainly used to divide the given images. The Ultrasound images can be applied with N Cut method. However, combining this method with anisotropic diffusion filter gives out the best results for MRI images [9].Three

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parameters are present. Difpixels is defined as the first parameter to specify the maximum difference between two pixels. The second parameter is threshold and third one is window size and it is kept static. This type of clustering is used in segmenting amniotic fluid which is present in fetus during ultrasound imaging. N cut technique is mainly used to get best segmented output by selecting clusters. Here, in this technique the user using can select the area to be segmented and then calculating the geometric properties is performed. For this work, the boundaries of the segmented regions are compared.

3.2. Watershed segmentation

This type of segmentation is used in Image processing. When the image to be eliminated is touched it gets cut off automatically. Fattest regions of the image are found using this algorithm. The major disadvantage of this method is over segmentation[10].The disadvantages are It is very sensible to noise and those noise cannot be removed ,Poor detection, Without any obvious peaks or with broad and flat valleys it does not work well for image.

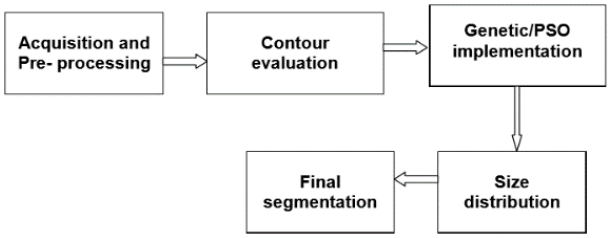

Fig. 1: Block Diagram of Segmentation.

The block diagram consist of the following steps

3.3. Acquisition and pre-processing

The main purpose of this block is to convert the image into digitized form and then it will be displayed and image enhancement is done. The general goal for image acquisition is to bring the image into the computerised domain of computer, where they can be displayed and then manipulated and altered for enhancement [11]. Four processes are involved in image acquisition

- Input
- Display
- Manipulation
- Output
- Manipulation is defined as converting the image to numerical values.

3.4. Contour evaluation

It is used for making a framework for describing an object outline from 2 D image which is known as snake models.

3.5. Genetic/PSO implementation

Genetic algorithms are the most powerful tool for optimization techniques. It is broadly used in image enhancement, segmentation, feature extraction and classification [12].

3.6. Size distribution

Steps involved in size distribution are Individual images should be labelled with various colors. Those individual images must be labelled with various colours. Histogram method is used to extract area values from the objects identified. To define and describe the backgrounds which are not uniform, Morphological method is used. For dividing, segmenting and removing the background Image subtraction is used. Finally the new values will be extracted and comparison of values will be done.

4. Methodology

4.1. Genetic algorithm

Genetic By using the concepts of inheritance, recombination, selection and inheritance Genetic algorithms have been introduced [13].Genetic algorithms have been developed by using evolutionary algorithms. The Genetic algorithm was termed by Holland. It is a globally algorithm which is selected quickly through quick search. This algorithm is based on natural evolution. It has a high efficient output [14].Many operators are present namely selection, mutations, cross over. It does not have a clear/definite pattern and improvement for a solution. It needs few components [15].The solution of the concerned member should be represented properly. Fitness function is defined as the calculation of a candidate solution. Mutation is defined as the slight change in a candidate to obtain a better candidate [16].

5. Results and discussion

5.1. PSO algorithm results

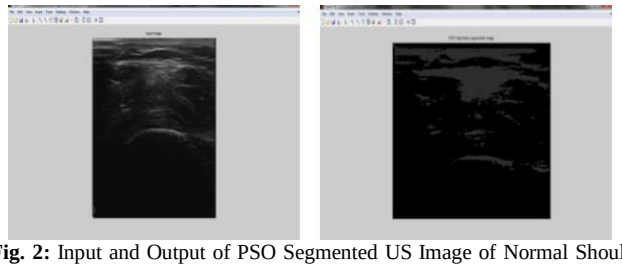

Fig. 2: Input and Output of PSO Segmented US Image of Normal Shoulder Joint.

Above fig.2, shows the PSO segmented output of normal shoulder US image. we have collected the image from a 50 years old patient . The image we have taken is the sub scapular part of shoulder which result in most of the functional activity of the particular joint. After applying the PSO algorithm, the image shows highlighted synovial boundaries and shows normal thickening.

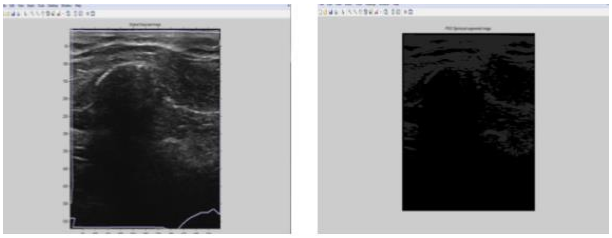

Fig. 3: Input and Output of PSO Segmented US Image of Abnormal Shoulder Joint.

Above Fig.3.shows the segmented output of abnormal shoulder US image after applying the PSO algorithm. This is an image of 55 years old patient with defecting sublenoid cavity of shoulder joint. After PSO segmented, the output images show the cavity and the position of dislocation in the cavity.

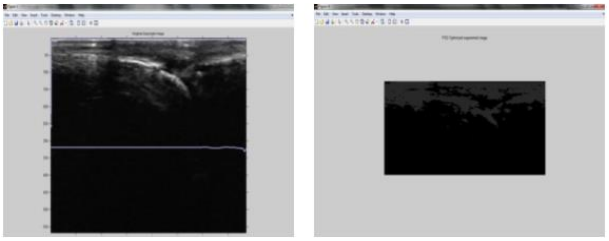

Fig. 4: Input and Output of PSO Segmented US Image of Normal Metacarpophalangeal Joint.

The above Fig.4 shows the segmentation output of PSO segmentation in normal metacarpophalangeal US joint. This image has been collected from 21 years old person. We know that metacarpophalangeal joints are condyloid kind, formed by the reception of the rounded heads of the metacarpal bones into shallow cavities on the proximal ends of the phalanges . The input is US captured image of metacarpophalangeal joint of first digit. The PSO segmented output shows the layers and synovial cavity of the particular joint.

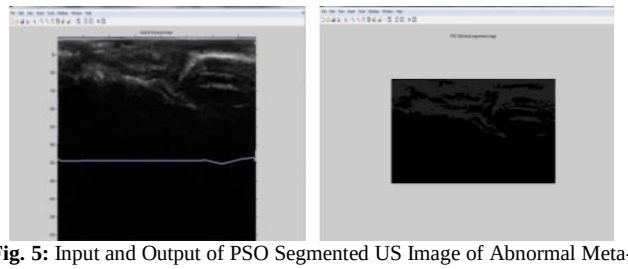

Fig. 5: Input and Output of PSO Segmented US Image of Abnormal Metacarpophalangeal Joint.

The above image is the output image of PSO algorithm application in segmentation of US image of abnormal metacarpophalangeal joint. The abnormality of the joint is subluxation in the first metacarpophalangeal joint of 55 years old patient. The segmented output shows deviation in the joining point of metacarpal and phalanx, which diagnose the defect of subluxation.

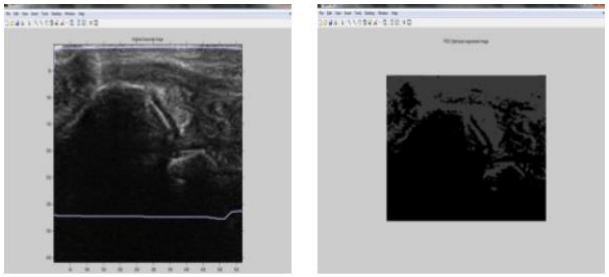

Fig. 6: Input and Output of PSO Segmented US Image of Abnormal Ankle Joint.

The above image Fig.6 is the output image of applying PSO algorithm in segmentation of US image of abnormal ankle joint. The abnormality in this image is the inflammation of ligament of ankle bone joint of 35 years old patient. The output shows differenciation between the inflammated region and the bone clearly after applying this algorithm.

5.2. Genetic algorithm results

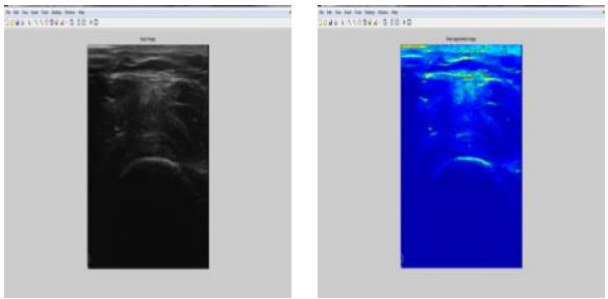

Fig. 7: Input and Output Of GA Segmented US Image of Normal Shoulder Joint.

The above image is the output of application of segmentation using genetic algorithm in normal shoulder joint. We have collected the image from a 50 years old patient. The image we have taken is the sub scapular part of shoulder which result in most of the functional activity. After GA segmentation, we can identify the synovial layer and the other characteristics of shoulder US image easily. Thus, we can find that there is no abnormality in the image.

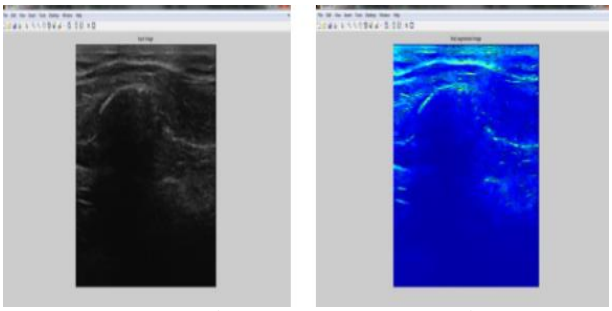

Fig. 8:. Input and Output of GA Segmented US Image of Abnormal Shoulder Joint.

The above image shows segmented output of normal shoulder US image after applying genetic algorithm. . This is an image of 55 years old patient with defecting sublenoid cavity of shoulder joint. After GA segmentation, the output images shows the cavity and the position of dislocation in the sublenoid cavity.

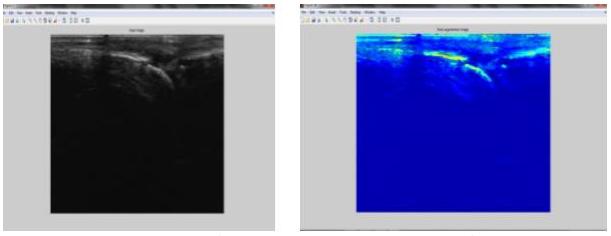

Fig. 9: Input and Output of GA Segmented US Image of Normal Metacarpophalangeal Joint.

The above image Fig.9 shows the segmentation output of GA segmentation in normal metacarpophalangeal US joint. This image has been collected from 21 years old person. . The input is US captured image of metacarpophalangeal joint of first digit. The GA segmented output shows the layers and synovial cavity of the particular joint.

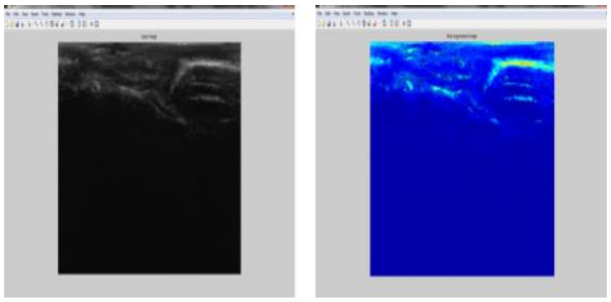

Fig. 10: Input and Output of GA Segmented US Image of Abnormal Metacarpophalangeal Joint.

The above Fig.10 shows the output image of PSO algorithm application in segmentation of US image of abnormal metacarpophalangeal joint. The abnormality of the joint is subluxation in the first metacarpophalangeal joint of 55 years old patient. The GA segmented output shows deviation in the joining point of metacarpal and phalanx, which diagnose the defect of subluxation.

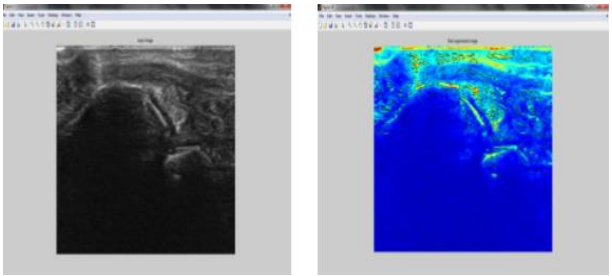

Fig. 11: Input and Output of GA Segmented US Image of Abnormal Ankle Joint.

The above image Fig.11 shows the output of segmentation of US image of abnormal ankle joint after applying GA. The defect in the input image is that inflammation in the ligament of the ankle joint, of a 35 years old patient. The output image gives details of thickness of swelling or inflammation in ligament and can differentiate between ankle bone and the ligament inflammation.

Table 1: Comparison Analysis

Ultrasound image	Genetic Algorithm	PSO Algorithm
Normal shoulder joint	223.128	368.77
Abnormal shoulder joint	193.566	334.45
Normal metacarpophalangeal joint	424.977	434.868
Abnormal Metacarpophalangeal joint	443.776	448.097
Abnormal ankle joint	115.659	227.184

The above table shows the computation time of segmentation of different joint ultrasound images by using genetic and PSO algorithm. As we see, the genetic algorithm has less computational time when compared to PSO algorithm. Therefore, genetic algorithm is better in time consumption than other methods, in the case of ultrasound images.

6. Conclusion

This project is efficient method for detecting the abnormalities in joint US images. The proposed approach gives promising result in finding the defects in the joint US image. Most of the existing methods can segment and detect the abnormal images. Whereas this proposed method with help of effective image processing techniques, can able to diagnose the defects in the joint earlier. Based on the experimental results, PSO and GA segment the images with their own principles, so they can be applied in US images [17]. Comparison between these algorithms by applying on US images shows that GA have less computational time than PSO algorithm and also genetic algorithm output gives fine details about the synovial boundaries, bone and its abnormalities like dislocation, erosion, synovial thickening and inflammation than PSO [18]. Therefore, we can conclude the better method for segmentation as GA. This will help the radiologist and rheumatologist to diagnose the joint abnormalities early and give treatment quickly [19].

7. Future work

After reviewing a set of papers on image segmentation, we acquired knowledge about different techniques applied on segmentation. Thus, from the application of two optimization techniques like Genetic and PSO algorithm in segmentation of ultrasound image of joints it concludes that Genetic algorithm is better algorithm in ultrasound images [20]. The problems and prospects related to genetic algorithm in ultrasound images can be improved by combining any other optimization methods like Differential Evolution and Estimation of Distribution Algorithm with genetic algorithm and applying on ultrasound images gives more information about the defect in joints [21]. Therefore, by taking together the features of any other optimization techniques and genetic algorithm, proficient segmented image can be achieved.

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