Deep Feature Extraction of MRI Image– A Reliable Tool for Shoulder Pain Analysis

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Abstract

Pain in shoulder is the most common complaint from patients. The shoulder joint is a complex structure that needs the complete coordination of Bone and soft tissues typical for its regular function at its extremity. Damage of shoulder or its continuous usage causes dysfunction of shoulder and needs proper medication. In general, shoulder problems are solved by a physician without surgery which require a keen diagnosis of the underlying cause and its perfect management. To revaluate accurate outcome regarding patient diagnosis and information related services investigation will require huge amount of information for that big data is used.

Review studies reveal that classification of various types of shoulder disorders is needed for diagnosis and is complicated task to differentiate shoulder diseases. Clinicians face a challenge to categorise patients with chronic cases, high pain issues or both. Since that, the diagnostic classification is primary source to perform treatment, poor diagnosis results in unsatisfactory medication. Hence, the reproducibility, improvement for effective treatment is highly essential.

The objectively precise pain detection system stemming from the scientific and medical significance of emotion detection, as well as the merits promised by the prospect are built to facilitate such possibilities by using images analysis. The segmentation algorithms like Watershed and Region based algorithms are used to analyse the shoulder pain. Also proposed a hybrid segmentation algorithm for the analysis of shoulder pain. Image segmentation will extract the information from the object but feature extraction technique can redefine the image in to a set of features of image. So feature extraction techniques like GLCM, GLRM, LBP and deep feature extraction techniques are also applied on MRI images to analyse the exact cause for the shoulder pain.

Keywords: Shoulder Pain, MRI image analysis, Watershed Segmentation algorithm, Region based Segmentation algorithm, Hybrid Segmentation Algorithm, Big Data, Feature Extraction Technique, GLCM, GLRM, LBP, Deep Feature Extraction Technique.

1. Introduction

The detection of cause for shoulder pain is a challenging task due to different aetiologies [1]. They are very wide ranging from minor traumas to large tears that include muscle strains, sprains, etc. Some shoulder pain related issues cause severe pain restricting the movement of shoulder like adhesive capsulitis, glenohumeral joint (GHJ) osteoarthritis, impingement syndrome, calcific and biceps tendonitis [2].Improper functioning of any one of these parts may result to shoulder problems [5].

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The defects in the shoulder leads to its stiffness, loss of flexibility, limiting movement, shoulder weakness affecting the person's capability to perform daily works like playing, eating, personal hygiene and so on [6]. General medication for shoulder pain includes oral glucocorticoids, intraarticular(joint) glucocorticoid steroids, anti- inflammatory painkillers and physiotherapy practices. Physical investigation of shoulder analyses the exact symptoms and helps in the diagnosis. Clinical examination also enables the physician to start prognostication and draw proper conclusions on the shoulder problems of patient. Orthopaedic tests will also be conducted after complete investigation on patients that include injury causes, examination of shoulder movements, joint movements, nerve-related observations, inspection and clinical examinations and fleshy and bony tissue palpation [7].

To revaluate accurate outcome regarding patient diagnosis and information related services investigation will require huge amount of information for that big data is used.

Analysis of shoulder pain through MRI image involves a technique of marking shoulder graph showing the pain localization and its character. Shoulder disorders can be assessed by image analysis which is a modest and affordable tool especially for primary care physicians and also to conduct research studies on the same [4].

This analysis evaluates whether the shoulder pain validates clinically in everyday practise. In a study, colour coded shoulder pain maps were generated showing different pain patterns for different shoulder disorders [4]. The motto behind this MRI image analysis is 1) to diagnose the fractures and dislocations of shoulder. 2) to have better decision making for both the patient and the surgeon, and 3) to predict the consistency and time of the modified shoulder pain.

2. Big data

Big data analysis models [7] have been under development for a long time to handle a large number of datasets that involves input data, images and videos for optimal utilization of Bigdata to a greater extent. In both structured and unstructured, analytics is applied for which hardware, software and algorithms are required for original data analysis. This is helpful to the Entrepreneurs like defence academies and healthcare industry for analysing the hidden pattern both known and unknown correlations. The large sized images in Big data and data analytics together is called Image data analytics[8]. Although image processing is a mature technology, the establishment of image processing models based on big data analysis can encounter several technical difficulties including the visualization analysis required by image processing technologies, semantic expression and storage of massive image samples, the complexity of the algorithms required feature extraction, recognition, and prediction analysis based on big data and the time and memory consumption. In addition to these, the low speed of recognition of a model will also be a big problem. The application of big data in image processing is becoming increasingly wide with the development of information technology. By analysing the working principles, technologies, and advantages of big data technology [9] in image processing, the establishment of image processing models based on big data analysis will have broad application prospects in all fields of image processing.

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3. Image Analysis

Diagnostic imaging [10] in case od shoulder pain conditions, is a powerful and perfect tool for physiotherapists. Diagnostic images include MRI, CT-scan, X-ray and Bone scans. These images help in accurate prognosis, conclusion and assessment of injuries and defects. However, unwanted imaging creates loss not only financially but also increases the failures of conservative physiotherapies and conduction of early surgeries.

Hence, it is more significant to understand the appropriate imaging. There are various tools to analyse shoulder disorders right from history and physical investigation to imaging techniques like MRI, X-ray, Ultrasound, etc [2]. Due to the complexity in the anatomy of Shoulder joints, the diagnosis of existing disorders and the reason for occurrence of pain is tough despite the advanced imaging methods. A few studies emphasized the improvement of diagnostically imaging techniques for understanding shoulder pathology. In addition, the standards of a practitioner accuracy in performing clinical diagnosis, especially in terms of anatomy is directly related to the use of imaging diagnosis. Further, symptoms and medical imaging shows negative correlation[3].

4. Proposed Methodology:

The methodology contains details about how the experiment is done with a step by step process. which includes study design, methods that are used as well as the plan undertaken to achieve the goal to diagnose the Shoulder pain through MRI images as shown in figure 1.

Step 1: Shoulder MRI images are taken

Step 2: Noise is removed from the image through masking

Step 3: Reason based segmentation algorithm is applied to the images for finding which region causes the shoulder pain.

Step 4: Watershed algorithm is applied to know particular area which is affectedcausing the pain in the shoulder MRI image.

Step 5: Hybrid Segmentation Algorithm is applied to find the defected region with location.

Step 5: Feature extraction with three different algorithms are applied to the Shoulder MRI images to diagnose accurate area that causes the shoulder pain

Step 6: Deep feature extraction method is applied to the shoulder MRI images and exact location is found that causes the shoulder pain

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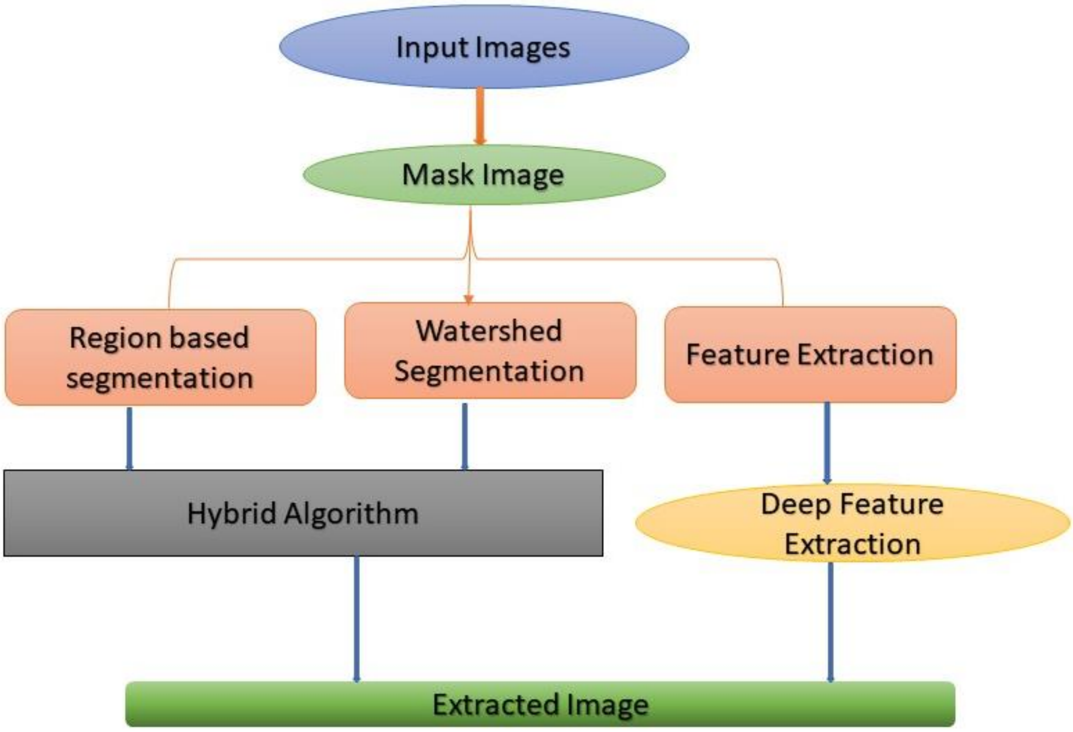

Figure 1: Schematic of proposed Methodology for Shoulder MRI Image Analysis

5. Methods

5.1. Region-Based Segmentation (RBS)

Algorithms of region-based segmentation [14]works by dividing the image into different sections of same features. Each region has a pixel group in which a seed point either a small or large section is located from the input image. The next step includes adding or shrinking of pixels in order to merge different seed points.

Two types of RBS methods can be categorised namely Region Growing and Region Splitting merging.

Region Growing (RG)

In RG technique, the small pixel sets starts merging more pixels iteratively considering a few similar parameters. In this algorithm[12], an arbitrary seed pixel from the image is selected and assessed with neighbouring pixels which expands the region matching the seed point.

If a region in the image is not matched or grown, then other seed pixel not related to the previous region will be chosen by the algorithm. In this case, many attributes of the image can be found in a single region. This error is removed by simultaneous growth of multiple regions found in Region growing Algorithm. However, images subjected to the RG algorithm shows noise making edges and creating difficulty in finding them.

Region Splitting and Merging (RSM) method

In this technique, splitting and merging of a region occurring at the same time is found[15]. These regions include various image portions.

Initially, the images of similar attributes are split into region followed by merging of adjacent regions which are same.

Unlike RG algorithm, the whole image is not considered, but focussed on a single specific point. A divide and rule policy are followed by RSM method. The image is splitted into various sections and

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starts merging based on parameter similarities, following default conditions. Hence, it is also named as Split-Merge Algorithm.

As this region based segmentation represented in curve C in Ὠ is represented by a level set function $\phi: \Omega \longrightarrow R$, zero ϕ=0 at object boundary in image I. curve C divides a sub region w_k c Ὠ into two sub regions w, ŵ with ϕ, such that

$$inside\ (c) = w\{x \in w_{\mathcal{K}}: \Phi(x) > 0\}$$

$$outside\ (c) = \hat{w} = \{x \in \Omega : \Phi(x) < 0\ U\ x \in \Omega \backslash w_{\mathcal{K}}\}$$

In general sub region can be calculated as

$$\varpi_k = \omega_{k-1} - \omega_k$$

5.2. Watershed Segmentation (WS) method

A grey scale image is transformed by Watershed segmentation algorithm [11] in image processing techniques referring to the drainage or geological watershed. In this technique, WS algorithm considers the image as a topographic map and applies the pixel brightness as its height to find lines that run on ridges tops.

Various technical denotions and applications are found in WS method. This algorithm not only identifies the pixel ridges, but also focusses on defining the basins at opposite of ridges and marks the basins till they meet WS lines across the ridges.

Since many markers are present in basins compared to ridges, the image gets divided into various sections as per the height of each pixel. WS method converts image into Topographical map via their pixel grey values.

Hence, three dimensional views of the landscape with ridges an valleys can be observed considering the 3d structure aspects which act like Image representation and generate "catchment basins".

The flooding can be directly transported by using the function f. For illustration the flooding of $z_{i+1}(f)$ is conducted in the influential zones of the connected components of $z_i(f)$ in $z_{i+1}(f)$ is not reached by the flood. The minima at level i+1 be added to the flooded area as formula:

$$w_{i+1}\,(f) = \left[iz_{z_{i+1(f)}}(x_i(f))\right] \cup m_{i+1}(f)$$

Where $w_i(f)$ is the section of level if the catchment basins of f and $m_{i+1}(f)$ is the function minima at height i+1. At level i+1, the minima is denoted as

$$m_{i+1}(f) = \frac{z_{i+1}(f)}{Rz_{i+1}(f)\big(z_i(f)\big)}$$

This equation is a loop algorithm which is initialized with $w_{-1}(f)$ = ϕ. In the end,WS algorithm is derived as

$$DL(F) = W_N^C(f)\ (with\ \max(f) = N)$$

WS algorithm has significant applications in medical field especially in Imaging techniques like MRI. In fact, it is a mandatory task for image processing aspects specifically in performing image sedimentations.

5.3. Hybrid Segmentation (HS) algorithm

A hybrid algorithm is defined an algorithm that combines more than two algorithms that solve the same problem.

Step 1: The image is loaded and removed the noise form the image

Step 2: applied Region based segmentation algorithm to find the defected region with location in shoulder MRI image by using dynamic curves in the object boundaries.

Step 3: The boundaries of the segmentation proceed by the watershed segmentationalgorithm.

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Step 4: By combining both region based and watershed segmentation algorithm is formed our Hybrid Segmentation algorithm.

5.4.Feature Extraction (FE) method

Feature extraction [16]decreases the feature space and enhances the accuracy in prediction and reduces the computation time. Feature extraction of an image is performed by different techniques of Image processing. The process of localised extraction differs in smaller regions ensuring the complete area capturing, which is attained by deleting unnecessary, repeated, noisy features. The subset of features is selected in such a way that they give precise performance in computation time and dimensionality reduction is performed.

In practise, a medical image classification features include shape features, texture features, color histogram and color moment features. Medical images are classified globally by employing all the features. Color and texture features are more prominent in identification of targets and henceforth, extracted color, added shape and texture features together called as global features [5].

In the current study, the image feature extraction is computed using three methods that are described below;

Grey-Level Co-occurrence Matrix (GLCM)

GCLM is one of the feature extraction methods which relies on statistical analysis. The spatial rapport of pixels will be considered as the grey level co-occurrence matrix (pixel-of-interest) or as grey level dependence matrix. The straight neighbouring pixels are able to state the additional spatial rapport in the mid of two pixels followed by the computation of subsequent grey level co-occurrence matrix element which is the sum of the occurrence times od the pixel value in the indicated spatial rapport to that of the input image. The GLCM is denoted by the formula:

$$ASM = \sum I(i,j)^2$$

Where $I(i,j)^2$ represents to the standard grey level Co-occurrence matrix.

ASM value will be lesser if matrix **I** elements are same and vice versa. A large amount of uncertain information with largest ENT value will be found, if all elements of matrix **I** are almost equal. At this point, grey value distribution in image becomes highly complex.

$$ENT = \sum I(i,j)(\log(I(i,j)))$$

$$IDM = \sum \frac{I(i,j)}{1+(i-j)^2}$$

Grey- Level Run-Length Matrix (GLRM)

In an image matrix, GLRM is the encoding method of defining strings of symbols. Here, the set of simultaneous collinear pixels with grey level is the Grey Level run. The run length can be defined as the number of pixels in the 0000111100111 run. The texture feature extraction is performed by run length matrix. Moreover, the texture thickness is confined by the run length statistics. Henceforth, specifying direction and counting the runs for each grey level and length in a single direction is the so-called Grey Level Run Length Method.

$$\boldsymbol{GLRM = Avg\left(\frac{1}{H}\sum_{i}\sum_{j} GLRM(i,j), j^2\right)}$$

Where H represents to the number of homogeneous runs index, (i, j) is the index matrix, i corresponding to grey level i, j corresponding to the number of run j.

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Local Binary Patterns (LBP) method

LBP is a texture gtratified imaging. In this method of local binary patterns, the evidence of the texture will be customised from a native neighbourhood. At first, the radius is defined for local neighbourhood with a specific deliberation. The operator draws a binary code which describes the local pattern of texture in the nearby pixel sets. Smearing the grey value of the threshold neighbouring midpoint, the binary code is defined.

Later, the rehabilitation of a binary code to a fraction signifies the code of Local Binary Pattern, indicating that LBP utilizes the statistics of grey scale invariant textures.

$$LBP(x_c, y_c) = \sum_{i=0}^{n-1} (f_i, f_c) 2^i$$

$$S(f_i, f_c) = \begin{cases} 1, & f_i > f_c \\ 0, & f_i < f_c \end{cases}$$

Where, (x_c, y_c) is the center pixel f_c is the centre pixel value f_i is the neighbour grey value and n is the number of leading neighbours.

5.5. Deep Feature Extraction (DFE) method

In Deep Feature Extraction [6,17], the number of dataset features is reduced by creating new features from old features replacing the latter. The new features can summarise the information of original feature sets. The procedure includes:

Step 1: The image dimensions is found.

Step 2: The features of the image are found by using reshape method

Step 3: The edges of the object is extracted

Step 4: By deep feature extraction technique extracted the eccentricity, convex area, inertia_ten, major axis length, minor axis length and convex ratio features from the image.

Step 5: The extracted features are evaluated and resized to diagnose the exact defect location in the Shoulder MRI image.

6. Experimental analysis

For diagnosis shoulder pain patient’s Shoulder MRI images are taken which has different set of images of one patient. For our analysis set of different patient’s shoulder MRI images are used which contains large data so MongoDB is used to store and retrieve the data in to python programming language for that initially installed required packages and then retrieved MRI images for analysis.

The first step includes the removal of noise from the image followed by the application of region-based segmentation algorithm where the segmented regions are partitioned based on the initial pixels. To find the effected region in shoulder MRI image, the seeds are selected, later splitting and merging of segmentation. The image is split into spaces of same properties and similarities which are then merged to analyse the causes od shoulder pain in a particular region.

The pixel and region similarities are observed upon application of Watershed algorithm.The region is computed for each pixel to know particular area which is affected to cause the pain in the shoulder MRI image as shown in figure 2.

Further, Hybrid algorithm is applied which is a combination of region based and watershed segmentation algorithms to the images to find the region and to show the

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particular area causes the pain and which type of pain it is as shown in figure 2 and then compared the performance of hybrid algorithm with region based segmentation and watershed segmentation algorithms individually by its accuracies and speed as represented in table 1 by observing the table 1 hybrid algorithm is the best among them. Here MRI image segmentation algorithms simplify the image for better analysis of shoulder MRI image. The set of image features will be re-defined by the application of feature extraction techniques.

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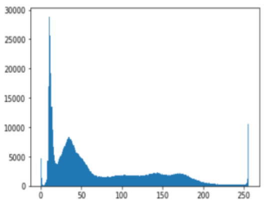
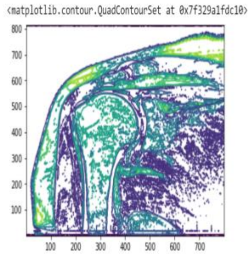
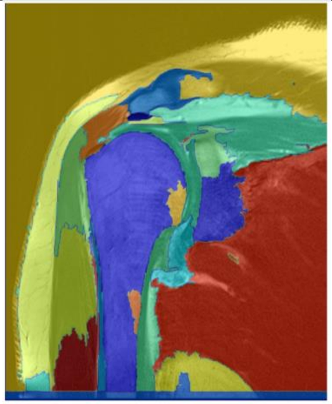
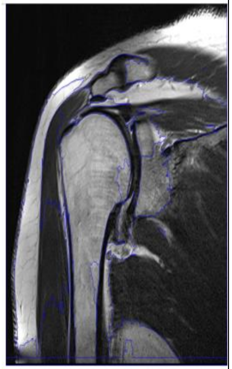
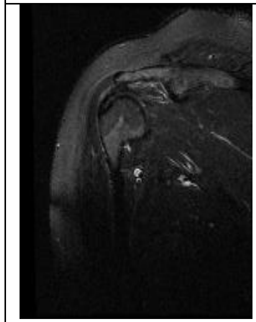
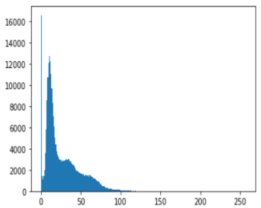
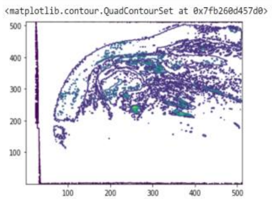
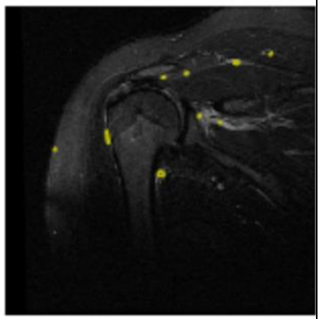
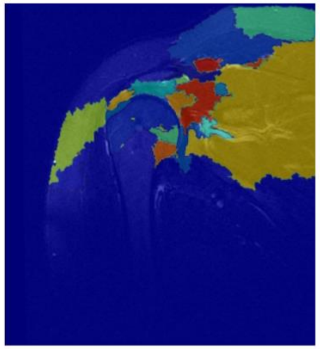
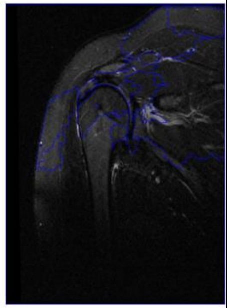
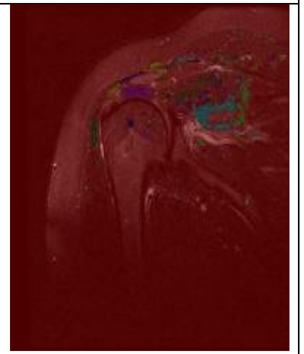
Input image	**frequency of image**	**Mask of image**	**Region based segmentation using Deep learning methods**	**Watershed segmentation with different colours for easy analysis using deep learning**	**Watershed segmentation line using deep learning**	**Hybrid Segmentation**
 Normal image						
						

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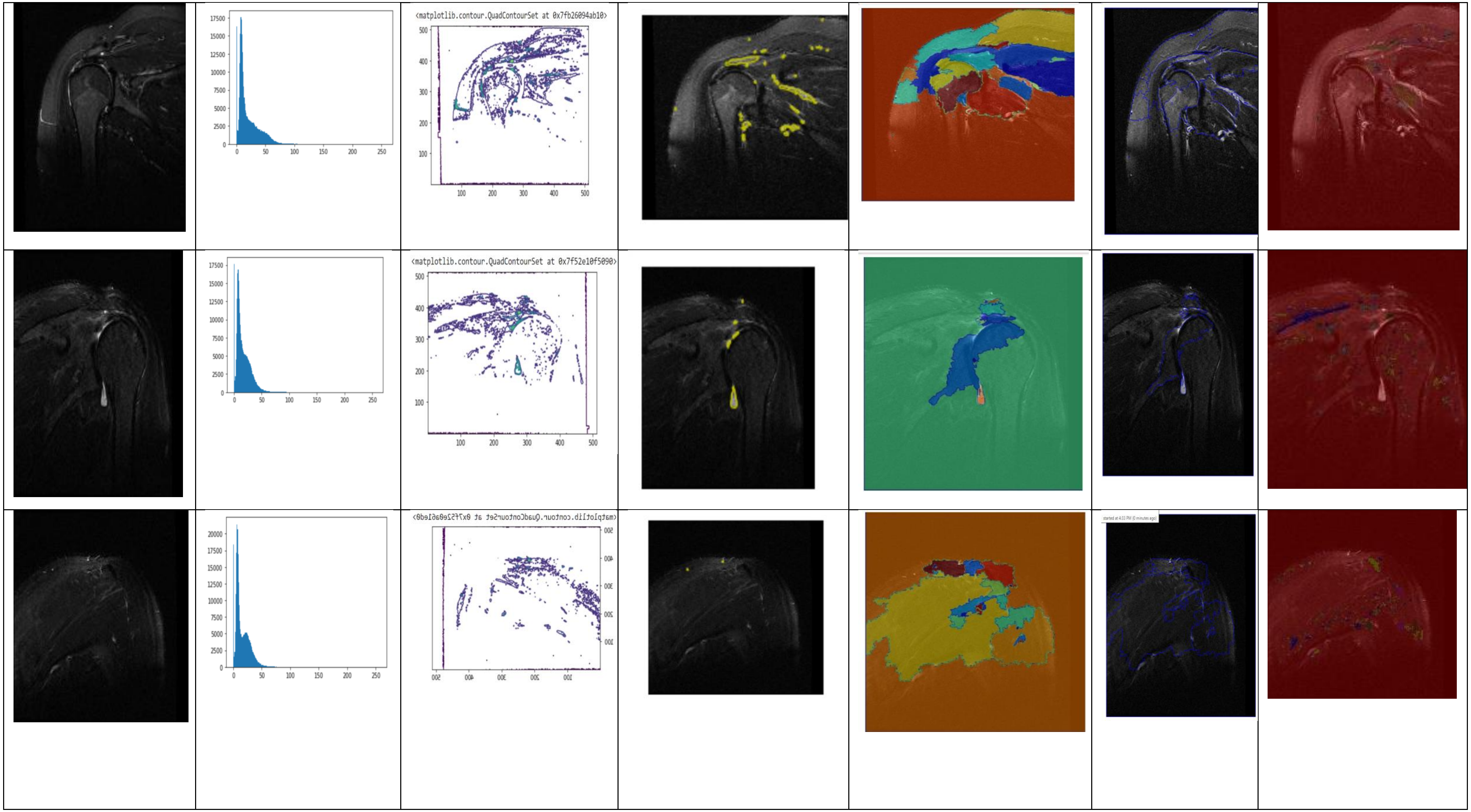

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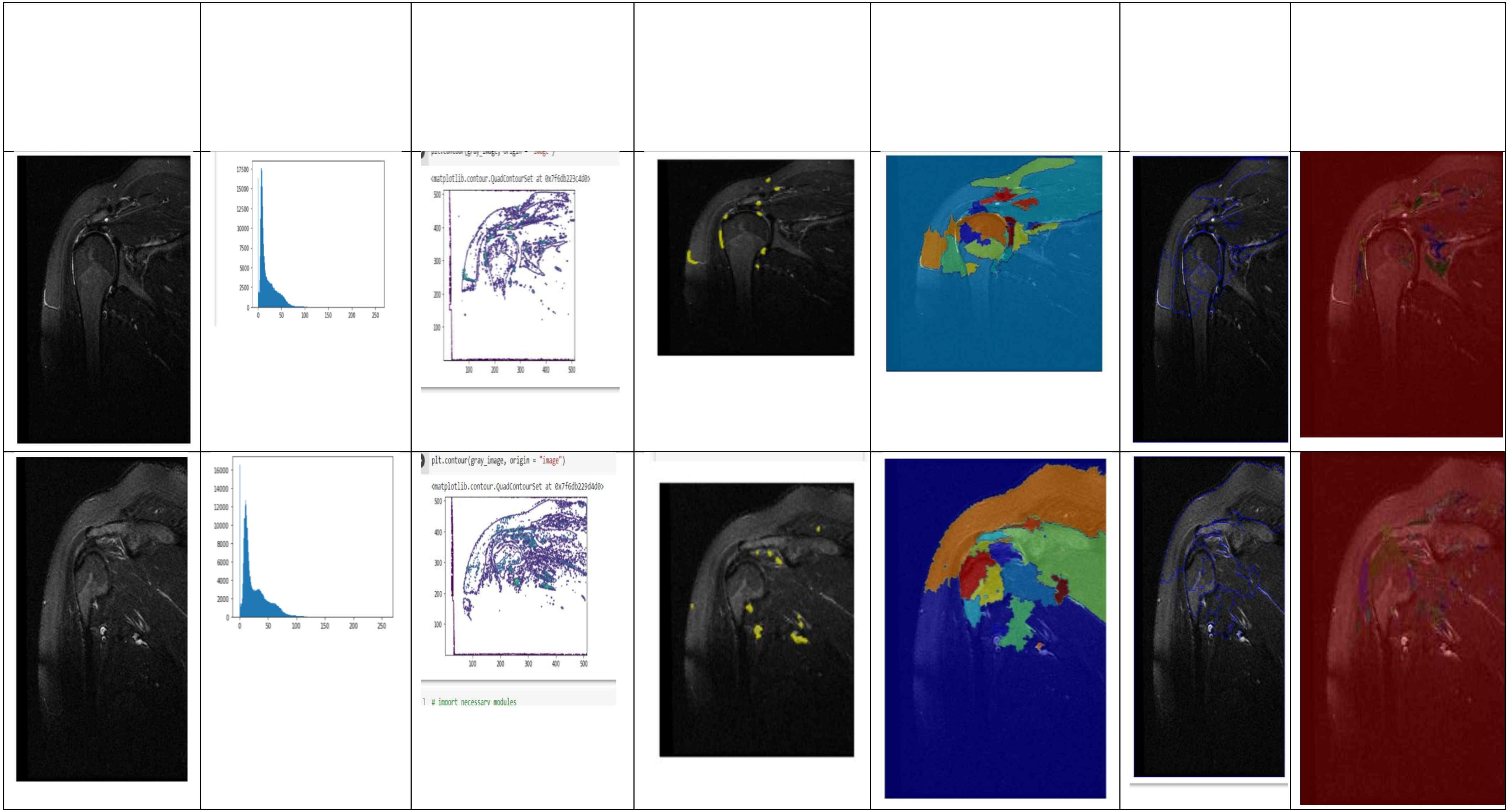

Figure 2: MRI Shoulder Image Analysis using Different Segmentation Algorithms

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This feature extraction is worked based on every pixel value that generated one after the other to form an image. Each image shape and features are collected, then it is reshaped through the NumPy package to know the dimension of an image later applied different feature extraction algorithms like GLCM, GLRM, LBP to know accurate area that causes the shoulder pain as show in in figure 3.

Later applied deep feature extraction to the shoulder MRI images as to reduce the unwanted area and find the exact area that cause the shoulder pain. This can be done through by analysing the MRI image area, eccentricity, convex area, inertia_ten, major axis length, minor axis length and convex ratio of an image is found and then using their data exact location is found that causes the shoulder pain and by seeing the effect area we can find which type of pain it is as shown in figure 3.

Finally compared all the algorithms to know which algorithm will give the best results by their accurate and speed of the algorithm during the execution as shown in table and. By observing the table 1 in all terms deep feature extraction will give the best results with its 99.9% accuracy and 1.86 sec speed of execution rate.

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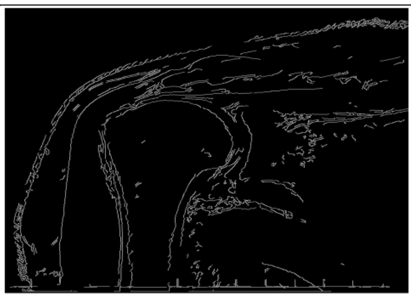
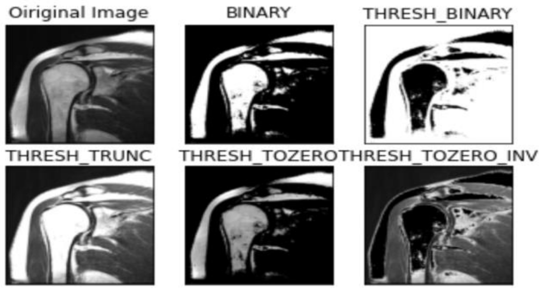
<tr><td>1.</td><td>
Normal Image</td><td>
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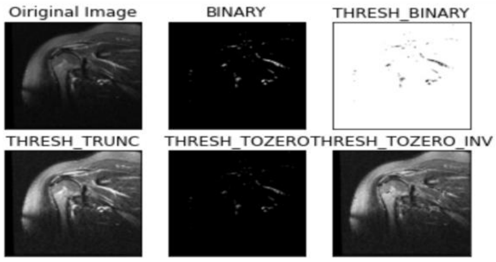
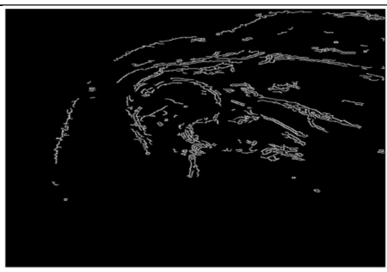
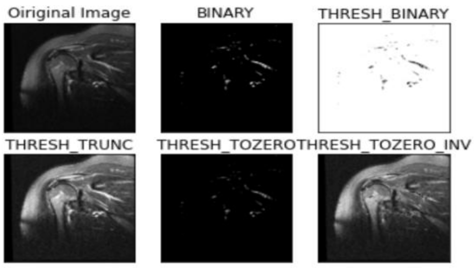
<tr><td>2.</td><td></td><td></td></tr>
<tr><td>3.</td><td></td><td></td></tr>
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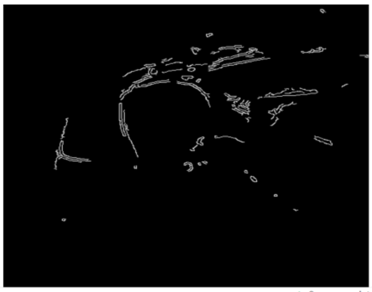

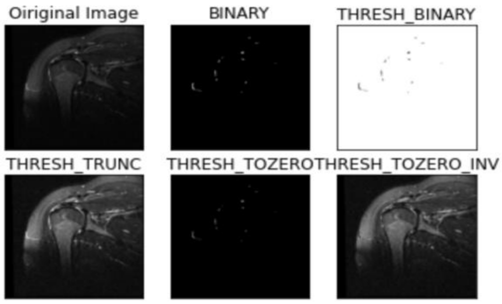

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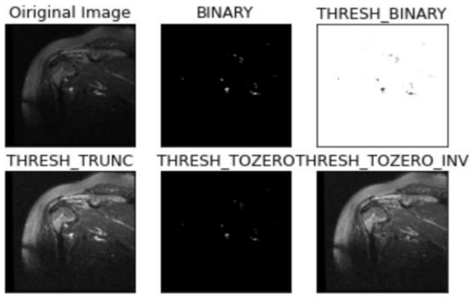

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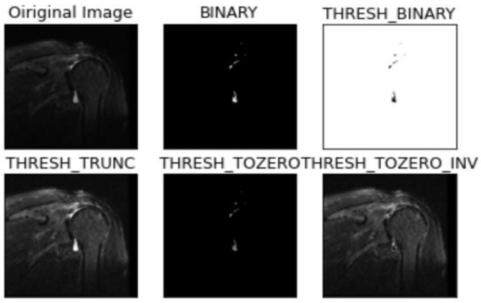

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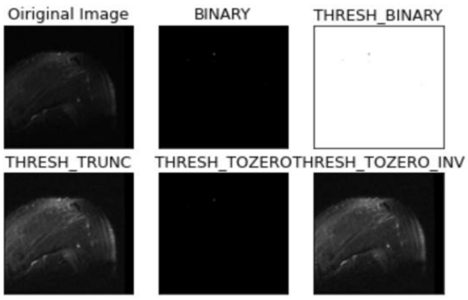

Figure 3: Shoulder MRI Image Analysis through Feature Extraction and Deep Feature Extraction

Table 1: Comparison of different methods

Methods	**Accuracy**	**Speed (Sec)**
Region based segmentation	0.9456	2.86
Watershed segmentation	0.9464	2.86
Hybrid Segmentation	0.9634	2.42
Feature Extraction	0.9823	2.36
Deep Feature Extraction	0.9924	1.86

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By observing the deep feature extraction applied Shoulder MRI image as in Figure 3 sl.no 1 is a general shoulder MRI image becauseit does not diagnose any defect in the shoulder. The 2nd, 3rd ,6th figures in figure 3 is diagnosed as arouter cuff disorder because at the shoulder joint it shows the defect. Then 4th, 5th, 7th diagnosed as frozen shoulder.

7. Conclusion

Through the said techniques, Examiner will be enabled to perform a prognostication and suitable intervention in Shoulder Image analysis. For that firstly, masking of the image is applied to remove the noise from MRI images and then Region based segmentation and watershed segmentation algorithms individually applied on MRI images to segment the regions. In present work a hybrid algorithm is proposed which is a combination of region based and watershed segmentation is applied on MRI images to segment the regions and to identify the shoulder disorders.

Application of Feature extraction technique to the input MRI images extract the disorder features. Deep feature extraction technique is applied for in-depth analysis of the shoulder disorder and type of shoulder pain. These methodsare compared with their accuracies and speed. Among them deep feature extraction has the highest accuracies rate of 0.9924 and execution speed 1.86 sec. This MRI image analysis is done to diagnose at which area the pain is occurring and what type of pain it is.

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