



Assessment of Arthritis Inflammations Using Fuzzy C Means Clustering Algorithm

KEYWORDS

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ABSTRACT Arthritis is a disease that spread worldwide. Recent statistics shows that almost 80 percent of the total world population is affected by this disease. A number of invasive and non invasive techniques are used to identify the disease. This paper discusses a non invasive method to diagnose arthritis from digital X-ray images. Fuzzy C Means (FCM) clustering algorithm is used to diagnose the inflammations of the disease. The final result showed a significant difference between the normal and abnormal knee joints.

1.0 Introduction

Arthritis is a syndrome that occurs in bone joints. The disease once struck cannot be cured but can be controlled with proper diagnosis and treatment. The consequence of arthritis ends in pain, joint swelling and joint immobility. A number of diagnosing methods are available to diagnose the disease at its preliminary level. This paper discusses an alternate method to diagnose the inflammations of Arthritis from digital X-ray images using fuzzy C means clustering algorithm. This paper is organized as follows. Section 2 discusses the existing work done by researchers for the diagnosis of arthritis. Section 3 discusses the proposed method using FCM. The results are discussed in section 4 and the conclusion is given in section 5.

2.0 Literature survey

A number of diagnosing algorithms are available to diagnose the disease at the earliest. A few of them has been discussed below.

Evanthia E. Triploti et al. (2007) developed an automated method for the segmentation of inflammatory tissues in hand joints from Magnetic Resonance Images (MRI). Various image processing techniques such as identification of clusters, image preprocessing, segmentation and image post processing were involved in this work.

Kannan and Pandiyarajan (2009) used Fuzzy C Means (FCM) clustering technique for the segmentation of T_1 - T_2 brain MRI. The objective of the work is to segment the Gaussian noise from brain MRI. The algorithm used various FCM such as conventional FCM, modified FCM and improved FCM techniques. The final results concluded that conventional FCM was able to segment these noise signals effectively from those images.

Linju Lu et al. (2012) developed a segmentation method using FCM clustering technique to segment MRI. The grey level intensities were used for segmentation. The segmented portions were classified using K-Nearest Neighbor (K-NN) Classifier. This method of segmentations found successful to segment MRI with also with noise. This method can also be extended for the diagnosis of arthritis.

Min Li et al. (2008) developed an improved FCM for the segmentation of MRI. This uses the standard histogram for minimizing the iteration ties. This algorithm was able to

segment in 216.3 seconds over the conventional segmentation algorithm which made the segmentation in 459.7 seconds. The final results concluded that this method is more accurate and faster than the standard FCM and fast FCM algorithm. Moreover the determination of cluster points is also easier with this method.

Mohamed Ahmed et al. (2002) used FCM clustering technique for the segmentation of imperfection image areas from MRI data. These imperfections were caused due to the radio frequency coils or due to the error in the image acquisition sequences. The algorithm concluded that FCM is much effective with the segmentation of noise signals from MRI data.

Selvanthi et al. (2013) used FCM algorithm for the segmentation of tissues from MRI. The MRI were subjected to wrapping based curve let transform before the application of FCM algorithm. Tissues such as white matter, grey matter, cerebrospinal fluid from MRI of brain were segmented by this algorithm. The specificity produced by this algorithm was 87.2

Sudip Kumar Adhikari et al. (2012) used FCM to segment brain MRI. Images with intensity in homogeneity and intensity non-uniformity in MRI were easily segmented using this technique over the conventional segmentation technique. The analysis was done by computing standard deviation and root mean square error between the segmented image and the image with zero noise. The final results produced by the algorithm were satisfactory.

The segmentation in the work was carried out using FCM algorithm. The algorithm can be used for the quantification of inflammatory tissues. The classification rate produced by the algorithm was 83.35 %.

In this work FCM has been used to identify the change in the pixel formation caused due to abnormality from radiographic images. As arthritis erodes the synovial membrane and reduces the synovial fluid in bones, the pixels during image formation also get varied. This results in the variation of clusters. The proposed method uses this concept for the diagnosis of Arthritis.

3.0 Proposed Method

The block diagram of the proposed system is given in Figure 1.

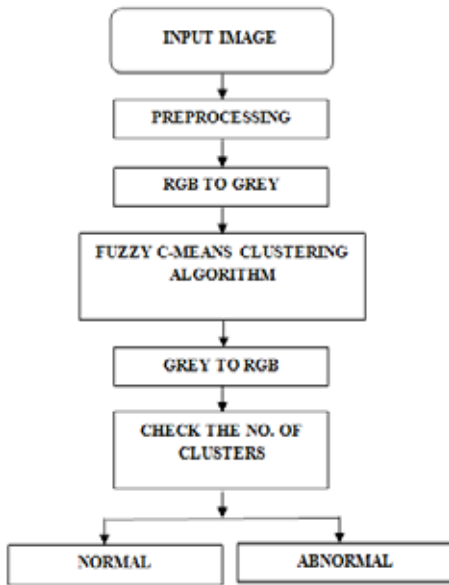


Figure 1. Block Diagram of Proposed System for Diagnosis of Arthritis using FCM

3.1 Fuzzy C-Means (FCM) Clustering Algorithm

FCM clustering is an unsupervised clustering algorithm which clusters image based on the Euclidean distance between the pixels. The most prominent Fuzzy clustering algorithm is the Fuzzy C Means algorithm.

The FCM algorithm receives the data or the sample space, an $n \times m$ matrix where n is the number of data and m is the number of parameters. The number of clusters c , the assumption partition matrix U and the convergence value ϵ must be given to the algorithm. The assumption partition matrix has c number of rows and n number of columns and contains values from 0 to 1. The sum of every column has to be 1. The first step is to calculate the cluster centers. This is a matrix v of dimension c rows with m columns.

The second step is to calculate the distance matrix D . The distance matrix constitutes the Euclidean distance between every pixel and every cluster center. This is a matrix with c rows and n columns. From the distance matrix the partition matrix U is calculated. If the difference between the initial partition matrix and the calculated partition matrix is greater than the convergence value then the entire process is repeated from calculating the cluster centers to the final partition matrix. The final partition matrix is taken and is used for reconstructing the image.

The objective function of FCM is given by,

$$J(U, y) = \sum_{j=1}^c \sum_{k=1}^n u_{jk}^m E_j(x_k) \tag{1.1}$$

(1.1)

where,

$X = \{x_k | k \in [1, n]\}$ is the training set containing n unlabeled samples

$Y = \{y_j | j \in [1, c]\}$ is the set of centers of clusters

$E_j(x_k)$ is a dissimilarity measure (distance or cost) between the sample x_k and the center y_j of a specific cluster j .

$U = [u_{jk}]$ is the $c \times n$ fuzzy c -partition matrix, containing the membership values of all samples in all clusters.

The algorithm seeks optimum combination of (U^*, y^*) that produces minimum value for the J function.

$$J(U^*, y^*) = \min_{U \in M_c} J(U, y) \tag{1.2}$$

where, $M_c = c^n$

The Fuzzy C-Means (FCM) algorithm consists of the iteration of the following formulae.

$$y_j = \frac{\sum_{k=1}^n (u_{jk})^m x_k}{\sum_{k=1}^n (u_{jk})^m} \quad \text{for all } j \tag{1.3}$$

$$u_{jk} = \begin{cases} \left(\frac{\sum_{l=1}^c \left(\frac{E_j(x_k)}{E_l(x_k)} \right)^{\frac{2}{m-1}}}{\sum_{l=1}^c \left(\frac{E_j(x_k)}{E_l(x_k)} \right)^{\frac{2}{m-1}}} \right)^{-1} & \text{if } E_j(x_k) < E_l(x_k) \forall l, k \\ 1 & \text{if } E_j(x_k) = 0 \text{ and } u_{jk} = 0 \forall l \neq j \end{cases} \tag{1.4}$$

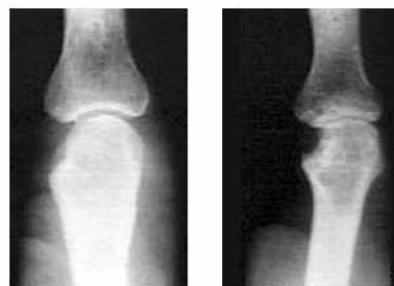
where, in the case of the Euclidean space,

$$E_j = \|x_k - y_j\|^2 \tag{1.5}$$

The final partition matrix is taken and is used for reconstructing the image.

3.2 Data

The digital X-ray image of knee joints is used to study the results of the developed algorithm. The size of the actual image is 1000 X 1000 pixels and the Region of Interest (ROI) which is the AS is cropped manually to a size of 200 X 200 pixels from the actual image. The actual image and the ROI image are shown in the Figure 2 (a) and (b) respectively.



(a) Normal AS Joint (b) Abnormal AS Joint

Figure 2. Digital X-Ray Images of Normal and Abnormal Bone Joints

Since it is the primary part of the work the Knee X-ray image in which the abnormality is clearly visible is used for the study.

The above image preprocessing techniques is done manually. The image is then converted from RGB to grey scale image before subjecting to FCM clustering algorithm. The results obtained with normal and abnormal bone joints with Fuzzy C Means Clustering is shown below in Figure 3(a) and (b).

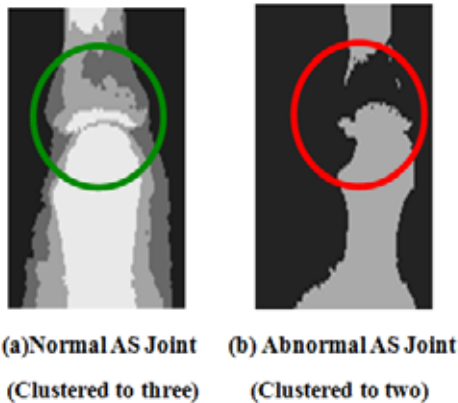


Figure 3. Clustered Images of Normal and Abnormal Bone Joints

4.0 Results and Discussion

With the applications of FCM to the images the following results are obtained. The image with normal knee joint is clustered to three and with abnormal knee joint is clustered to two. The image of a normal AS has the pixels from three regions of the bone namely synovial membrane, synovial fluid and from the bone joints. The X-rays emerging out from regions of bone joint causes a difference in the pixels during image formation. On the other hand the image with abnormal AS has its pixels from two regions of a bone joints named bones and the muscles surrounding the bone. The differences in the clusters are due the difference in the pixels emerging out from the different portions of the bone joint. Hence an image with normal AS is clustered to three and the image with abnormal AS is clustered to two. From the results it can be concluded that the pixel formation in the images of bone joints will vary with the abnormality.

5.0 Conclusion

The above results show a significant difference between the normal and the abnormal knee joints. Hence this method can be used as an efficient method for the diagnosis of arthritis. This method is also applicable for the diagnosis of early stage of arthritis.

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