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AUTOMATIC DETECTION OF CARTILAGE THICKNESS FOR EARLY DETECTION OF KOA

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ABSTRACT

Knee Osteoarthritis is a common joint disorder that is most prevalent in the knee joint. Knee osteoarthritis (OA) can be characterized by the gradual loss of articular cartilage (AC). Articular Cartilage is a hard but greasy coating on the end of each bone which forms the joint. Cartilage seizes up and erodes away in OA. In this work, image processing techniques are applied on magnetic resonance images (MRI) of knee, the Adaptive histogram equalization, Contrast enhanced image process, Gaussian Filter, Ostu Thresholding Algorithm, Edge Detection Technique, Automatic Region Detection Method, Euclidean and connected component algorithm are adopted in this work. Quantification of cartilage thickness is carried out for normal and OA cases. The results are useful in the study of measurement of articular cartilage for OA and for therapeutic decisions.

Keywords: knee osteoarthritis, cartilage, knee joint, magnetic resonance imaging (MRI), image processing, articular cartilage.

1. INTRODUCTION

Osteoarthritis (OA) is the most common type of arthritis. According to recent estimates, over 70 million peoples have the condition, which primarily affects the people who are 60 years of age or older. [1] OA is a leading cause of disability among non institutionalized adults; OA of the knee affects 28 percent of adults over age 45 and 37 percent of adults over age 65. [2] It is a progressive disorder in which cartilage cushions the ends of the bone thins or wears away causes bony spurs at the surface and margins of the joints. [3]Most types of treatment for osteoarthritis work best when started early, Loss of cartilage in osteoarthritis (OA) is difficult to measure, for this reason establishing an accurate diagnosis is important. This approach results in accurate measurements that can be used to detect cartilage thickness. [4]Magnetic resonance imaging (MRI) is used to image the knee joint because of its high resolution to soft tissue contrast. An MRI (Magnetic resonance imaging) may be ordered to determine Cartilage thickness for early detection and progression of the disease in case of OA affected patients. [5]MR imaging methods optimize the cartilage evaluation, improved clinical evaluation, and provide detailed information for studies of the surgical or therapies. [6] From various papers, it was found that the Cartilage is a highly specialized a-vascular and a-neutral tissue in our body. The normal thickness of articular cartilage is approximately 1:6 in ratio. Hyaline cartilage always exists in a thin layer from 5-6mm thickness between tibia and femoral bones of knee. The cartilage thickness on femur bone and tibia bone in normal case is found as 0.73mm to1.825mm and 2.24 with a deviation of 0.34mm. In total, the cartilage dimension at tibia femoral joint should be 3.45mm on average with a deviation factor of 0.9mm, so the particular case is classified as normal on cartilage thickness.

2. PROPOSED METHOD

MR imaging provides excellent characterization of the articular cartilage thickness in OA. This provides an accurate diagnosis and information regarding location of OA. Knee joint images are collected from scanning center. The image processing techniques used in the proposed method is shown by flow chart in Figure-1.

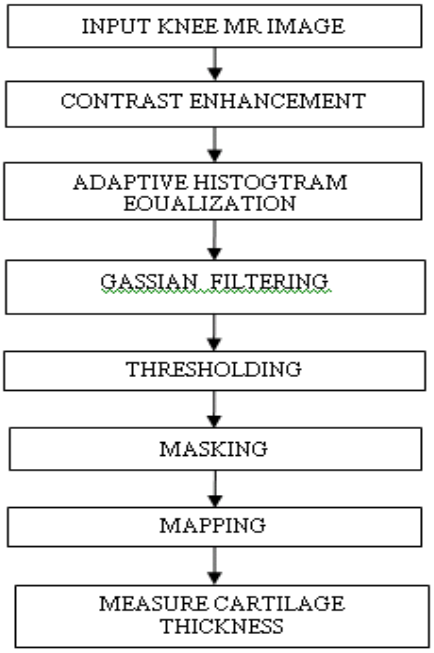

Figure-1. Image processing steps for quantification of cartilage.

This method consists of six modules as Preprocessing, Filter, Binarization, Edge detection, Masking, and measurement of thickness. In this work, for Preprocessing_ Adaptive histogram equalization and Contrast enhanced image process are used, For

Filter__Gaussian Filter is used; For Binarization__Ostu Thresholding Algorithm is initiated. In Edge Detection__Vertical Edge Detection Technique has been put forward. For masking _ Automatic Region Detection Method is used and _Finally the Euclidean and connected component algorithm are used For Measuring Cartilage Thickness.

(i) Preprocessing: Preprocessing is used to increase the intensity level of input image for better image processing. There are totally two steps in pre-processing. They are Contrast Enhancement and adaptive histogram equalization, The input image (Figure-2 (a)) of knee is subjected to contrast enhancement.

Figure-2(a). Input Image.

Contrast enhancement is done for the better view of anatomical boundaries as shown in Figure-2 (b). In Contrast Enhancement the image is processed entirely to find out the black and white pixel values. The values are then applied to the input image for enhancement. The enhanced image will have more number of white pixels compared to the black pixel values. The Adaptive Histogram Equalization distribute pixels to different gray levels, Figure-2(c) shows the adaptive histogram image Histogram equalization is carried out for an image to form equally distributed noise pixel values. Initially histogram is calculated for the image to be processed; with the obtained histogram values the brightness level is increased.

Figure-2(b). Contrast Enhancement.

Figure-2(c). Adaptive Histogram Equalization.

(ii) Filter: Gaussian filter is used to remove random noise and other noises present in the image. Biomedical image will have more noise as the CMOS sensor used in taking the input will not be accurate. Gaussian filter is created to remove those noises for better cartilage thickness detection. As shown in Figure-2 (d) Gaussian filtering is a non-linear digital filtering technique, often used to remove noise from images and at the same time preserves the edges.

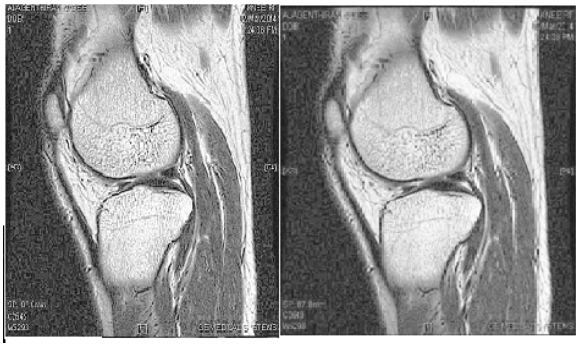

Figure-2(d). Gaussian filtering.

(iii) Binarization: Images are converted into black and white pixels to find the edge of cartilage area. Ostu thresholding algorithm is based on a threshold value (T) to turn a gray scale image into a binary image is shown in Figure-2 (e). Ostu Thresholding Algorithm is used for converting gray scale image properties into white and black values using threshold value.

Figure-2(e). Thresholding.

(iv) Edge detection: Edge of an image is found out for the exact thickness measurement from the binarized image. Here we propose a new method for edge detection by adding mask layer to the original input to derive the edge properties. Edge detection mention the process of identifying keen discontinuities in an image. Automatic detection is done by using bounding box property. Bounding box is represented as a 4 vector. In that, first two entries are represented as the x and y coordinates of the upper left corner of the bounding box and the last two

entries are the width and the height of the box Hence, rectangular box will be obtained automatically which will be indicating the required region Figure-2 (f) shows the automatic edge detection image. A completed selection then enables the masking process.

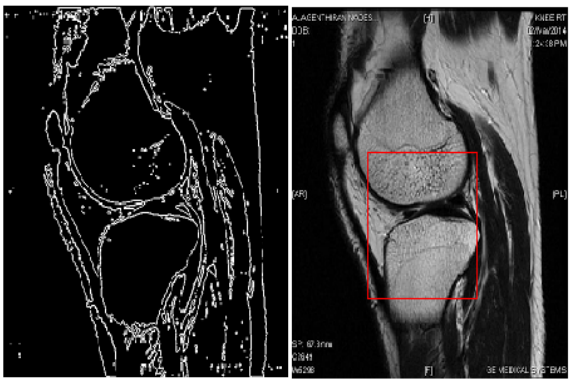

Figure-2(f). Edge detection.

(v) Masking: Region of interest is carried out for right region extraction using automatic process. The marked ROI is extracted from the edge image for cartilage area. In masking the region of original image is mapped with binary image. Here, exact matching point between original and processed image is found Shown in Figure-2 (g).

Figure-2(g). Masking.

(vi) Thickness: Euclidean distance formula is processed for the entire masked image with connected component labeling algorithm. With the edges of the cartilage-bone the normal at each point on the bone surface is determined by a surface-fitting technique. Each normal is extended to meet the cartilage interface, and the cartilage thickness is calculated as the distance between the points of intersection of the normal to the two interfaces. With the help of the distance obtained thickness is calculated. Hence, it is easy to relate with pixels in an image .So that it generates accurate result with exact pixel matching. This measurement of cartilage thickness is shown in Fgure-2 (h).

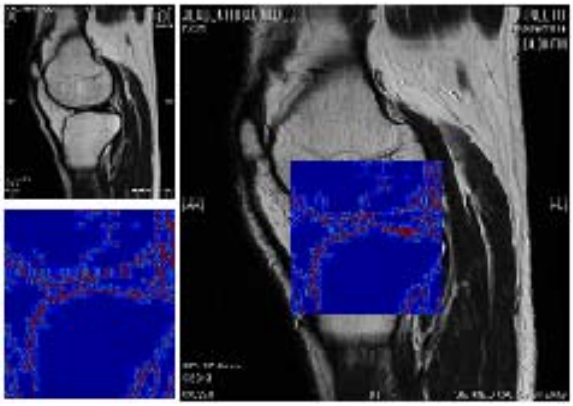

Figure-2(h). Measurement of thickness.

3. RESULTS

Findings from current studies suggest that muscle weakness is a predictor of knee OA, while evidence regarding the accurate measurement of OA progression is conflicting. The MR image of articular cartilage is needed to be recognized to avoid errors. In OA case it is found that cartilage thickness is reduced near the tibia and femoral region. Thickness measurements are compared in the region of femur tibia interface; therefore results obtained are accurate through algorithm to calculate the thickness of cartilage in millimeter. The average cartilage dimensions were found and the thickness obtained was compared with normal cartilage thickness. If the cartilage dimensions obtained were falling in the given normal range a particular case was classified as normal, else it is classified as Osteoarthritis case.

Comparison of various samples and their Knee cartilage thickness are shown below:

Case	Age	Sex	Thickness of cartilage in mm	Diagnosis
Case 1	30	Male	2.8	Doubtful
Case 2	45	Male	4.2	Normal
Case 3	43	Female	2.81	Normal
Case 4	38	Female	3.4	Normal
Case 5	40	Female	2.2	KOA
Case 6	48	Male	2.81	Doubtful

4. CONCLUSIONS

This study shows that images acquired in MRI system can generate an adequate quantitative data that enable the estimation of AC. Here a various algorithms such as Ostu algorithm, Vertical Edge Detection Technique Automatic Region Detection Method and Euclidean and connected component algorithm are used. They are classified as pixel based and model based methods. This model will be useful for testing as well as for identifying cartilage thickness in knee. We conclude that this method is potentially suitable for non-invasive measurement of articular cartilage.

5. FUTURE SCOPE

We can further develop this approach to get even better accuracy of thickness to measure Osteoarthritis (OA) by using other algorithms.

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