Measurement of Cartilage Thickness in Osteoarthritis and Visualization of Meniscus Tear of Knee MRI Image Processing

Jaimin A. Patel¹, Hardik Modi², Himanshu Patel³
¹Charotar University of Science and Technology, Changa-388421, India
²Charotar University of Science and Technology, Changa-388421, India
³Charotar University of Science and Technology, Changa-388421, India
¹jaimin5591@gmail.com, ²Modi8584@yahoo.com, ³himanshu_ap37@yahoo.in

Abstract—Knee joint is very complex and delicate joint in human body structure. Due to weight load, stress, knees can be injured and damaged and Osteoarthritis (OA) is one of the common diseases of knee injury. It is a degenerative joint disease in which cartilage slowly degrades. Another problem of knee is meniscus tear. Meniscus act as a weight distributor on joint surfaces and gives stability by preventing lateral movement of the knee joint. The medial and lateral meniscus of the knee is a C shaped cartilage pad between the tibia and the femur bones. Sports can make the injury of knee meniscus. In this work, image processing techniques are applied on magnetic resonance images (MRI) of knee and work out on the cartilage and menisci. Histogram equalization, thresholding, canny edge detection techniques, region of interest (ROI) processing and masking techniques are used for the processing. This method segments cartilage and menisci from femur and tibia. Calculation of cartilage thickness is carried out for normal and OA affected knee. Cartilage thickness or menisci is compared with the standard cartilage thickness or normal menisci given by research groups. The results are useful in the study of progression of OA and Meniscus tear and for therapeutic decisions.

Keywords—Knee osteoarthritis, cartilage, knee joint, osteoarthritis grade, cartilage thickness, meniscus tear visualization, magnetic resonance imaging (MRI), Image processing.

I. INTRODUCTION

Knee cartilage is plays important role in knee of human. Knee Cartilage Image Processing is very tough thing to do because knee cartilage of human is set under the bone of knee. Cartilage is ultra-slippery very thin layer of good-quality material which covers the edge of bones for comfort movement of the joint. Knee Cartilage covers the patella femoral and tibia femoral joints. Osteoarthritis (OA) is a disease of cartilage degradation. Osteoarthritis (OA) is usually seen
among older people and it is a arthritic type. It is a degenerative joint in which cartilage slowly wears away. OA affected bones slide together due to degradation of cartilage [1].

Menisci tear is another common problem of knee disease. There are two types of menisci in human knee: (1) lateral menisci (2) medial menisci. The menisci are able to spread weight and therefore decrease the stresses on the tibia. Due to some physical and sports activity, traumatic injury has occurred. The menisci are of C-shaped, fibro cartilage structures composed of thick fibers. The meniscus works as a shock absorber in sharing the forces of weight-bearing on the joint surfaces. It also works as a lubricating on the knee joint, provides some stability, and is necessary for the normal biomechanics of the knee joint. The structural of own body allows the meniscus to perform many functions like the sharing of stresses over the articular cartilage, the taking up the shocks during axial loading, the strength and stabilization of the joint in flexion and joint lubrication, they also give a secondary stabilization of the knee after cruciate ligament injuries. weight across the knee joint are so high as two to four times body weight during walking and, up to six to eight times body weight during running [2].

Mainly Sports persons are at risk for meniscal tears. Tears are denoted by their look after wear and tear. Figure 1.3 shows menisci and different types of some common tear shapes like longitudinal, transverse, flap, bucket handle, and torn horn etc. [2].
Here MRI image has been taken for processing. The algorithms calculate Menisci tear and the thickness of femur and tibia cartilage together at joint location, so degradation of cartilage can be efficiently found. Based on the results, it is possible to correctly identify a particular case as normal or knee osteoarthritic. The methodology follows simple and unique image processing techniques to get Menisci and cartilage details [1].

II. METHODOLOGY

Visualization of Cartilage

Case-1

The knee MR Image in DICOM format is the input Image for process. Image is in sagittal view. Histogram of an image is shown in figure 4(b). Now image is histogram equalized adaptively.
After Adaptive histogram equalization the image is passed through the Gaussian low-pass filtering to eliminate unnecessary high frequency edges around the cartilage, zero crossing detection can calculate the thickness of cartilage. The image is contrast enhanced for making the anatomical boundaries of knee more visible before thresholding. The thresholded version of image is shown in figure 5.

Figure 4(b): Histogram of Image (a) [1]

Figure 4(c): Adaptive Histogram equalization [1]

Figure 5: Thresholded image [1]
Now, canny edge detection is applied after thresholding to find the boundaries of cartilage.

![Canny edge detected image](image1)

**Fig 6: Canny edge detected image [1]**

The masks are generated automatically because the cartilage is situated at the center of the Knee MR image. Masked image is shown in figure 7. Then Zero- Crossing detectors are help to calculate the cartilage in the image. Finally these image calculations are help to find actual thickness of image.

![Masked Image](image2)

**Figure 7: Masked Image [1]**

**Case-2**

Figure 8(a) shows knee joint MR image in sagittal view. Image is cropped to have the portion of cartilage, menisci, femur and tibia boundaries. Figure 8(b) shows histogram plot of the cropped image.

![MRI knee joint (normal)](image3)

**Figure 8(a): MRI knee joint (normal) [6]**
Figure 8(b): Histogram plot of cropped image of Figure 8(a) [6]

Histogram equalized image and plot of it shown in figure 9(a) and figure 9(b) respectively.

Figure 9(a): Histogram equalized image [6]

Figure 9(b): Histogram plot of 9(a) [6]
Contrast stretching operation is performed to have good view of the anatomical boundaries. Gray level thresholding is performed on the image to obtain a binary image. Thresholded version of the image is obtained and is shown in Figure 10.

With the help of fixing the points of ROI polygon, masks are developed. Edge detecting an image reduces the amount of data and removes useless information. Using canny edge detection technique, boundaries of the femur and tibia are given. Canny edge detected images are used in choosing the points on ROI polygon. Canny edge detection image shows edges of cartilage as shown in Figure 11. Cartilage is visualized as shown in Figure 12. This visualization of the image helps to identify the information regarding the thickness of cartilage.
**Menisci Visualization**

Knee MR Image has been taken randomly for the processing of menisci visualization as shown in figure 13. By applying contrast enhancement on the image, it is get better visualization after adjust of an image. Contrast enhancement image is shown in figure 14 and canny edge detection is shown in figure 15.
Segmentation has been applied to the output of canny edge detection. Segmentation of femur, tibia and menisci is shown in the figure 16. Visualization of tear menisci after segmented image is shown in figure 17.
III. Results

Cartilage:

Figure 18(a): Thickness in normal case [6]

Figure 18(b): Thickness in OA [6]

OA is divided into 0 to 4 grades according to cartilage thickness. Grade 0 and grade 4 is shown in figure 19(a) and figure 19(b).

Figure 19(a): OA Grade 0 [7]
Menisci:

Figure 19(b): OA Grade 4 [7]

Figure 20: Plot of menisci thickness [2]

Figure 21(a): Knee MRI with suspected menisci tears [2]
Calculation of cartilage thickness is shown in below table.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Thickness of Cartilage in mm</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>31</td>
<td>Male</td>
<td>2.81</td>
<td>Doubtful OA</td>
</tr>
<tr>
<td>Case 2</td>
<td>30</td>
<td>Male</td>
<td>2.8</td>
<td>Doubtful OA</td>
</tr>
<tr>
<td>Case 3</td>
<td>48</td>
<td>Male</td>
<td>4.21</td>
<td>Normal</td>
</tr>
<tr>
<td>Case 4</td>
<td>45</td>
<td>Male</td>
<td>4.12</td>
<td>Normal</td>
</tr>
<tr>
<td>Case 5</td>
<td>34</td>
<td>Male</td>
<td>4.2</td>
<td>Normal</td>
</tr>
<tr>
<td>Case 6</td>
<td>42</td>
<td>Female</td>
<td>2.81</td>
<td>Normal</td>
</tr>
<tr>
<td>Case 7</td>
<td>39</td>
<td>Male</td>
<td>3.51</td>
<td>Normal</td>
</tr>
<tr>
<td>Case 8</td>
<td>54</td>
<td>Male</td>
<td>2.109</td>
<td>OA</td>
</tr>
<tr>
<td>Case 9</td>
<td>41</td>
<td>Female</td>
<td>2.2</td>
<td>OA</td>
</tr>
<tr>
<td>Case 10</td>
<td>53</td>
<td>Female</td>
<td>2.9</td>
<td>Normal</td>
</tr>
</tbody>
</table>

Figure 21(b): Processed image showing menisci tears [2]
IV. CONCLUSION

Image processing techniques are applied to calculate cartilage thickness and visualize a tear of menisci. Articular cartilage and menisci are visualized in 2D view. Cartilage thickness is calculated in normal and OA subjects. In OA case it is found that cartilage thickness is reduced near the medial tibia femoral compartment. Thickness measurements are compared in the region of femur tibia interface. In meniscus problems of knee, Menisci has wear and tear which is visualized by Image processing. In this method, the mask generation is based on ROI polygon. It can be visualize in 3-Dimentional view in future.

REFERENCES


[4] View of Menisci type : Available:

[5] Types of Menisci tear : Available:
http://www/howardluksmd.com/types-meniscus-tears/


