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Improvement in accuracy in knee joint using semi-automatic segmentation

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Abstract: ***In this paper semi-automated methods is presented for segmentation of bones and cartilage in Magnetic Resonance Imaging (MRI) of the knee. The MRI of a knee gives potential of analysis of the cartilage. The most complex joint of the human body is knee joint. Because of the complex joint it has the cause to get frequently injured. According to various surgeons the risk of knee problems are high as compared to other cardiac diseases. Thus, to find the causes or to study the anatomy of the knee some instruments were used to get the result in a good manner. The most widely instruments used to highlight the knee joints are Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans, provides alot of information about the functioning, structure and the behavior of the joints. The presentation of the slippery hyline material in the articular cartilage gives the movement to the joints so that they can slide easily and prevents the rubbing of the bones over each other. Due to continuous movement this material starts reducing its slippery property and causes the deformation in the joints, due to this the bones starts rub against each other causes weathering of bones in the joints. This leads to cardiac disease named osteoarthritis also known as OA. This happens generally to 60 above aged people but nowadays this problem has a raised in 25- 55 aged peoples.***

Key words: knee joint, MR images, segment process.

I. INTRODUCTION

The ends of articulating bones in diarthrodial joints are covered by a thin (1 mm to 6 mm), dense connective tissue called articular cartilage. In the knee joint, articular cartilage covers the patella, tibia and femur, mainly in the regions where these bones come in contact to one another. The patellar cartilage is the thickest (3.0 mm on average) and the tibial is the thinnest (1.6 mm on average). More study of the knee joint can be extracted from the textbook Basic Biomechanics of the Musculoskeletal System.

The simulation of the cartilage is must to get the nature of the material of the fluid. Some tests such as in vitro and in vivo where the viscoelastic behaviour of the material is performed on the basis of the compression and the to get the behaviour of an object. The cartilage compression represents the boimedical behaviour of the material which acts on the basis of compression level in invitro test. Because of its excess amount and the non-monitoring problems it is not possible to simulate it. Instead of this in vivo tests are performed to get the dynamic behaviour of the material.

Some in vivo tests are based on the modern equipments such as Magnetic Resonance Tomography (MRT), Computed Tomography (CT), Pistron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT) and ultrasound provides the full dataset of the joint and the study of the structures. For comparison purposes we can compare images of x-ray, CT scan and MRI but in all this imaging technology MRI suits best for imaging of cartilage. This technology is based on nuclear magnetic resonance which was discovered in 1946 by Felix Bloch and Edward Mills Purcell. The first MRI image was produced in 1973 at that time it took several hours for the result. Therefore, the acquisition speed and the resolution has increased for better results. The structure of knee is presented in fig 1.

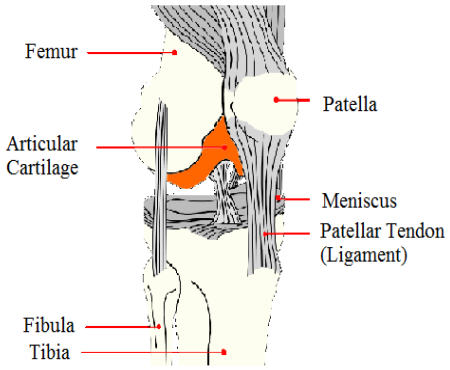


Fig: 1 Anatomical structure of knee.

These modern techniques provide full 3D dataset where the visualization and quantification of images can be done. It provides the similarities and diffrences between the different datasets to get the accurate results with the help of various techniques. Some of the techniques were used one of them is segmentation of images. This segmentation technique gives various information of the data related to its physical shape, size, appearance, value, etc. segmentation is done on the basis of the need as it has the ability to perform its task at any point in image. Hence, some of the techniques are manual, automatic, semi-automatic and fully automatic segmentation techniques used on the basis of their requirement in the object.

II. Literature Review

Due to the reduce in the bones results in pain, connective and non connective t issues covering in the affected joint may become lax, results in the disability causes movement. One of the main cause of OA is the degradation of the ability to move in joints. It mainly affects the heavy weight bearing joints such as knee and hip but also small hand joints. The remedy of this treatment is very expensive in terms of financial and human resources. The graph of this problem is increasing on a daily basis , the healthcare cost and utilization project which includes the hospitalizations says the stat of this disease has been increased from hundreds to thousands and the peoples are not of same age group they are from 28, 35, 55 and so on.

The articular cartilage is a highly specialized tissue, whose functions consist of distributing the joint load over a wider area of the bones and allowing movement of the opposite joint surfaces with minimal friction and wear. Accordingly, articular cartilage is a viscoelastic material with two distinct phases: a solid phase (the organic extracellular matrix) and a movable fluid phase (the interstitial water with inorganic salts dissolved in it). Consequently, on considering a fluid-filled, porous-permeable medium whose compressive viscoelastic behavior is caused primarily by the flow of the interstitial fluid and the intrinsic viscoelasticity of the matrix.

III. Design

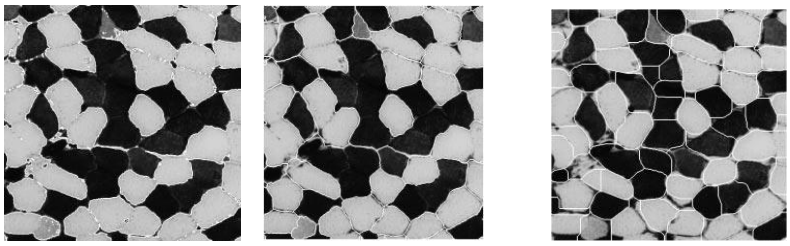
The automatic and semi automatic have been used especially after the high resolution and contrast images with 3D flat suppressed pulse sequences. As these images provides good imaging at bone cartilage interface hence, many methods of detection have been explored. Due to the noisy characteristics a semi automatic which is an interactive technique based on edge and splines is used with the aim of reduction in time and efforts while preserving accuracy. Grey level and shape based interpolation techniques should be performed before 3D analysis of segmented cartilage.

Part of the semi-automatic tools was also ported to the program that implements the automatized method for patellar cartilage segmentation. Consequently, they can be used to correct the segmentation results along with the performing interactive delineation of any structure present in the MR data volume. This program was named “Automatized Cartilage Segmenter” also known as “ACS” throughout the remaining of this thesis.

Here, the presentation of the first part of the practical outcome of this research, namely the semi-automatic segmentation tool implemented in the stand-alone application named "Segment 2002". The chapter is organized as follows: at first, the methodology employed for acquisition of 3D MRI scans of the knee joint is described.

A. Thresholding : The technique which gives results in a simplest and with its powerful applications is called as thresholding. It gives the images having light objects in dark background. It is based on the characteristics of image in space regions and has the capability to convert multilevel image into the binary one. Dividing the pixels into several regions and then placing it into the background by separating objects which further gives the pixel value as a part of an object if its intensity value becomes greater than or equal to the threshold value otherwise pixel belongs to the backgroung.

On applying this method we get the values in their different format. On considering a soil image, we get the boundaries produced by three segmentations of muscle fibres by prewitt's edge filter removing small regions and by watershed algorithm from a variance filter with Gaussian weights.



(a) (b) (c)

Fig 5.8: (a) threshold output, (b)Prewitt's edge filter, (c)watershed algorithm

On considering the threshold '*t*' with manually selected values as 7, 10, 13, 20, 29 and 38. Then we get the six elements of the soil image with the corresponding approximated values of 10%, 20%, ..., 60% respectively having the image being displayed black. In this application, the main aim was to isolate soil material from air filled pores appears as the darker pixels the segmentations of this soil images.

B. Histogram based Thresholding : In this thresholding let the pixel values have the histogram namely *h*0, *h*1,.....,*hN*, where *hk* represents the number of pixels with a greyscale value *k* and *N* is maximum pixel value (255). A simple algorithm was proposed for choosing a single threshold is called as intermeans algorithm.

This algorithm states that there should be a possible value for threshold from which the pixels mean values in two categories could be done. On calculating the mean values again we get a new threshold value. This is done until the threshold stops changing its values.

Mathematically, considering an initial guess at *t* set to median pixel value hence we get,

$$\sum_{k=0}^{t} hk \geq \frac{n^2}{2} > \sum_{k=0}^{t-1} hk \qquad (1)$$

Where, $n^2$is no of pixels in *n* x *n* image.

Calculating the mean pixel value, for values ≤ *t*,

$$\mu 1 = \sum_{k=0}^{t} khk \ / \sum_{k=0}^{t} hk \qquad (2)$$

And for values > *t*,

$$\mu 2 = \sum_{k=t+1}^{N} khk \ / \sum_{k=t+1}^{N} hk \qquad (3)$$

Hence on calculating we get *t* ,

$$t = [\frac{\mu 1 + \mu 2}{2}] \qquad (4)$$

where, brackets denotes integer of the expression between brackets.

Here, repeat the above steps until *t* stops changing value between consecutive evaluations.

IV. Conclusion

We have seen that the automatic segmentation of medical imagery is a difficult problem for which no generic solution can be expected in the near future. In order to improve the reliability of cartilage delineation from MR scans of the knee, we have developed a tool that performs automatic segmentation of the patellar cartilage. The same tool also implements manual and semi-automatic methods of interacting with the segmented structures, thus supplying fast and simple means of correcting any eventual inaccuracies that may affect the automated process. Also, a customized registration algorithm was developed that can be used, alone or in conjunction with the automatic segmentation, for estimation of the deformations that occur in the patellar cartilage during in vivo compression experiments. In the following, the description of the main features and implications of the proposed frameworks are given. After correcting the possible inaccuracies, the user propagates the adjusted curve to the neighboring slices and performs the same adjustment operations, using it as an initial estimate of the object's shape in those slices.

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