DETERMINATION AND ANALYSIS OF ARTHRITIS USING DIGITAL IMAGE PROCESSING TECHNIQUES

[1]BHAVYASHREE K G, [2]SHEELA RAO N

[1,2]Department of Instrumentation Technology, Department of Instrumentation Technology, S.J.C.E., Mysore
E-mail: bhavyagkshetty@gmail.com, sheelaraon@gmail.com

Abstract- Arthritis is a common bone disease that mainly affects the joints of the body; basically fingers, hands, knees. This may lead to disability, premature mortality and chronic ill-health. In this work, MRI images of knee have been used for analysis. The estimation of volume or thickness of cartilage at knee plays an important role in determining arthritis. The image is first preprocessed with B-Splines creation before segmentation. Then the edges are fine tuned with canny and log edge detectors. Finally the distance between the edges is calculated in order to find cartilage thickness. The thickness is measured as the number of the pixels between edges. Then depending on the thickness value the abnormality is decided about arthritis. This is a very simple and efficient way to determine arthritis based on threshold cartilage thickness value.

Keywords- Arthritis, B-Spline, Anisotropic diffusion, Articular cartilage.

I. INTRODUCTION

Arthritis is a common chronic, systemic, inflammatory disease that mainly occurs in the joints of the body; basically fingers, hands and knees. It targets synovial joints, in which there is a massive accumulation of blood-borne cells such as T cells and macrophages. Blood vessels are formed to support this new tissue and the whole mass is called a pannus, which leads to disability in patients. Arthritis affects about 0.5% – 1% of the population (ratio of female to male patients is about 3:1).Mainly after the third year of the start of the disease 75% of all patients become disabled. Also life expectancy of a patient may reduce by 4 – 10 years. Till today there is no proven cure for the disease, hence close monitoring of the disease is important in medical treatment of the disease. This may help in preventing further damage to the bones. The morphological degeneration of articular cartilage is a general significant feature of Arthritis. Magnetic resonance imaging (MRI) images helps in quantitatively analyzing and visualizing the cartilage thickness and volume.

Many Researchers have presented their ideas for determination of Arthritis. Visual inspection or interactive analysis has been used in and it is not found to be very effective. Morphological operations like dilation and erosion followed by perimeter determination and Skeletonization is used in. Other methods like cropping, ROI and Histograms techniques have also been used for the determination of the disease. But, the results presented here are preliminary and focused only on the reproducibility aspects of the technique.

In this work, first input MRI image is taken and pre-processed to remove various noises and to make it suitable for the further analysis. Then Bezier Splines curve is obtained. On the Bezier Spline, anisotropic diffusion algorithm is applied to smoothen the image and fine tune the edges of the objects. Edges in the resulting image are enhanced by applying canny edge detection and Log edge detection algorithms. Later, the auto adjustment algorithm is used to shift the control points to the actual edge. Once the edges are made to appear properly, thickness is measured as the distance between the two edges in terms of number of the pixels.

II. PROPOSED METHOD

The proposed method for achieving the desired cartilage quantification and visualization is shown in Fig. 1. In this method MRI image of the knee is taken as the input and a set of control points are first selected. The random curves are created by joining these control points called Bezier splines. This is created by placing control points around and closer to cartilage contour. The control points are created by selecting the area of interest using trial and error method. Then the image is smoothened using non linear anisotropic diffusion. Edges are enhanced by applying Canny and Log edge detection methods. Later, the automatic shifting of the spline curve is done to the actual edge control points. Finally the thickness is measured in terms of pixels between the edges by measuring distance between them.

Bezier Splines creation:

Bezier splines or curves are piecewise polynomials with pieces smoothly connected together in order to obtain a continuous representation of a discrete signal in one or more dimensions. In this work, the control points are created by identifying the area of interest using trial and error method. The curve is formed by joining these control points.
Edge detection:
This algorithm is used to find the edges in the image.

The points at which image brightness varies sharply are typically organized into a set of curved line segments and are termed as edges.

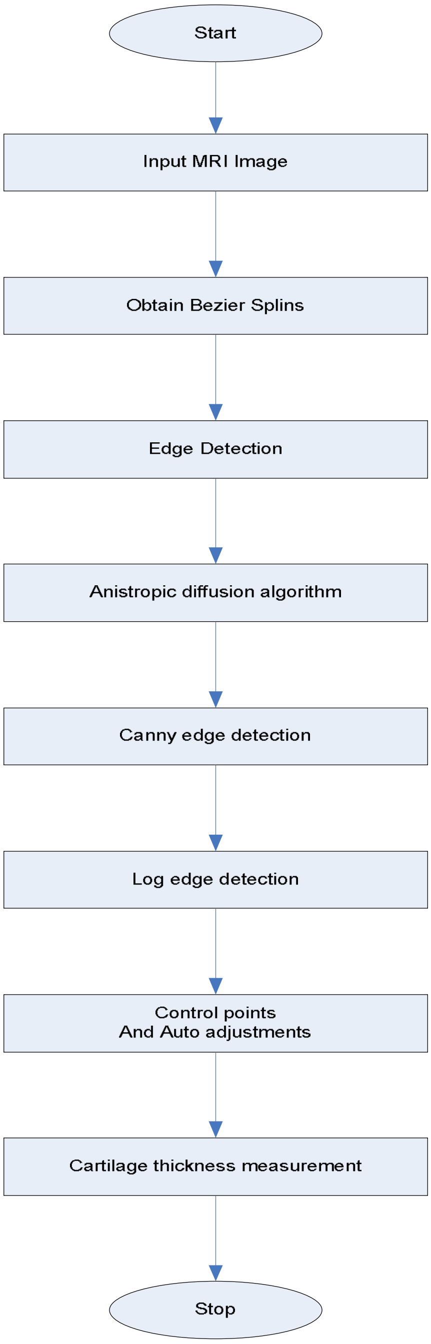

Fig.1 Proposed method Flow diagram

Anisotropic diffusion Algorithm:
This is the method used to smoothen the image by removing unwanted data and retaining significant data used in future. Here, non-linear anisotropic diffusion method is applied in which, pixels are treated with varying intensity depending upon its neighborhood qualities. This is basically a filter that smoothens inside the region but skips the edges in the image. The procedure is as follows.
The gradient of brightness function is given by

$$\nabla I(x, y, t) = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}\right) \quad (1)$$

It can be see that when the gradient is high, pixel could be treated as edge points.
Estimate edge or not-edge using

$$E(x, y, t) = \nabla I(x, y, t) \quad (2)$$

Create function g that controls blurring intensity according to $\|E\|$

$$g(\|e\|) = e^{-\left(\frac{\|E\|}{k}\right)^2} \quad (3)$$

Where k is a constant.
Find the co-efficient that controls how much smoothing is done in (x, y) as

$$C(x, y, t) = g(\|\nabla I(x, y, t)\|) \quad (4)$$

C(x, y, t) is large when (x, y) is not a part of edge and vice versa.
This method provides good intra region smoothing and generally keeps the edges as they were.

Edge enhancement:
The purpose of edge enhancement in general is to significantly reduce the amount of unwanted data in an image, while preserving the structural properties to be used for further image processing. Cartilage edge detection is further improved by using combination of two different types of filters. Canny edge detector is applied for detecting the bone-cartilage interface. This gives accurate detection of edge that plays an important role in Euclidean Distance Transform (EDT) based measurement of cartilage thickness. The articular cartilage contour is detected by using Laplacian of Gaussian (LoG) filter.

Control Points Automatic adjustment:
Here, the control points are adjusted or shifted to the actual edge. In this method a 7*7 matrix (mask) is taken and moved pixel by pixel on edge points by checking whether the middle pixel is 1 or not. If the pixel is 1, then there is no need to change the position. If not, then nearest point having pixel value 1 is selected and the control point is shifted to that point. The distance for the nearest point is determined using Euclidian distance.

Cartilage thickness measurement:
The cartilage thickness is measured in terms of pixels. The image is scanned starting from first pixel and wherever two edge points are found, the distance is calculated between those two edges. The mean of the distances is taken as cartilage thickness.

III. RESULTS & DISCUSSION

Visualization of quantitative data helps a lot in easy identification and assessment of cartilage at knee, which in turn facilitates arthritis determination. Resulting images of different steps involve in the visualization process is shown below.

Fig.2 Input image

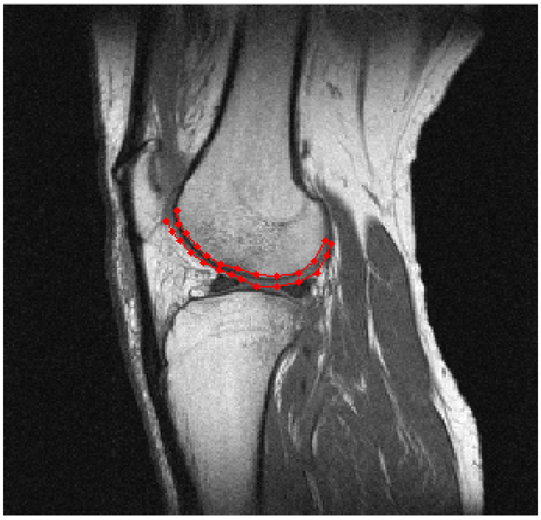

Fig.3 Selected Control points

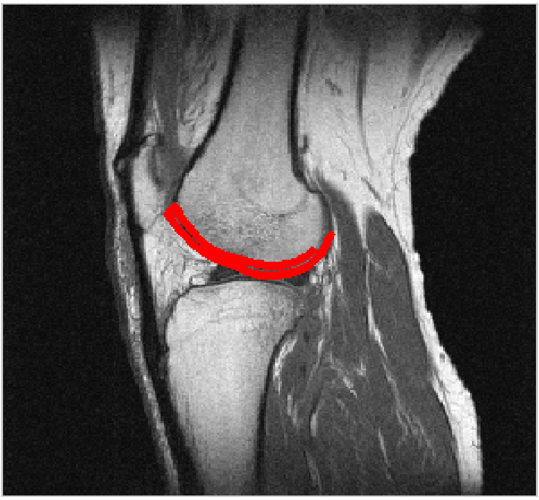

Fig.4 B-Spline output

The input image taken for analysis is shown in fig.1. The control points selected in the region of interest is shown in fig.2.The control points are connected and spline is created called B-Spline shown in fig.3. The smoothened image using anisotropic diffusion algorithm is shown in fig.4. The edge enhanced image obtained using Canny and Log edge detector output is shown in fig.5 and 6 respectively.

Fig.5 Anisotropic diffusion algorithm

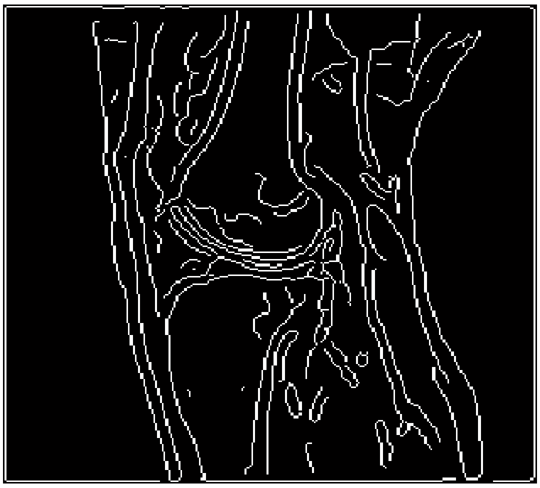

Fig.6 Canny edge detection output

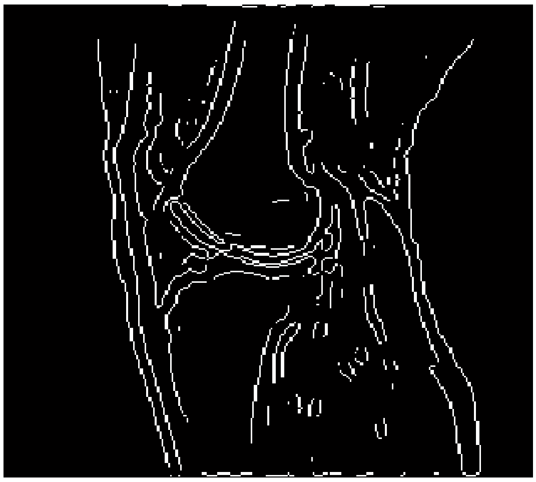

Fig.7 Log edge detection output

The control points adjustment and shifted images are shown in fig.7 and 8 respectively. The thickness measurement using a shining vertical line is shown in fig.10. The determination of the disease is done using thresholding method. The thickness above the threshold value is declared as normal and the cartilage having thickness less than the threshold is abnormal and confirms arthritis.

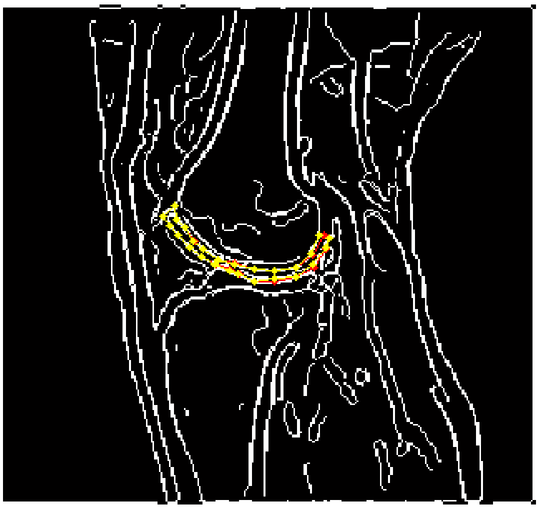

Fig.8 Control points adjustment

Fig.9 Control points adjusted image

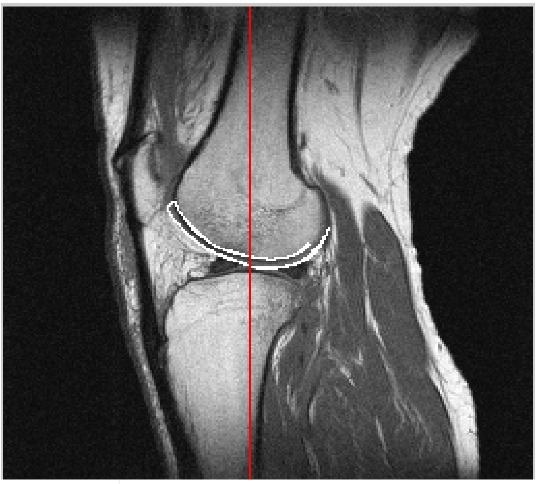

Fig.10 Result

The method is tested for some 31 images where sensitivity or true positive rate is 92%. Specificity or true negative rate is 88%. Precision or positive predict value is 87% and negative predict value is 94%. Accuracy of the proposed method result is 90%. False positive rate is or fall out is 12%. False discovery rate is 13%.

CONCLUSION

The visualization of quantitative result helps in determining and analysis of the arthritis disease. The method is simple and efficient in attaining the aim of early arthritis detection based on cartilage thickness. This algorithm can be improved further by implementing automated technique for threshold selection. This technique can also be used for the determination of gap between the tibia and femur of knee for more accurate detection of arthritis.

REFERENCES

[1] Jurgen Fripp, Erin Lucas, Craig Engstrom, “Automated Morphological Knee Cartilage Analysis of 3D MRI at 3T”, MAGNETOM Flash, Feb/2013

[2] Syed Afaq Ali Shah, K. M. Yahya, G. Mubashar, Abdul Bais, “Quantification and Visualization of MRI Cartilage of the Knee: A Simplified Approach”, 6th International Conference on Emerging Technologies (ICET), 2010.

[3] Arpita Mittal1, Sanjay Kumar Dubey, “Analysis of Rheumatoid Arthritis through Image Processing”, IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 6, No 2, November 2012

[4] Arpita Mittal , Sanjay Kumar Dubey, “A Literature Review on Analysis of MRI Images of Rheumatoid Arthritis through Morphological Image Processing Techniques”, IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 2, No 3, March 2013.

[5] Kelvin Ka-fai Leung, Longitudinal analysis of MRI images in rheumatoid arthritis, IJCSI, November 16, 2007.

[6] Y.-L. You,W. Xu, A. Tannenbaum, andM. Kaveh, “Behavioral Analysis of Anisotropic Diffusion in Image Processing”, IEEE Trans. Image Proc., Vol. 5, pp. 1539 – 1553, 1996.

[7] G.T. Shrivakshan1, Dr.C. Chandrasekar, “A Comparison of various Edge Detection Techniques used in Image Processing”, IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 5, No 1, September 2012.

[8] Karen A. Panetta, Eric J. Wharton, “Logarithmic Edge Detection with Applications”, September 2008.

[9] Yongjian Yu and Scott T. Acton, “Speckle Reducing Anisotropic Diffusion”, I EEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 11, NO. 11, NOVEMBER 2002.

[10] J. J. Clark, “Authenticating edges produced by zero-crossing algorithms”, in IEEE Trans. Pattern Analysis and Machine Intelligence 11, Nr. 1, S. 43-57, 1989

[11] A. Goshtasby, “On edge focusing”, in Image and Vision Computing12, Nr. 4, S. 247-256, 1994.

[12] A. Persona, T. Shiota and J. Malik, “Anisotropic Diffusion”, in Geometric Driven Diffusion in Computer Vision, Volume 1, PP 73 –92, 1994.

★★★