Analysis of MRI Images of Rheumatoid Arthritis through Morphological Image Processing Techniques

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Abstract

This paper is application of image processing techniques for identification of most common disease i.e. Rheumatoid Arthritis (RA). Till date there is no proven cure for the disease, hence close monitoring of the disease is important in the medical treatment of this disease. In this paper Fingers and Knee images of the patient having RA have been analyzed through Morphological Image processing techniques. This includes erosion, dilation, Perimeter determination and Skeletonization. The processed images find their application in the field of Medical Science and can be beneficial for doctors in identification of disease stages from monitoring point of view.

Keywords: Rheumatoid Arthritis (RA), Morphological Image processing, erosion, dilation, Perimeter determination and Skeletonization.

1. Introduction

Rheumatoid Arthritis (RA) is a disease, which is a common, chronic, systemic, autoimmune inflammatory disease in nature that mainly affects the joints of the body; basically fingers, hands, knees and cause disability, premature morality and chronic ill-health [1]. 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 progressive erosion to cartilage and bone leads to disability in patients. RA 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 75% of all patients get disabled [2]. The life expectancy of a patient is reduced 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. There are various methods available for treatment of the +disease, among which Joint damage assessment in hand radiographs is the most frequently used method [2]. Additionally, the sensitive biomarkers of the disease progression are being developed, so that the performance of the candidate disease by the modifying drugs can be quantified in a short period of time [3].

Signs and Symptoms of Rheumatoid Arthritis (RA): Since Rheumatoid Arthritis mainly occurs in the joints of the body, so it includes the problems involving the other organs of the body [4].

During the last two decades, traditional techniques such as bone ultrasound scintingraphy, contrast enhanced and most recently used MR, mainly contrast enhanced MR, and was used in two ways: firstly for theearly diagnosis, and secondly for assessing the effectiveness of the often and the expensive toxic therapies. However, on clinical background MR remains incompletely accepted [5] [6]. The major limitations encountered in early work were its large size of sensors, low resolution, and the limited power of computers for the image post processing [7]. The use and development of imaging biomarkers are now becoming more critical and important in the

drug discovery. The Drug administration (FDA) and US Food report "Innovation/Stagnation: Challenge and Opportunity on the Critical Path to New Medical Products" addresses the recent slowdown in innovative medical therapies submitted to the FDA for approval, describes the most urgent needs for modernizing the medical product development process - the Critical Path - to make product development more predictable and efficient [8]. In this paper, fully automated, a new, content-based system is being proposed for the knee bone segmentation from magnetic resonance images (MRI). The purpose of the bone segmentation is to support the discovery and characterization of imaging biomarkers for the incidence and progression of osteoarthritis, a debilitating joint disease [9] [10]. Image Compression is basically a technique in which unnecessary noise/data is reduced and is generally referred as Digital Compression. There are two types of image compression techniques: "Lossless" or reversible compression and "Lossy" or "irreversible compression" A Lossless Compression technique is a technique in which there is no loss of information and image data while in Lossy Compression technique there is image transformation, quantification, and encoding [11].

All these methods work with a common objective, i.e.,to provide a solution for efficient automatic medical image segmentation. Now-a-days the use of wavelet transformation and morphological transformation are gaining more attention for segmenting medical images Morphological transformation combines geometrical features and edge features to segment the image. With the use of morphological-based segmentation the problem of over and under segmentation can be avoided [12].

2. Methodology

For modification of pixels in an image the technique known as Morphological image processing is used. For grayscale image, the pixels are identified by their binary values i.e. 0 and 1, and for this process is conducted by using either sophisticated image processing algorithms or by less mathematically complicated operations, which includes erosion and dilation as well as opening and closing of images. Basically the main purpose of the Morphological Image Processing is to remove unwanted artifacts in an image or to improve image's clarity. In the presented paper for the identification of disease, I am using the techniques of erosion and dilation along with the combination of Skeletonization and Perimeter determination. For image representation of objects of an image, specific set of pixels called object pixels is used. Background pixels are white and are represented separately. By erosion operation, the conversion of the pixels associated with the object's boundary to pixels in the background is possible, while with the help of dilation operation, the bordering background pixels can be changed to the ones that are associated with the object. Basically erosion process is used for making the objects smaller and dilation process is used for enlarging or even for merging the object.

2.1 Dilating an Image

For dilating an image, the imdilate function is used. The imdilate function is a function that mainly accepts two primary arguments i.e. the input image, which is to be processed (binary, packed binary image or a gray scale image).For returning a structuring element an object, either the strel function is used, or a binary matrix defining the neighborhood of a structuring element can be used. The minimum value afforded by the data type is assigned to the Pixels beyond the image border. These pixels are assumed to be set to 0, for binary images and in case of grayscale images, for the uint8 images; the minimum value is set to 0.

With the help of structuring element *b* the Morphological dilation of *f* image is given as:

$$\delta (f, b)(s, t) = \max\{f (s - x, t - y) + b(x, y) / (s - x, t - y) \in Df ; (x, y) \in Db\}$$

Where *Db* and *Df* mainly are the domains of the *b* and *f functions*, respectively.

2.2 Eroding an Image

For eroding an image, the imerode function is used. The imerode function mainly accepts two primary arguments i.e. The input image which

is to be processed (binary, packed binary image or a gray scale image).For returning A structuring element object, either strel function, or a binary matrix that defines the neighborhood of a structuring element is used and for the pixels that beyond the image border are mainly assigned the maximum value afforded by the data type. These pixel values for binary images, are assumed to be set to 1 and for the grayscale images, the maximum value for the uint8 images is set to255.

Basically the Morphological erosion of an *f* image by the structuring element is given by:

$\varepsilon(f, b)(s, t) = \min\{f(s+x, t+y) - b(x, y) / (s+x, t+y) \in Df ; (x, y) \in Db\}$

Where *Db* and *Df* are mainly the domains of *b* and *f* functions, respectively.

2.3 Structuring Element

The dilation and erosion functions accept structuring element objects, called STRELs. The strel function is use to create STRELs of any arbitrary size and shape. The strel function can be of many common shapes, mainly as periodic lines, disks, diamonds, balls and lines. Here in this paper I typically chosen a structuring element which is of diamond, rectangular and arbitrary shaped. It should be noticeable that the structuring element must be of the same shape and size as that of the object's input image.

2.4 Combining Dilation and Erosion

For implementation of image processing operations combination of dilation and erosion are mainly used, for example, the definition of a morphological opening of an image says that it is erosion which is followed by dilation, with the help of the similar structuring element for both operations. The related operation, for morphological closing of an image, is just the reverse, which consists of dilation followed by erosion with the similar structuring element. Skeletonization and Perimeter determination are which are mainly the two common images processing operations based on the techniques of the dilation and erosion. For reducing all objects in an image to lines Skeletonization is used, in which the essential structure of the image is not changed, on the other hand the Perimeter pixels of the objects in a binary image is the operation called Perimeter Determination. For a pixel that is to be considered as a perimeter pixel if it satisfies both of these criteria i.e. the pixel should be on and one (or more) of the pixels in its neighborhood should be off.

3. Results and Discussion

First read the images of Fingers and Knee having Rheumatoid Arthritis into the MATLAB workspace than create a structuring element. For eroding an image, the structuring element should be is of diamond and rectangular in shape type and the structuring element taken should be large enough to be to be to remove the lines, but it should not be large enough to remove the rectangles. It should be contains all 1's, and so on large contiguous patches of foreground pixels it should remove everything. Finally for restoring the rectangles to their original sizes, the eroded image using the same structuring element is dilated, SE, will removes all the lines, but also shrinks the rectangles. The diamond shape structuring element creates 9x9 matrix, having all 1's in diamond shape along with 41 neighbors. Similarly arbitrary shaped structuring element creates a diagonal structuring element object having 5x5 matrix having all diagonal element 1, a Flat STREL object containing 5 neighbors. For enhancing the performance of Structuring Element Decomposition, the strel function may break down the structuring elements to smaller pieces, a technique is called as structuring element decomposition.

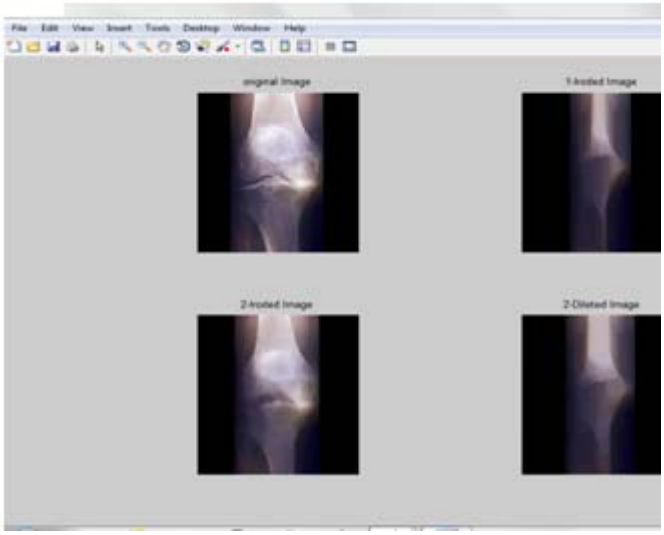

Figure 1: Iroded and Dilated Images of Knee Image 1 Iroded/Dilated-images are generated due to Rectangular structuring function and 2 Iroded/Dilated-images are generated due to diamond shape structuring function. Image sequence (2, 3, and 6) is the skeletonised hand image.

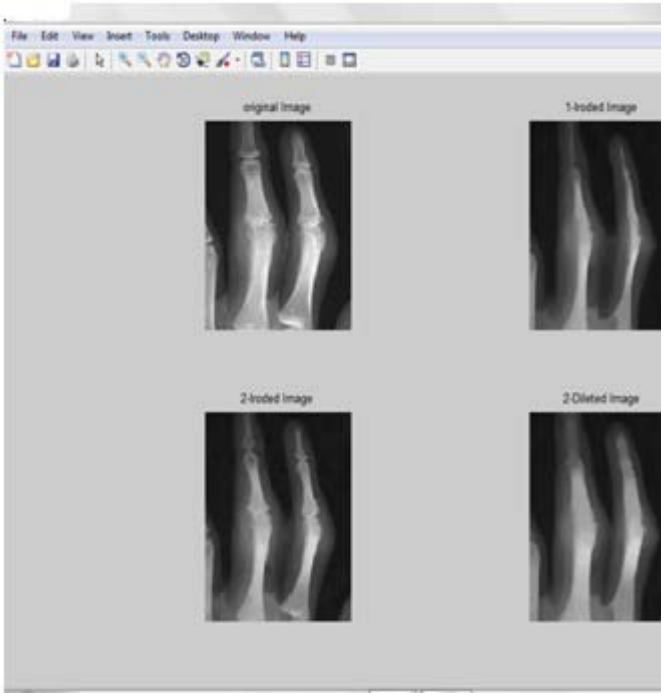

Figure 2: Iroded and Dilated Images of Fingers Image 1 Iroded/Dilated-images are generated due to Rectangular structuring function and 2 Iroded/Dilated-images are generated due to diamond shape structuring function. Image sequence (2, 3, and 6) is the skeletonised Fingers image

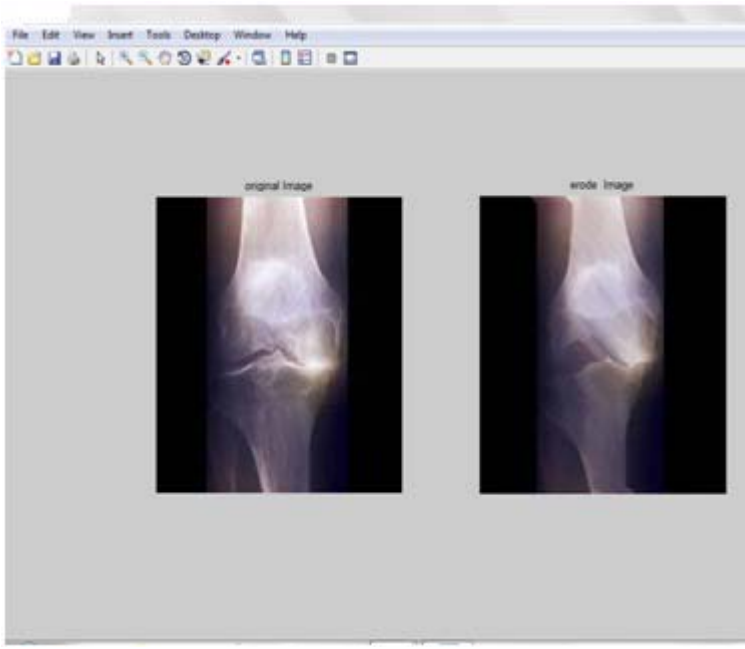

Figure 3: Iroded and Dilated Images of Fingers Image, generated due to arbitrary shaped structuring function.

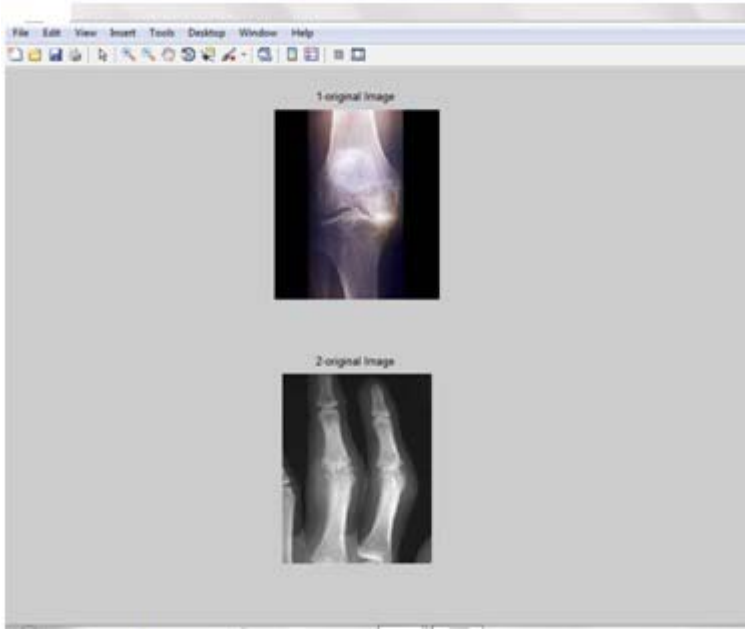

Figure 4: Parameterised Images of Knee and Fingers.

4. Conclusion and Future Scope

For developing an image technique that will become fruitful for medical imaging bones. For those Doctors will not be able to diagnose the

diseases in the earlier stages, if Rheumatoid Arthritis will not be occurring in the earlier stages, doctors will ask for Ultra Sounds and X-Rays, again and again. By the work presented in this paper they will be able to diagnose the disease in the first X-Ray, MRI and Ultra-sound. In this paper a radiographic Image processing based methodology is presented to Results that are obtained from the clinical trial data should be providing a better understanding. The presented project provides accurately and reliably diagnosis of the presence of disease Rheumatoid arthritis. The results presented here are preliminary and focused only the reproducibility aspects of the technique. This technique is being applied towards monitoring early stage rheumatoid arthritis patients in an ongoing clinical trial.

thought of better understanding towards the disease in a comparative way.

References

1. M. Akil and R. S. Amos. ABC of Rheumatology RHEUMATOID ARTHRITIS–I: CLINICAL FEATURES AND DIAGNOSIS. BMJ, 310(6979):587, 1995.
2. Kelvin Ka-fai Leung, Longitudinal analysis of MRI images in rheumatoid arthritis, November 16, 2007.
3. Monique Frize, Cynthia Adéaa, Pierre Payeurb, Gina Di Primioc, Jacob Karshd, Abiola Ogungbemilea, Proc. of SPIE, Vol. 7962, 79620M-1, Medical Imaging 2011, CCC code: 1605- 7422/11/$18.
4. Anne-Christine Rat and Marie-Christophe Boissier. Rheumatoid arthritis: direct and indirect costs. Joint Bone Spine, 71(6):518–524, November 2004.
5. P.P. Cheung, M. Dougados, L. Gossec. “Reliability of ultrasonography to detect synovitis in rheumatoid arthritis: a systematic literature review of 35 studies (1,415 patients)” Arthritic Care Res (Hoboken). 2010 Mar; 62(3):323-34.
6. J.E. Freeston, P. Bird, P.G. Conaghan. “The role of MRI in rheumatoid arthritis research and clinical issues.” CurrOpin Rheumatol. 2009 Mar; 21(2):95-101. Review.
7. M.A. Cimmino, M. Parodi, E. Silvestri et al. “Correlation between radiographic, echographic and MRI changes and rheumatoid arthritis progression.” Reumatismo, 2004 Jan-Mar; 56(1 Suppl 1): 28-40 Italian.
8. D. Symmons, G. Turner, R. Webb, P. Asten, E. Barrett, M. Lunt, D. Scott, and A. Silman. The prevalence of rheumatoid arthritis in the united kingdom: new estimates for a new century. Rheumatology, 41(7):793, 2002.
9. Automatic graph-cut based segmentation of bones from knee magnetic resonance images for osteoarthritis research bySufyan Y. Ababneh, Jeff W. Prescott, and Metin N. Gurcan Med Image Anal. 2011 August; 15(4): 438–448.
10. Bourgeat P, Fripp J, Stanwell P, Ramadan S, Ourselin S. MR image segmentation of the knee bone using phase information Med Image Anal. 2007;11(4):325–335.
11. Euclid Seeram RTR, BSc, MSc, FCAMRT Associate Consultant INSITE Consultancy Inc Ottawa – Canada, Irreversible Compression in Digital Radiology-A Literature Review,INSITE Consultancy Inc.,2004.
12. Najman, L. and Schmitt, M. (1996) Geodesic saliency of watershed contours and hierarchical segmentation, Pattern Analysis and Machine Intelligence, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol.18, No. 12, Pp.1163-1173.