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Segmentation of cartilage from knee MRI images using the watershed algorithm

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ABSTRACT

We present here watershed segmentation method for the segmentation of knee cartilage. Watershed segmentation is a state of the art method and involves great simplicity of application. MRI images of the knee cartilages are used for segmenting and early detection of the osteoarthritis. MRI images offer better visualization of the soft tissues like cartilage still visualization of the tissues prone to damage is needed to be detected earlier. However method incorporates noise while segmentation stills its great simplicity attracts researchers for its use.

Keywords: *Knee cartilage, dicom images, watershed segmentation etc.*

1. INTRODUCTION

Osteoarthritis (OA) is a highly prevalent joint disease for the older people across the globe, where the cartilage around bone-joints degenerates, which can adversely limit the range of movement. Cartilages are the soft tissues found between the joints of bones such as knees, ankles elbows and are important for the proper functioning of the joints. These tissues are made up of chondrocytes cell, which are capable to bear physical stress however; there are no blood vessels for the supply of the blood to these cells. Thus growth and repair of these cartilage tissues are slow compare to other tissues. MRI is the major clinical trial method for the cartilage tissue morphology however visual analysis of MRI imaging may sometimes fail to predict the partial loss to the cartilage which is prone to more damage in future.

A computerized method of segmentation of the cartilage tissues is described in this paper which is based on the morphology of the cartilage tissues. A well-known watershed method of segmentation of two contours separated by an intensity level is applied here for identification of cartilage tissue damage. Since the knee cartilage tissue has different contrast level than the bones therefore these are easily identifiable in MRI images between the femur and tibia. Current method uses MRI images to detect the damage in cartilage tissues early so as to check the further deterioration in the tissues.

Some automated or semi-automated methods for cartilage segmentation of knee region have been reported in literature some of these are for bone segmentation [5-7], tissue classification [8] models. Some more sophisticated snake based methods such as Chan-Vese based models have proved to be more stable in some cases [9]. In a few reported clinical studies some traditional and ad-hoc image analysis methods such as intensity threshold, texture analysis, and pattern classification with support. Compared to other method or method is a simple and robust and suitable for high contrast MRI images.

Figure 1 Anatomy of knee with (a) healthy cartilage (b) damaged cartilage

2. DATA ACQUISITION

MRI images of the Knee cartilage data has been acquired from the web address http://www.mr-tip.com during November-December 2017. Database acquired from above address has been used solely for research and full credits have been given to the MR technology group for providing the database for research purpose. From the available coronal, sagittal and transversal images we selected coronal and sagittal images. Since MRI images contain many slices for each patient only those slides which show complete cartilage are used for our purpose. Figure 2 below shows sample MRI image of knee cartilage.

(a) (b)

Figure 2 MRI image of knee cartilage (a) coronal (b) sagittal view

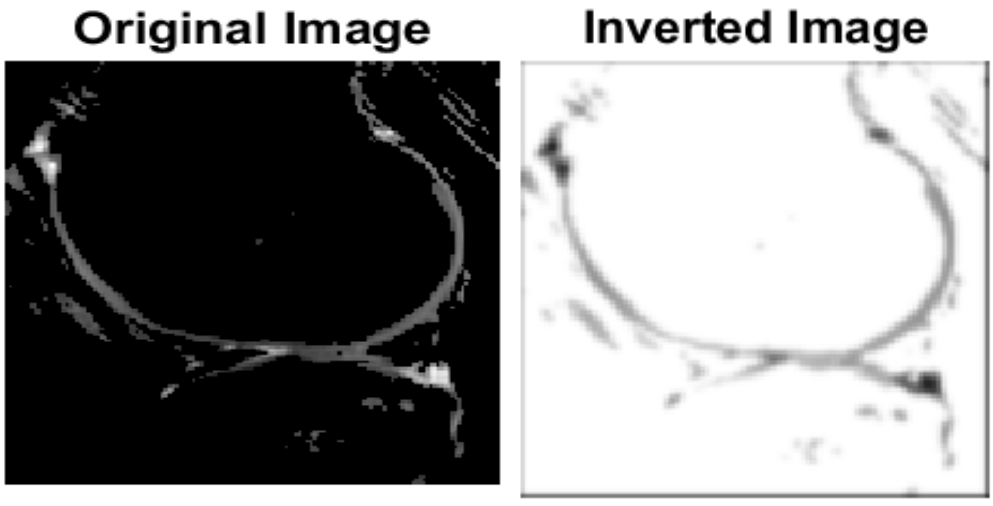
3. METHODOLOGY

Watershed segmentation is a widely used algorithm for image segmentation [1-4]. The method describes a landscape flooded by water and the watersheds divide the contours between the basins. These positions are described as the local minima, where water from different basins meets while filling the excavation. Watershed method of segmentation of images involves recursive increment in grey levels which is analogous to the water flooding over the depression.

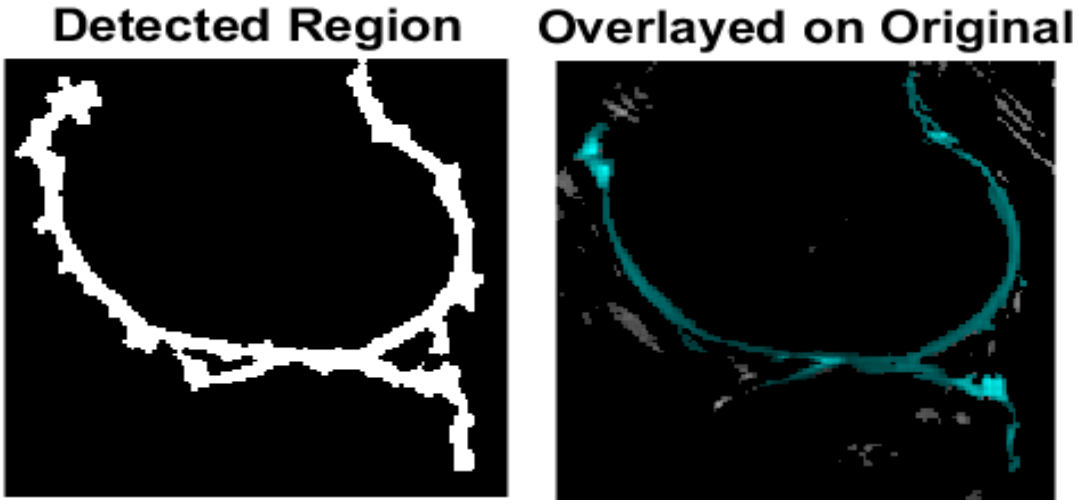
Watershed algorithm is generally applicable to the images which are described by the high contrast edges, and can be identifiable with respect to background due to differences in their contrast values. Thus watershed method is often applied after the edge filtering operation. We mainly focus on images which are surrounded by the ridges. Watershed algorithm gives better performance on the images surrounded by the ridges as compared to the intensity based segmentation method; however this method suffers with severe limitation discussed later in this paper.

4. EXPERIMENTS AND RESULT

In this paper watershed segmentation is successfully applied on knee cartilage for segmentation**.** The MRI DICOM (Digital Image and Communication in Medicine) images has taken for segmentation, as in experiment the original MRI DICOM image is successfully converted in inverted image and by using of original and inverted images detect the cartilage region in knee. And finally overlaid the detected region into original Knee MRI DICOM image. The overlaid image is very useful diagnosis of knee damage.



(a) (b)



(c) (d)

Figure 3 Segmented cartilage image (a) original image (b) inverted image (c) detected region (d) Overlaid on original

5. DISCUSSION

As we already discussed watershed segmentation algorithm is widely used algorithm but there is some important drawbacks also exist. Some drawbacks are as following:-

A. Over segmentation

When the watershed transform infers catchment basins from the gradient of the image, the result of the watershed transform contains a myriad of small regions, which makes this result hardly useful.

B. Sensitivity to noise

Local variations of the image can change dramatically the results. This effect is worsened by the use of high pass filters to estimate the gradient, which amplify the noise.

C. Poor detection of significant areas with low contrast boundaries

If the signal to noise ratio is not high enough at the contour of interest, the watershed transform will be unable to detect it accurately. Furthermore, the watershed transform naturally detects the contours with higher value between markers, which are not always the contours of interest.

D. Poor detection of thin structures

When the watershed transform is applied on the gradient image, the smoothing associated with gradient estimation, together with usual approach of storing gradient values only at the image pixel positions rather than with sub-pixel accuracy, make it difficult to detect thin catchment basin areas. Often this is critical for successful segmentation of medical images.

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