Interactive Hip Joint Cartilage Segmentation

Pavel Dvorak[1,2], Wolf Dieter Vogl[3], and Vladimir Juras[4]

[1]Institute of Scientific Instruments of the ASCR, v.v.i., Brno, Czech Republic, [2]Department of Telecommunications, Brno University of Technology, Brno, Czech Republic, [3]Computational Image Analysis and Radiology Lab, Department of Radiology, Medical University of Vienna, Vienna, Austria, [4]MR Centre of Excellence, Department of Radiology, Medical University of Vienna, Vienna, Austria

Purpose

This work deals with hip joint cartilage segmentation, which is an important task in joint diseases diagnosis. Since the manual segmentation, commonly used nowadays, is a tedious and lengthy task, this work brings new idea into its automation and simplification of the medical expert work.

Methods

The proposed method is an interactive algorithm for hip joint cartilage segmentation, and hence it requires some user interaction, which is common and usually desired in medical image processing. The first step of the method is a selection of several points not lying in a plane. The purpose is a rough delimitation of the cartilage area using a sphere fitting to these points. This delimitation is based on the assumption that the femur head has approximately circular shape. The next step consists of the manual selection of the suitable axial slice and the subsequent several reference point determination. These points are interpolated by a cubic spline in clock-wise order with respect to the center of the circle that best fits the points. The spline creates the foreground mask for subsequent segmentation. The background mask is created as inverted morphological dilation of the spline with particular dilation size dependent on the image resolution.

The labels for points in between foreground and background are computed by Graph Cut segmentation technique [1]. The result of the Graph Cut segmentation is corrected by Bayesian Quadratic Discriminant Analysis [2], where the training data consists of pixels inside and outside the segmentation result with respect to their label in the mask. To the pixels with previously unknown label the new label is assigned again and isolated ones are eliminated.

As a next step, the segmentation result can be corrected or confirmed by user and it is used as reference segmentation for neighbor slices. The points from the neighbor slice lying inside the dilated mask from the previous slice are again classified by Bayesian Quadratic Discriminant Analysis, where pixels from previous slice are used for training. Isolated pixels are eliminated and the result can be again corrected by user, because its precision play significant role in the subsequent segmentation in further slices.

Results

The algorithm was tested on 20 3D isotropic True-FISP volumes of patients with femoroacetabular impingement. All MR images were obtained using a 1.5 T system (Avanto®, Siemens Healthcare, Erlangen, Germany) with the voxel size of 0.63x0.63x0.63 mm and the volume size of 512x512x321 px. The ground truth performed by a medical expert was available. More information about the data can be found in [3].

The results were evaluated by commonly used Dice Similarity Coefficient (DSC) and Accuracy Coefficient (AC), where only the space inside the bounding box for enlarged fitted sphere was considered. If the whole volume had been considered, the DSC would reach the same value, but the accuracy would be very close to 1 and would not reflect the algorithm performance. No interaction or manual correction was performed during this testing procedure. The results are summarized in Table 1 using the both coefficients for initial selected slice and the whole 3D volume. For each of 20 cases, the algorithm was repeated three times with different initial slice, where 10 points were chosen in the initial slice. An average example of the result for an initial slice is shown in Figure 1.

Table 1 Evaluation of the automatic segmentation using DCS and AC for initial selected slice and the whole 3D volume

	DSC	AC
Initial slice	0.81±0.05	0.94±0.02
3D volume	0.62±0.07	0.96±0.01

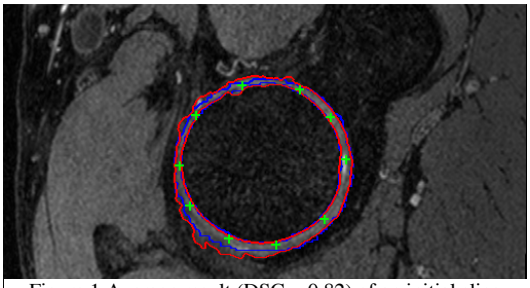

Figure 1 Average result (DSC = 0.82) of an initial slice segmentation (red) compared to ground truth (blue) for manually selected 10 points (green).

Discussion/Conclusion

This work describes the initial research in the automation of the hip joint cartilage segmentation task. The result of this work is a tool for the automated interactive segmentation, which speed up this tedious task in the diseases diagnosis and research. There are only few papers dealing with this particular problem (e.g. [4]), and these do not contain quantitative results; therefore the proposed method cannot be compared with them. The future research will be focused on improving the accuracy of the automated segmentation of the hip cartilage and will be prospectively used for the segmentation of quantitative MR maps (T1 and T2) in femoro-acetabular impingement (FAI) investigation.

References

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