A Study of Segmentation Method of Renal Region with Autosomal Dominant Polycystic Kidney Disease

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Abstract: As evaluation of disease progression or prediction of prognosis of patients with polycystic kidney disease (PKD), measurement of total kidney volume (TKV) has widely been accepted clinically. To establish automatic TKV measuring method with accuracy in PKD, we developed a segmentation algorithm of renal region. The coronal section of MRI T1 weighted images were used for the present study to capture the irregular boundary of polycystic kidney which often contacts with liver due to nephromegaly. Since biphasic luminance value of cysts and renal parenchyma was distributed, the GraphCut algorithm was utilized to discriminate renal region from the other organs. Then, the likelihood of pixels in foreground and background were calculated using Gaussian Mixture Model (GMM), and the GraphCut was performed. Segmentation results were evaluated by precision and recall, and compared with the method of the previous studies applying the region growing method and the level set method. The proposed procedure indicated high recall and precision compared to the previous studies.

Keywords: Segmentation, GraphCut, ADPKD, MRI

1. Introduction

Polycystic kidney disease (PKD) is a disease that a large number of cysts were occurred and enlarged progressively in renal parenchyma. For example, about half of the patients with autosomal dominant polycystic kidney disease (ADPKD) would be developed renal failure and required to have renal replacement therapy or renal transplantation. As evaluation of disease progression or prediction of prognosis of patients with PKD, measurement of total kidney volume (TKV) has widely been accepted clinically. Recently, administration of Tolvaptan is reported to restrain the growing speed of cysts in patients whose TKV is greater than 750 mL. Thus, accurate measurement of TKV is required to guarantee the validity as a reliable cutoff value in selecting patients to start therapy with severe adverse effects. The segmentation method [1] of the renal region with PKD using MRI T2 weighted images have been proposed, however, its segmentation precision is not sufficient such as lack of renal parenchyma and over extraction of liver region including hepatic cysts, for the automatic analysis of polycystic kidney [2, 3]. On the other hand, in clinical practice, TKV is measured with software equipped in 3D workstation or approximate calculation by assuming the kidney shape as a spheroid and measure height and width of the kidney manually. Since manual segmentation with 3D workstation wastes much time and labor load to the hospital staffs and the approximated TKV is not accurate and lacks reproducibility.

To establish automatic TKV measuring method with accuracy in PKD, we developed a segmentation algorithm of renal region and tested its ability comparing other methods proposed in the previous studies.

2. Methods

The coronal section of MRI T1 weighted images were used for the present study to capture the irregular boundary of polycystic kidney which often contacts with liver due to nephromegaly. Since biphasic luminance value of cysts and renal parenchyma was distributed, the GraphCut algorithm was utilized to discriminate renal region from the other organs. At First, a rectangle that surrounds the kidney was manually drawn, and the internal region of rectangle was defined as the foreground and another side the background. Secondly, the operator depicted the detail of the foreground area and background information in the foreground region selected in the first step. Fig.1 shows an example of image after indicating a rectangle, detail of foreground area, and detail of background area. Then, the likelihood of pixels in foreground and background were calculated using Gaussian Mixture Model (GMM), and the GraphCut was performed. Then, segmentation output of foreground was computed again by GMM and then foreground segmentation was calculated by GraphCut.

Fig.1 Input of GraphCut
Segmentation results were evaluated by precision and recall and F-measure, and compared with the method of the previous studies applying the region growing method and the level set method.

3. Results
Segmentation results using region growing method and level set method showed false extractions at the vague boundary of the kidney. On the other hand, the proposed procedure indicated high recall and precision compared to the previous studies (Fig.2). Table1 indicate that the F-measure in each segmentation method. Besides, renal region that include clear cysts configuration was obtained by using segmented results as a mask image for the same sectional T2 weighted image. Comparing to the previous studies, using T1 weighted images was effective to reveal detail segmentation showing clear anatomical boundary of organ. In addition, the GraphCut algorithm, which can contain larger information about the difference of the foreground and background area, helped to improve precision of the segmentation results.

![Segmentation result of GraphCut](image)

<table>
<thead>
<tr>
<th>Segmentation method</th>
<th>The mean ± standard deviation</th>
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<tbody>
<tr>
<td>Region Growing</td>
<td>0.53 ± 0.19</td>
</tr>
<tr>
<td>Level Set</td>
<td>0.75 ± 0.12</td>
</tr>
<tr>
<td>Graph Cut</td>
<td>0.93 ± 0.029</td>
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4. Conclusion
Segmentation method of renal region by GraphCut algorithm using coronal of T1 weighted images was proposed for TKV measurement of PKD cases. It was considered to be feasible to extract renal region with high precision and recall ratio.

5. References
