# Kidney Segmentation in DCE-MRI Based on Curvelet Transform and Snake Model

Hao Li[1], Bin Chen[1], Xiaoying Wang[1,2], and JUE ZHANG[1,3]
[1]*Academy for Advanced Interdisciplinary Studies, Peking University, Beijing, Beijing, China,* [2]*Radiology, Peking University First Hospital, Beijing, Beijing, China,*
[3]*College of Enigneering, Peking University, Beijing, Beijing, China*

**Purpose:**

In dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI), segmentation of internal kidney structures is essential for functional evaluation. However, manual morphological segmentation of cortex and medulla remains difficult and time-consuming. In this paper, a semi-automatic segment method for renal DCE images is proposed to reduce segmentation time and make the segmentation task easier.

**Materials and Methods:**

***Data source:***

In this study, four healthy subjects underwent DCE-MR scan. The images in our database were acquired on a 3.0T MR scanner. A 3-D enhanced fast gradient-recalled echo (EFGRE) sequence for T1-weighted images was used with the following parameters: 4/0.8 [repetition time(ms) /echo time(ms)]; flip angle, 12°;matrix,256×256; field of view, 380 mm; slicethickness, 4-mm; and acquisition time, 4s per frame. Totally 70 frames were acquired after an adminastration of 0.025mmol/kg of Gd-DTPA. 288 images of normal kidney during corticomedullary phase were selected to test the feasibility of our segmentation method.

***Segmentation method:***

**Enhancement based on Curvelet transform:**

According to the distribution of different renal segment in Curvelet domain, different enhancement functions are designed, in order to obtain one enhanced image suitable for external contour segmentation and another suitable for cortex/medulla segmentation: to enhance cortical part and suppress medullary part to obtain one for cortex/medulla segmentation, and to suppress medullary part to obtain one for external contour segmentation.

Here, a flexible operator is used to enhance the low frequency subbands and the high frequency subbands separately[1]:

$$G(x) = \frac{sigm\big(c(x-b)\big) - sigm(-c(x+b))}{sigm\big(c(1-b)\big) - sigm(-c(1+b))}$$

Where $sigm(x) = 1/(1+e^{-x})$, $b$ is the enhancement and attenuation split point, and $c$ is the enhancement or attenuation rate.

**Segmentation using GVF and Snake model**

GVF snake model is adopted in this paper. Balloon force is also added in order to improve the segmentation ability.

**Comparison with manual segmentations**

Our semi-automatic segmentation results are compared with morphological manual segmentations by the method proposed in [2]. The images were segmented by two experienced radiologists (OP1 and OP2) manually. One of the manual segmentations was chosen as a reference. The functional segmentation obtained by the proposed method or another manual one were both compared to this reference. Three similarity measures, PO(Percentage overlap), PE(Percentage extra) and SI(Similarity index) were then computed for cortex region. An unpaired t-test was used and a P-value <0.05 was considered statistically significant.

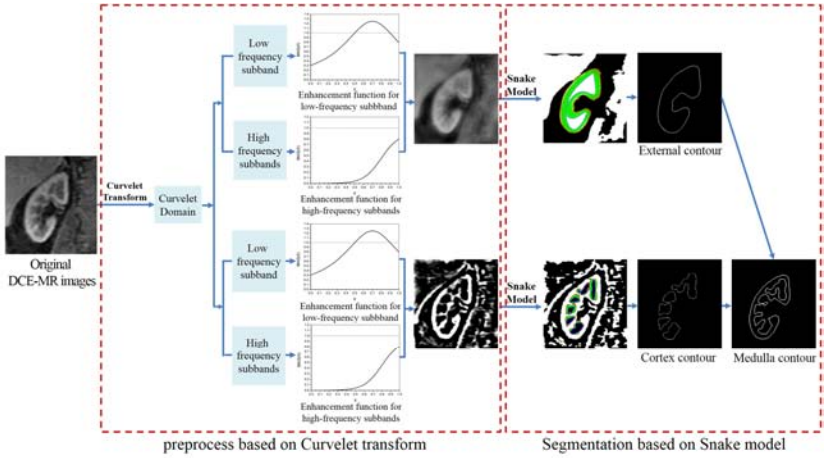


Fig.1 Flowchart of the proposed method

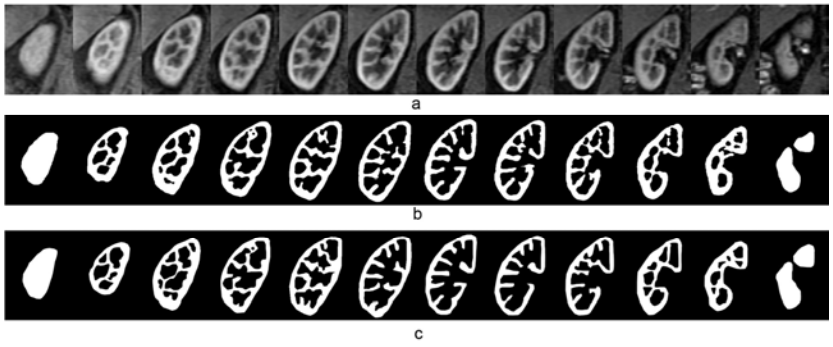


Fig.2 A series of DCE-MR images segmented by the proposed method and manual method. (a) original renal images (b) images segmented by the proposed semi-automatic method (c) images segmented manually

**Results:**

Figure 2 shows the results of the semi-automatic segmentation and manual segmentation of a series of DCE-MR images. Figure 3 shows the similarity measures of the proposed segmentation and manual segmentation. As is shown, the experiment shows that discrepancy measures between two manual segmentations are similar to those observed between semi-automatic and any of the manual segmentations. Besides, this method greatly reduces the segmentation time, from about 60 second per image to 20 second per image.

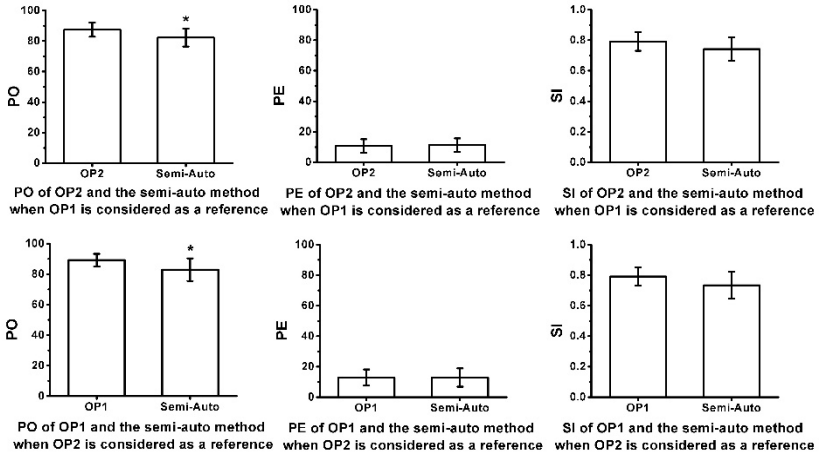


Fig.3 Means and SDs of similarity measures of the proposed segmentation and manual segmentation. (a) PO. (b) PE (c) SI. (*, $P < 0.05$)

**Conclusions:**

In this study, a kidney segmentation method in DCE-MRI is proposed. Compared with manual results, the semi-automatic method achieves an accuracy closed to manual method, indicating that the semi-automated method provides a viable alternative for renal segmentation in DCE-MR images.

**References:**

[1] Hao Li, Guanying Huo. Intelligent Computing Technology. Springer Berlin Heidelberg, 2012. 357-364.

[2] Chevaillier, Beatrice, et al. Acoustics, Speech and Signal Processing, 2008. ICASSP 2008. IEEE International Conference on. IEEE, 2008.