DETECTION OF RENAL CYSTS BASED ON COMPLEX SEGMENTATION OF CT IMAGES

Veska M. Georgieva

Faculty of Telecommunications, Technical University of Sofia, Bulgaria
1000 Sofia, "Kl. Ohridsky" str.8
T. (+359 2) 965-3293; E-mail: vesg@tu-sofia.bg

Antonia D. Nankova

Faculty of German Engineering Education and Industrial Management, Technical University of Sofia, Bulgaria
1000 Sofia, "Kl. Ohridsky" str.8
E-mail: antoniananankova@gmail.com

Abstract

In the paper is presented an approach for detection of renal cysts. It consist of preprocessing and complex segmentation method of Computed Tomography (CT) images. This method is a combination of 2 basic methods for image segmentation such as color based K-mean clustering, following of split & merge algorithm. As preprocessing stage can be used choosing a region of interest (ROI), grayscale conversion or filtration.

Some experimental results are presented, obtained by computer simulation in the MATLAB environment. Implementation results are given to demonstrate the visual quality in the perspective of clinical diagnosis and the right treatment decisions.

1. INTRODUCTION

A renal cyst is a small oval or round thin-walled sac with watery fluid insides. A cyst may grow in any part of the kidneys, such as renal cortex, renal medulla, renal parenchyma, etc.

Two broad categories of renal cyst exist [1]:

- Simple cyst;

These cysts are spherical in shape and filled with fluid. They are very commonly found (up to 27% of people older than 50 have asymptomatic simple cysts) very low risk of being or becoming cancerous.

- Complex cyst;

These cysts are often irregularly shaped and contain both a thick outer wall and thick septa, they are often calcified, and they often receive their own blood supply. They are an irregularly shaped cyst that is suspicious for cancer.

Monitoring of renal function by standard measurements, follow-up of patients with Autosomal Dominant Polycystic Kidney Disease (ADPKD) is based on radiologic investigations that are performed with ultrasounds, computerized tomography (CT), or magnetic resonance imaging (MR), with the aim of evaluating renal cyst morphology and volume and estimating the amount of residual renal parenchyma. [1].

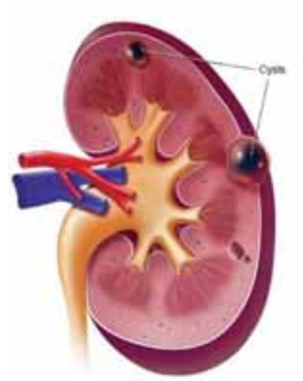

Fig. 1. Kidney with cysts

In our investigations we use CT images. CT has the advantages of widespread availability, more rapid examination time in comparison with MR imaging, and lower cost than MR imaging. Three kidney tissue classes were characterized on CT images: Cysts, parenchyma, and intermediate volume. [2].

Segmentation is a classical method in image processing. The goal of segmentation is to simplify and to change the representation of an image into something that is easier to analyze. Image segmentation is typically used to locate objects and their boundaries (lines, curves, etc.) in medical images. There are some publications based only on basic methods of segmentation for detection of kidney cysts [3, 4].

We propose to use a complex segmentation method, based on combination of color based K-mean clustering, following of split & merge algorithm with the goal to obtain more information and better defined boundaries of the cysts. As preprocessing stage can be performed choosing a region of interest (ROI), gray scale conversion or filtration to reduce the effect of noise on the acquired images.

The paper is arranged as follows: In Section 2 is described the main algorithm of processing; in Section 3 are presented some experimental results, obtained by computer simulation and their interpretation; in Section 4- the Conclusion.

2. COMPLEX SEGMENTATION OF CT IMAGES

In the paper is proposed to use of combination of two basic image segmentations techniques in order to effectively solve a medical image segmentation problem for a problem domain. As first stage is applied clustering. Clustering technique classifies the pixels with the same characteristics into one cluster, thus forming different clusters according to coherence, between the pixels in a cluster. Clustering analysis assigns a set of observations into subsets called as cluster so that the observations in the same cluster are similar in some sense. We have selected the L*a*b* color space which is a perceptually uniform orthogonal Cartesian coordinate system. The differences between two pixels in L*a* b* color space is the same with the sense of the human eyes visual system and this color space enables doctors to quantify these visual differences. Color-Based Segmentation using K-mean clustering segments colors in an automated fashion using the L*a*b* color space and K-means clustering method. K-means clustering treats each object as having a location in space. It finds partitions such that objects within each cluster are as close to each other as possible. K-means requires that the number of clusters to be partitioned should be specified and also a distance metric to quantify how close two objects are to each other [5]. Fig.2 presents the basic flow diagram for the computation procedure by this stage.

By the next stage of processing is used as basic image this cluster, which obtains the most information about the investigated object. For this stage of processing is used the Split and merge segmentation techniques. A region is split, for example, into four sub regions until a given uniformity condition is achieved for the (sub)regions. For gray-level images, this condition can be that the variance of the gray-levels within a region is smaller than a given threshold value *T*. When this condition for a region is not met, this region is further split up.

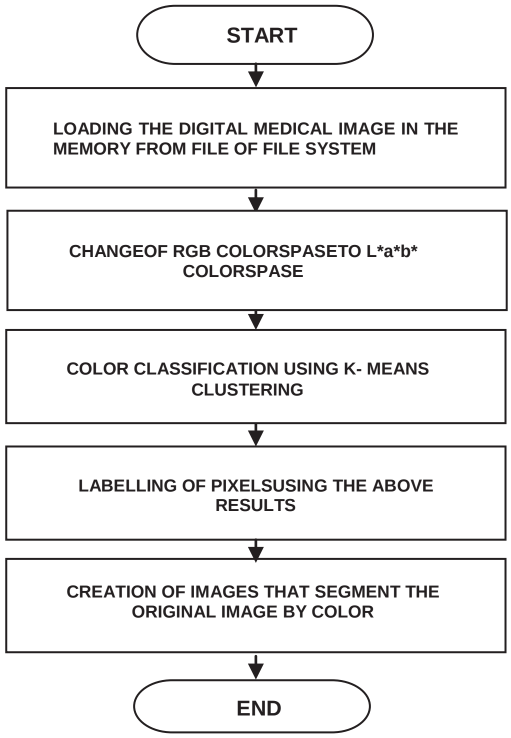

Fig. 2. Block diagram of Color-Based Segmentation using K-mean Clustering

Figure 3 illustrates an example [6]. There R indicates the entire image. Each node correspondsto a (sub)region, whereby in this example only region R4 was further divided up.If the image is divided up only into regions, adjoining regions will be similar inthe final division. These will be merged together in a following step according tothe given condition of uniformity in order to attain uniform regions of maximalsize.The predicate of homogeneity for a region R is based on two criteria:

1. The average gray level of the region R is lower than a threshold.
2. The variance of the gray levels in the region R is greater than a threshold.

This approach tends to be computationally intensive.

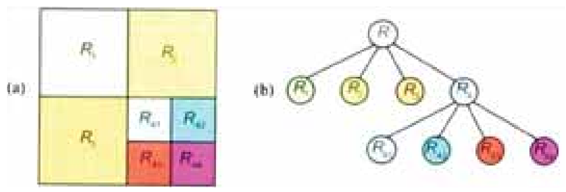

Fig. 3. Illustration of Split & Merge Algorithm:
a) a splited image; b) the corresponded quadtree

In preprocessing stage, which can be applied before the segmentation we propose to be used some standard techniques such as choosing a region of interest (ROI), grayscale conversion or filtration to reduce the effect of noise on the acquired images. They are not obligatory for all images. It is dependent on the specific quality of the image and medical information of the objects, which are investigated.

3. EXPERIMENTAL RESULTS

The formulated stages of processing are realized by computer simulation in MATLAB 7.14 environment by using IMAGE PROCESSING TOOLBOX [7]. The experiments are implemented by using of special graphic user interface, which is created for that purpose [8].

In analysis are used 10CT images from kidney in coronal and 10 CT images in axial planes with size 533x370 pixels in png file format. For processing they are converted in bmp format. Some results from simulation, which illustrate the working of proposed algorithm, are presented in the next figures below.

In Fig. 4 is shown the original CT abdominal image in axial plane with kidney cysts.

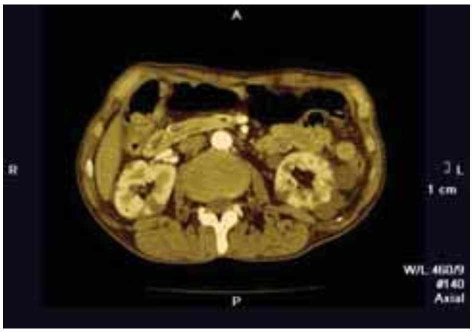

Fig. 4. Original CT image with kidney cysts

In Fig.6 ispresentedcluster 1 of CT image.

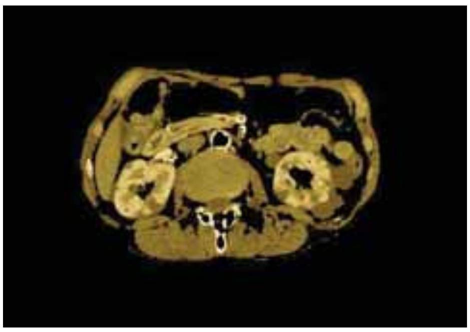

Fig. 5. Cluster 1 of CT image with kidney cysts

The gray scale color conversation of cluster 1 is shown in Fig. 6. It is needed for next step of complex segmentation, based on split and merge algorithm.

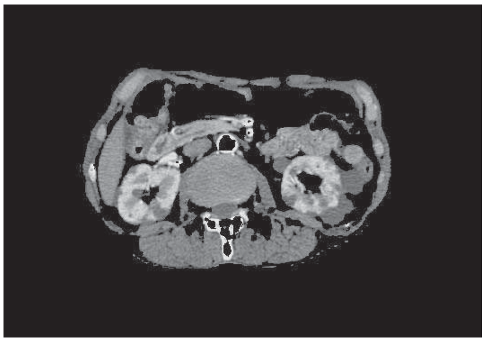

Fig. 6. Grayscale modification of Cluster 1

In Fig. 7 are presented the selected ROI image of Cluster 1. This image of is of size 121x113 pixels from right kidney.

Fig. 7. ROI image of Cluster 1, presented right kidney

In Fig. 8 are presented the same ROI image and its modification, obtained by split & merge algorithm. The value of standard deviation by split and merge algorithm is defined in the case of more gray in the ROI image in grayscale. In this case are visible more details of contours of renal cysts.

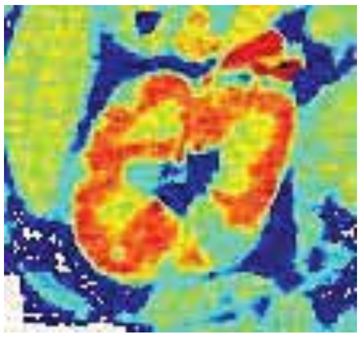

Fig. 8. Modification of ROI image of Cluster 1, obtained by split & merge algorithm

The advantages of results, obtained by the proposed method can be compared to results obtained by complex segmentation based on color segmentation, using K-mean clustering and region growing algorithm.

In Fig. 9 is presented the modification of ROI image of Cluster 1, obtained by region growing algorithm. The best result is obtained for the value 0.12 of the parameter threshold by region growing algorithm.

Fig. 9. Modification of ROI image of Cluster 1, obtained by region growing algorithm

4. CONCLUSION

In the paper is presented an approach for detection of renal cysts, based on complex segmentation in CT images. The obtained results give detailed information about detected cysts in axial as in coronal plane of CT images.

The proposed method can be used to locate specific objects and their boundaries. It can be used also in real time to provide important anatomical information in medical images to physicians and specialist upon which can be made more precise diagnoses of different diseases. It can be used also in monitoring the disease progression.

The results by segmentation of sequences of CT images can be used for future application in 3D visualization.

Our future work will be concentrated in measurement of some statistical parameters, which are necessary for classification and analysis by renal cysts.

References

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