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2D Anatomical Structure for COVID-19 Medical Images

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Abstract. For many clinical goals like surgical planning and radiotherapy treatment planning is necessary to understand the anatomical structures of the organ that is targeted. At the same time the 2D/3D shape of the organ is important to be reconstructed for the benefit of the doctors. For that reason, *accurate* segmentation techniques must be proposed to overcome the big data medical image storage problem. The main purpose of this work is to apply segmentation techniques for the definition of 3D organs (anatomical structures) when big data information has been stored and must be organized by the doctors for medical diagnosis. The processes would be implemented in the CT images from patients with COVID-19.

Keywords. Anatomical structures, medical images, COVID-19, segmentation techniques

1. Introduction

Segmentation is the process that separates an image into its important features. A first step is to partition the image volume into different regions, which are homogeneous with respect to some formal criteria and correspond to real (anatomical) objects [1, 3, 5]. This process is called segmentation. The segmentation process might involve complicate structures and, in this case, usually only an expert can perform the task of the identification manually on a slice-by-slice base. The main drawback of the above-mentioned method is its typical limitation to 2D structures. In this case more reflex segmentation techniques must be introduced where they take advantage of the image properties and the elasticity of the potions. These techniques are based on the deformable template defined as active contours or snakes [2, 4, 7].

2. Segmentation with active contours

Active contours [1, 2, 4] are 2D image curves, which are adjusted from an initial approximation to image features by a movement of the curve caused by simulated forces. The so-called external force is produced by image features. An internal tension of the curve resists against highly angled curvatures, which makes the Active contours

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movement robust against noise. After a starting position is given, it is adapted to an image by relaxation to equilibrium of the external force and internal tension. To calculate the forces an external energy has to be defined. The gradient of this energy is proportional to the external force. Defining the external energy as the distance to the next maximum of the opacity function [4] produced good results. The segmentation by Active contours is due to its 2D definition performed in a slice-by-slice manner. Hence, the resulting curves for a slice is copied into the neighboring slice and the minimization is started again. The segmentation process may be controlled by the user, by stopping the automatic tracking, if the curves run out of the contours and define a new initial curve.

If the model is represented by a parametric curve in 2D v(s)=(x(s), y(s)). then each point in the neighborhood of vi an energy function is calculated [4]

$$E_i = aE_{\text{int}}(v_i) + \beta E_{ext}(v_i) \quad (1)$$

where E_{int} is the energy function dependent on the shape of the contour and E_{ext} is the energy function dependent on the image properties. Based on [4], a generalized active contour model is proposed based on

$$E = \int_0^1 E(v_r) = \int_0^1 \left(E_{\text{int}}(v_r) + E_{\text{i}mage}(v_r)\right) + E_{ext}(v_r)\,dr \quad (2)$$

where E_{int} is the internal energy of the model and characterizes the smoothness of the curve, E_{image} is the image energy and characterizes of the curve and E_{ext} is the external energy model and characterizes the user interaction into the model.

Results of the process are given in Figure 1. In this image, patient is diagnosed with COVID-19. The regions with uncertain diagnose are given in the square shape. A binary image illustrated based on the region growing algorithm [6,7]

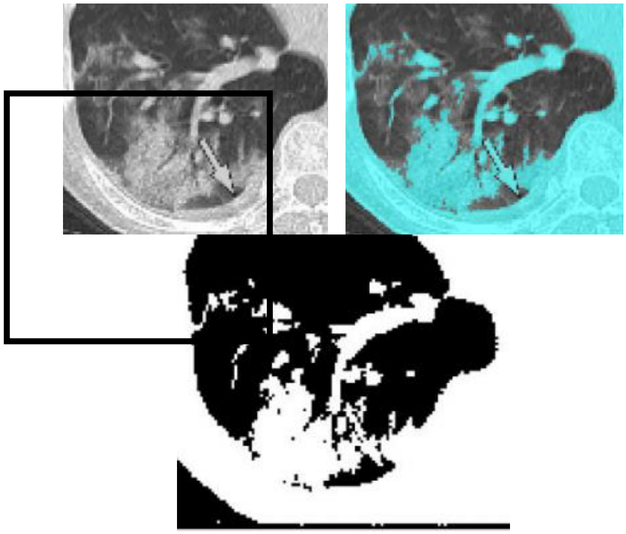

Figure 1. Example of the snake algorithm applied to CT images of COVID-19 segmentation. From left to right: Original image with uncertain region; Segmented image based on the region growing; Binary final segmented image using active contour analysis

From Figure 1, it is evident that the regions with the medical problems are indentified clearly in the applied method considering region growing process and active contours analysis. Especially the small regions in the original image are presented quite clearly in the reproductive results.

3. Conclusions

Many methods have been proposed to detect and segment 2D shapes, with advanced segmentation techniques called snakes or active contours having been used, to reproduce anatomical structures. These techniques are based on the properties of the image (brightness, sharpness, and boundaries) for the final reconstruction of the shape contour.

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