Knowledge Extraction for Heart Image Segmentation

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Abstract. This paper focuses on the problem of knowledge extraction, which is necessary to find heart ventricles in computed tomography (CT) images. In the proposed approach *potential active contours* are used as a segmentation technique. An energy function used during the evolution of contour requires a proper identification of blood inside heart ventricles as well as an approximate localization of intervetricular septum. The methodology effectively allowing to extract that semantic information from the images is described.

1 Introduction

The *active contour* term was proposed by Kass, Witkin and Terzopoulos in [3] to distinguish a new group of image segmenation methods that are able to use high-level knowledge during low-level image segmentation. The basic concept of techniques belonging to that group can be defined as follows: for the image that is segmented define a set of acceptable contours as well as an energy function evaluating those contours and next find the best contour according to that function. In this definition contour is understood as a structure capable of identifying which part of the image should be considered as an object and which should be treated as a background. The simplest contour model used in [3] is a polygon where the interior of the polygon in the image indicates the localization of the sought object. Other models can be found in [1, 2]. In this paper potential contour proposed in [5] is used for this purpose. The choice of contour model is impoartant as it determines the set of objects that can be found. However, the crucial element of the *active contour* methods is a choice of energy function. This function expresses our expectations concerning the searched optimal contour and consequently should contain any available knowledge from the considered domain. This work focuses on the

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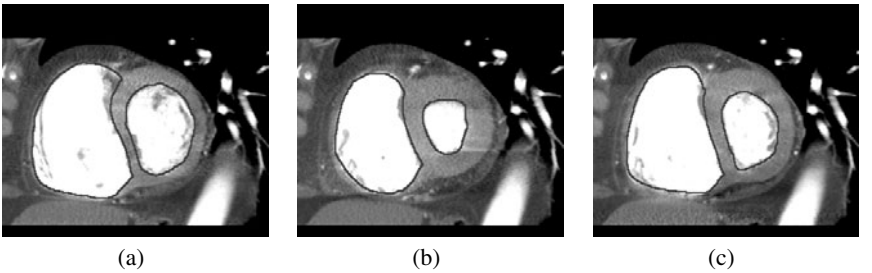
problem of proper knowledge extraction that enables obtaining satisfying segmentation results of heart ventricle in computed tomography (CT) images using *active contour* approach.

2 Problem

Pulmonary embolism determines a serious diagnostic problem since it is one of the most frequent cause of death among the population in the most developed societies. Development of computed tomography (CT) allowed to introduce new diagnostic methods. One of them bases on the assessment of right ventricle systolic pressure which leads to shifts in interventricular septum curvature. However, that approach requires drawing of endocardial and epicardial contours, which, when it is done manually, is time-consuming as well as prone to errors due to technical mistakes and tiredness. That is why this paper focuses on the task of automating that process. The analyzed image data were obtained using ECG-gated computed tomography scanner in a standard chest protocol after intravenous injection of contrast media. Next, heart cycle was reconstructed in 10 phases and two chamber short axis view is generated leading to 4D image sequence, i.e. the set of 2D images for each reconstructed slice and for each phase of heart cycle. Further image in each phase is called a frame.

The experts knowledge needed to find the proper contours can be expressed using the following statements:

- Contour describing the interior of the ventricle should contain all the pixels representing blood inside that ventricle.
- Contour should be possibly small but smooth since the interior of the ventricle can contain not only the blood but also fragments of heart muscle.
- The blood with injected contrast is represented by bright pixels.
- The interventricular septum is a part of heart muscle separating both ventricles.
- The interventricular is represented by darker pixels between the interiors of left and right ventricle.



(a) (b) (c)

Fig. 1 Sample images of the same heart (the same slice and three different phases of heart cycle) with contours drawn by an expert.