USING GREY SCALE HIT-OR-MISS TRANSFORM FOR SEGMENTING THE PORTAL NETWORK OF THE LIVER

Benoît Naegel[1,2], Christian Ronse [1] and Luc Soler [2]

[1] *LSIIT UMR 7005 CNRS-ULP*
Pôle API, Boulevard Sébastien Brant, B.P. 10413, 67412, Illkirch CEDEX, France

[2] *IRCAD, Virtuals*
1, place de l'Hôpital, 67091 Strasbourg Cedex, France

Abstract In this paper we propose an original method of segmentation of the portal network in the liver. For this, we combine two applications of the grey scale hit-or-miss transform. The automatic segmentation is performed in two steps. In the first step, we detect the shape of the entrance of the portal vein in the liver by application of a grey scale hit-or-miss transform. This gives the seed or starting point of the region-growing algorithm. In a second step, we apply a region-growing algorithm by using a criterion still based on a hit-or-miss. Our method performs better than a previous method based on region-growing algorithm with a single threshold criterion.

Keywords: Vessel segmentation, grey scale hit-or-miss transform, shape detection, CT-scan.

1. Introduction

In liver surgery, non-healthy segments are removed to prevent tumoral proliferation. The liver, indeed, is an organ composed of eight functional segments. Liver's functional segmentation is based on one of its vessel systems: the portal network. Hence, precise segmentation of this network is highly desirable since it improves the preoperative planning.

In this work, we propose to detect the portal network from 3D CT-scan images of the abdomen. For this, we use a priori knowledge about the intensity and the shape of the starting point of the portal network: the extra-hepatic part of the portal vein. In a first step, we achieve a shape detection of this structure by using a definition of the grey scale hit-or-miss transform operator. In a second step, we use a region-growing algorithm with a hit-or-miss criterion to detect the points belonging to the portal network.

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A method for the segmentation of the portal network has been given by Selle et al. in [15–17] and Zahlten et al. in [26, 27]. A seed voxel of the portal vein close to its entrance into the liver is selected interactively. Then the algorithm iteratively accumulates all 26-connected neighbors whose grey values exceed a given threshold, by using a classical region-growing algorithm. In order to reconstruct the greater part of the portal network without including other structures, the authors compute an optimal threshold for the region-growing algorithm.

In [5, 6], Dokládal proposes two approaches to preserve the topology of the structure: one which adds only simple points during a region growing process and one which homotopically reduces a simply connected superset of the object to segment.

A method based on histogram thresholding and topological refinement is described by Soler in [22].

We can also cite the work of Krissian et al. [8] which describes a template-based approach to detect tubular structures in 3D images.

It should be mentioned that some of the previous methods perform only on the liver mask, which reduces greatly the problem.

The method proposed in this paper tries to combine the advantages of previous methods. Our method performs the segmentation of the portal network from a whole CT-scan image. Moreover, it is fully automatic: it does not require user interaction.

2. Shape detection: the hit-or-miss transform

A morphological operator that can be used to perform shape detection is the hit-or-miss transform. The binary hit-or-miss transform is widely used, for example in document analysis [2, 3]. Hardware implementations with optical correlators have been studied in [7, 9, 10, 14, 24, 25].

Binary definition

Definition of hit-or-miss transform in the binary case is very common:

$$X \otimes (A, B) = \{x \mid A_x \subseteq X, B_x \subseteq X^c\} \tag{1}$$

where A and B are two structuring elements. Of course, A and B must be disjoint sets: $A \cap B = \emptyset$.

Grey scale hit-or-miss transform

Few works address the grey scale hit-or-miss transform. Principal definitions are the following: