Interactive *Real-Time* Segmentation for Vertebral Bodies and Intervertebral Discs in Sagittal Planes

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Purpose – Interactive segmentation approaches like [1, 2] get more and more popular, because automatic segmentation methods are typically only suitable for a specific type of pathology in a specific imaging modality and still fail time-by-time. Moreover, most automatic approaches need precise parameter settings to provide good results. The state of the art or rather clinical practice is in the most medical departments still manual slice-by-slice segmentations which are very time consuming. In this contribution, we present the initial results of an interactive graph-based approach for vertebral bodies and intervertebral discs segmentation that provides *real-time* feedback to the user during the segmentation process. The speed and *real-time* behavior makes this approach even suitable for MR-guided biopsies of vertebral bodies where several planes are used in planning and executing the interventions [3].

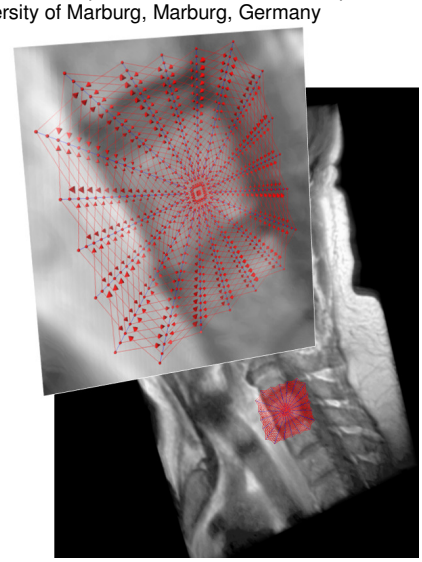

Figure 1 – Graph within a MRI dataset.

Methods – The *Square-Cut* scheme [4] was used and extended for this study. Briefly, the *Square-Cut* algorithm sets up a directed 2D-graph *G(V,E)* in two steps: (I) sending rays through the surface points of a square template and (II) sampling the graph's nodes $n \epsilon V$ along every ray (Figure 1). In addition, a set of edges $e \epsilon E$ is generated, which consists of edges between the nodes and edges that connect the nodes to a source *s* and a sink *t*. After graph construction from a user defined seed in the image (which is the square's center), the minimal cost closed set on the graph is computed via a polynomial time *s-t-cut* [5], which results in the segmentation outcome. For an initial study we implemented a C++ module within the prototyping platform *MeVisLab* (http://www.mevislab.de).

Results – With our interactive segmentation technique the user gets *real-time* feedback of the segmentation result. To demonstrate our technique and for an initial feasibility study we implemented an interactive version to segment vertebrae (discs) in 2D. Therefore, we applied a graph-based method that uses a square template like presented in [4] and made it interactively by allowing the user to move the graph's center point over the image. This could be achieved in *real-time* for a graph consisting of 900 nodes, 870 *z*-edges and 900 (1800) *xy*-edges (template diameter was 35mm, 30 rays, 30 points-per-ray and a delta value of 5). Figure 2 below illustrates – from the left to the right – how the user can interactively move the graph's center point (white dot) to find satisfying segmentations (red dots) by getting on the same time *real-time* feedback.

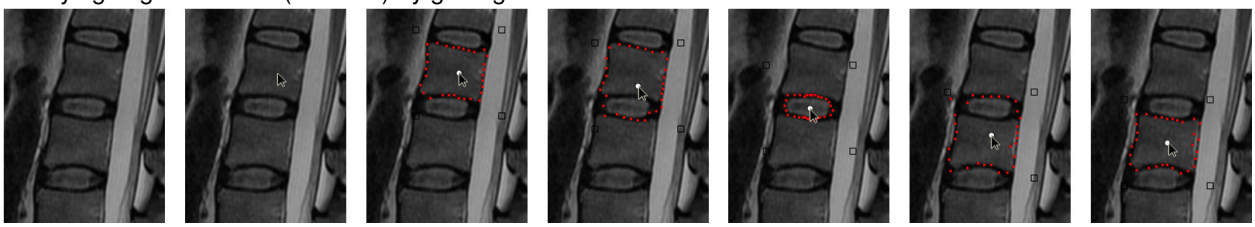

Figure 2 – From left to right: several screenshots from a video demonstrating our interactive *real-time* segmentation for vertebral bodies and intervertebral discs in a sagittal plane of a MRI scan. The white dot is the graph's center point, the black boxes define the corners of the square template and the red dots are the segmentation outcomes.

Conclusions – In this initial study, we showed that the *Square-Cut* scheme can be used as an interactive approach for vertebral body and intervertebral disc segmentation in sagittal planes. However, the presented principle can also be applied to other images and dimensions (e.g. non-medical, color-level, 3D) and potential application examples for different templates in 2D and 3D are presented in [6]. In a next step, we plan to extend the interactive approach to 3D for vertebral body segmentation based on a cubic template [7].

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