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Preliminary Results with a New Annotation Tool for Liver Volume and Inner Vessels from DCE-MRI Data

Jonas Lamy^a, Thibault Pelletier^b, Guillaume Lienemann^c, Benoît Magnin^c,
Bertrand Kerautret^a, Nicolas Passat^d, Julien Finet^b, Antoine Vacavant^{c*}

^a Université Lyon 2, LIRIS (UMR 5205) Lyon, France

^b Kitware SAS, Villeurbanne, France

^c Université Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000, Clermont-Ferrand, France

^d Université de Reims Champagne Ardenne, CReSTIC, EA 3804, 51097 Reims, France

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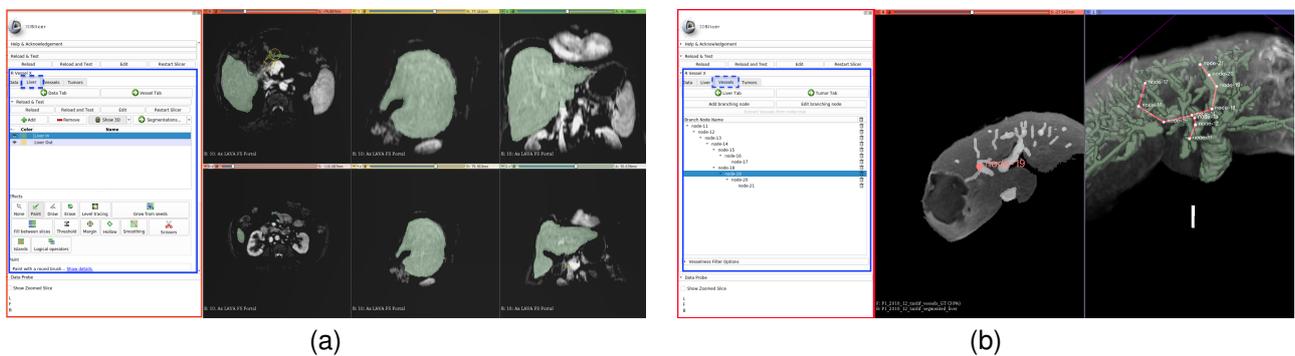


Figure 1: View of our software. (a) Whole liver segmentation. (b) Centerline annotation.

1. Context

Annotation plays a key role in the creation of reference datasets that are useful to evaluate medical image processing algorithms and to train learning based architectures [4]. The efficiency of the datasets generation generally depends on the interface ergonomics that is proposed to medical experts. While the development of annotation interfaces is quite standard in 2D, its design in 3D requires more attention to handle precisely the interactions between 3D structures and photometric constraints. DCE-MRI (Dynamic Contrast Enhanced MRI) is a popular image modality choice for the diagnosis of liver cancer (e.g. for hepato-cellular carcinoma). To our best knowledge, no database of hepatic vessels annotation is publicly available for this image modality. Such database would be of great help for the design of vascular segmentation tools used in surgical planning. However, the manual annotation by experts of thin and low-contrasted structures is a long, tedious and error-prone task.

We present a plug-in for the 3D Slicer software aimed at speeding up hepatic vessels annotation. We have created a complete pipeline dedicated to segment the liver volume and inner vessels by means of different image processing tools (seeded region growing or centerline-based vessel reconstruction for instance). In an agile process, we have developed and

tested iteratively our annotation tool, so that clinical practitioners may be able to handle it efficiently during clinical routine or for specific clinical research activities.

2. Methods

2.1 3D Slicer

The annotation tool is delivered as a plug-in for 3D Slicer [1, 5]. This free and open-source software platform developed by Kitware Inc. already offers various features including 2D and 3D visualization, segmentation tools and handles most medical image formats. It is also designed to be highly modular making the integration of custom tools easier. 3D Slicer also includes an *Extension manager* where community-developed plug-ins can be shared publicly.

2.2 Our plug-in

The annotation process is divided into four steps:

- loading and managing medical imaging data;
- liver segmentation;
- vessels annotation;
- tumor segmentation;

organized into dedicated tabs in the plug-in module (highlighted in blue in Fig. 1). The liver segmentation

and vessels annotation tabs are highlighted in dotted lines respectively in Fig. 1-a and Fig. 1-b.

The modularity of 3D Slicer is sometimes a drawback especially with data properties and their visualization shared across two different modules. The first tab aims at unifying these properties in a single interface in order to avoid back-and-forth use of the modules. The second tab is the integration of the already existing segmentation tools of 3D Slicer. As depicted in Fig. 1-a, these allow voxel annotation using manual (paint, eraser, scissors, *etc.*) as well as automated tools (level-set tracing, seeded region-growing, thresholding, *etc.*). For the vessels annotation strategy of the third tab, we have chosen to use centerline annotations instead of voxel-based segmentation. The centerlines are defined as sets of keypoints connected by lines that can be edited manually or generated automatically between two end-points using the Vascular Modeling Toolkit Module (VMTK) [2] (see Fig. 1-b). This automated step will be improved in the future by using algorithms to be designed in the context of the R-Vessel-X project (see acknowledgements). The last tab uses once again 3D Slicer segmentation tools for tumoral segmentation.

Finally, we added a split 2D/3D view to allow the expert to annotate and control his/her work at the same time. In particular, we observed that overlapping annotations in 3D with the MIP (Maximal Intensity Projection) view of the liver was an efficient way of detecting missed vessels.

3. Results and discussion

To assess the efficiency of the plug-in, we asked two radiologists trained to use 3D Slicer to segment a liver (whole liver and inner vessels) with and without the plug-in. In their clinical practice, they usually employ embedded image processing tools as the General Electric AW solution (Server 3.2) for such annotations. We have tested our plug-in with DCE-MRI acquisitions obtained from 6 “healthy” patients (*i.e.* not suffering from any hepatic disease) and 4 patients with liver cancer and cirrhosis. DCE-MRI exams were performed on a 1.5T SIGNA™ Artist (General Electric, Milwaukee, WI) with a phased array coil.

Tab. 1 and Tab. 2 present annotation times obtained with our plug-in vs. the conventional approach, for patients without and with cirrhosis and liver cancer respectively. These tables show that our plug-in allows a faster annotation of liver volume and inner vessels, for both patient populations. The General Electric AW software proposes less intuitive interaction for vessel labeling within DCE-MRI sequences, which is particularly critical for sub-branches beyond left and right portal veins for instance.

4. Future works

The next steps are the adaptation of the interface design to other advanced algorithms not yet included in

Segmentations	GE AW	Our plug-in
Liver	10 ± 5 min	3 ± 2 min
Vessels	30 ± 10 min	5 ± 3 min
Total	40 ± 15 min	8 ± 5 min

Table 1: Annotation time of the liver volume and inner vessels for healthy patients, with standard approach (General Electric AW software) and with our plug-in.

Segmentations	GE AW	Our plug-in
Liver	15 ± 10 min	4 ± 2 min
Vessels	35 ± 15 min	7 ± 4 min
Total	50 ± 25 min	11 ± 6 min

Table 2: Annotation time of the liver volume and inner vessels for patients suffering from cirrhosis and liver cancer, with standard approach (General Electric AW software) and with our plug-in.

the 3D Slicer framework. For instance, the estimation of orthogonal planes during the annotation process should be a relevant feature to improve the precision of the centerline positioning defined by the user [3]. The development of new algorithms during our project or technological transfer of previous work [6] would also increase the pertinence of our plug-in with more automatic steps, particularly for vascular reconstruction.

5. Acknowledgements

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