A Web-based Remote Collaborative System for Visualization and Assessment of Semi-Automatic Diagnosis of Liver Cancer from CT Images

Alexandra BRANZAN ALBU, Denis LAURENDEAU, Marco GURTNER, and Cedric MARTEL
branzan@gel.ulaval.ca
Computer Vision and Systems Laboratory, Laval University,(Qc), G1K 7P4, Canada

Abstract. We propose a web-based collaborative CAD system allowing for the remote communication and data exchange between radiologists and researchers in computer vision-based software engineering. The proposed web-based interface is implemented in the Java Advanced Imaging Application Programming Interface. The different modules of the interface allow for 3D and 2D data visualization, as well as for the parametric adjustment of 3D reconstruction process. The proposed web-based CAD system was tested in a pilot study involving a limited number of liver cancer cases. The successful system validation in the feasibility stage will lead to an extended clinical study on CT and MR image databases.

1. Introduction

Modern virtual environment technologies supporting medical applications are mainly designed for diagnosis, education, training, and rehabilitation purposes. Interactive data visualization techniques are expected to help radiologists and other healthcare professionals in improving the accuracy of image-based diagnosis of various diseases.

The computer-aided diagnosis (CAD) of liver cancer is a powerful alternative to the traditional assessment of this disease. We propose a web-based collaborative CAD system allowing for the remote communication and data exchange between radiologists and researchers in computer vision-based software engineering. Prior to the clinical use of a CAD system for liver cancer, a thorough validation of its reliability is necessary. Therefore, this paper presents a comparison of the semi-automatic segmentation results with the ground-truth manual segmentation performed by an expert radiologist.

The rest of the paper is organized as follows. Section 2 contains a description of our approach. The experimental results are discussed in section 3. Section 4 contains the conclusions as well as a brief discussion about the future work directions.

2. Proposed approach

This section begins with a brief technical presentation of the system. Next, the basic principles of the proposed tumour segmentation and 3D reconstruction algorithms are presented. Finally, we describe the validation protocol applied to the CAD interface.

The proposed web-based interface is implemented in the Java Advanced Imaging Application Programming Interface. This environment is compatible with the Internet

Imaging Protocol and thus supports client such as laptops to desktops and high-end servers. As shown in Figure 1, the different modules of the interface allow for 3D and 2D data visualization, as well as for the parametric control of the reconstruction process.

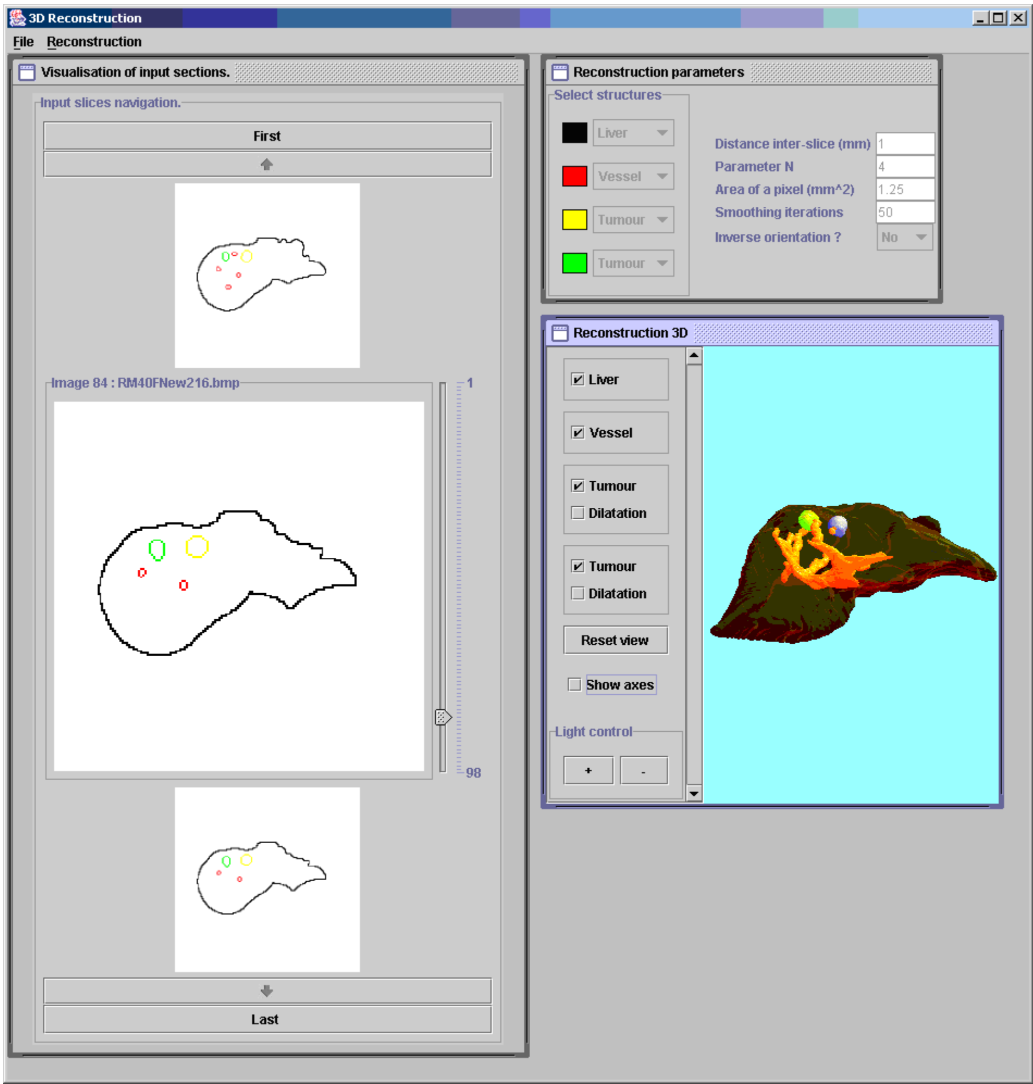

Figure 1. The main window of the interface. Left: sub-window for 2D data visualization; Right (upper part): sub-window for the parametric control of the 3D reconstruction; Right (lower part) sub-window for the visualization of the hepatic tumours in their anatomical context

The *2D semi-automatic segmentation algorithm* [1] requires the specification of one reference pixel inside the tumour of interest. The lesion is then detected with an algorithm based on iterative pixel aggregation and local textural information. The limited patient exposure to X-rays results in CT input data with different intra-slice and inter-slice resolutions. Our proposed *3D reconstruction approach* [1] estimates the missing slices using shape-based interpolation and extrapolation. To allow for a context-based visualization, a reconstruction of the liver and the liver vessels from manual segmentations of these structures is also performed, in addition to the tumour reconstruction.

The *proposed validation protocol* uses the 3D reconstructed tumour models from semi-automatic and manual reference segmentations respectively and analyzes the statistical error distribution. The 3D validation technique is implemented in *Polyworks*^{TM}, a software dedicated to the inspection of high density point clouds.

3. Results

We have tested our method on four CT data sets of liver cancer cases, courtesy of the Radiology Department at the Georgetown University Medical Center (WA, USA). An expert manual segmentation for every dataset was also made available. The anisotropy of the input data (pixel spacing of 0.6 mm along the X and Y direction, and 5 mm along the Z direction) was corrected in the reconstruction process. As shown in Table 1, containing the statistical error distribution for the liver tumour in Figure 2, the validation process was successful. The mean error value for the four analyzed cases was 0.23 mm^3.

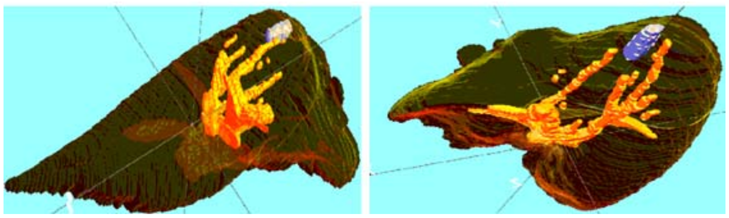

Figure 2. Two different views in the visualization of the liver, the tumour, and the major liver vessels .

Table 1. Statistical error distribution for the liver tumour in Figure 2

Tumour model no. 1	Semi-automatic segmentation
Reference tumour model	Expert manual segmentation
Number of points (voxels)	5135
Mean error (mm^3)	0.1508
StdDev (mm^3)	0.7059
Maximum absolute error (mm^3)	3.3573
Points within +/- (1*StdDev)	3610 (70.31%)
Points within +/-(2*StdDev)	3795 (93.05%)

4. Conclusion

The main contribution of our work consists in the design of one of the first CAD systems dedicated to liver cancer and evaluated with a 3D validation protocol. The proposed web-based CAD system was tested in a pilot study involving a limited number of liver cancer cases. The successful system validation in the feasibility stage will lead to an extended clinical study on CT and MR image databases.

The web-based design will allow radiologists to perform the manual segmentation and to compare their diagnosis with the result of the semiautomatic CAD system. Therefore, our system facilitates communication between remote computer vision-based software engineering and medical communities.

The proposed interface allows for visualizing the 3D segmented lesions within the liver and with respect to the major liver vessels. When cryotherapy is a suitable treatment option, the planning of the optimal trajectory of the cryoprobe will consider the 3D liver, tumours, and vessels models provided by the proposed CAD system.

References

[1] A. Branzan Albu, D. Laurendeau, C. Moisan and D. Rancourt, "SKALPEL-ICT: Simulation Kernel Applied to the Planning and Evaluation of Image-Guided Cryotherapy", in *Perspective in Image-Guided Surgery*, (T. M. Buzug and T. C. Lueth Eds.), World Scientific, ISBN 981-238-872-9, pp. 295-302.