Efficient Liver Surgery Planning in 3D based on Functional Segment Classification and Volumetric Information

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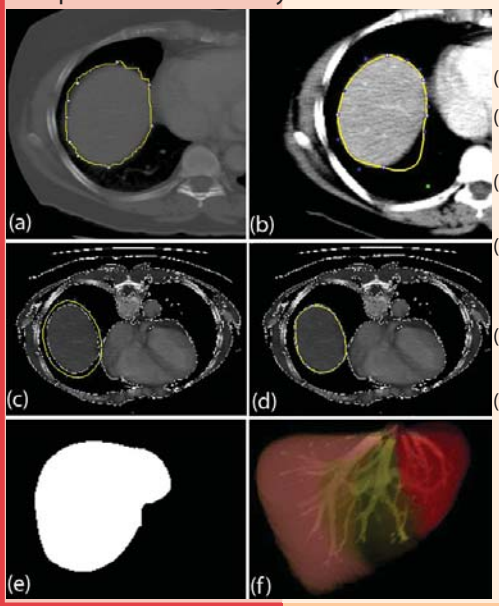
Purpose

The general goal of this work is to propose a new methodology for liver surgery planning using computer assisted image segmentation and classification of the liver segments.
Another specific goal is to potentialize the use of these tools directly by the surgeons, making them efficient to run on commodity personal hardware.

Methods

Our approach consisted on the development of two computational tools, and the possibility to use the results on the surgery room:
-SmartContour, an environment for CT segmentation based on a combination of image processing and computer graphics algorithms to quickly extract the liver shape and volume from a general dataset.
-LiverSegments, a classification tool to interactively extract the vessel branching within the liver and define the areas affected by both the portal and venous systems.



Liver segmentation using **SmartContour**:

(a) original livewire;

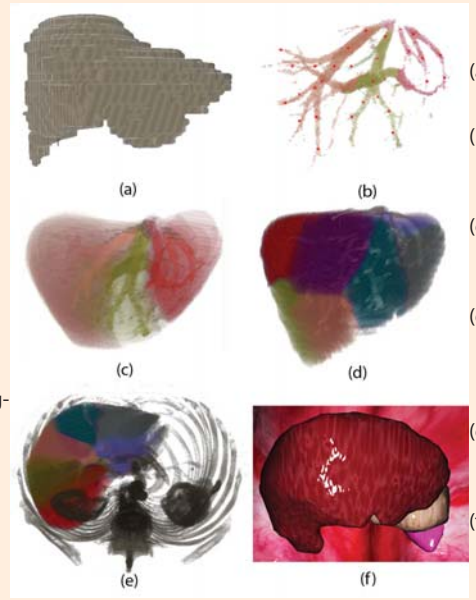
(b) Bézier curve derived from the livewire;

(c) contour pasted on the following slice;

(d) previous slice contour automatically fits to the liver border;

(e) example of segmented slice;

(f) 3D volume view of the segmented data.



Segment classification using **LiverSegments**:

(a) the segmented liver is input from SmartContour;

(b) contrast is ajusted to display blood vessels upon which the user defines points;

(c) points in the hepatic vein branching define the drainage sectors;

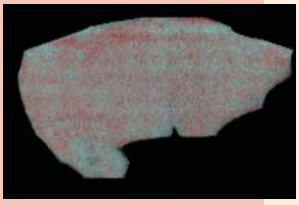
(d) points in second and third level branching of the portal system define the 8 Couinaud segments;

(e) 3D volume visualization allow to choose which items to display and when;

(f) concept for a planning application using a reconstructed 3D mesh with texture.

Results

We performed comparative experiments to evaluate the SmartContour and the LiverSegments in the context of volume estimation for hepatectomy planning. The tests are based on 4 CT datasets. The volume calculated with our methods is close to the CT workstation by a monotonous margin inferior to 5%.



(a) Volume: 1168:46cm3

(b) Volume: 1141:78cm3

Segmented liver obtained with a CT workstation (a) and our method (b).

id	Gender	Age	Slices	V. Works.	V. Smart	Diff.
1	M	27	354	1337.84	1353.50	1.16%
2	M	54	377	1814.74	1753.46	3.49%
3	M	43	345	1508.39	1491.72	1.12%
4	F	71	169	1168.46	1144.98	2.05%

Comparing volume estimation by the CT scanner workstation and our method. Volumes are in cm3. The volume differences are inferior to the error margin of the validated workstation method.

Conclusion

We present a new strategy for liver surgery planning which takes into account the blood vessel branching within the organ.
The algorithms focus on 3D imaging and can run in comodity PC, which tremendously increase the access to the surgeons. The methods allow accurate volume calculation of the liver and its functional segments, which might improve diagnostic and treatment planning.

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