Semi-automatic liver volume estimation

For surgery planning and evaluation

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Introduction

Image guided surgery planning utilize for example CT-scans as a part of the evaluation of the surgically prospect of the patient. At the moment, the evaluation of patients' possibilities is based on the individual opinion of a surgeon. This individuality can cause misunderstandings and a higher degree of uncertainty, which could have been avoided, with a program that reduce the individuality. Therefore, a program is desired, that have the ability to find the edges of the liver, with a semi-automatic method, in order to determine the liver volume. If this purpose is fulfilled, it will provide a wide background for the surgeon, in order to plan the surgery.

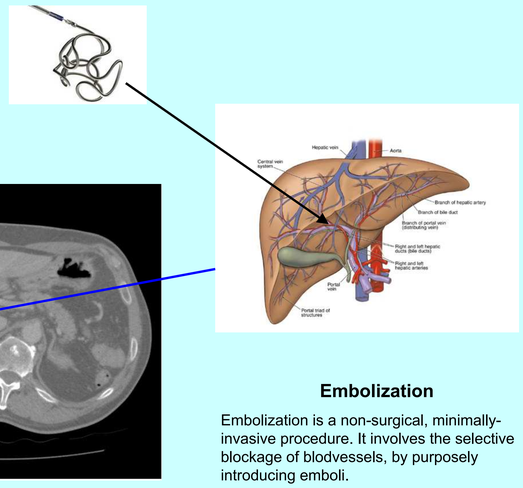
In this report, a program that satisfies these conditions is explained based on data processing, results and analysis at a specific case obtained at *Rigshospitalet* in January 2009.

The semi-automatic program is based on dynamic algorithms that detect the edges, where a change in the first order gradient forms the basis of a cost image. The understanding of the underlying mechanism of the program is helped by a complete explanation of liver-anatomy, physiology, CT-scans, cancer and clinical conditions. This makes the report useful for clinically as well as technologically backgrounds.

The result is an appreciable tool, in sense of a semi-automatic program for volume determination of the liver in a clinical context. This is done by reducing the variation of the operator, in contrast to manual volume estimation. The semi-automatic program is fully used at the clinical data of the case, in order to determine the possibility of a surgery of the patient.

Case

- The patient has a liver tumor.
- Because the tumor is too large, it is not possible to remove it. Therfore, an embolization is a solution to increase the liver volume, and make the tumor decrease.



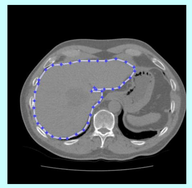
Embolization

Embolization is a non-surgical, minimally-invasive procedure. It involves the selective blockage of blodvessels, by purposely introducing emboli.

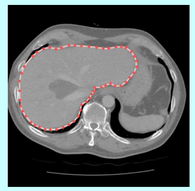
Data

- **How?** CT-scan: Toshiba Aqulion, 64 slices. Data collection diameter: 400 mm Slice Thickness: 3 mm
- **Where?** Abdominal CT obtain from *Kir. Gastrointerologisk afd. Rigshospitalet*
- **What?** The patient has had a 3 phase CT scan before embolization and a regular CT scan after embolization.
- **Why?** In this way the surgeons are able to follow their patient, in order to discuss the probabilities of surgery.

Before Embolization



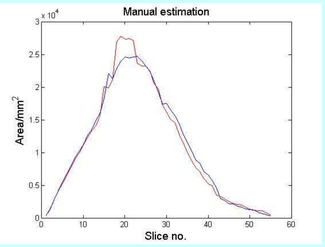
After Embolization

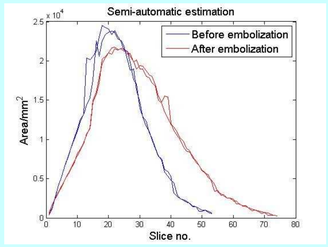


Methods

- The operator manually annotates a sparse set of points around the liver on each slice of the volume
- In each slice the points are connected into a poly-line
- The slice image is resampled around the poly-line as marked by the red area
- The result of the resampling is a new image, where the sought border is assumed to be an edge going from the top to the bottom of the image
- The resampled image is filtered to enhance the edge
- Dynamic programing is used to find the optimal path going from the top to the bottom of the image
- The optimal path is defined as the path with the lowest accumulated edge values
- Finally, the found border is transferred from the resampled image back to the original image

Results





Left: Looking at the figure above it is seen that the operator variance is big in the middle of the liver.

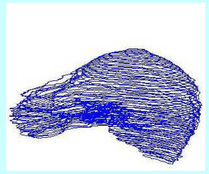
Right: With the semi-automatic method the operator varians becomes smaller.

Scan	Volume/ kg
Before embolization	1.920
After embolization	3.325

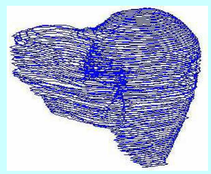
The volume of the liver is increased by approximatly 73 % .

The liver has grown in the vertical direction, but has become smaller in the horizontal direction. This fits the theory concerning embolization.

3D visualization **before** embolization



3D visualization **after** embolization



3D visualization support the earlier result that the increase in volume is primary in the vertical direction.

The volume estimation time has been reduced by 40 %

Conclusion

✓ **Anatomical correct results**

-The estimated liver volume and liver volume change after embolization fits well with the findings in the literature

✓**Less time for volume estimation**

-On average the operator time for liver volume estimation was minimized by 40 %

✓**Less operator varians**

-The inter-operator variance was reduced from 3.5 % to 2.3 %