#199 - ISCAS / Lecture or Poster

HepaPlan: a CAD software for planning hepatic surgeries

Clinical Applications / Surgery and Subspecialties / Hepato- biliary and pancreatic

Fernando López-Mir[1], Valery Naranjo[1], Rafa Verdú-Monedero[2], **Sandra Morales**[1], Sara Brugger[3], Eugenia Pareja[3]

1. Universitat Politècnica de València - LabHuman, Valencia, Valencia, Spain
2. Universidad Politécnica de Cartagena, Cartagena, Murcia, Spain
3. Hospital Univesitario y Politécnico la Fe, Valencia, Valencia, Spain

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Purpose

The hepatocellular carcinoma is the most common cause of liver cancer. Surgery is the most effective treatment for this disease and liver transplantation or resection obtains good results in a high percentage of cases. The diagnosis and monitoring of this type of pathologies are often done with CT images or MRI taking advantage of clinician experience and skills. The use of software tools (as computer-Aided Decision systems) is not extended in these cases due to the complexity of use, the high cost for the hospital or the learning difficulties.

In a hepatic surgery planning, the first step is the segmentation of the liver tissues and the registration of these structures. Several authors develop methods for liver segmentation with accurate results but in general, a high computational cost or a difficult training or initialization is required, so its use is limited in clinical environments. Besides, different contrast-enhanced studies are used in the hepatic liver segmentation due to the need that each internal structure has to be enhanced in different phases. These studies are acquired in a continuous mode but there is no exact correspondence between them, so a registration algorithm is needed after the fusion of the different information in a common 3D scenario. With the segmentation and the registration of all images, different tools should be provided for clinical planning, treatment or monitoring of liver diseases.

The main goal of this paper is to present HepaPlan software. In particular, the segmentation methods, the registration algorithm and different tools implemented in the tool.

Methods

The block diagram of HepaPlan is shown in figure 1.

Figure 1. Block diagram of HepaPlan.

First, a segmentation algorithm is applied in two studies of the patient (the portal and the arterial studies). The liver is extracted from the portal image using a 3D region-growing algorithm. For this purpose, a filter based on internal statistic parameters as the mean and the standard deviation is applied to reduce the noise of this type of images. Next, an initial segmentation is obtained with the 3D region-growing algorithm and the result is improved with 3D mathematical morphology. For the vessel segmentation, the method based on the Hessian matrix is used to obtain several seeds [1]. With these seeds, a region-growing algorithm is applied and the vessels are extracted. For lesions, a method based on morphological reconstruction by erosion and a classifier is carried out [2]. In order to improve the segmentation results, HepaPlan provides several 2D/3D user-guided tools.

Another block of our system is the registration procedure. A non-rigid registration method based on an efficient implementation of variational image registration is performed in the HepaPlan software [3].

Finally, different tools are implemented once the liver and its internal structures are presented as a 3D model: computation of the lesion volume, ratios in relation to healthy tissues, computation of distance from any structure (hepatic/portal veins or arteries) to the closest lesions. Other provided tool is the virtual surgical knife that allows clinicians to make virtual resections for planning surgeries.

Results

Actually, the liver segmentation algorithm and the registration procedure have been validated. For the liver segmentation, 30 studies were used, 20 for training and 10 for testing the method. Three coefficients were computed in this validation: the volume overlap error, the Hausdorff distance and the Average Symmetric Surface distance. Table 1 shows the results in two conditions: first when the automatic liver algorithm is applied on the 10 test datasets and the second row is when manual corrections are applied to some of the 10 datasets (those where 3 experts considered that the segmentation results were not accurate enough). In the first case, the average runtime is 0.54 seconds per image and in the second case is 7 seconds.

To validate the registration method two measures were evaluated before and after the registration procedure: the peak signal-to-noise ratio (PSNR) and the correlation ratio (CR). Six 3D studies of two patients were registered and the results are shown in table 2.

Conclusions

The registration and segmentation methods implemented in HepaPlan software fulfil the requirements needed to use the tool in real environments. Registration algorithm is fully automatic and the results are better than other state-of-the-art methodologies, so the fusion in a common scenario is adequate and accurate enough after the application of the registration procedure. Regarding to the segmentation procedure, the automatic algorithm is accurate enough in most of the cases.

HepaPlan is being validated in the hospital La Fe de Valencia in situations as donor liver cases, simulation of real hepatic surgeries, liver diseases monitoring, etc.

References

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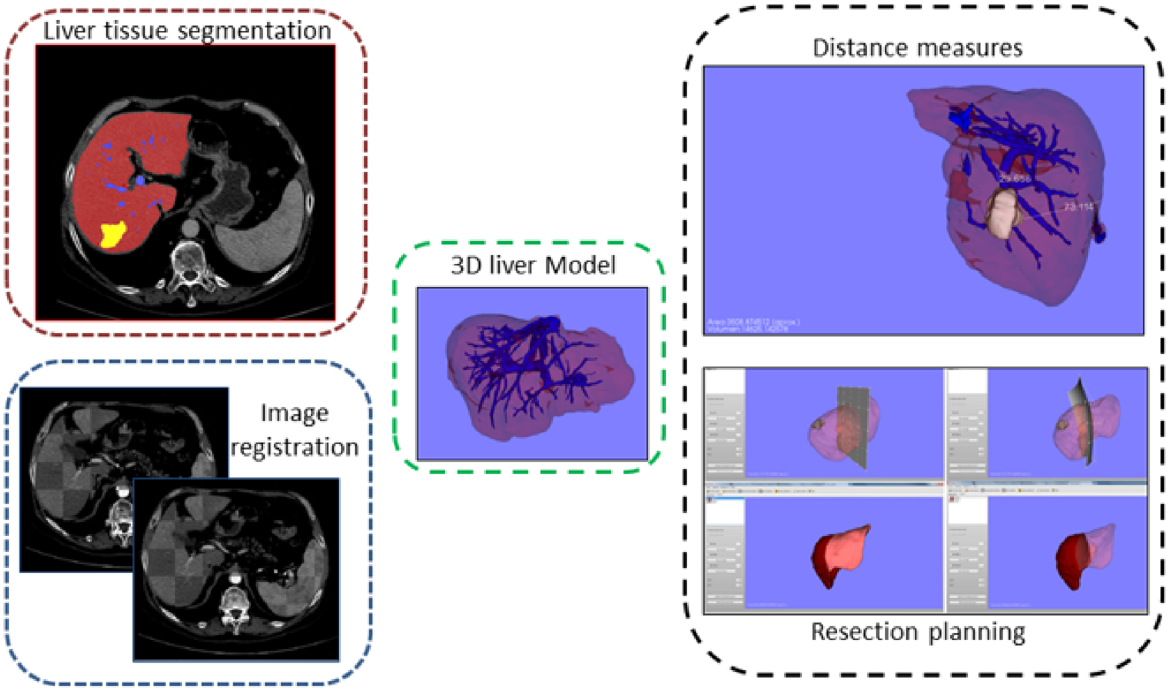

	VOE (%)	ASSD (mm)	Haus. Distance (mm)
Automatic segment.	11.17	2.06	29.15
With user guided tools	6.28	0.77	15.25

Table 1. Liver segmentation results.

	Patient 1			Patient 2		
	AP / PP	AP / NC	AP_1 / AP_2	AP / PP	AP / NC	AP_1 / AP_2
PSNR before registration	40.53 dB	15.72 dB	15.59 dB	16.46 dB	18.65 dB	20.46 dB
PSNR after registration	43.31 dB	31.39 dB	27.28 dB	27.06 dB	29.39 dB	27.73 dB
CR before registration	99.52 %	37.84 %	32.74 %	60.28 %	71.53 %	81.64 %
CR after registration	99.77 %	99.21 %	96.76 %	97.59 %	99.06 %	98.72 %

Table 2. Registration results (AP: arterial phase; PP: portal phase; NC: non-contrast; $AP_{1/2}$: arterial phase of the same patient but acquired with different scanners at two different times).