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VISCERAL SURGERY VIDEOS

Augmented reality guidance in laparoscopic hepatectomy with deformable semi-automatic computed tomography alignment (with video)

Video Animation

B. Le Roy[a,b,*], E. Ozgur[a], B. Koo[a], E. Buc[a,b], A. Bartoli[a]

[a] *UMR6602, Endoscopy and Computer Vision group, faculté de médecine, institut Pascal, bâtiment 3C, 28, place Henri-Dunant, 63000 Clermont-Ferrand, France*
[b] *Department of Digestive and Hepatobiliary Surgery, Hospital Estaing, CHU de Clermont-Ferrand, 1, place Lucie-et-Raymond-Aubrac, 63003 Clermont-Ferrand cedex, France*

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Deformable 3D model;
Overlay

Laparoscopic liver resection has many known advantages but its use remains limited in clinical practice. A major reason for this limitation is the difficulty to use laparoscopic ultrasonography to localize intrahepatic tumours. Today, augmented reality (AR) guidance for monocular laparoscopic hepatectomy requires the surgeon to manually overlay a rigid preoperative model onto a laparoscopy image [1,2]. This strategy is sometimes inaccurate because the liver deforms significantly [3]. We propose a new algorithm to improve AR guidance. This algorithm overlays a deformable preoperative model semi-automatically onto a laparoscopy image using a new AR software named ''Hepataug''. This software, developed in our group composed by surgeons and scientists, runs in several steps. First, a preoperative 3D model of the liver and its internal anatomy are reconstructed from the computed tomography (CT). Second, this model is aligned to a laparoscopy image and AR is delivered to the surgeon. Because the liver offers very few anatomical external landmarks, finding a method to compute the alignment was the core scientific challenge. ''Hepataug'' allows to complement the anatomical landmarks by natural visual cues such as the silhouette. Then, the software deforms the preoperative 3D model to compensate for the changes between the CT and the laparoscopy. This allows surgeons to locate tumors intraoperatively and resect those tumors in a safe manner. This video shows a proof-of-concept case of a laparoscopic segmentectomy 6 for two metachronous colorectal liver metastases. ''Hepataug'' was efficient in guidance where laparoscopic ultrasonography was not able to reveal the precise location of the tumors due to imaging artifacts. In this patient, the software indicated to the operating surgeon that the resection needed to be extended. Postoperative histopathology confirmed that margins were lower than 1 mm on the initial specimen but was greater than 1 cm on the secondary specimen.

* Corresponding author at: Department of HPB Surgery, Clermont-Ferrand University Hospital Estaing, 1, place Lucie-et-Raymond-Aubrac, 63003 Clermont-Ferrand cedex, France.
E-mail address: leroybertrand8@gmail.com (B. Le Roy).

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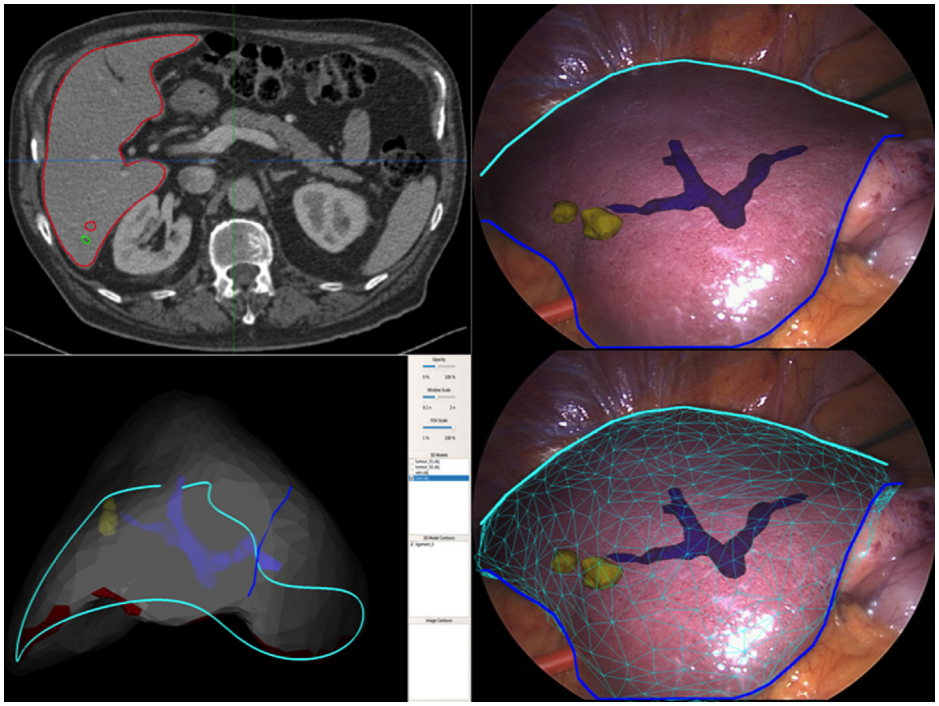

Figure 1. The top left image is a slice of the CT scan showing the two metastases. The bottom left image is a view of the reconstructed preoperative 3D model. The right images are two views of the intraoperative augmented reality.

In conclusion, this video showed the first AR software able to localize intrahepatic tumors accurately in monocular laparoscopy using a new algorithm capable of semi-automatic deformable alignment. ''Hepataug'' is easy to use and could be deployed in the future in any existing operating room. This tool represents a promising new step in AR with encouraging initial clinical results but it still needs good quality comparative assessment (Fig. 1).

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The software we used was developed by our research group within the computer science department of Université Clermont-Auvergne. It is a non-profit software used solely for research purposes within our group.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jviscsurg.2019.01.009.

Disclosure of interest

The authors declare that they have no competing interest.

References

[1] Bernhardt S, Nicolau SA, Soler L, et al. The status of augmented reality in laparoscopic surgery as of 2016. Med Imaging Anal 2017;37:66—90.
[2] Phutane P, Buc E, Poirot K, et al. Preliminary trial of augmented reality performed on a laparoscopic left hepatectomy. Surg Endosc 2018;32(1):514—5.
[3] Özgür E, Koo B, Le Roy B, et al. Preoperative liver registration for augmented monocular laparoscopy using backward-forward biomechanical simulation. Int J Comput Assist Radiol Surg 2018;13(10):1629—40.