Automatic registration of CT/MRI data on hepatic laparoscopy images for surgical assistance through augmented reality

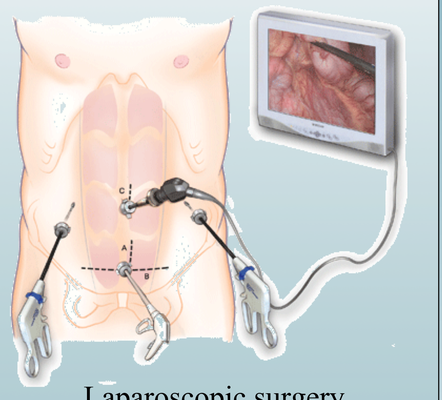
Yamid ESPINEL, Mourad ABDALLAH, Emmanuel BUC, Christophe TILMANT, Adrien BARTOLI

Ecole doctorale Sciences Pour l'Ingénieur

EnCoV group - Institut Pascal (UMR 6602 UCA / CNRS / SIGMA), CHU Estaing, Clermont-Ferrand

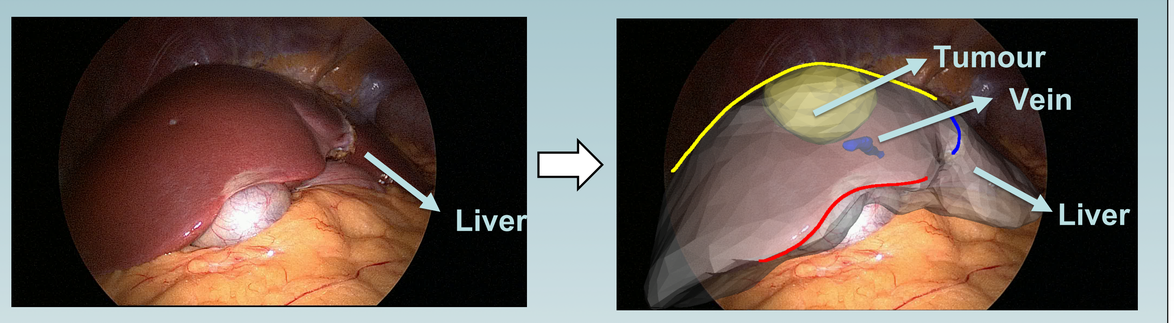
Introduction

- Laparoscopy is a technique to perform minimal invasive surgery through the usage of a small camera and thin, light instruments.
- It requires small incisions and thus is less traumatizing.
- The large size of the liver and the reduced camera's field of view makes it difficult to locate tumours and vessels.

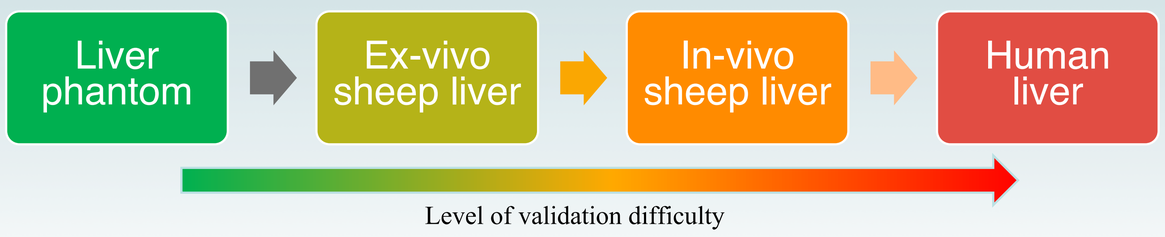


Laparoscopic surgery

- Augmented Reality (AR) tries to solve this problem by adding this invisible information on top of the laparoscopic video stream.
- This is done by registering a set of preoperative 3D models obtained from radiological data into the laparoscopic images [1].

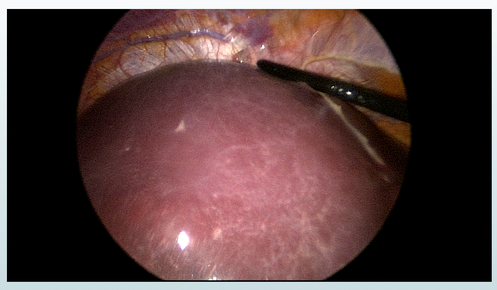


- How to measure quantitatively (validate) the accuracy of AR?



- How can we perform automatic AR on the liver?

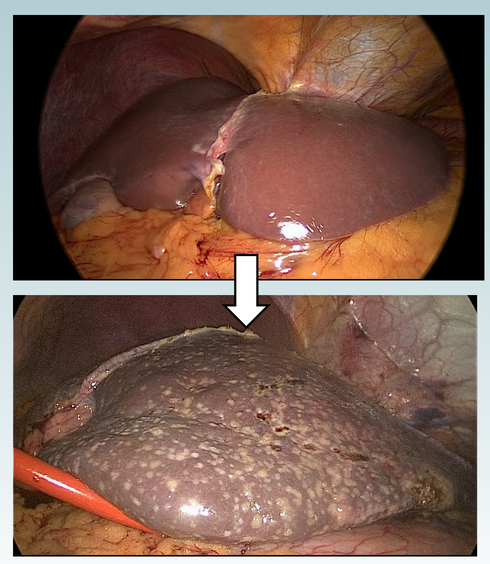
- Cases such as registrations with a lack of visual cues must be evaluated.
- What if we have to register with a very partial view of the liver?
- Inter-surgeon registration variability to assess the robustness of our method.



Partial view of the liver with lack of visual cues

LIVER DETECTION AND TRACKING:

- To place the preoperative models automatically in the images, features must be detected and matched, letting us to compute movement changes from both liver and camera.
- A common strategy for automatic AR on laparoscopy is to take an initial video footage of the organ before starting the surgery.
- This footage lets to reconstruct a map of the organ's surface and bring the preoperative models to where the reconstructed map is located [2].



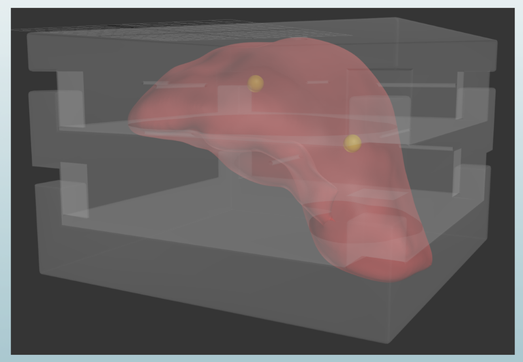
Healthy vs. cirrhotic liver

- Texture of a normal healthy liver is very uniform, while a cirrhotic one has visible spots.
- A robust way to detect features in the liver should be found in this case.
- How to quickly deform the preoperative models such that they fit with the real liver?

Methods

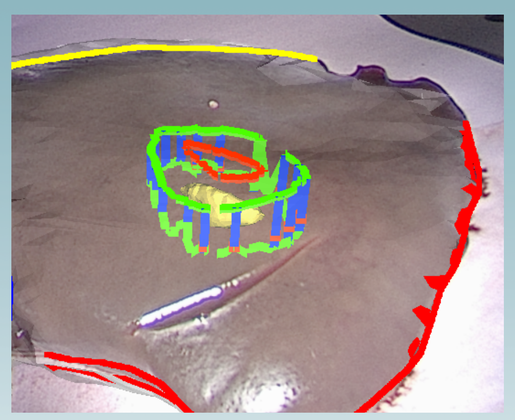
VALIDATION WITH LIVER PHANTOM:

- We created a model with two endophytic tumours.
- Phantom is deformed in several ways and registrations are made for each.
- Tumour positions shown by the augmentation are compared with the real positions of the CAD models.



Model of liver phantom with endophytic tumours and mold for 3D printing

VALIDATION WITH EX-VIVO LIVER:



Sheep liver with augmented tumour (in yellow) and generated resection mark (in green)

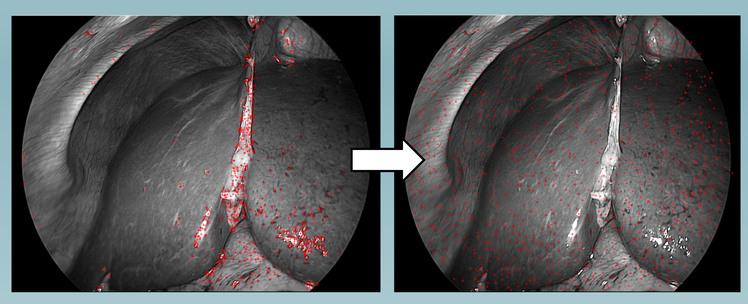
- For validation on ex-vivo and in-vivo animal livers, alginate is injected to create artificial tumours.
- CT scans are made to obtain the preoperative models.
- Resections are made as in a real surgery.
- Registration errors are measured, along with rate of successful resections using no US/AR, using US only, and AR only.

Results and Conclusions

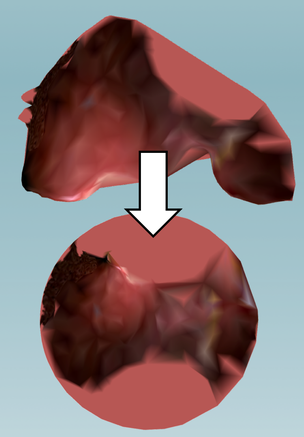
- SIFT descriptors deal better with changes in illumination and contrast.
- Flattening the liver texture through conformal mapping can help preserving a similarity transformation between features.

INCOMING TASKS:

- We will compare the matched features from in the original and the flattened textures to evaluate the convenience of this strategy.
- A first rigid tracking strategy will be implemented using SIFT features, assessing the results and possible improvements for deformable registration.



SURF features vs SIFT features. SURF features are highly localized around bright areas, compared to the more spread SIFT features



Conformal mapping of liver texture

Bibliography

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2. **Collins, T., Chauvet, P., Debize, C., Pizarro, D., Bartoli, A., Canis, M., Bourdel, N. A System for Augmented Reality Guided Laparoscopic Tumour Resection with Quantitative Ex-Vivo User Evaluation. CARE - MICCAI, 2016.**