

Registration-Free Laparoscope Augmentation for Intra-Operative Liver Resection Planning

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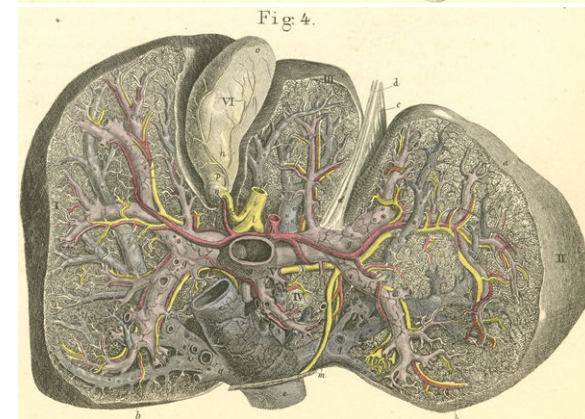
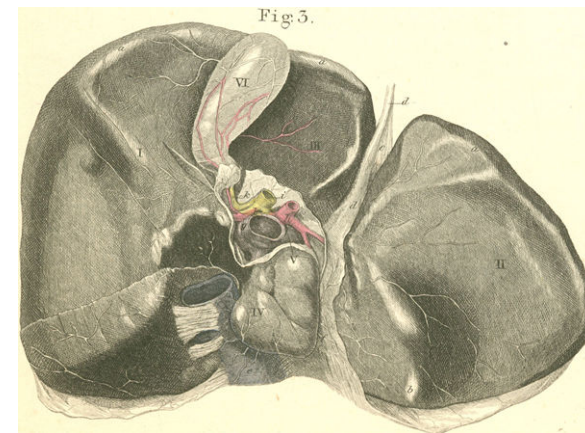
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Problem Statement – Laparoscopic Liver Resection

- The limited endoscopic view and missing tactile feedback constrains the surgeon
- Vessels supporting the liver segment to be resected need to be divided (clipped) prior to the resection to avoid bleeding
- Only the surface of organs can be seen, but not the underlying target region (i.e. tumors and vessels)
- Surgeon does not know exactly where to cut the organ
- Vessels need to be precisely located



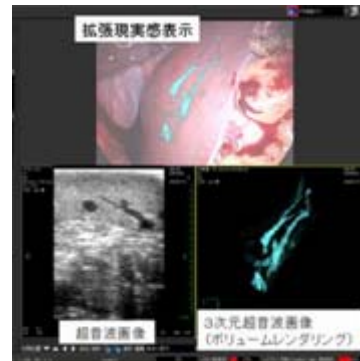
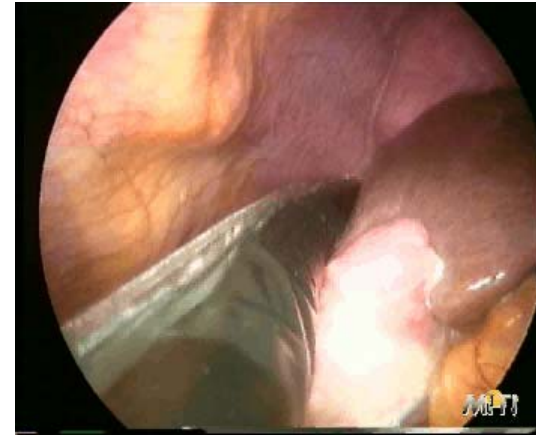
[www.anatomyatlases.org]

Related Work

Intraoperative image guidance by:

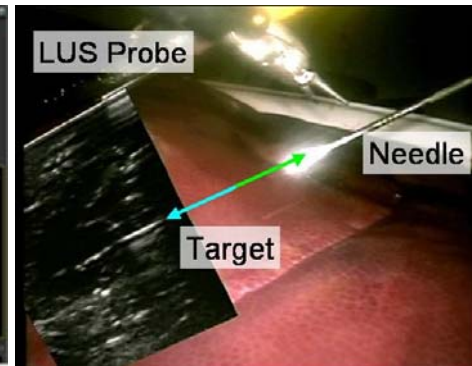
- Ultrasound
 - Image quality?
 - 3D data difficult to obtain
- CT/MRI
 - Bulky
 - Often only “in-plane” guidance
 - Patient motion?

[MITI,
Klinikum rechts
der Isar –
Harms et al 2004]

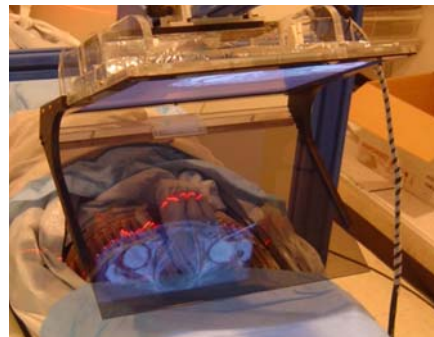


[Nakada et al 2003]

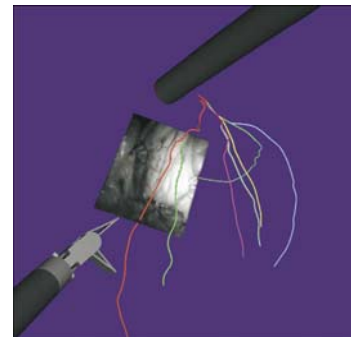
[Nakamoto et al 2002,2006]



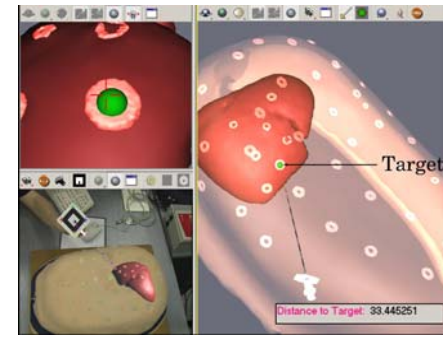
[Leven et al 2005]



[Fichtinger et al 2005]



[Mourgues et al 2003]



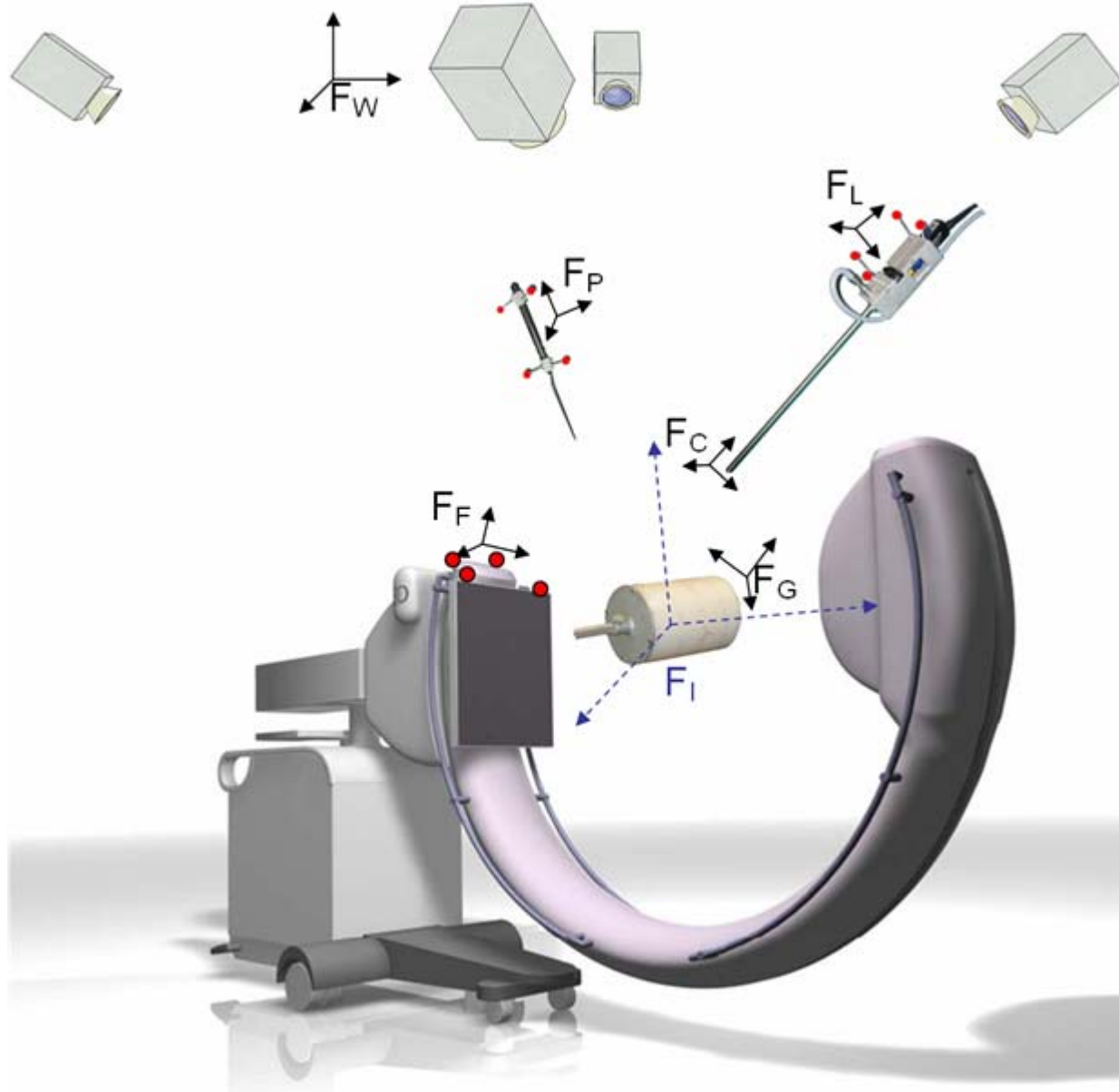
[Nicolau et al 2005]

Our Approach

- Intraoperative
 - Contrast agent application
 - Cone beam CT based C-arm reconstruction
 - Augmentation of the contrasted vessel tree directly on the laparoscope video by volume rendering **without** registration
- Offline prerequisites
 - Attachment of optical marker targets
 - C-arm calibration
 - Laparoscope calibration

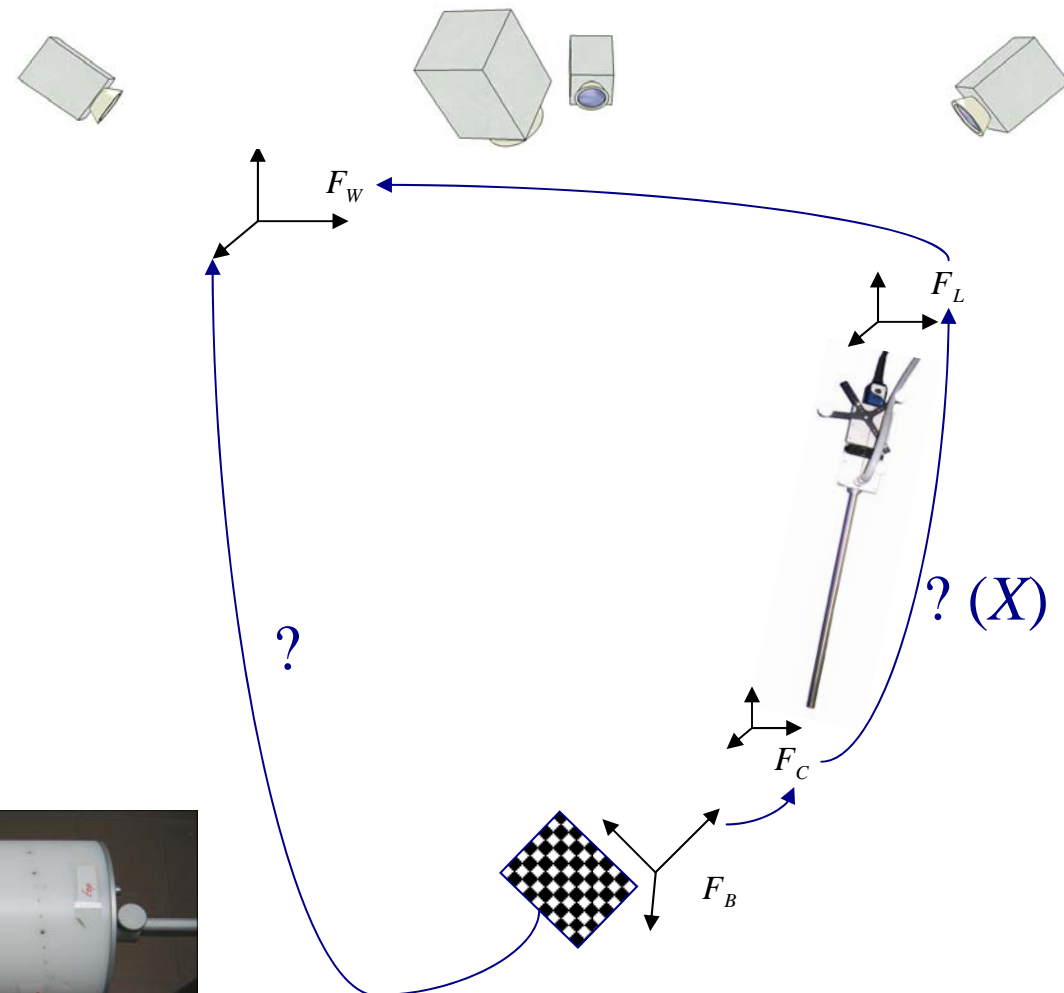


System Components



System Calibration

- Laparoscope calibration:
 - Camera calibration
 - Hand-eye calibration
- Pointer calibration
- C-arm calibration

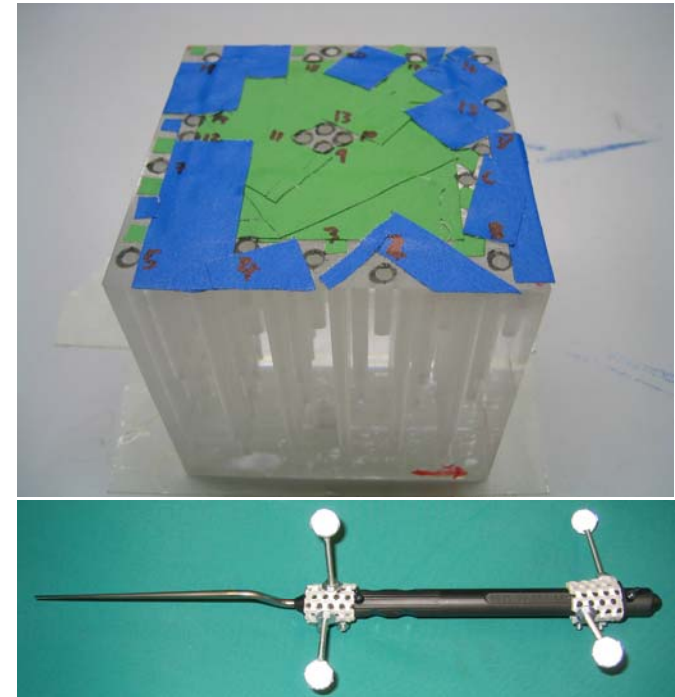


$$AX = XB$$

Accuracy Evaluation

- Navigation error:
 - Cubic evaluation phantom
 - Measured holes with tracked pointer
 - Filled bore holes with metal spheres
 - Cone beam CT reconstruction
 - Segmentation of spheres

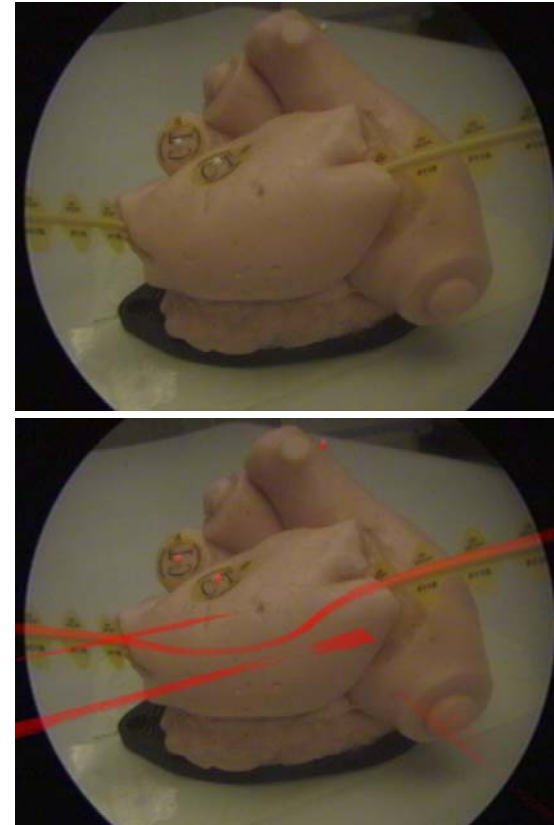
- RMS: 1.10 mm



Accuracy Evaluation

- Augmentation error:
 - Reconstruction of plastic model with CT markers (spots and line)
 - Augmenting laparoscopic view
 - Large number of views covering the interventional working space
 - Overlay error measured in pixels and scaled to mm

- RMS: 1.58mm
(latest results for full calibration of oblique laparoscope [Yamaguchi et al 2004] – included into submission to TMI)



Video Demonstration

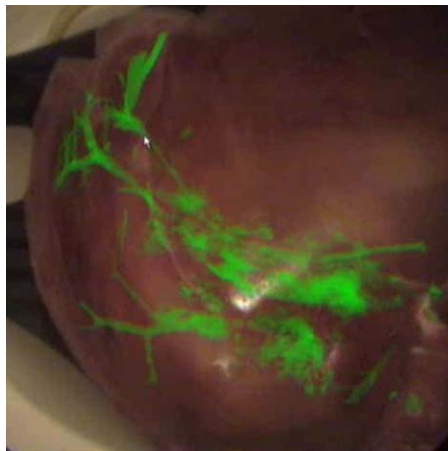
- Video showing latest results incorporating port placement, liver motion analysis, and in vivo studies (under review at TMI)



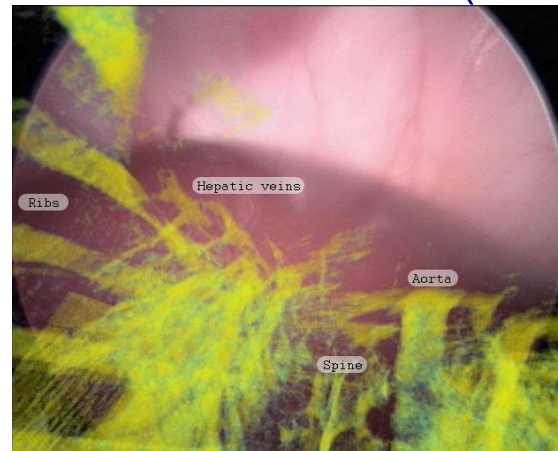
Summary – Laparoscopic Liver Resection Planning

- No need to perform an intraoperative patient registration due to **intrinsic registration** in one common tracking coordinate system
- First time usage of two independent intraoperative imaging systems, i.e. X-ray C-arm and laparoscopic camera within a registration-free navigation framework

Ex-Vivo



In-Vivo (under review at TMI)



Summary – Laparoscopic Liver Resection Planning (cont'd)

- One of the first trials of a flatpanel based mobile C-arm on soft tissue reconstruction
- Also applicable for example to partial nephrectomy, where fluoroscopic guidance can be used (easier in terms of deformations caused by breathing)
- Future work:
 - Improvement of timing and protocol of contrast agent administration
 - Intraoperative segmentation of liver vessels may improve the visualization quality

Thank you for your attention!