ENHANCED VISION SYSTEM TO IMPROVE SAFETY IN ROBOTIC SINGLE INCISION LAPAROSCOPIC SURGERY

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Abstract

- **Robotic systems can overcome the maneuverability drawbacks of single incision laparoscopic surgery (SILS).**
- **Enhanced vision system is proposed to merge pre-operative planning, intra-operative 3D reconstruction and organ tracking in order to define active constraints to improve safety in robotic SILS.**
- **This work focus at the evaluation of the calibration accuracy of our stereo imaging system.**

Context

Single Incision Laparoscopic Surgery is the next step towards **less invasive surgery**.
Robotic arms inside the abdomen overcome limitations of SILS in terms of maneuverability.

However, **difficulties** for the surgeon remain:

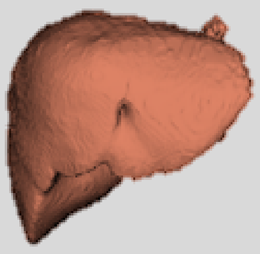
- the **loss** of **depth perception** in case of monocular endoscopic camera;
- **limited field of view** of the endoscopic camera;

In order to **improve** the **vision** of the surgical field and the **safety** of the surgery, it would be useful to combine pre-operative 3D modeling with intra-operative information provided by endoscopic stereo cameras to develop a **computer guiding system**.

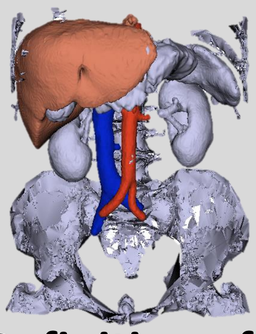
Pre-Operative Phase

3D models of patient-specific **organs** from CT scan:

Segmentation



Surface rendering



Definition of constraints

Intra-Operative Phase

First step for 3D reconstruction is the **stereo calibration**.

Set up:

- Stereo cameras (640x480 px, 15fps, synch).
- Planar chessboard (8x6, square 4.1 mm).

Experimental protocol:

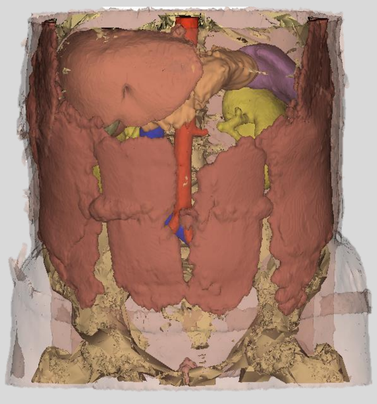
- Evaluation of the **re-projection error** (rpe) between **corners detected** (p_d) and **re-projected** (p_r) changing the number of frames.

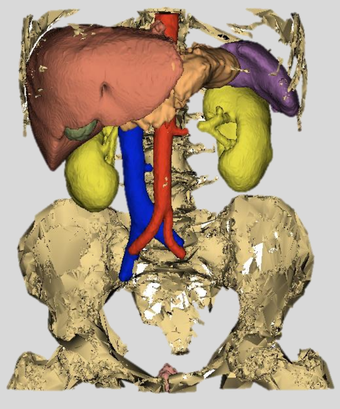
$$rpe = \frac{\sqrt{\sum_{i=1}^{N} (p_d - p_r)_i^2}}{N}$$

$N = number\ of\ frames\ x\ corners$

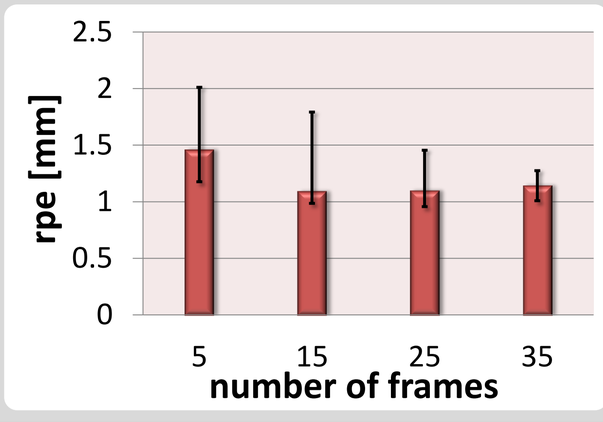
Results

1- 3D Models





2- Calibration



1- Surface rendering can be used to help the surgery and plan the entry point of the robotic system.

2- The results show that the **dispersion** from the **median** of **re-projection error** decreases as the number of frames used for calibration increase.
The median of the re-projection error using 35 frames is 1.14 mm.

Future Work

3D reconstruction to know the pose of the organs with respect to the robot.
Dynamic active constraints real-time adapted to **compensate** for tissue **motions** and **deformations.**

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