A Laparoscopic Liver Navigation Pipeline with Minimal Setup Requirements

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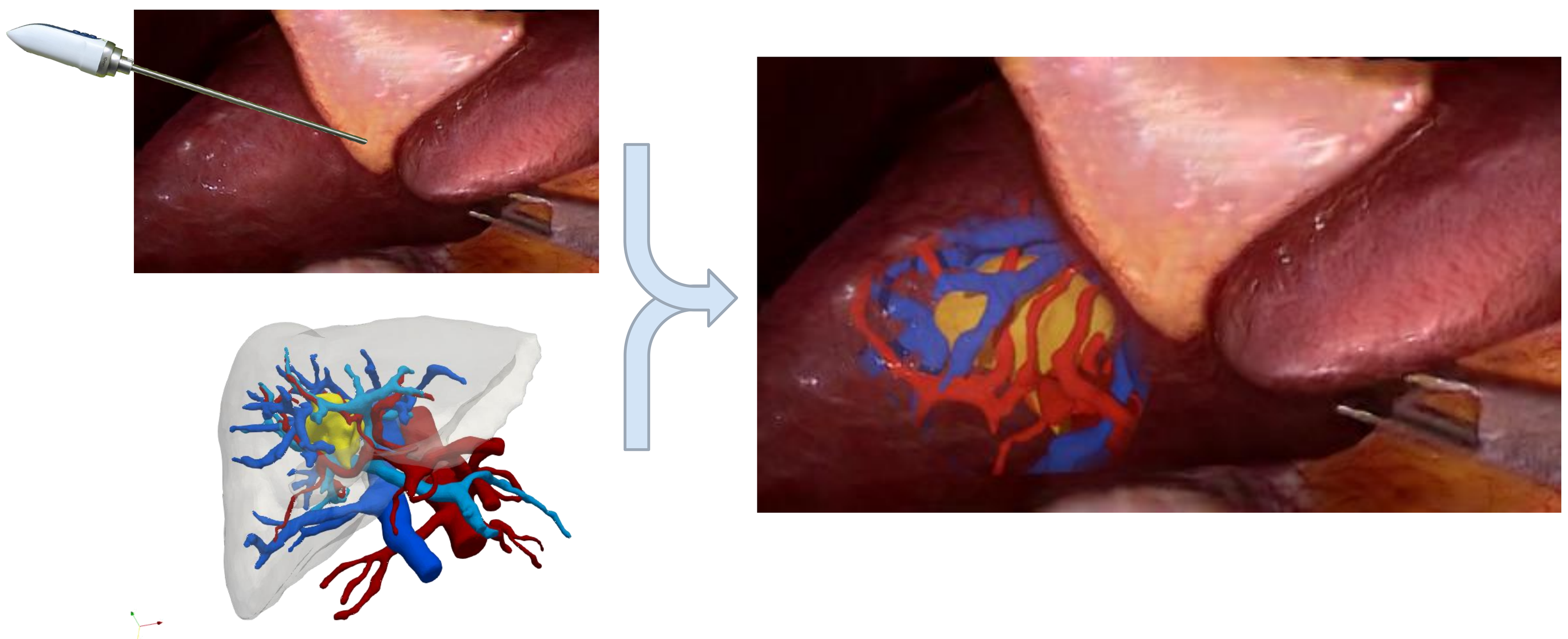
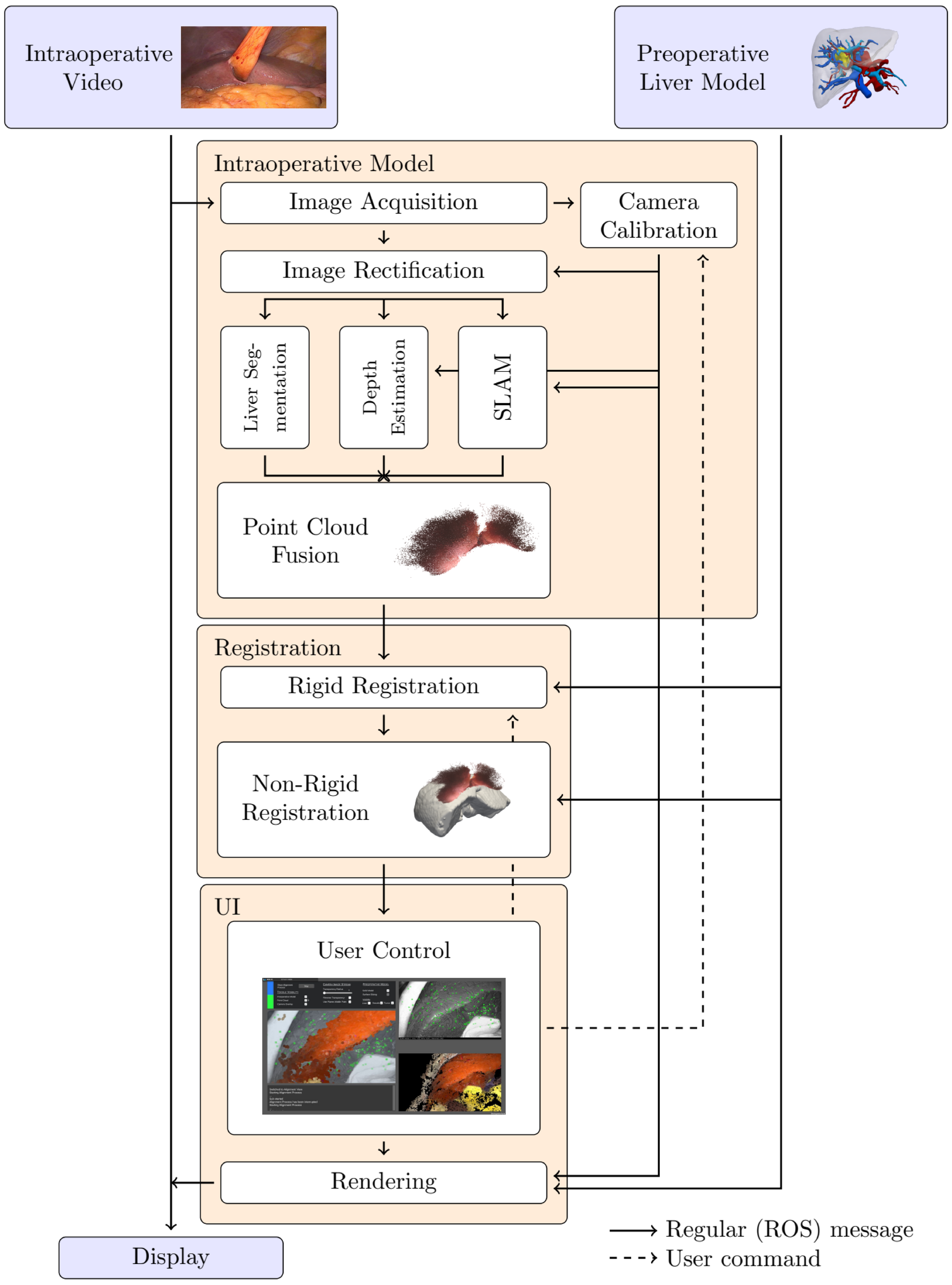
Introduction

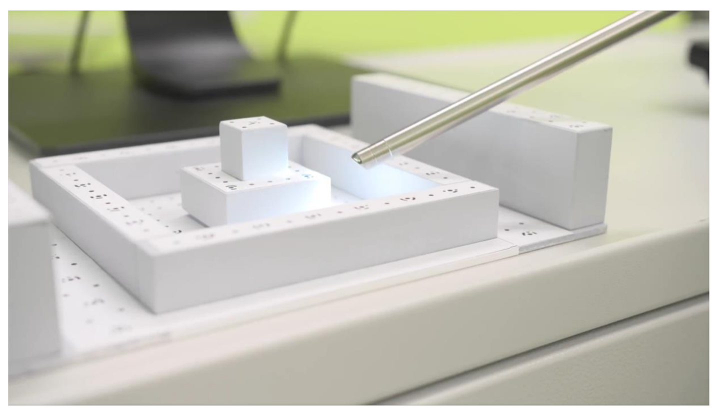


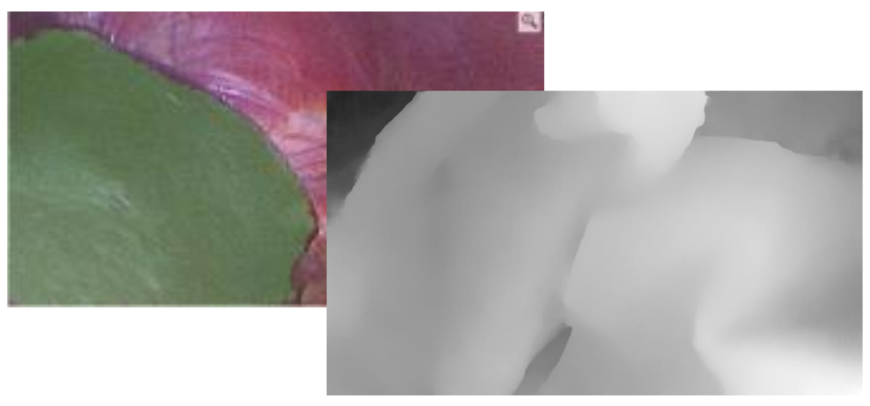
- Difficulty of orienting oneself during **Minimally Invasive Surgery (MIS)** creates desire for navigation aids to locate target structures
- *Video-based* **Image Guidance Navigation Systems** (IGS) use endoscope video data in together with CT scans to highlight **tumours** and **blood vessels**
- Existing approaches often use **optical tracking devices** to track endoscope, which is **sensitive to drop-outs** and incurs a **significant setup burden**
- We put forward a navigation pipeline with significant distinctions, some of which are:
    - Replaces optical tracking with a **Simultaneous Localisation and Mapping** (SLAM) method
    - Incorporates a new, more reliable, and **guided** calibration method featuring a **3D calibration field**
    - **Liver segmentation** and **disparity estimation** modules optimised to run at full framerate

System Design & Results



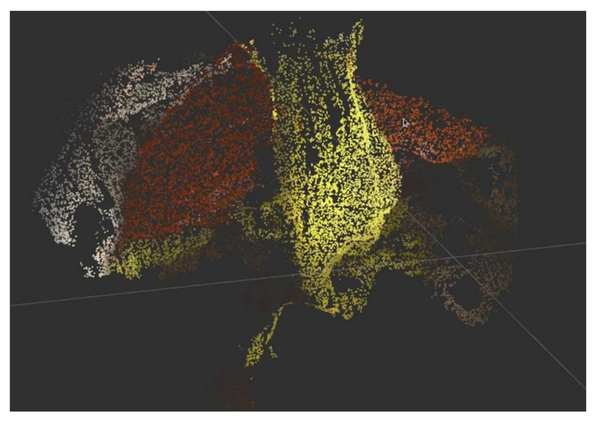
- Guided **calibration** method allows **faster** and more **reliable** results
- Calibration easily assessed using an **accuracy check**
- **3D Calibration field** allows for fewer images to be captured [1]

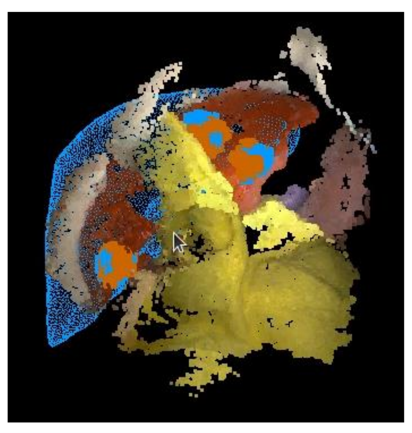




- **Liver segmentation** [2] optimised: 640% → 100% CPU usage
- **Disparity estimation** [3] optimised: 2.9fps → 35.1fps on single GPU
- ***DALI*** pre-processing and ***TensorRT*** acceleration [4]

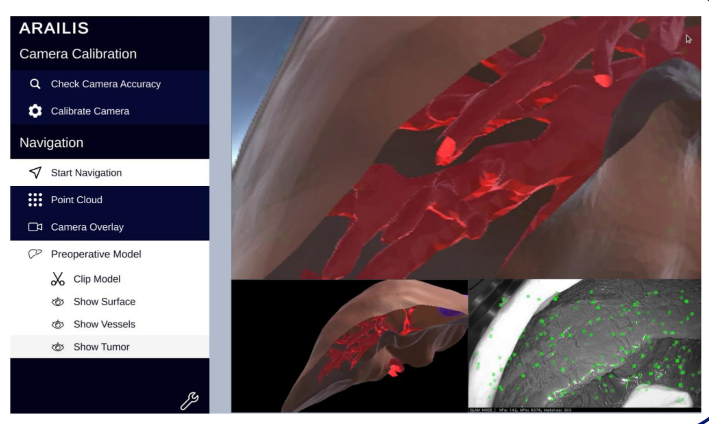
- The **ORB-SLAM2** [5] sparse SLAM method estimates camera poses
- Point clouds fused counting **repeat-occurrences** of points
- Observed points not recurring in predicted positions removed





- A **region-based ICP** method is used to **rigidly register** point cloud 'map' with CT scan
- **CNN-based** non-rigid registration follows, refining 'rough' registration with frequent automatic updates [6]

- Conduct calibration, navigation and assess functioning
- **User Interface** overlays CT scan with intraoperative video
- Highlight predicted positions of **tumours** and **blood vessels**



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Discussion & Conclusion

- Despite elimination of optical tracking, registration is effective and reliable
- Semi-automatic registration is dependable, requiring 2-3 minutes with automatic updates from non-rigid registration
- Calibration can be performed in under 2 minutes owing to user guidance
- Simplification of setup and operation lower barriers to clinical translation, and better meets clinical requirements with respect to time constraints.

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