Registration of Surgical Microscope Images with a CT Scan

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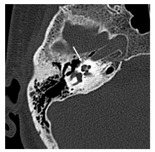
Motivation

- The ARRISCOPE is one of the first **digital stereo microscopes** intended for surgery
- No optical path to the eye: surgeon looks at a display
- Goal: Augment the displayed image with CT data and **give surgeon X-ray vision**



CT of patient

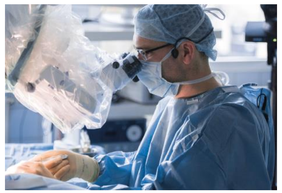
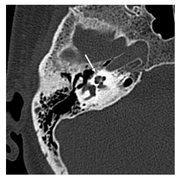


Image of patient

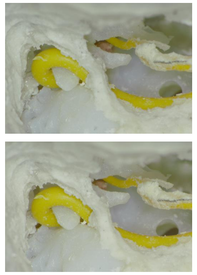
Main Problem: Initial Registration

Registration Procedure

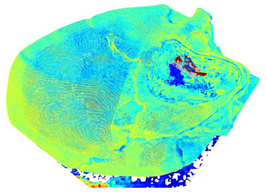
Input Data → **Convert to Surface Point Cloud** → **Detect Unique Keypoints and Calculate Local Descriptors** → **Match and Estimate 3D Rigid Transform** → **Refine Alignment and Check Correctness**



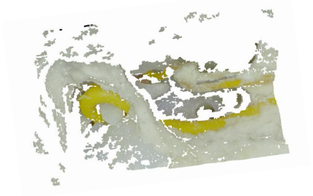
CT Data



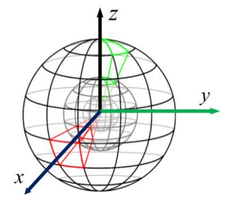
Stereo Images (Phantom)



3D surface point cloud from CT data

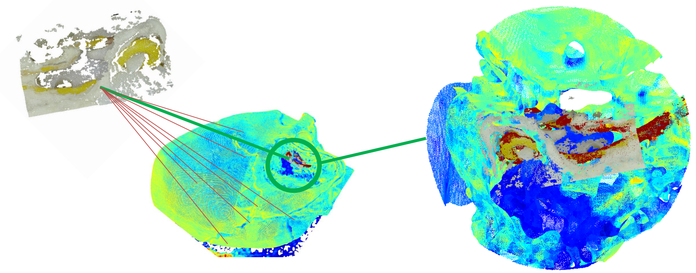


2.5D point cloud from stereo images



Local point count histogram

- Align points to local reference frame (PCA) for **rotation invariant descriptors**
- RootSIFT matching for robustness against outliers

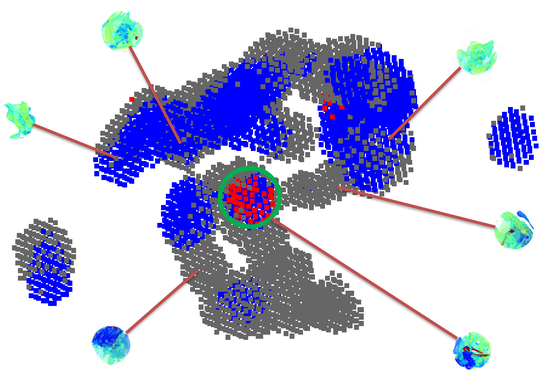


- RANSAC to estimate 6 degree of freedom rigid body transformation
- Match 2.5D point cloud against many local cropped regions from the model

- Use **rotation variant descriptors** (global alignment) to check correctness
- RANSAC to refine estimate

Initial Registration on Phantom

- Approach similar to **database retrieval,** where one database entry is one local region from the 3D point cloud (CT data)
- Simultaneously retrieve correct region and the 6 DoF transform needed for alignment

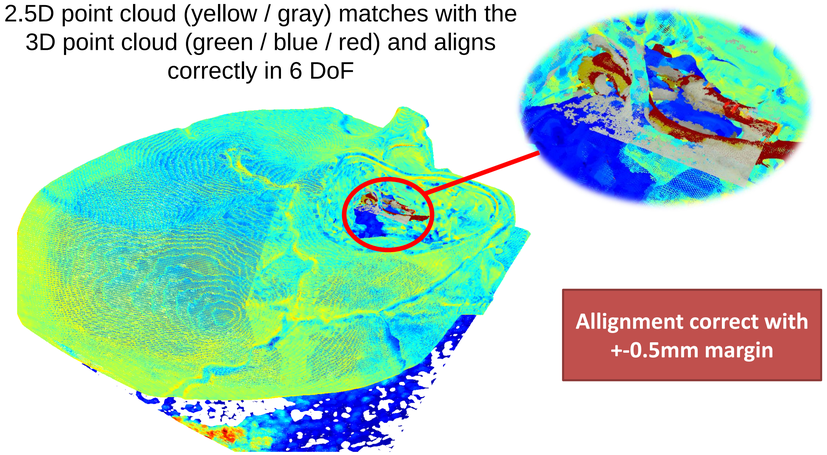


- One dot indicates one database entry
- RANSAC succeeds multiple times in the same local area of the 3D point cloud

5730 Matching Candidates
2773 RANSAC Candidates
61 RANSAC Successes

Preliminary Registration Result

2.5D point cloud (yellow / gray) matches with the 3D point cloud (green / blue / red) and aligns correctly in 6 DoF



Allignment correct with +-0.5mm margin

Conclusion and Future Work

Conclusion

- This is work in progress. Test on real patient data have yet to be performed.
- Registration works for the phantom, but real patient scenarios are more difficult due to reflecting surfaces and non-rigid material.

Future work

- Integrate structured light into the microscope for more reliable depth estimation
- Develop strategy for automatically segmenting tissue/ non-rigid material
- Motion Tracking after Initial Registration is successful

References

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