

Stereo Video Analysis for Tracking in Laparoscopic Surgery

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Introduction

- Image-Guided Surgery -

Image-guided interventions (**IGI**) use computer-based systems to provide virtual image overlays to help physicians to visualize and target the surgical site [1]

- IGI might enable new procedures and improve accuracy and success



SCATH catheter navigation platform (experiments)

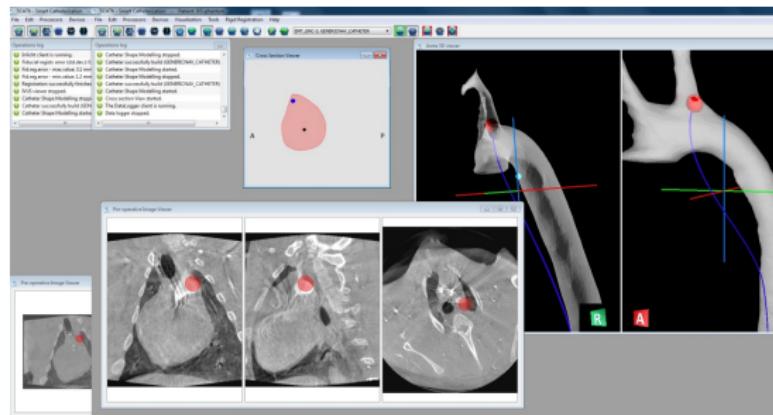
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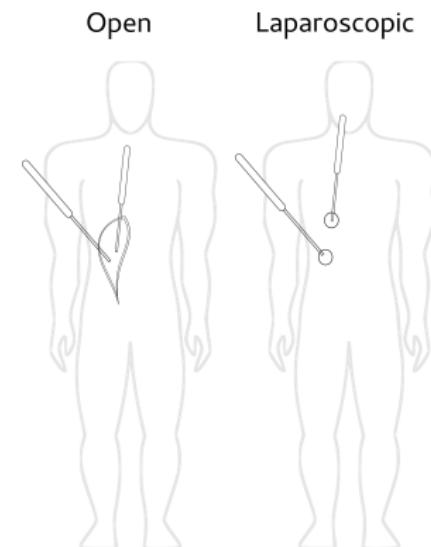
- Surgery is performed with instruments embedded in the body through small incisions

Advantages

- Less discomfort and pain
- Shorter hospital stay
- Less scarring

Challenges

- Reduced visibility while operating
- Reduced maneuverability while operating



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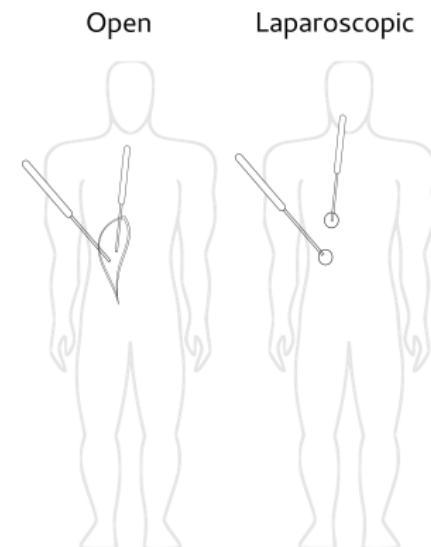
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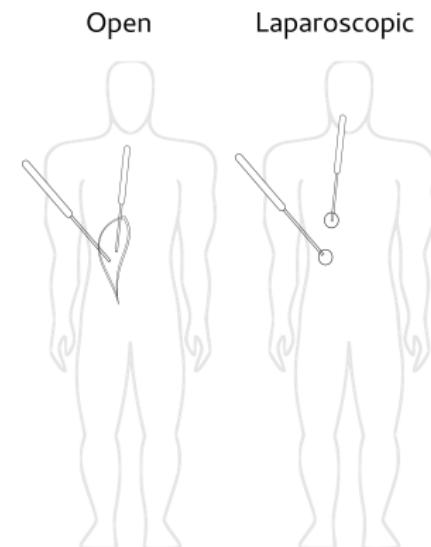
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- Components of an IGI system -

1 Computed Tomography (CT) acquired

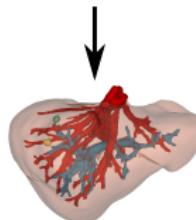
2 Models are generated

3 Registration with intra-operative reality

4 Navigation using tracking

Pre-operative

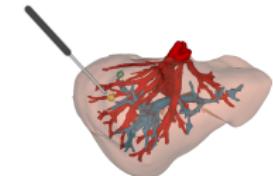
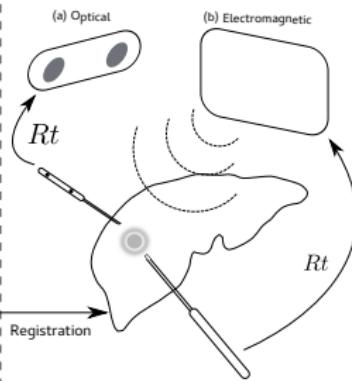
Segmented CT



3D Model

Intra-operative

Tracking



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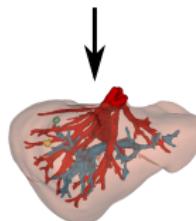
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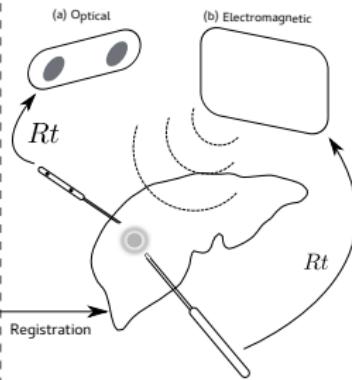
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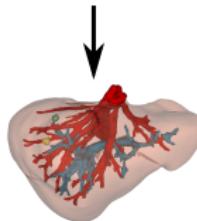
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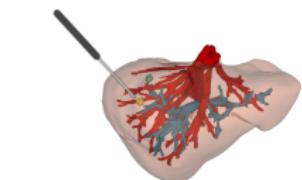
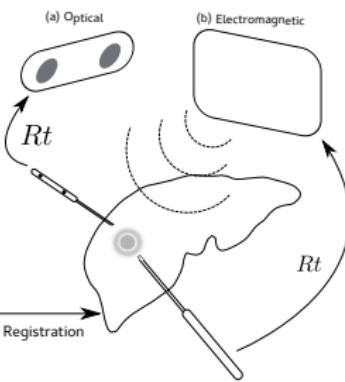
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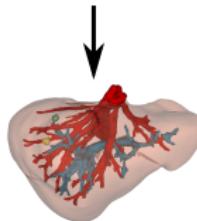
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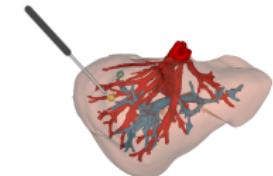
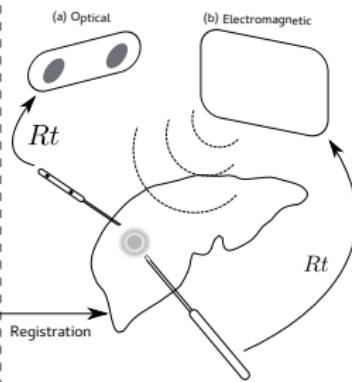
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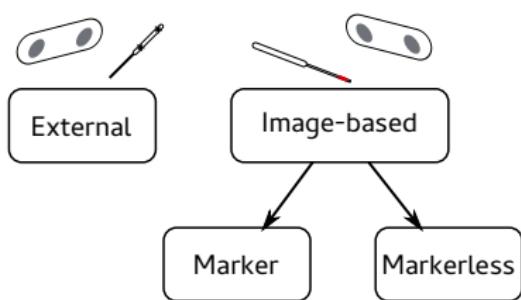
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Related Work

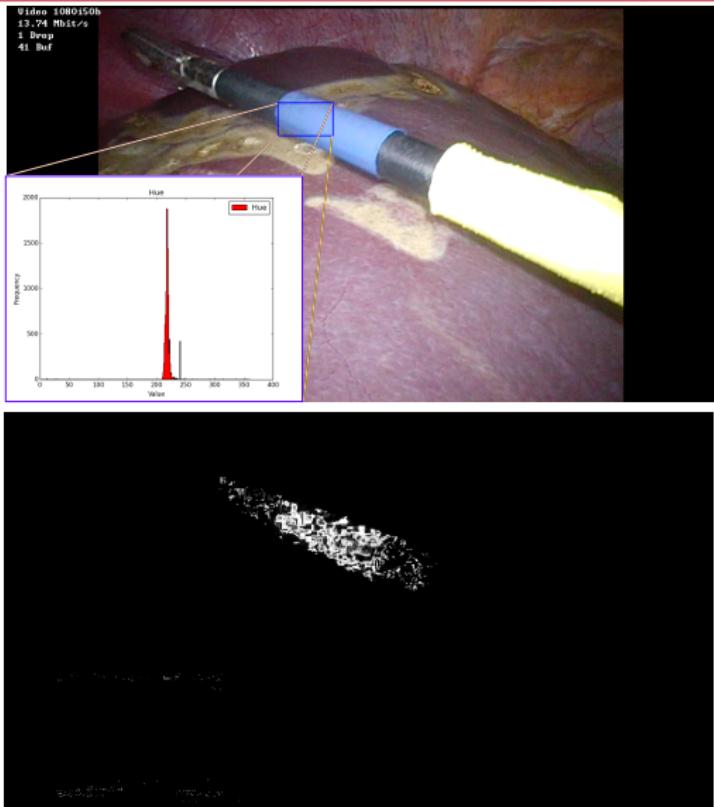
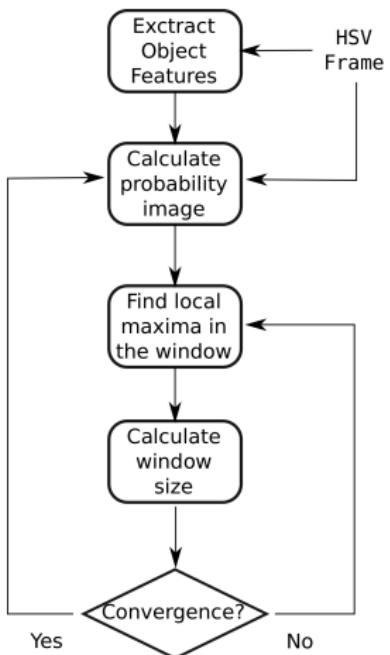
- Optical Tracking in Laparoscopic Surgery -



	Marker-based	Markerless
2D	<ul style="list-style-type: none">• Tonet05• Buarfa05• Speidel06• Doignon05	<ul style="list-style-type: none">• Voros06• Clement04• McKenna05• Cano06• Cano09• Wolf11
3D	<ul style="list-style-type: none">• Kilgus13• This work	<ul style="list-style-type: none">• Speidel08• Reiter13

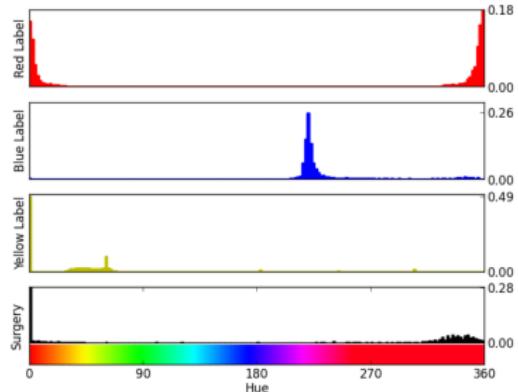
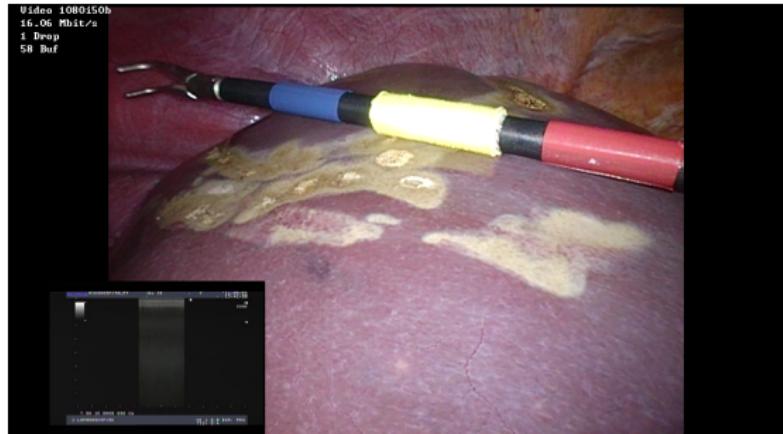
Methods

- Continuously Adaptive Mean Shift (CAMSHIFT) -



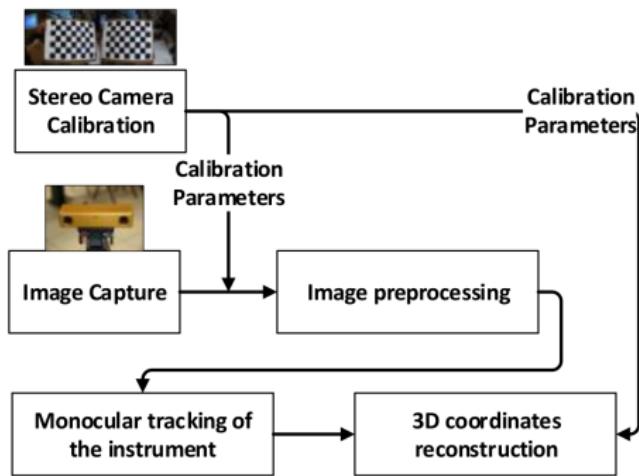
Methods

- Color Tags -



Methods

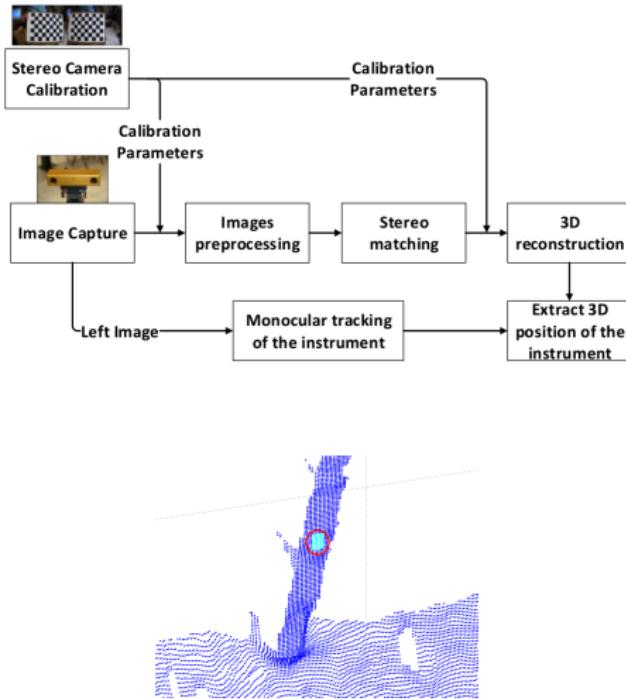
- Framework 1 -



- Calibration based on planar checkboard
- Tracking based on CAMSHIFT (2 windows)
- 3D Centroid extracted using triangle analysis

Methods

- Framework 2 -

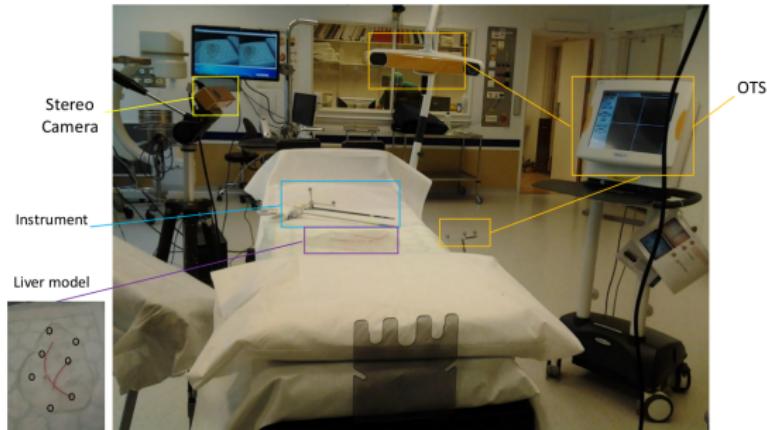


- Calibration based on planar checkboard
- Stereo reconstruction of the scene based on [2]
- CAMSHIFT applied to one component of stereoreo pair
- Centroid as average of matched points inside tracking window

[2] Andreas Geier, Martin Roser and Raquel Urtasun. “Efficient large-scale stereo matching”. Computer vision–ACCV2010.

Experiments

- Experimental Setup -



- Bumblebee stereo camera
- Polaris optical tracking system
- Standard tools used in laparoscopic surgery
- Sterilizable biocompatible color markers
- Liver phantom with fiducial points

Experiments

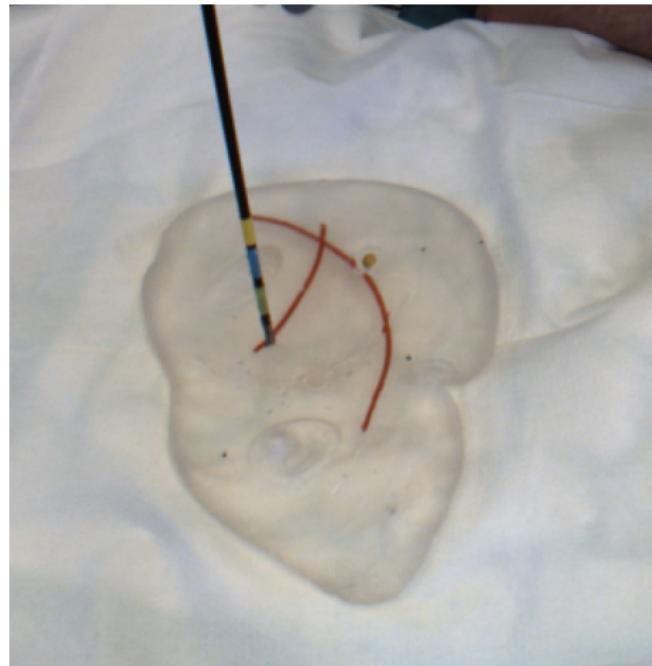
- Accuracy evaluation using *stat-of-art* surgical navigation tracking as ground truth.

Experiment 1

- Accuracy evaluation without movement

Experiment 2

- Accuracy evaluation with movement
- Introduces time synchronization problems



Experiments

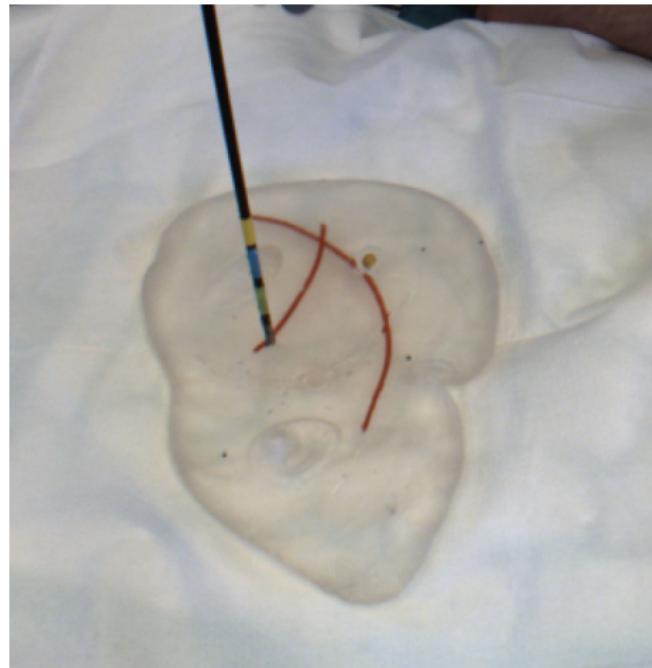
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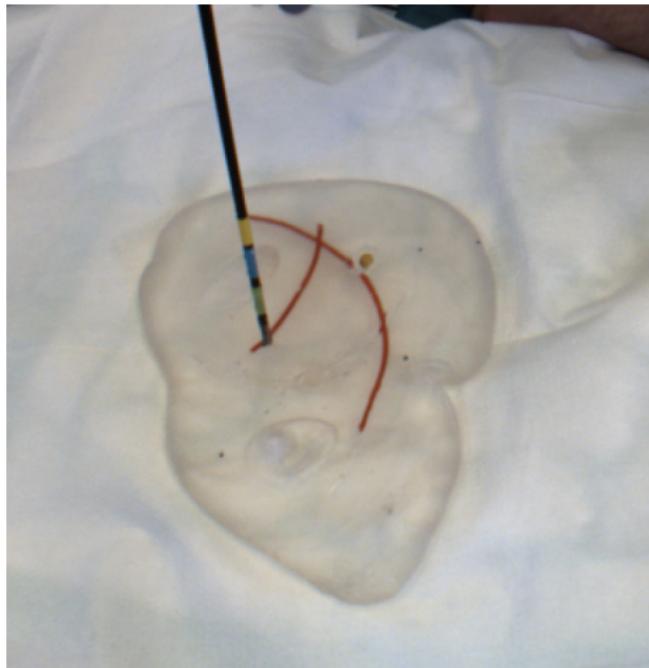
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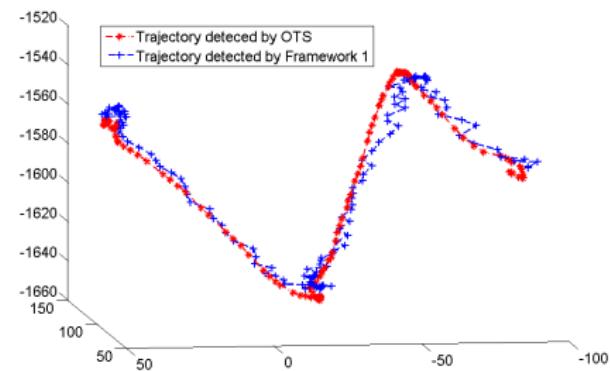
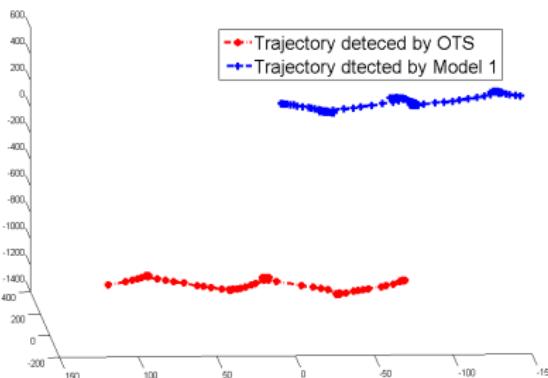
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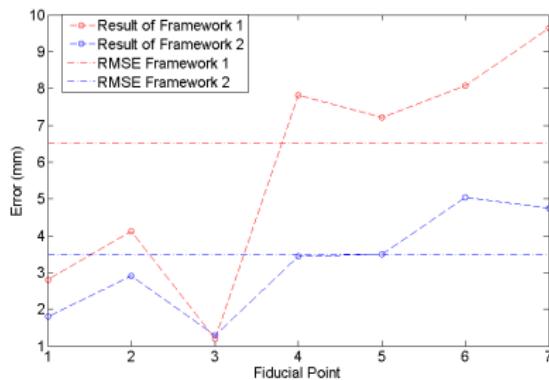
- Aligning the data -

- Different devices acquire data in different coordinate frames
- For evaluation, different coordinate frames must be aligned
- We employ rigid body transformation [3]

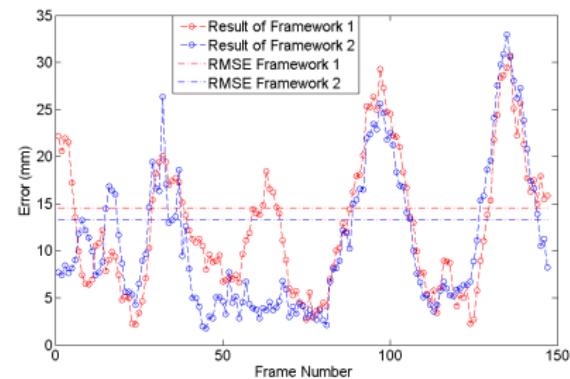


[3] John H Challis, "A procedure for determining rigid body transformation parameters," Journal of Biomechanics, vol. 28, no. 6, pp. 733–737, 1995

Experiment 1



Experiment 2



- Error 6.52mm RMS (F 1)
 - Error 3.49mm RMS (F 2)
 - Though errors are in the same order as other works, results are not directly comparable
- Error 14.59mm RMS (F 1)
 - Error 13.34mm RMS (F 2)

Conclusion

- Two frameworks to integrate CAMSHIFT-based tracking in a stereo setup
- Applications for laparoscopic surgery
- Scene analysis to find suitable markers was performed
- Accuracy results in the same order as similar works (results not directly comparable)
- Our setup employs only state-of-art equipment (no additional equipment is required)

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- Application of frameworks in a surgical setup
 - Stereo laparoscopes
- Comparison with other approaches
- Structured light laparoscopes
- Time-of-flight laparoscopes

Thank you for your attention

Questions?

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