

Magneto-Optic Tracking of a Flexible Laparoscopic Ultrasound Transducer for Laparoscope Augmentation

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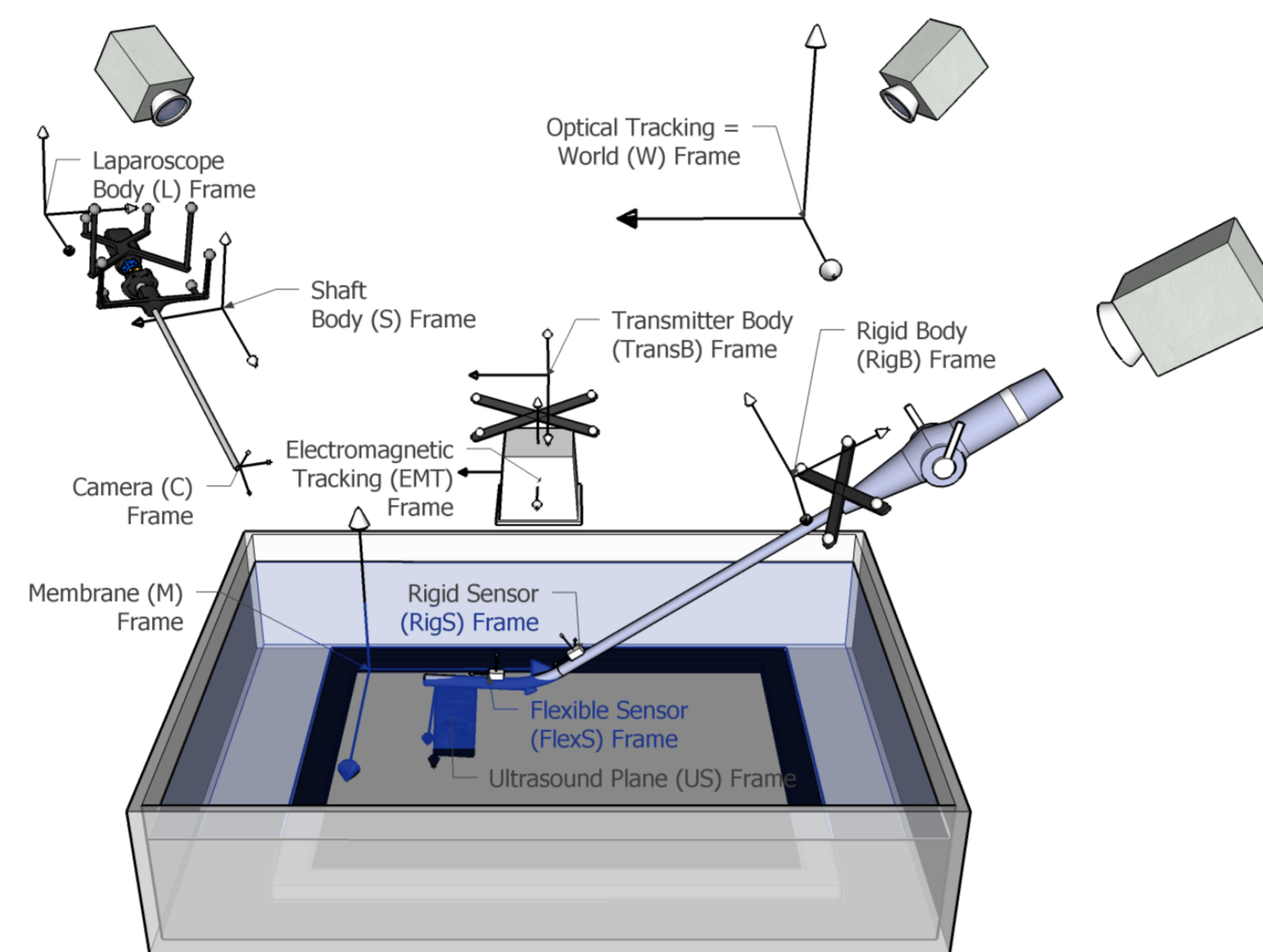
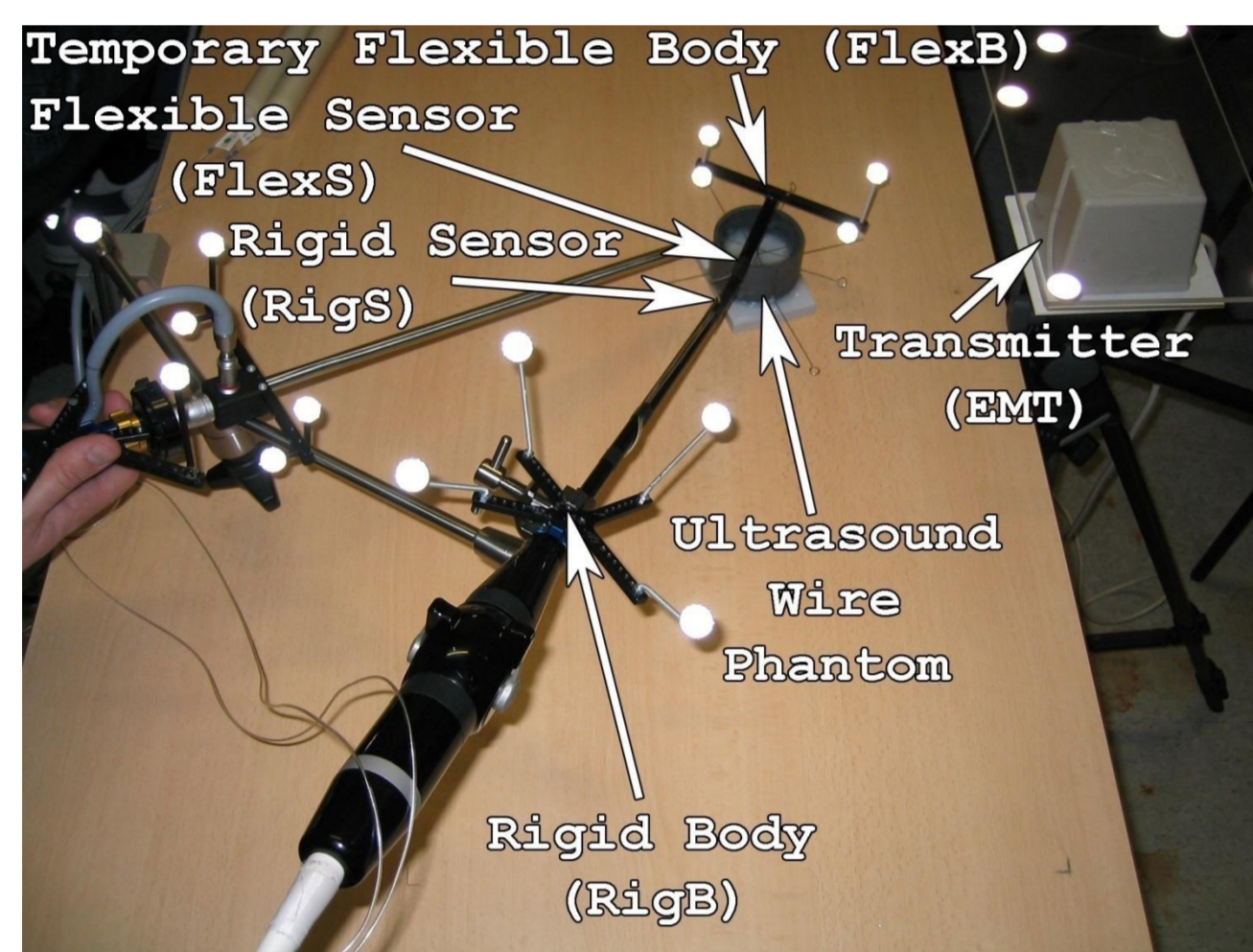
Problem Statement

- Laparoscopic ultrasound transducers are commonly localized by electromagnetic tracking systems
- Electromagnetic tracking is susceptible to ferromagnetic or electrically powered objects in its close vicinity, causing erroneous measurements due to field distortions
- Current approaches for detection or correction of field distortion are only applicable to static distortions or rigid instruments [1-5]

Conclusion

- New method for the detection and partial correction of static and dynamic magnetic field distortions online and in real time, i.e. intraoperatively, without the need for a precomputed distortion function
- Applicable to similarly constructed minimally invasive surgical instruments with bendable tips

System Setup



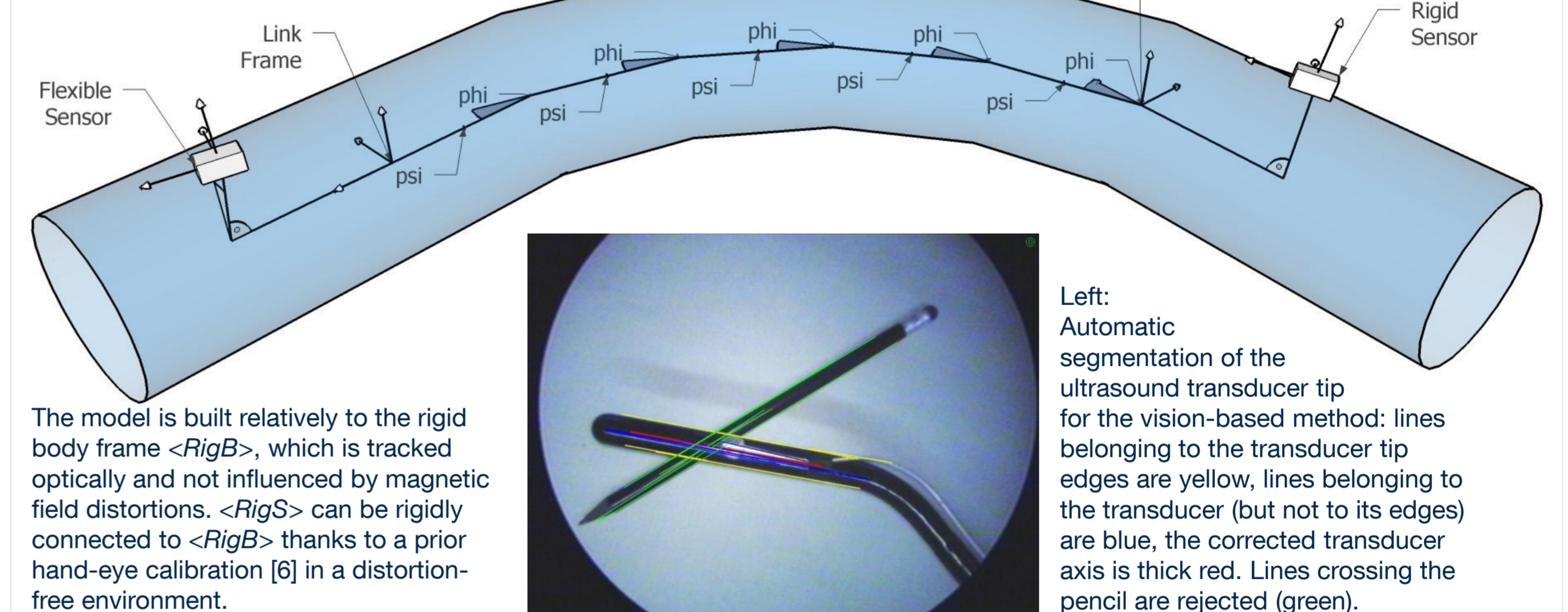
Methods

- Co-calibration of magneto-optic tracking setup by hand-eye calibration [6], followed by an optimization of the transformations $\langle EMT \text{ to } TransB \rangle$ and $\langle RigS \text{ to } RigB \rangle$ (and $\langle FlexS \text{ to } FlexB \rangle$ for error evaluation)
- Tracking redundancy-based detection and correction approach: Measurement of the deviation from the calibrated transformation $\langle RigS \text{ to } RigB \rangle$ is used as an approximation for the deviation of the flexible tip sensor

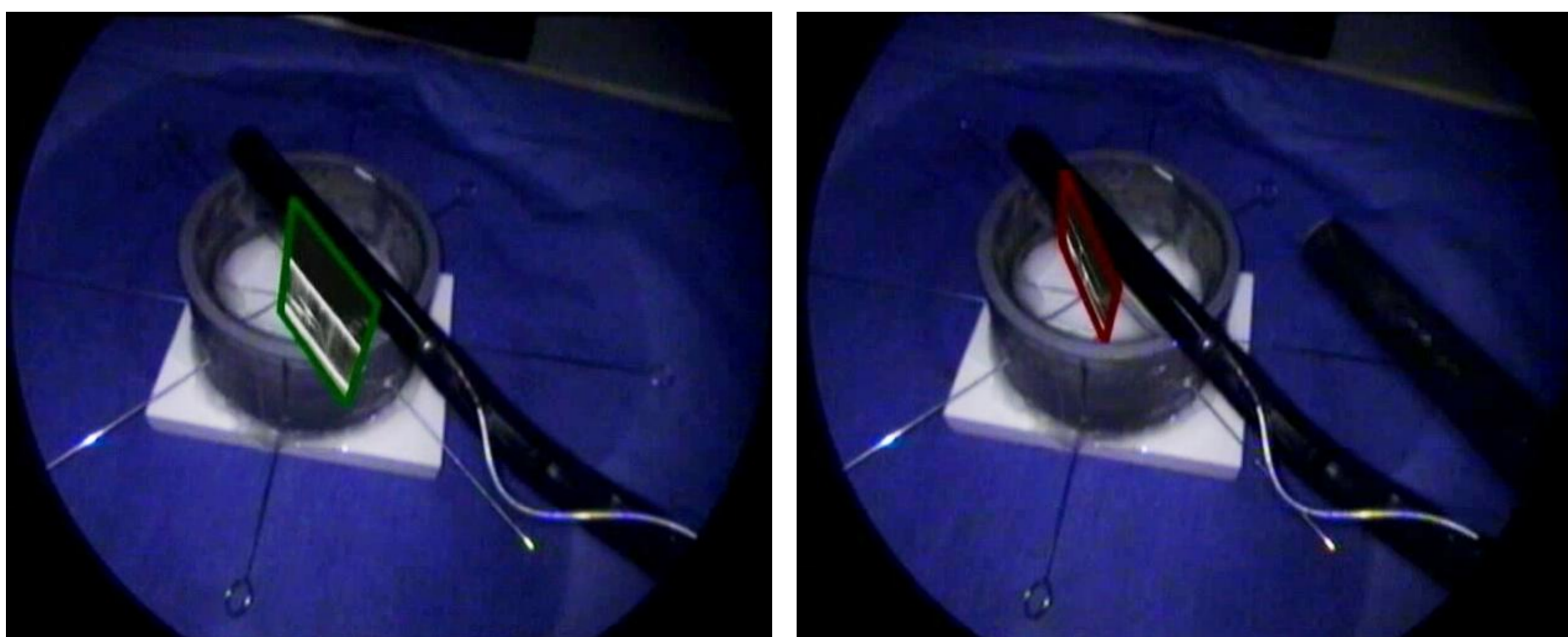
Outlook – Methods Submitted to IEEE TMI

- **Model-based method:**
 - Modeling all possible transducer tip movements by reducing the 6DOF of the flexible sensor to only 2DOF for a rotation about 2 axis by ϕ and ψ
 - Optimization of these 2DOF at runtime
 - Translation and/or rotation difference between optimized and measured tip position can be used to predict field distortions online
- **Vision-based method:** Further reduction of error by combination with automatic segmentation of transducer tip in laparoscopic view and adjustment of transducer tip axis

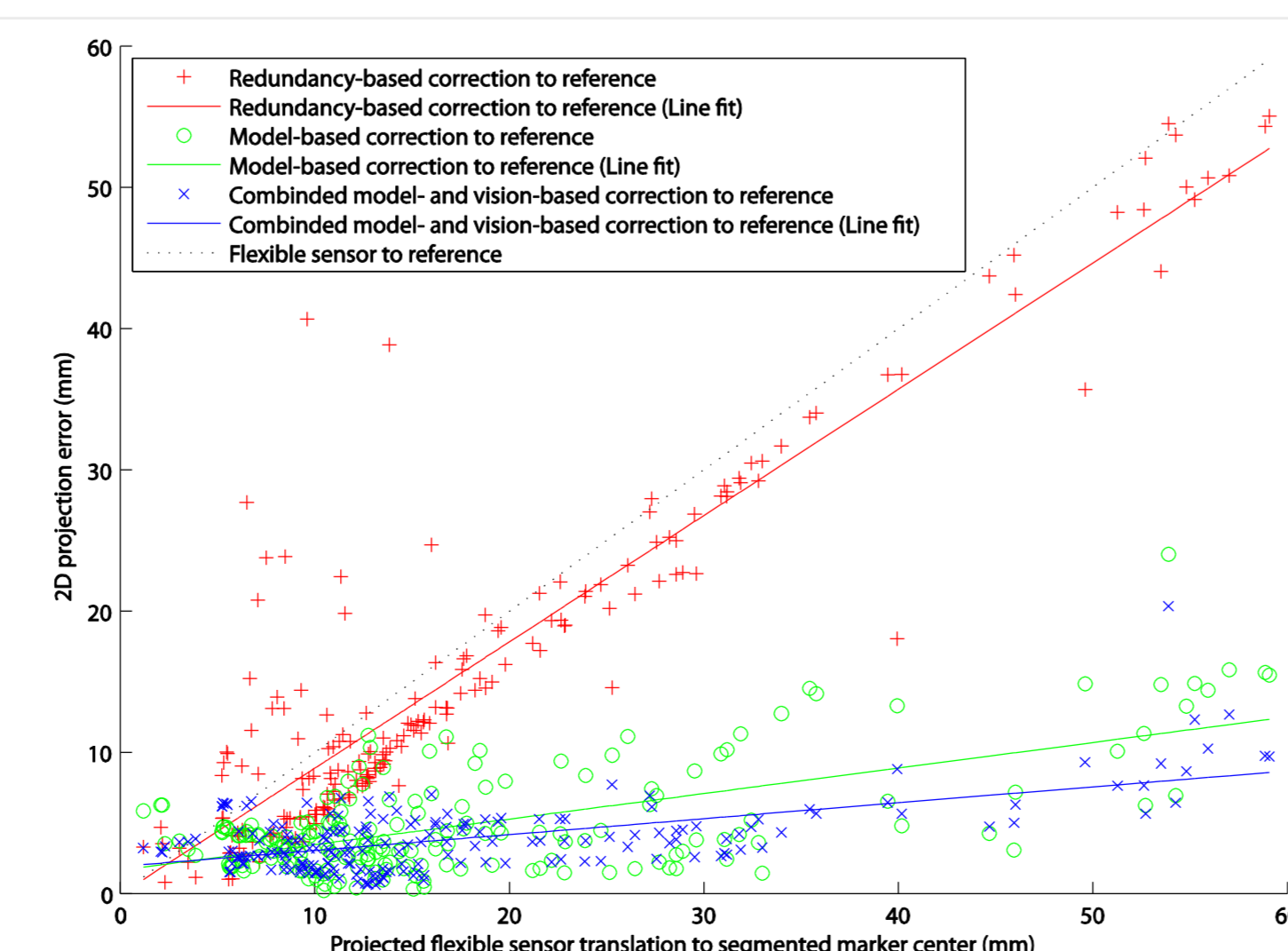
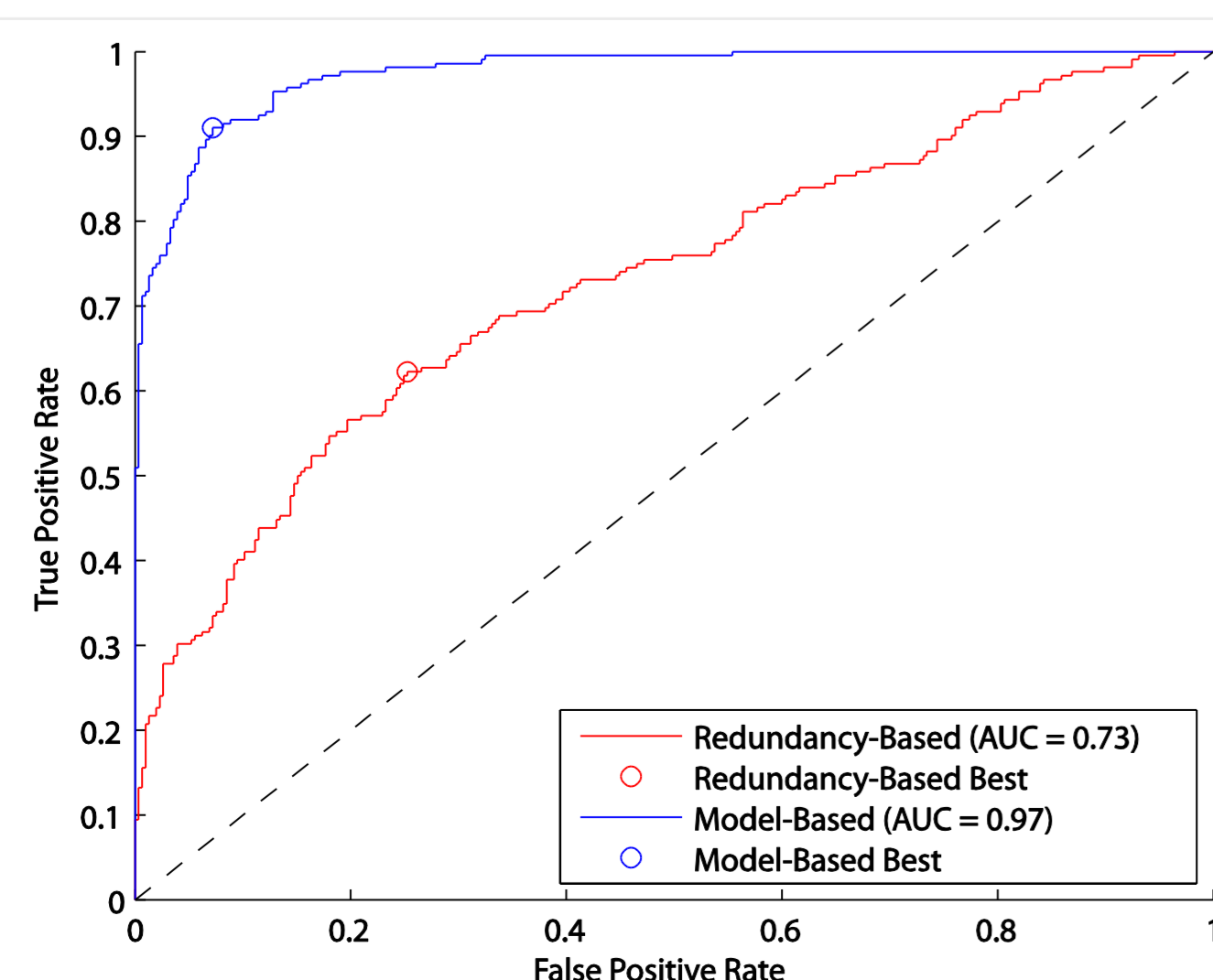
The possible transducer tip movements can be modeled as a transformation from the flexible sensor frame $\langle FlexS \rangle$ into the rigid sensor frame $\langle RigS \rangle$, with all parameters fixed except ϕ and ψ .



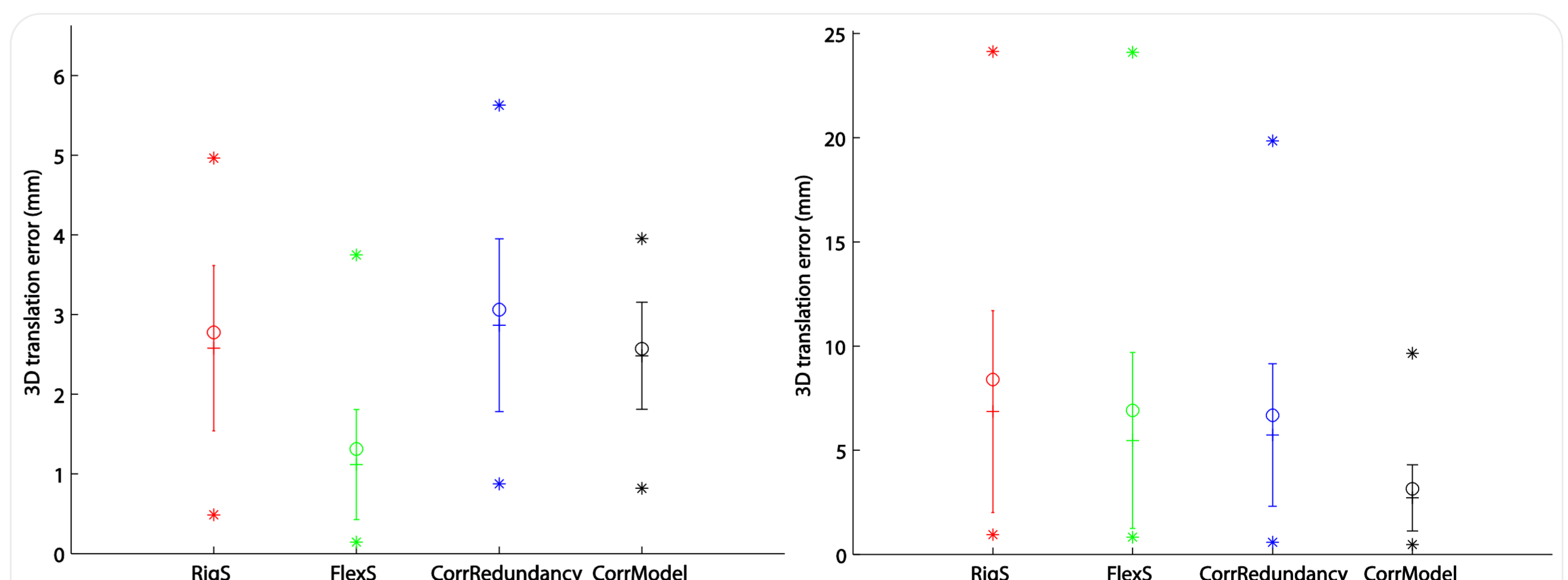
Results



Similar to [7], ultrasound B-scan images are overlaid onto the laparoscopic view (left); when distortions are detected, the frame border is colored red (right)



Error detection (left) and correction performance in terms of 2D error (right)



3D error for undistorted (left) & distorted measurements (right)

Way of Measurement	Rigid Sensor	Flexible Sensor	Redundancy-based	Model-based
Undistorted	2.91	1.28	2.92	2.27
Distorted	8.39	6.91	6.67	3.15

References

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