Synopsis: Closed-Loop Active Compensation for Needle Deflection and Target Shift During Cooperatively Controlled Robotic Needle Insertion

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***Abstract*—The abstract by Will goes here.**

***Index Terms*—IEEE, IEEEtran, journal, LaTeX, paper, template.**

I. Introduction

THIS demo file will be edited by Will. It is intended to serve as a "starter file" for IEEE journal papers produced under LaTeX using IEEEtran.cls version 1.8b and later. I wish you the best of success.

mds
February 7, 2023

A. Subsection Heading Here

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II. Methods and Materials

Sample text inside input file for Part 1 of materials and methods.

A. Feature Localization

For evaluation of the closed-loop active compensation during cooperatively controlled needle insertions, we use two cameras to capture real-time images of the needle tip and target within the robot workspace. This is a suitable substitute for medical imaging, in fact the compensation technique is not dependent on the modality of the medical image. The two cameras are placed orthogonal to each other, and are run by a standalone software application.

In the software application, we employed Farnebäck's algorithm [1] to execute on captured video frames to localize the moving needle tip and obtain homogeneous transformations of the tip and the target. We used a color segmentation technique to demonstrate the active compensation.

B. Active Compensation

Before any targeting takes place, registration is performed by rigidly attaching a marker to the robot. For example, we would attach the marker with MR visible fiducials when moving through an MRI machine. This is visually supported by Figure 1.

All authors are software engineers in their professional life.

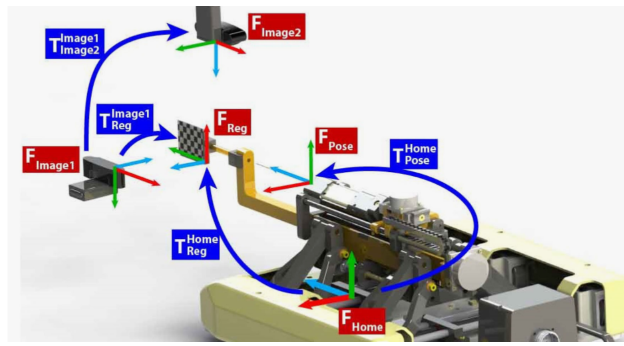

Fig. 1. Frames and transformations for image guidance registration

After the registration is complete, the marker is removed. The OpenIGTLink [2] communication protocol is used to pass down the frame and transformations from image-guidance software to the robot controller. As seen by Figure 1, the transformation sequence $T_{Pose}^{Home^{-1}} T_{Reg}^{Home^{-1}} T_{Reg}^{Image^{-1}}$ is used to express the registration with respect to the robot pose.

III. Results

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IV. Discussion

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Appendix A
Proof of the First Zonklar Equation

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Appendix B

Appendix two text goes here.

Acknowledgment

The authors would like to thank...

References

[1] G. Farnebäck, "Two-frame motion estimation based on polynomial expansion," in *Proceedings of the 13th Scandinavian Conference on Image Analysis*, ser. SCIA'03. Berlin, Heidelberg: Springer-Verlag, 2003, p. 363–370.

[2] J. Tokuda, G. S. Fischer, X. Papademetris, Z. Yaniv, L. Ibanez, P. Cheng, H. Liu, J. Blevins, J. Arata, A. J. Golby, T. Kapur, S. Pieper, E. C. Burdette, G. Fichtinger, C. M. Tempany, and N. Hata, "Openigtlink: an open network protocol for image-guided therapy environment," *Int J Med Robot*, vol. 5, no. 4, pp. 423–34, 2009 Dec 2009.

PLACE PHOTO HERE

Patrick Donelan Biography text here.

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Debbie Guenthner Biography text here.

Arjan Gupta Arjan Gupta is an Embedded Software Engineer employed by Lindsay Corporation. He graduated from the University of Kansas in May 2017 with a Bachelor of Science in computer engineering and a minor in mathematics. He is currently pursuing his Master of Science in robotics engineering at Worcester Polytechnic Institute.

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Will Yingling Biography text here.