# 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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*1) Subsubsection Heading Here:* Subsubsection text here.

## 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 serves as a proxy for medical imaging, and in fact the compensation technique is not dependent on the modality of the medical image. The two cameras are place 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.

### B. Active Compensation

## III. Results

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## IV. Discussion

The conclusion goes here.

## Appendix A
## Proof of the First Zonklar Equation

Appendix one text goes here.

## 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.


**Patrick Donelan** Biography text here.

All authors are software engineers in their professional life.

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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.