Pupil Variation and Its Application in Endoscope Manipulation

Literature Review

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Mentors:
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Dr. Masaru Ishii
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Reviewed Literature

[1] Cao, Y., Miura, S., Kobayashi, Y., Kawamura, K., Sugano, S., & Fujie, M. G. (2016, January). **Pupil variation applied to the eye tracking control of an endoscopic manipulator**. IEEE Robotics and Automation Letters, 1(1), 531-538.

[2] Cao, Y., Kobayashi, Y., Miura, S., Kawamura, K., Fujie, M. G., & Sugano, S. (2016, December). **Pupil variation for use in zoom control**. In Robotics and Biomimetics (ROBIO), 2016 IEEE International Conference on (pp. 479-484). IEEE.

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Introduction

- Laparoscopic surgery requires assistant to operate the laparoscope.
- Effort has been made to develop laparoscopic manipulator controlled by surgeons.
- The selected papers look into how pupil variation data can be used to control the manipulator.

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Relevancy

1. They **validated a relation** between pupil variation and endoscope manipulation during a surgery.

2. Their implemented control principles for gaze information indicated **potentially useful data** that we previously ignored.

3. They provided a guideline for **post-processing** those data.

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Paper 1: System Overview

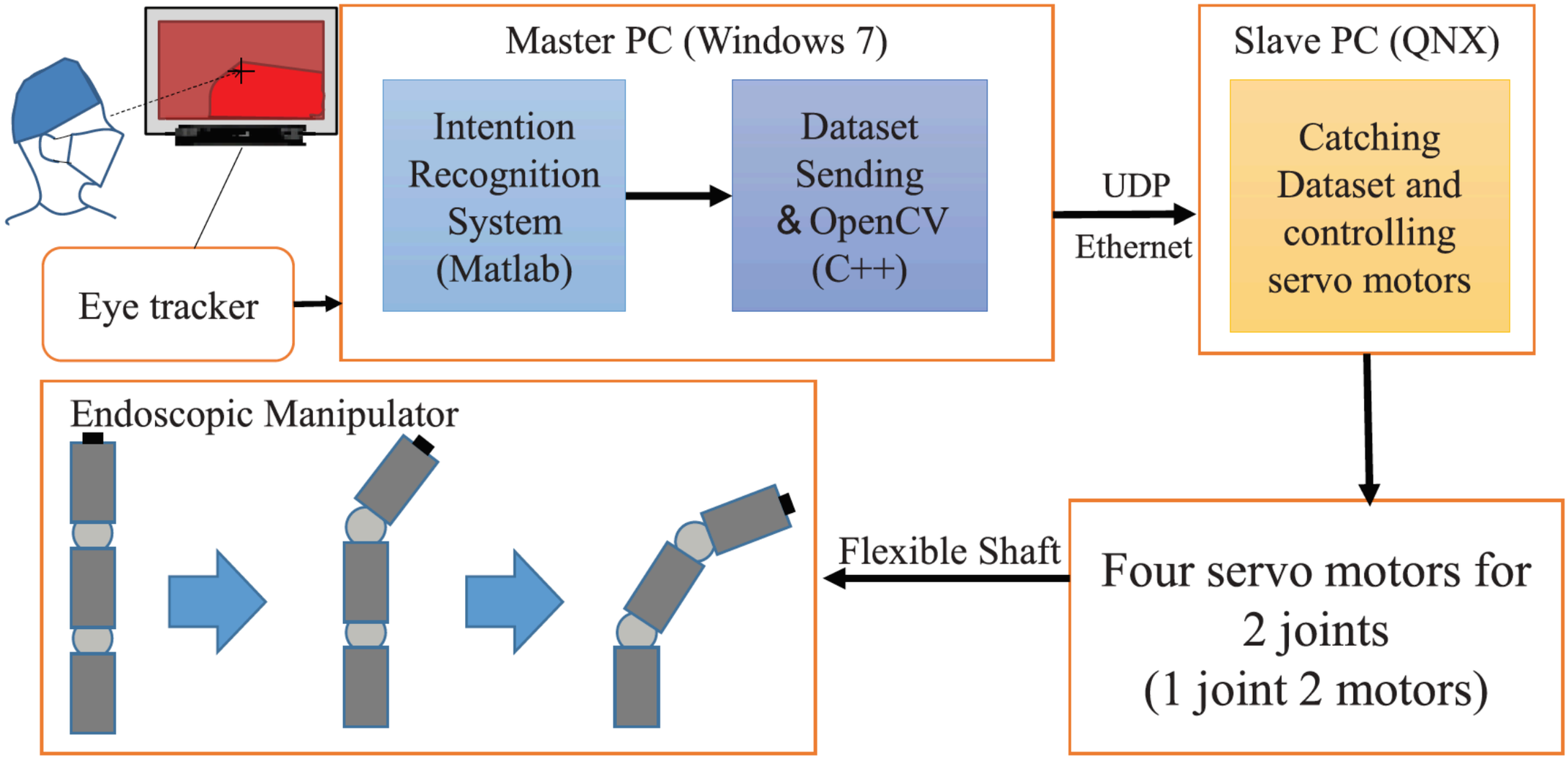

Figure taken from [3]

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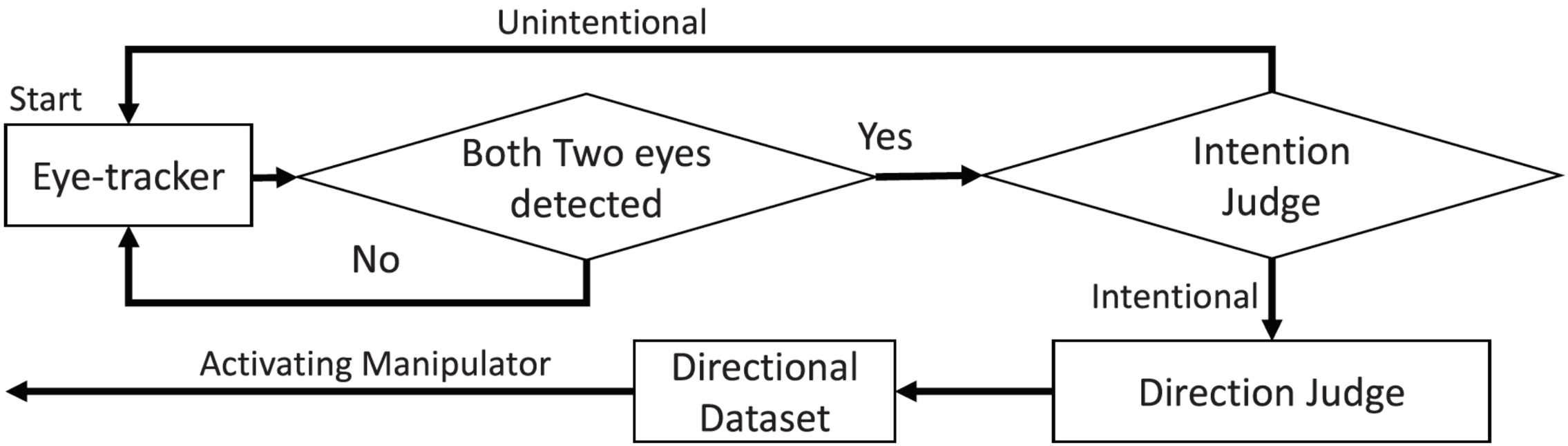
Paper 1: IR Algorithm



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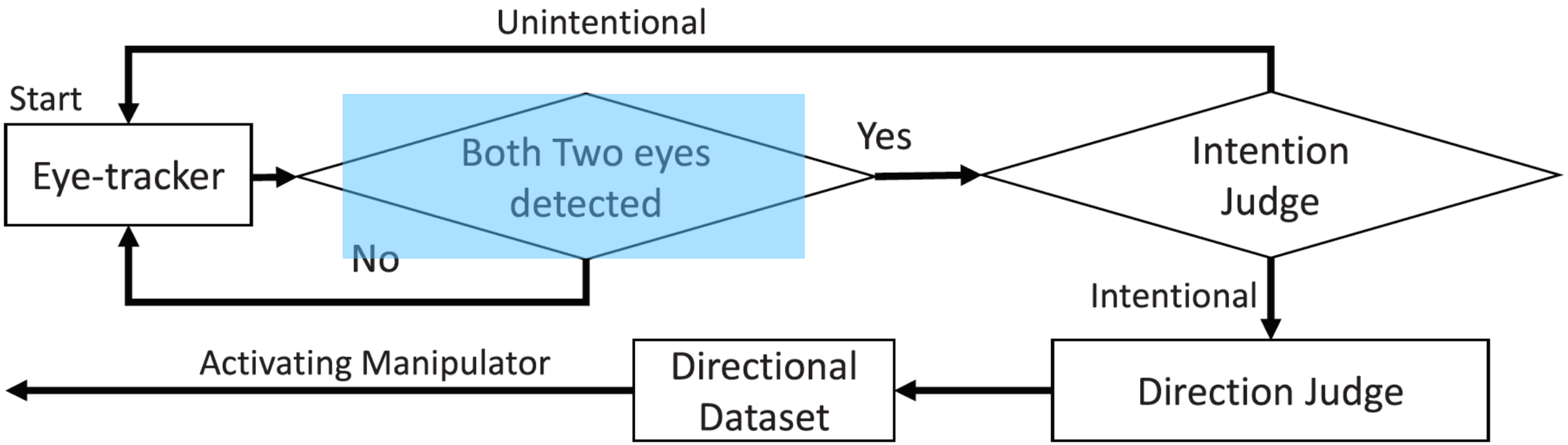

Figure taken from [3]

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Paper 1: Excluding Bad Reading

- **Validity Code**: how confident the eye tracker is about the gaze data it extracts.

- Scale from 0 to 4: 0 for both eyes are definitely found; 4 for neither eye is tracked.

- Only data with a validity value of 0 is kept.

- Exclude Blinking and Mistracking.

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Paper 1: IR Algorithm

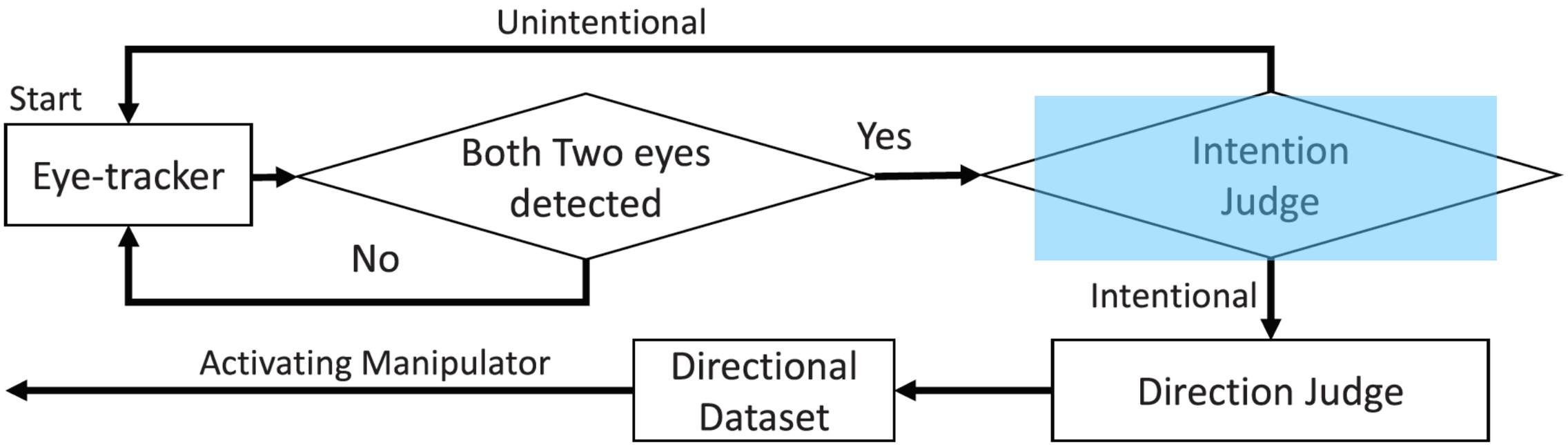

Figure taken from [3]

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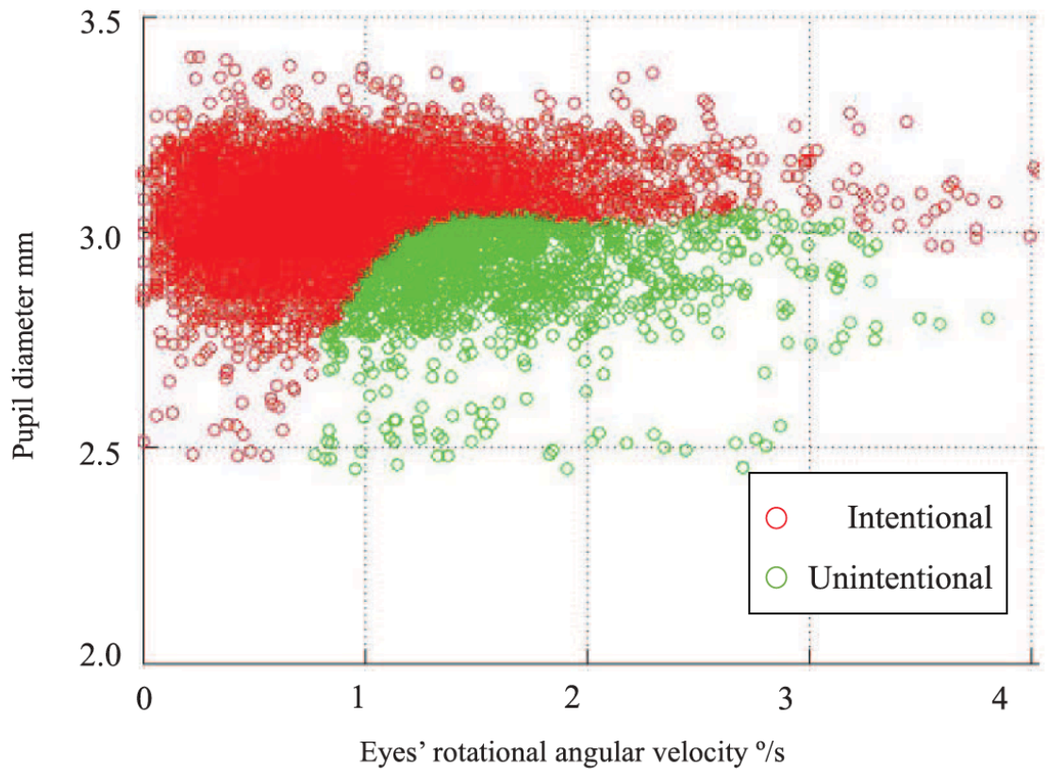
Paper 1: Intentionality Judge

- A nonlinear SVM model using a sigmoid hyperbolic tangent kernel.

- Data collected from 7 surgeons performing a suturing task. Labeled using Tobii I-VT Filter.

- 10-fold Validation gives 88.6% accuracy.



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Paper 1: IR Algorithm

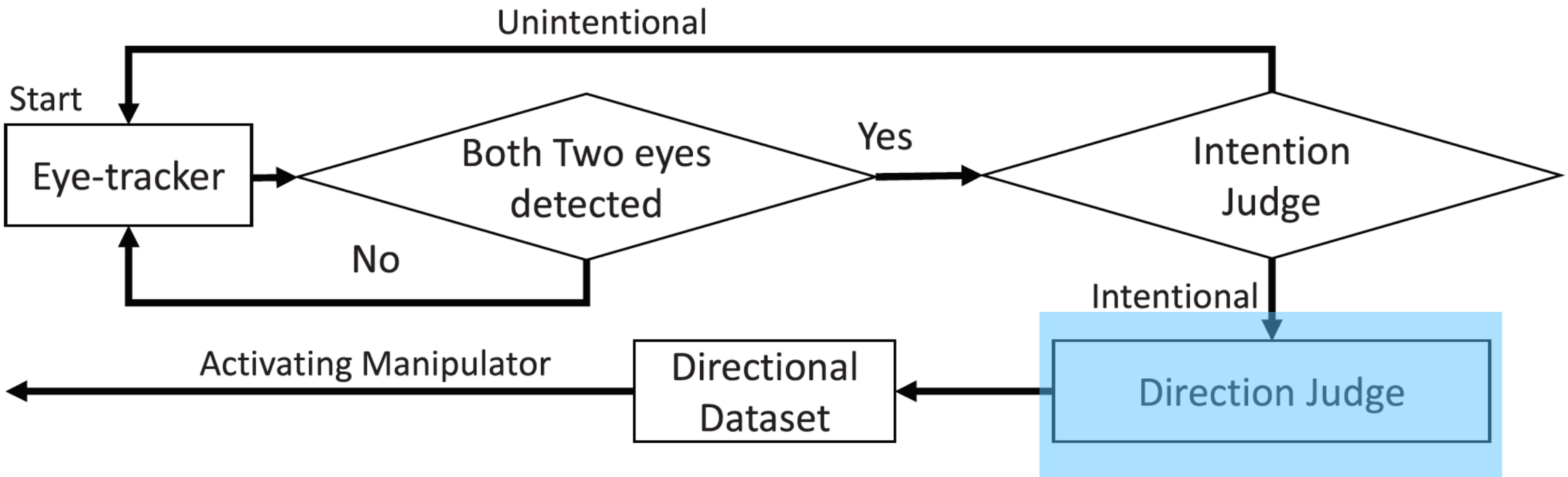

Figure taken from [3]

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Paper 1: Direction Judge

- Probabilistic Neural Network(PNN)

- Input: the position of user's gaze on the screen

- Output: Integer from 1—9 representing 9 directions

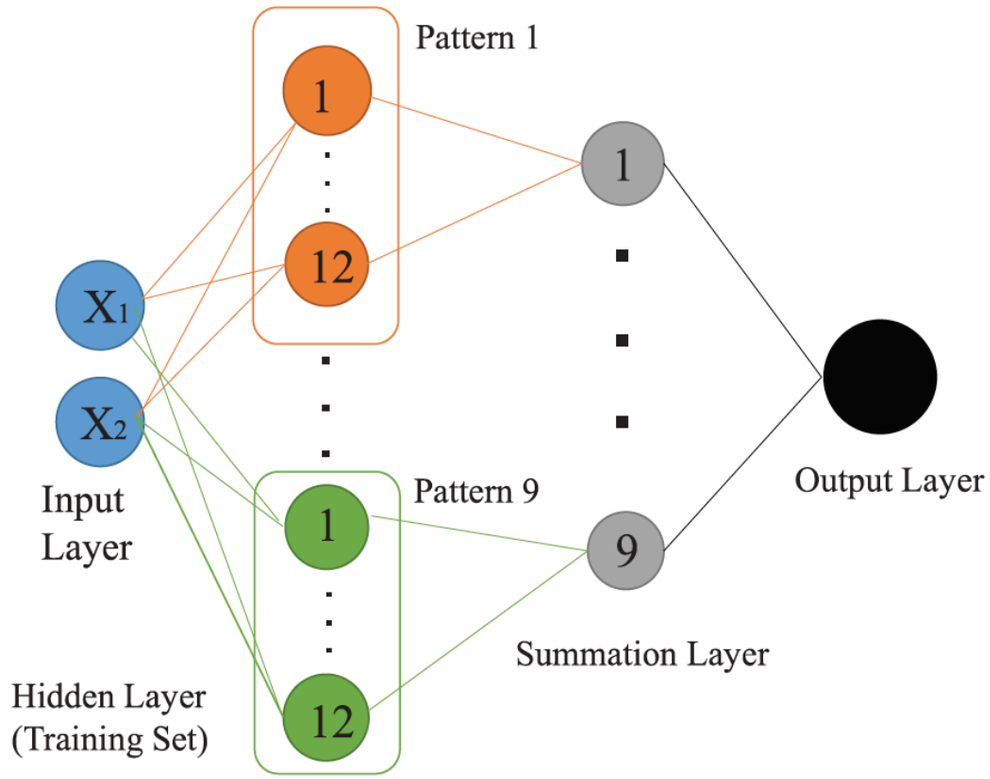

Figure taken from [3]

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Paper 1: Endoscopic Manipulator

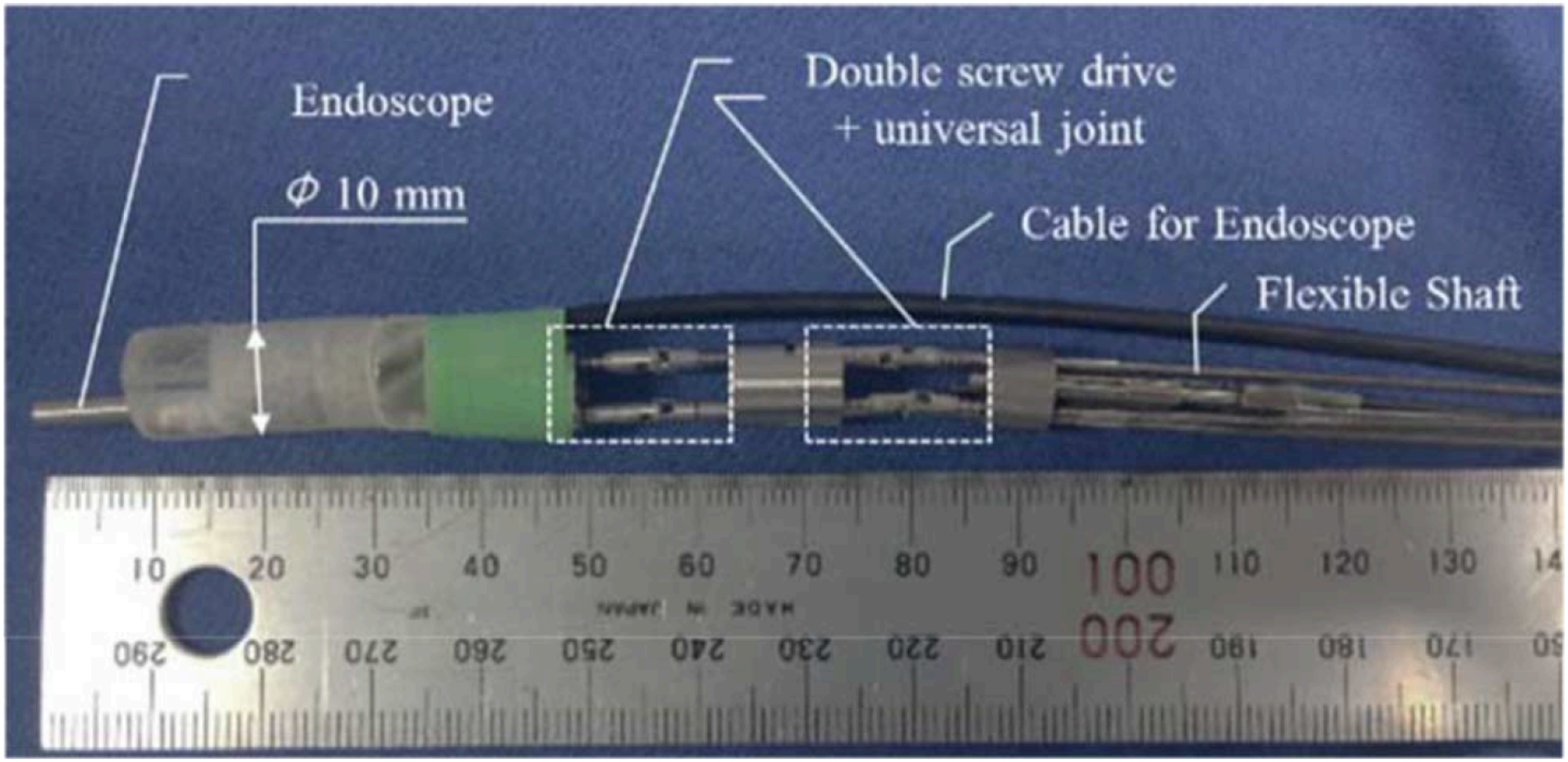

Figure taken from [3]

Ruiqing Yin *ryin6@jhu.edu*

Paper 1: Experiment

- A user study of 12 novice participants
- A peg transfer task is performed
- Control group: Assistant Mode

(a). Grasping (b). Transferring (c). Placing

Figure taken from [3]

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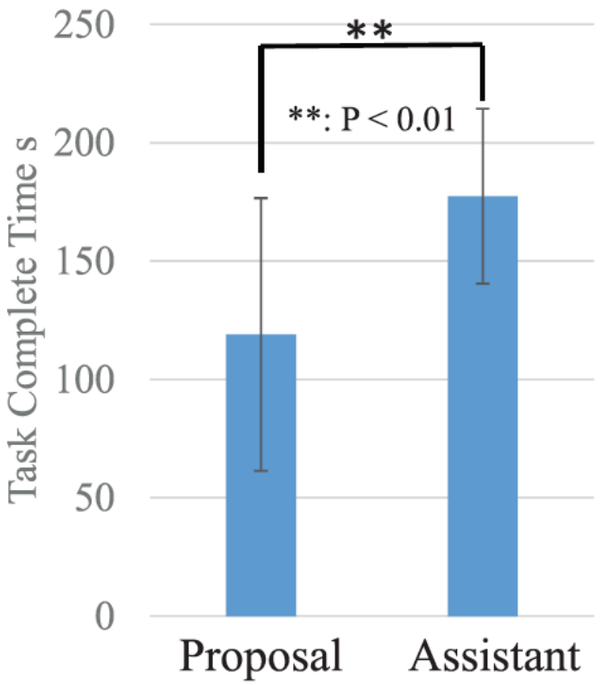
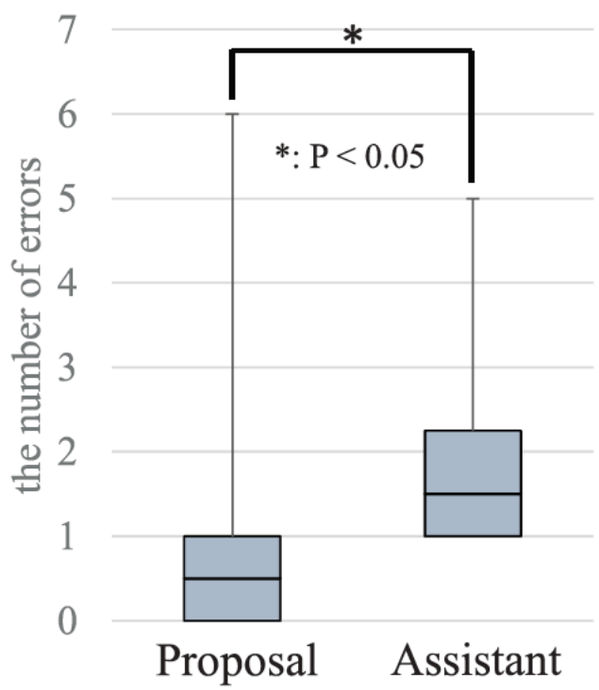
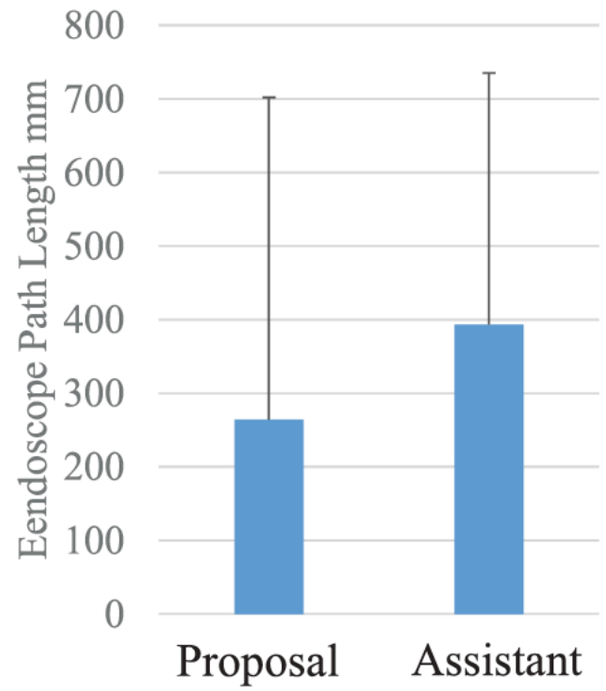
Paper 1: Results



Task Completion Time



Number of Errors



Endoscope Path Length

Interesting finding: Correlation between pupil size, pupil to screen distance, and endoscope movement.

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Paper 1: Strength and Limitation

Strength

1. Information about its hardware setup is clearly give.
2. Pupil variation aspect is innovative and worth exploring.
3. They provide a functional pipeline of endoscope control system using gaze tracking.

Limitation

1. The task for user study is too simple and naive for proof of clinical value.
2. Participants are all novice, which decreases the credibility of the results.
3. Explanation of algorithm details is lacking.
4. Poorly formatted.

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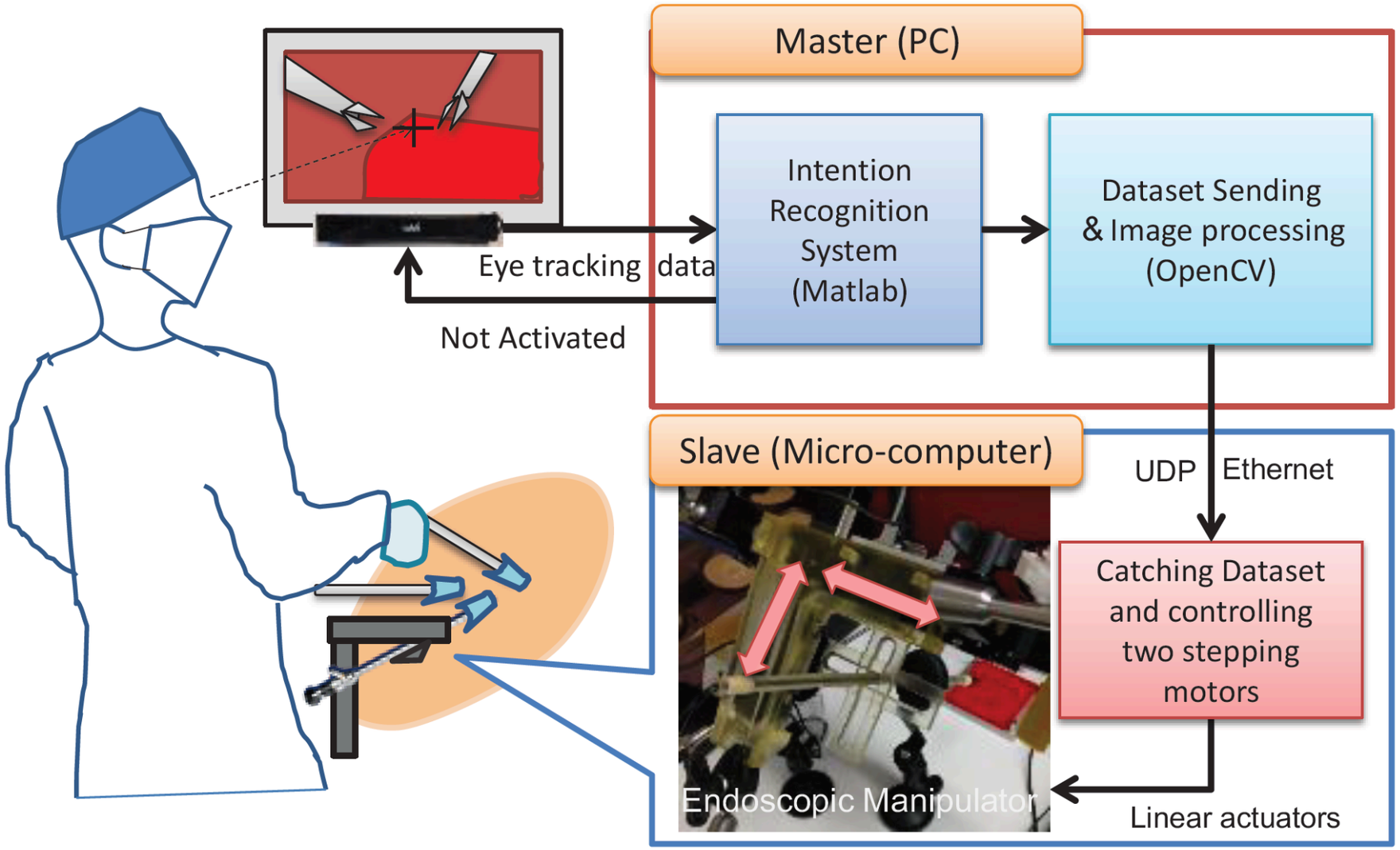
Paper 2: System Overview



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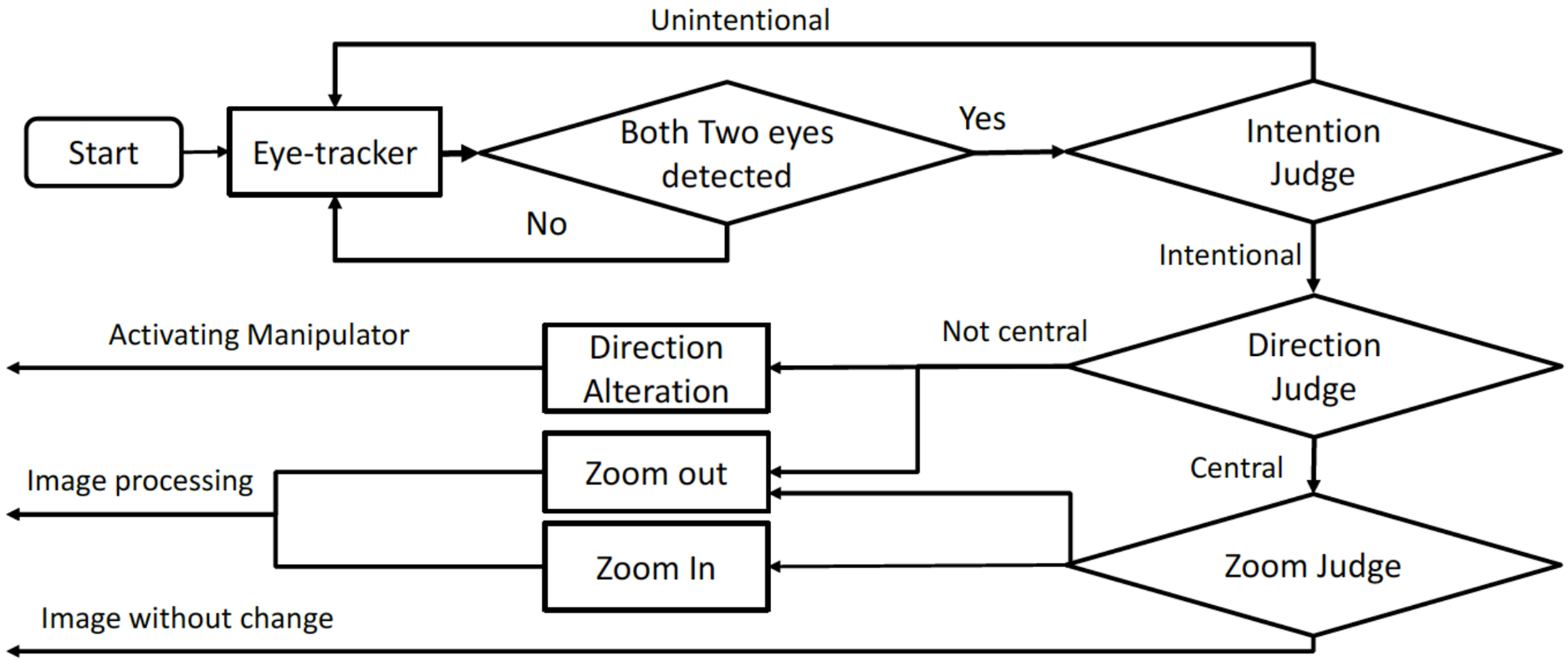
Paper 2: IR Algorithm



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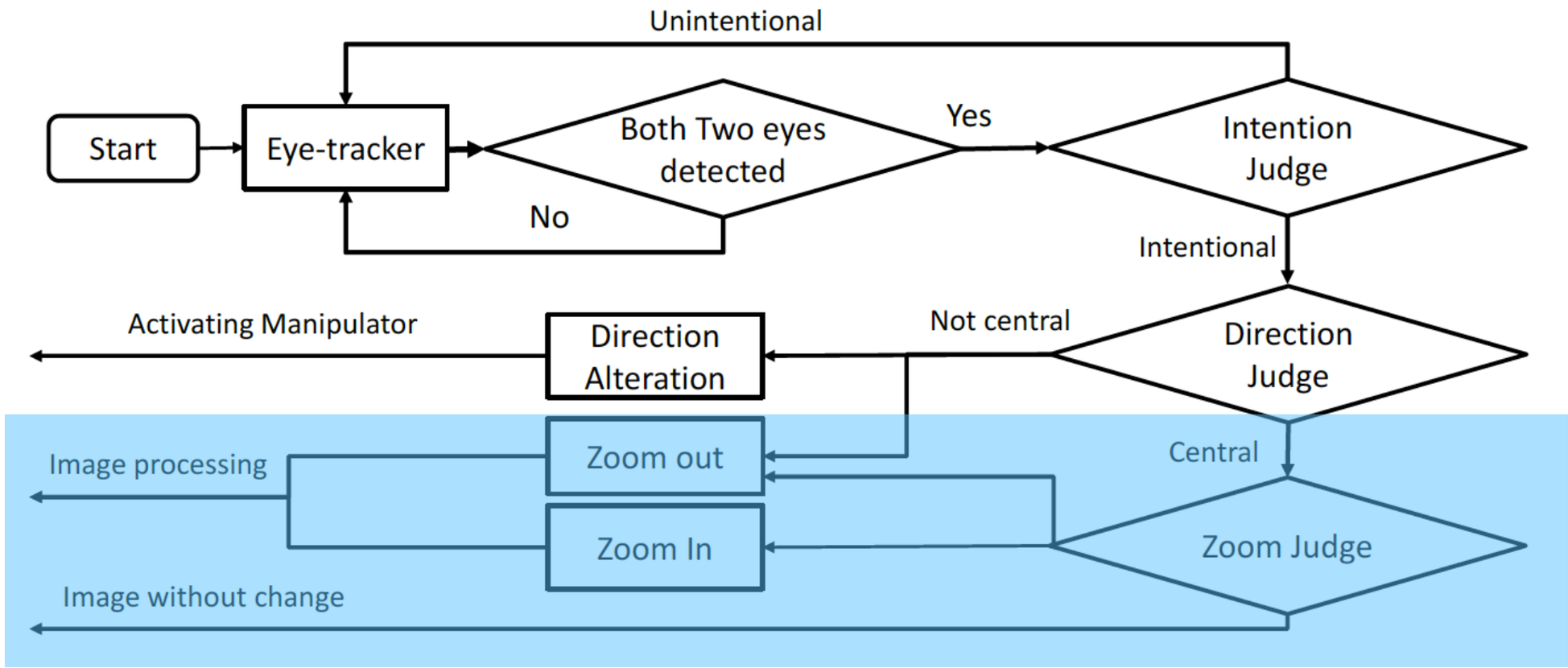

Figure taken from [4]

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Paper 2: Zoom Judge

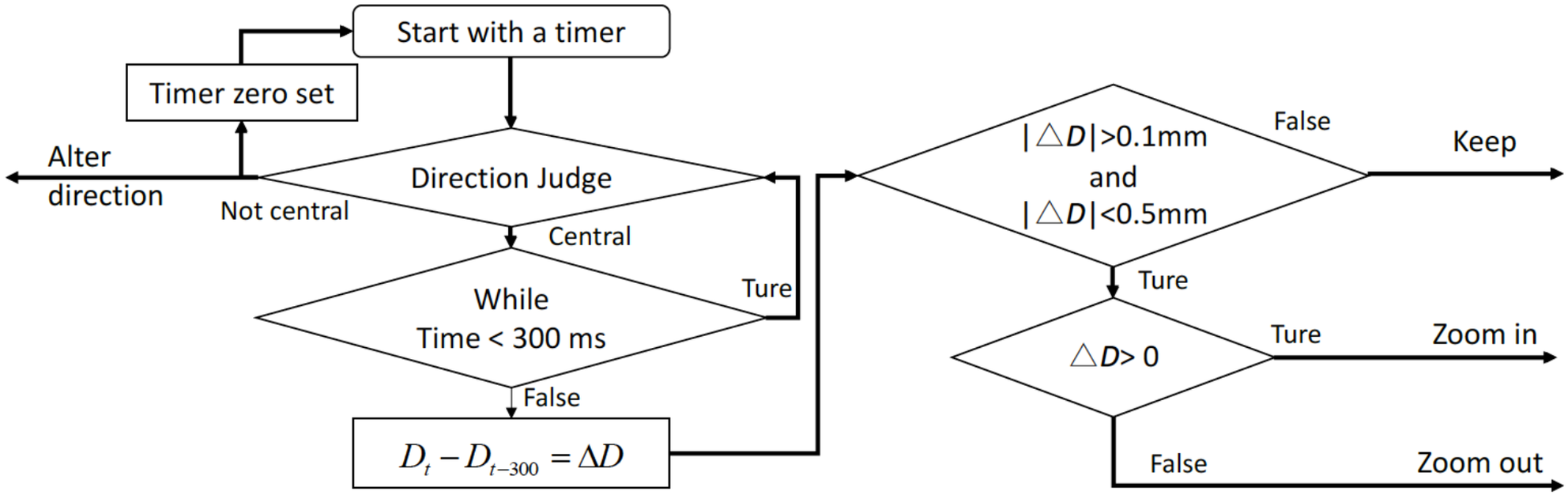

Figure taken from [4]

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Paper 2: Endoscopic Manipulator

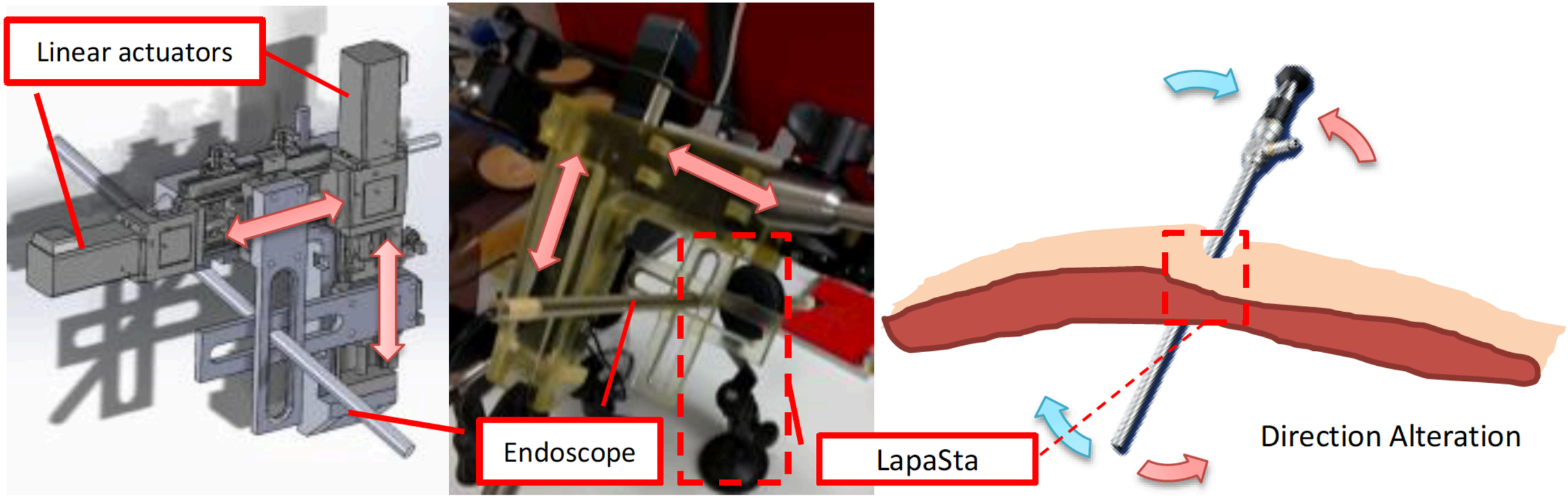

Figure taken from [4]

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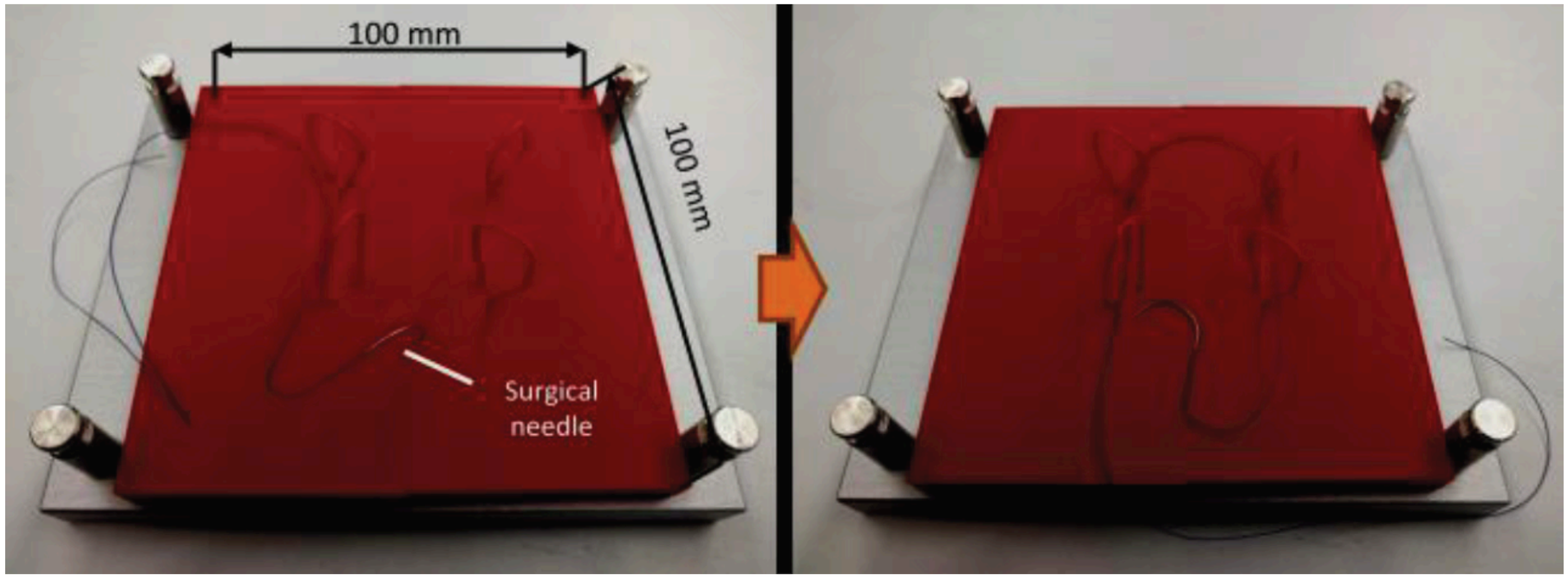
Paper 2: Experiment

- A user study of 9 novice participants
- A pipe cleaner task is performed.
- Control Group: Pedal Mode



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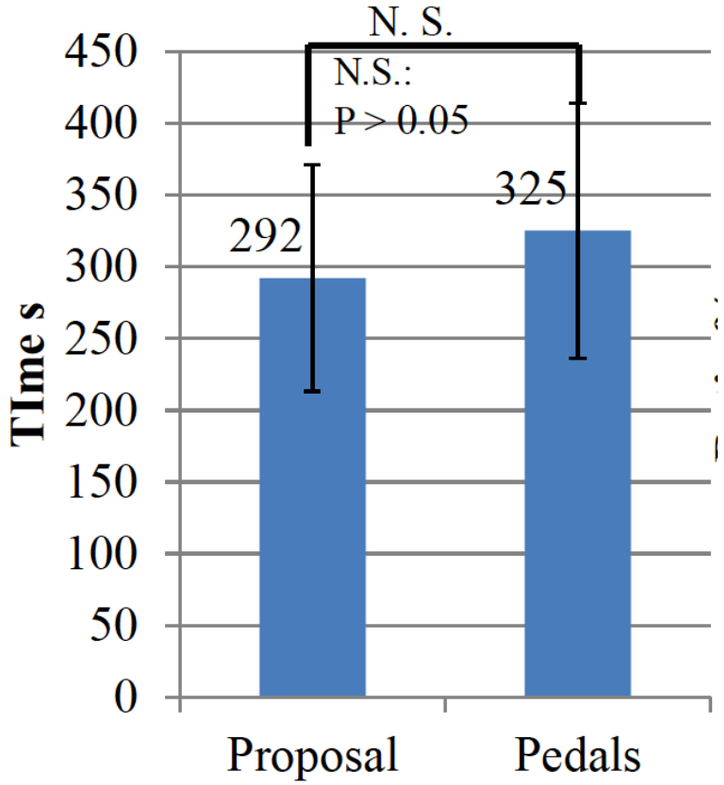
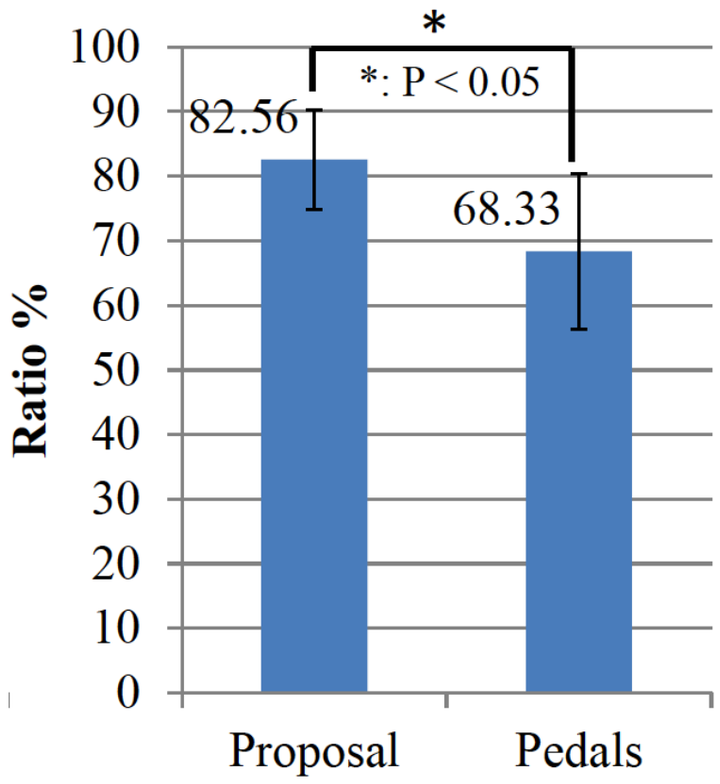
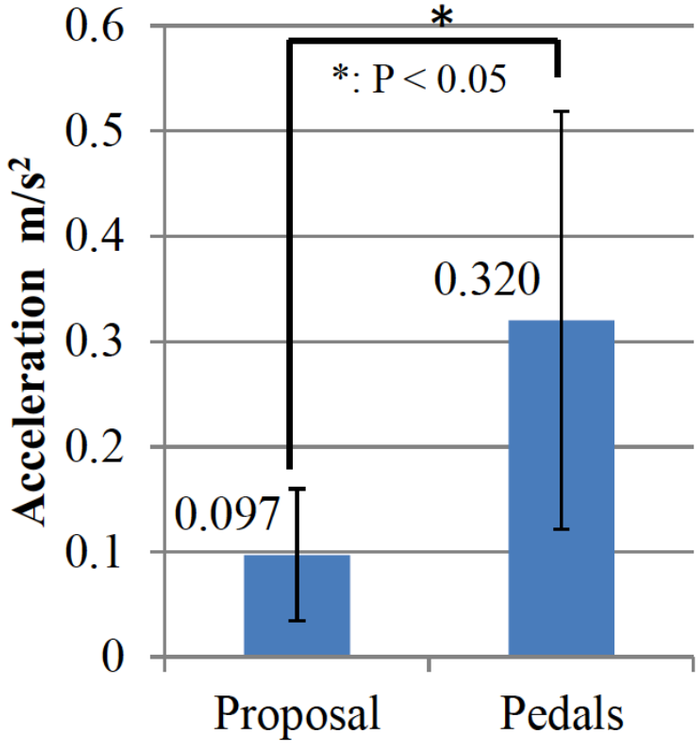
Paper 2: Results



Task Completion Time



Ratio of Gaze on Screen



Head Acceleration

Figure taken from [4]

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Conclusion

- Despite the difference in the types of surgeries, the selected papers provided a fair amount of knowledge of the potential of gaze tracking data.

- The Intention Recognition algorithms provide a systematic pipeline for post-processing gaze tacking data.

- The actual clinical value of proposed control system still needs to be further validated.

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Reference

[1] S. Horgan and D. Vanuno, “Robots in laparoscopic surgery,” J. Laparoendosc. Adv. Surg. Techn. A, vol. 11, pp. 415–419, 2001.

[2] M. Hashizume, Fundamental Training for Safe Endoscopic Surgery. Fukuoka, Japan: Innovative Medical Technology, Graduate School of Medical Science Kyushu University, 2005, p. 49 (in Japanese).

[3] Cao, Y., Miura, S., Kobayashi, Y., Kawamura, K., Sugano, S., & Fujie, M. G. (2016, January). Pupil variation applied to the eye tracking control of an endoscopic manipulator. IEEE Robotics and Automation Letters, 1(1), 531-538.

[4] Cao, Y., Kobayashi, Y., Miura, S., Kawamura, K., Fujie, M. G., & Sugano, S. (2016, December). Pupil variation for use in zoom control. In Robotics

[5] M. Hashizume, Fundamental Training for Safe Endoscopic Surgery, Innovative Medical Technology, Graduate School of Medical Science Kyushu University, pp. 49, 2005 (in Japanese).

[6] K. Jihad, H. George, G. Raj, D. Mihir, A. Monish, R. Raymond, M. Courtenay and G. Inderbir, “Single-Port Laparoscopic Surgery in Urology: Initial Experience,” Urol, pp. 3-6, 2008.

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Q&A

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