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Prototype of a Microsurgical Tool Tracker

Team 5
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600.466 Advanced Computer-Integrated Surgery

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Outline

Background
- Project Summary
- Specific Aims

Paper Choice

Technical Summary
- Experiments
- Result

Conclusion and Future Work

Critique

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Project Summary

- Problem: A need for tool tracker in eye surgery
  - Assess surgical performance
  - Ensure proper protocol

- Project Goal: Micro-Surgical Tool Tracker
  - Build a prototype of a goggle
  - Provide positional feedback

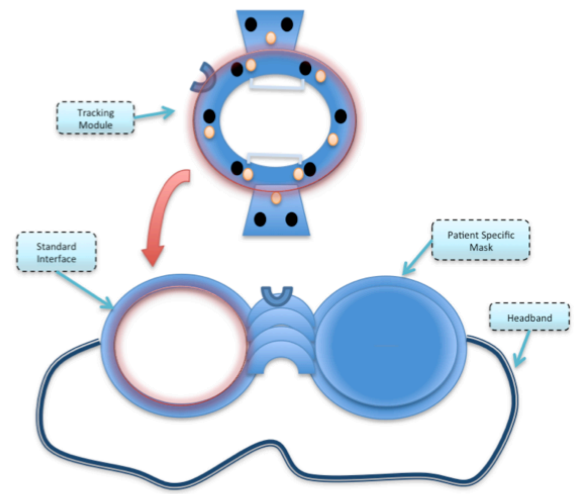

Figure 1. Idea proposed by Marcin Balicki

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Aims & Significance

Specific Aims
Create a miniature tracking system for the eye
Track surgical instruments in real time
Utilize redundancy to reduce line-of-sight problems
Utilize fiducial markers on tools for identification
Evaluate tracking accuracy

Significance/Future Directions
Monitor surgical protocols
Surgical skill assessment
Improve surgical safety
Robot-assisted surgery
Adaptation to other micro surgeries

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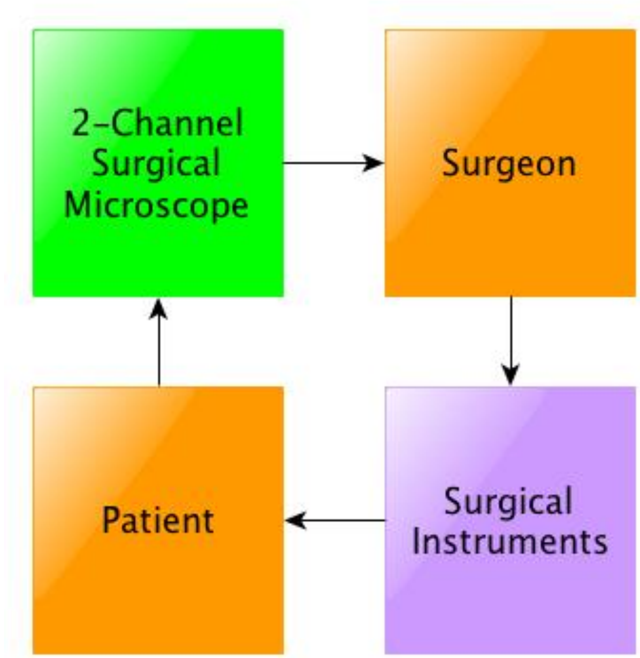
Paper Choice

- **Title: Evaluation of the motion of surgical instruments during intraocular surgery**
- Authors: J-P Hubschman, J Son, B Allen, SD Schwartz, J-L Bourges
- Published: Eye (2011) 25, 947-953. 2011 Marcilian Publishers

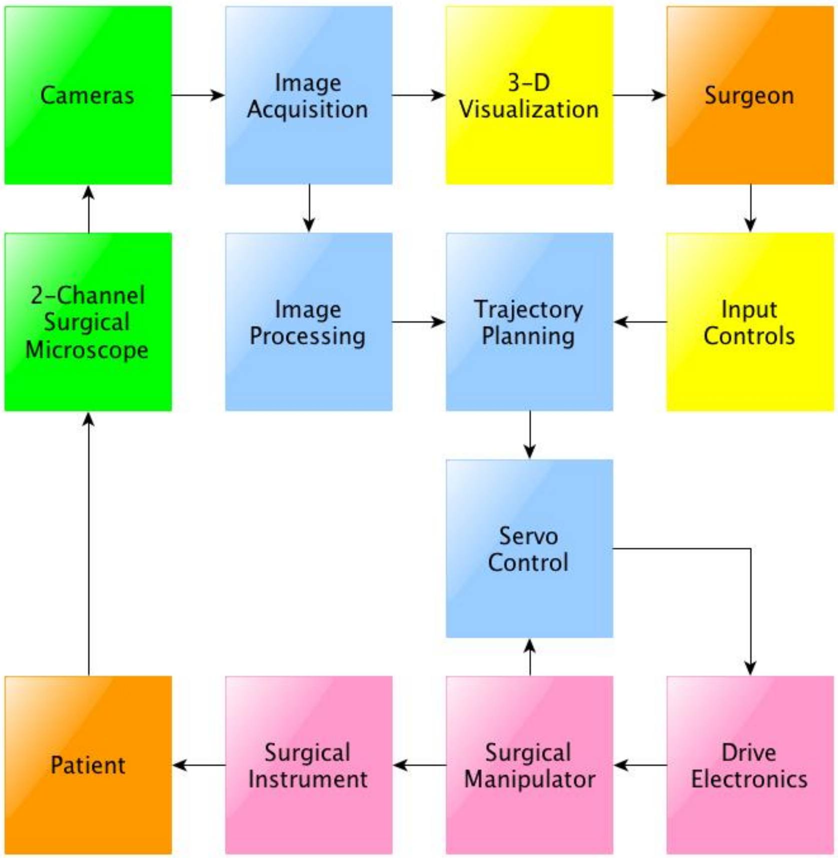
Traditional Ophthalmic Surgery



Based on schematics from [Pitcher et al]

Disadvantages
Not very precise, accurate, or stable
Hand tremor
Narrow field of view
Poor decision making/judgment
Poor interpretation of qualitative data
Lack of information for OR staff

Robot-Assisted Surgery



Based on schematics from [Pitcher et al]

Advantages
Precision, accuracy, stability
Amplified scale of motion
Reduced tremor
Automation
Association of imaging systems
Teleoperation

Technical Summary: Intent

- Purpose: To analyze the motion of microsurgical tools and fulcrum during intraocular surgery.
- Why: To determine the optimum remote center of motion for developing robotic surgical platform

Technical Summary:

- Electromagnetic Sensors
  - Used to track motion of five different surgical tools and fulcrum of the eye
  - Small in size
  - Works in a concentrated area.

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Technical Summary:

- Reliability test to assure accuracy of result.
  - Short and long translation in all three axis.
- Result were claimed near perfect.

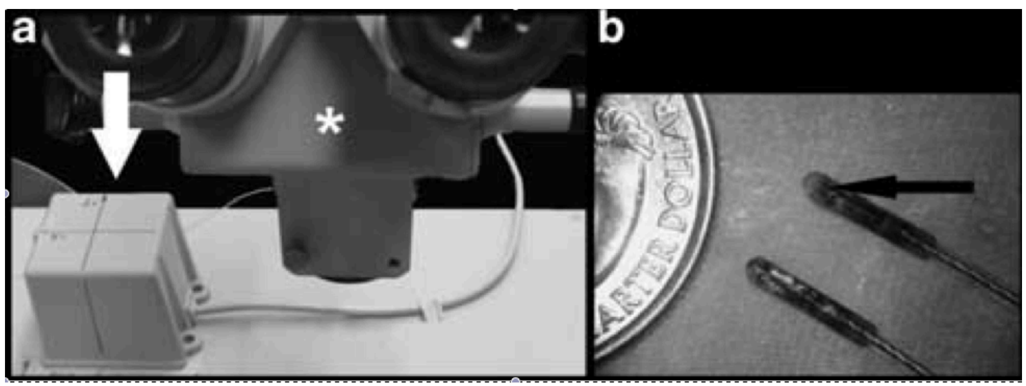

Image from paper

Project Background | Aims & Significance | Paper | Experiment | Result | Conclusion | Relevance | Critiques

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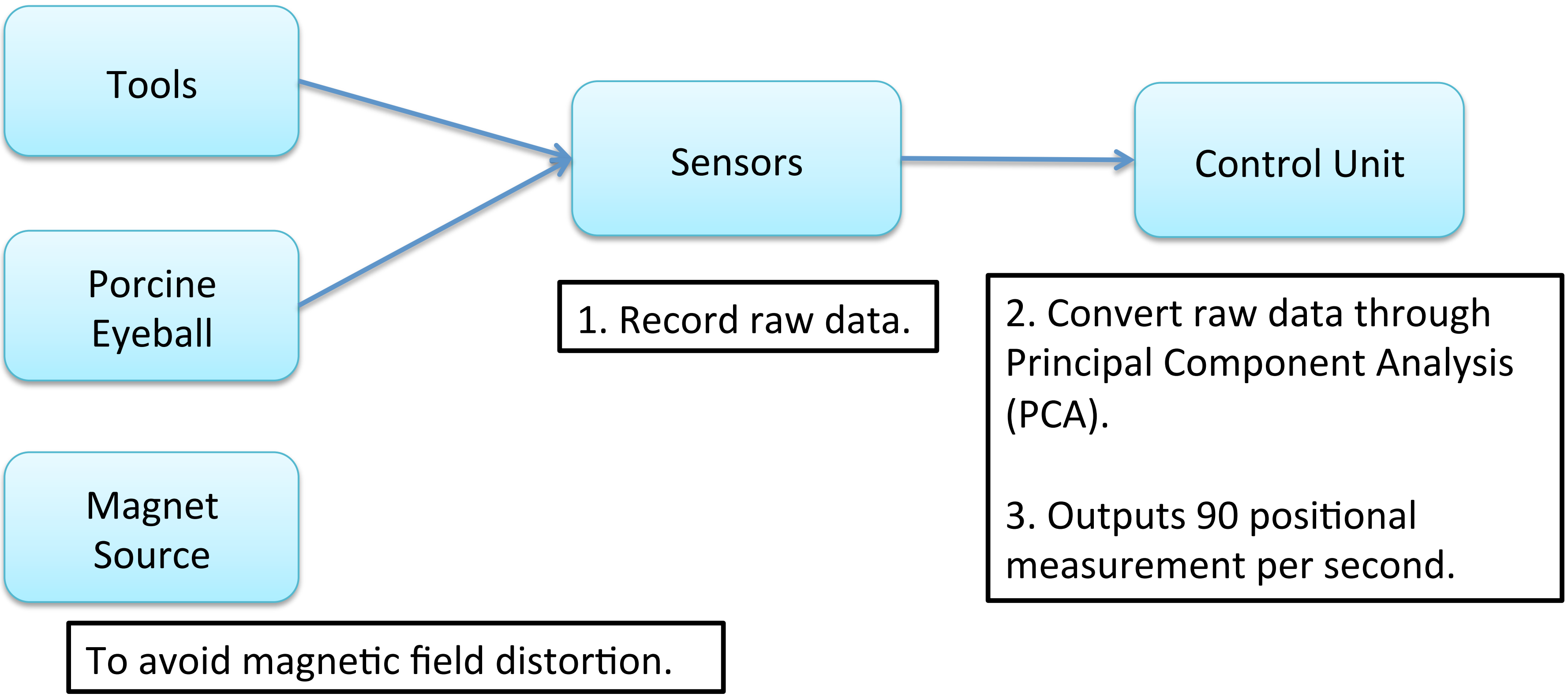
Technical Summary: Set-up



Technical Summary: Experiment

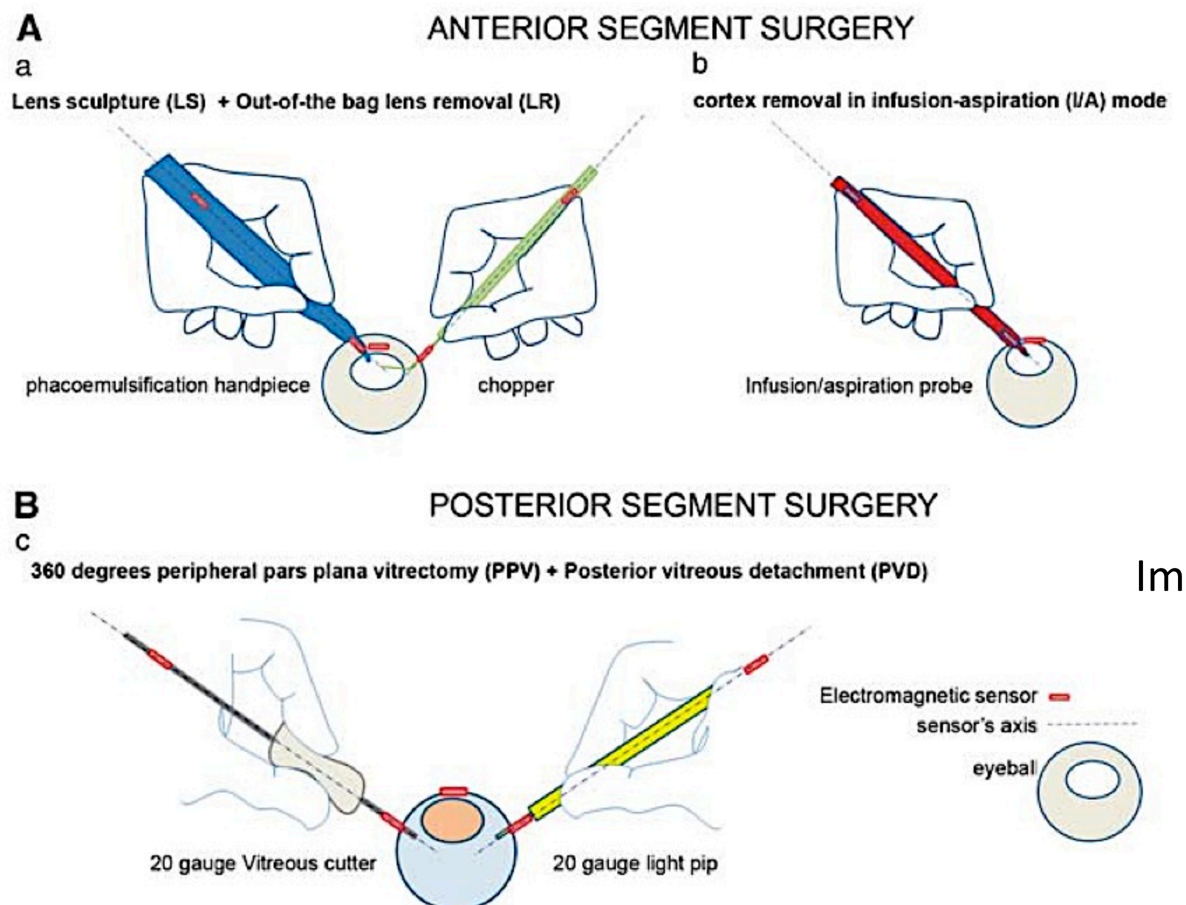


Image from paper

Technical Summary: Result: Motion of Tools

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Table 2 Rotation values in the three axes (*x*, *y*, *z*) and translation values in the *z*-axis surgical of surgical instruments during various steps of intraocular surgery

Surgical step	*Probe*	*x-axis rotation (degrees)*		*y-axis rotation (degrees)*		*z-axis translation (mm)*	
		Avg ± SD	*Min–Max*	*Avg ± SD*	*Min–Max*	*Avg ± SD*	*Min–Max*
LS	Handpiece	56 ± 20	38–98	32 ± 7	18–38	9 ± 2	7–12
LS	Chopper	23 ± 11	10–43	46 ± 14	35–74	16 ± 13	7–43
LR	Handpiece	60 ± 24	30–92	33 ± 7	23–46	20 ± 16	8–53
LR	Chopper	21 ± 19	6–59	31 ± 29	7–90	10 ± 9	2–30
I/A	Probe	72 ± 14	52–97	48 ± 10	29–61	15 ± 5	7–21
PPV	Cutter	96 ± 44	47–180	142 ± 39	84–180	30 ± 5	23–39
PPV	Light	38 ± 8	23–48	64 ± 10	49–77	19 ± 4	12–23
PVD	Cutter	81 ± 26	40–115	147 ± 48	61–180	24 ± 6	13–29
PVD	Light	23 ± 5	14–28	25 ± 6	14–31	11 ± 4	8–16

Abbreviations: Avg, average; I/A, infusion-aspiration; LR, lens removal; LS, lens sculpture; PPV, peripheral posterior vitrectomy; PVD, posterior vitreous detachment; SD, standard deviation.

Table from paper

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Technical Summary: Result: Motion of Eye

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Table 3 Calculated mean and maximal area of motion at the fulcrum (eye's entry site) during each task

Axis	*LS*		*LR*		*IA*		*PPV*		*PVD*	
	Avg ± SD	*Max*	*Avg ± SD*	*Max*	*Avg ± SD*	*Max*	*Avg ± SD*	*Max*	*Avg ± SD*	*Max*
X (mm^2)	6.27 ± 2.33	9.79	5.56 ± 2.22	9.22	12.15 ± 4.3	12.58	6.57 ± 3.66	11.85	6.14 ± 3.03	11.09
Y (mm^2)	3.56 ± 1.74	6.30	3.68 ± 1.46	5.88	6.93 ± 2.18	8.87	5.85 ± 2.84	7.84	3.29 ± 1.13	6.03
Z (mm^2)	1.74 ± 0.55	2.50	1.46 ± 0.31	1.97	2.18 ± 1.10	4.12	2.84 ± 1.63	4.13	1.13 ± 0.61	1.99

Abbreviations: Avg, average; I/A, infusion-aspiration; LR, lens removal; LS, lens sculpture; Max, maximal value; PPV, peripheral posterior vitrectomy; PVD, posterior vitreous detachment; SD, standard deviation.

Table from paper

Technical Summary: Conclusion

Optimum robotic surgical assistance should allow maximum range of motion for each instrument and surgical task.

Dependencies for Angle of Rotation &Translation
Microsurgical tool
Specific task Main task > Ancillary Task
Performing hand Dominant hand > Secondary hand

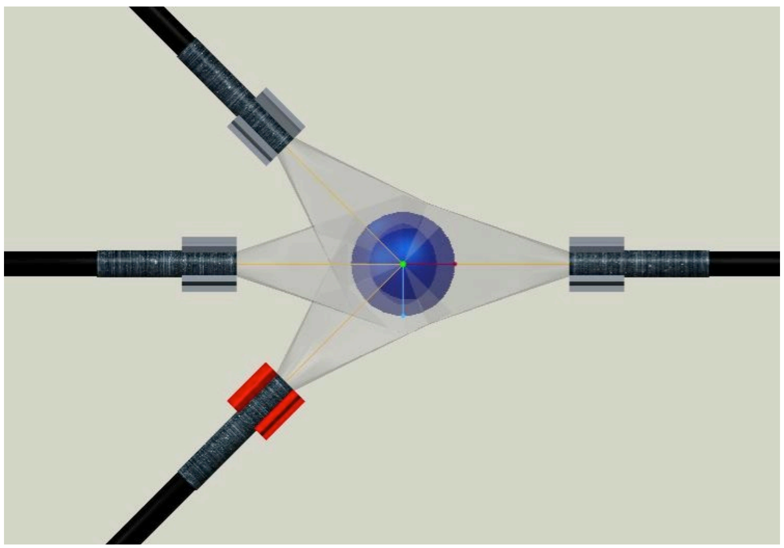
Future Work

- More motion analysis with different intraocular procedures.
- Comparison with motion analysis done with different sensors (optical, inertia, etc.)

Relevance

CIS Project Goal:

To build a device with sensors that output positional feedback of microsurgical tool during eye surgery.



Constraints for Design
Size of the camera
Field of view of the camera
Processing ability of the camera
Motion of the surgeon's hands
Available area around the patient's eye

Relevance

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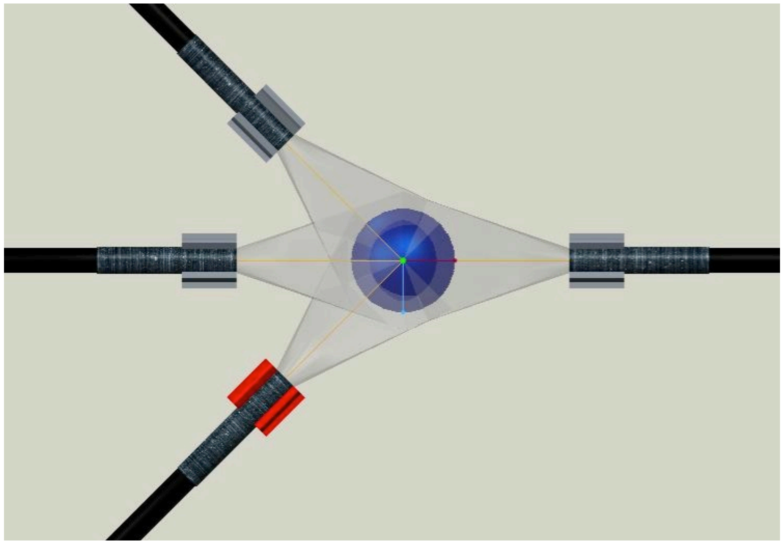

Constraints for Design
Size of the camera
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Available area around the patient's eye

Critique

Strength

- Clear purpose of the paper
- High accuracy of the study
- Repeatable method and set-up of the study
- Result accounted for varying surgical tasks, tools and performing hand.

Weakness

- Tabulated result difficult to visualize.
- Unhelpful in determining orientation of camera for my prototype.
- Open-ended paper

Questions?

Reference

1. Neily, Mills, et al. "Incorrect Surgical Procedures Within and Outside of the Operating Room." Archives of Surgery 16 Nov. 2009: Vol. 144, No. 11:1028-1034. Web. 12 Feb. 2013
2. J. D. Pitcher, J. T. Wilson, S. D. Schwartz, and J. Hubschman, "Robotic Eye Surgery: Past, Present, and Future," J Comput Sci Syst Biol, pp. 14, 2012.