Prototype of a Microsurgical Tool Tracker

Team 5

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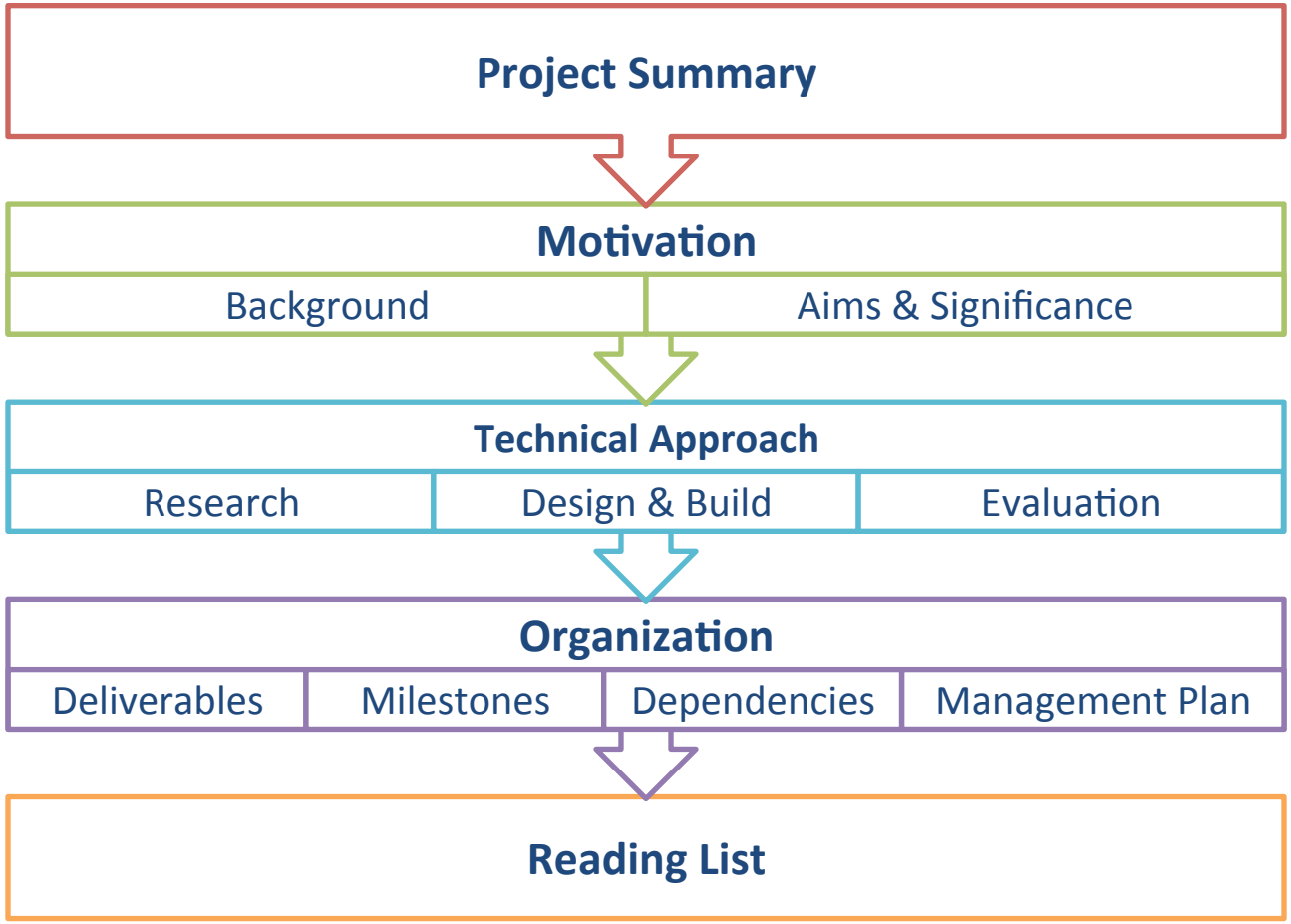

Project Summary

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- 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

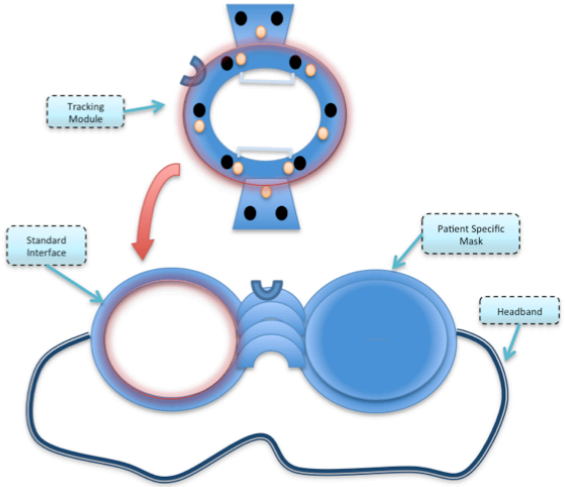

Figure 1. Idea proposed by Marcin Balicki

Background

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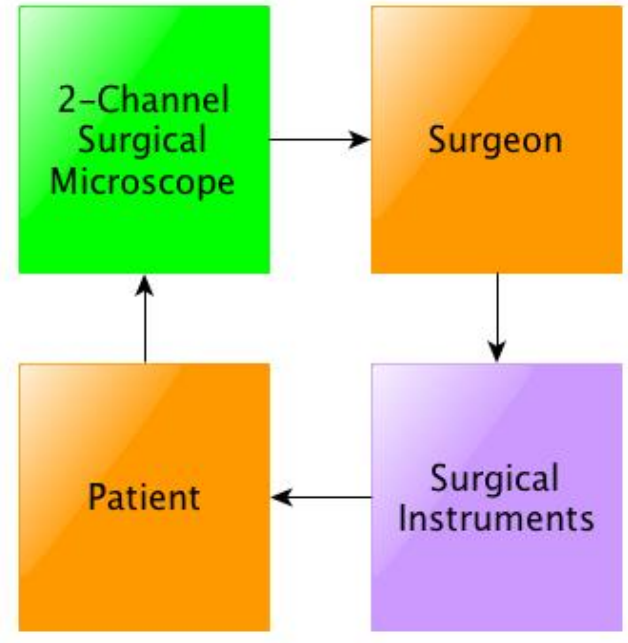
Standard Ophthalmic Surgery



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

Background

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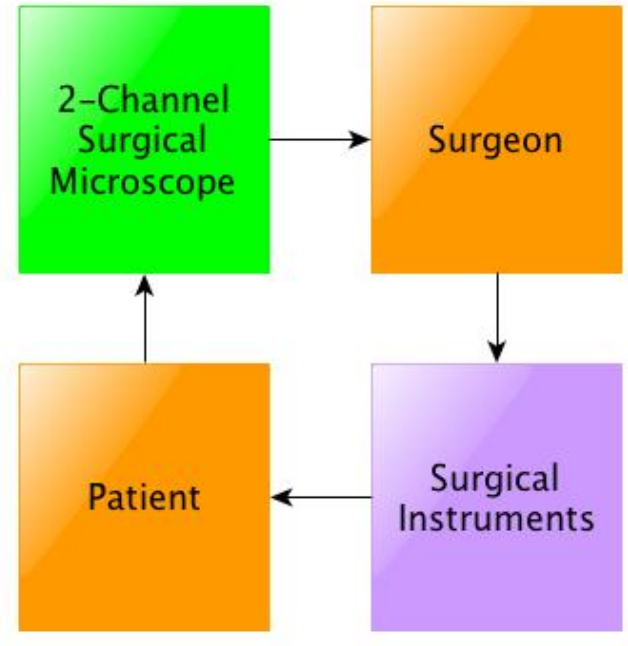
Standard Ophthalmic Surgery



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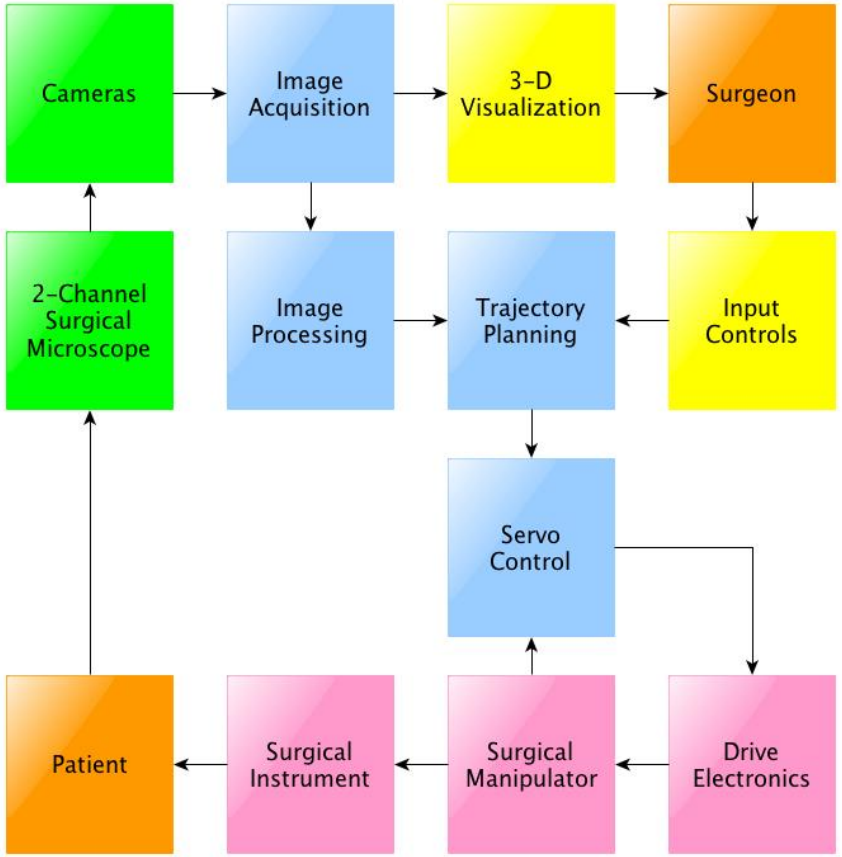
Robot-Assisted Ophthalmic Surgery



Based on schematics from [Pitcher et al]

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

Background

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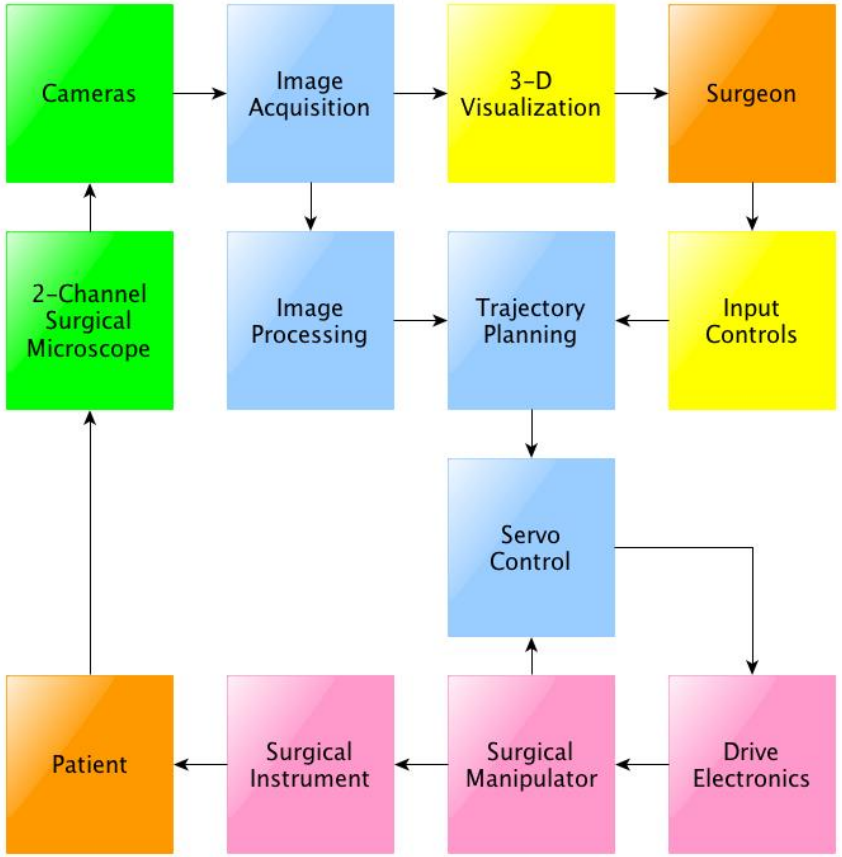
Robot-Assisted Ophthalmic Surgery



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Disadvantages
Poor decision making/judgment
Poor interpretation of qualitative data
Expense and maintenance
Availability
Possibility of malfunction
Patient trust

Background

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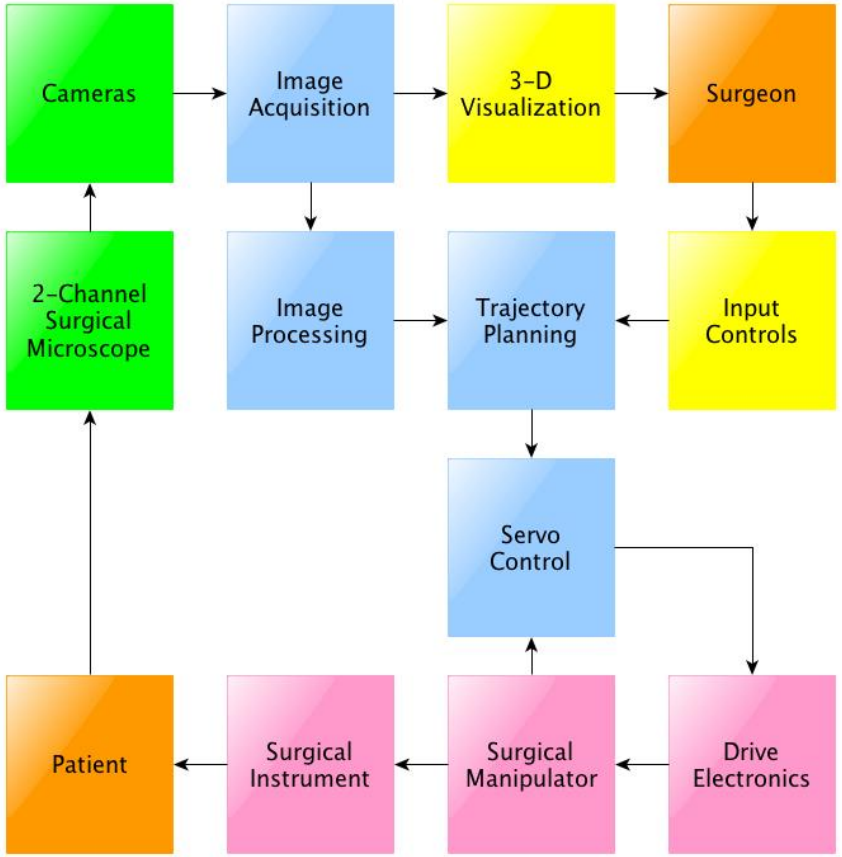
Robot-Assisted Ophthalmic Surgery



Schematics from [Pitcher et al]

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Aims & Significance

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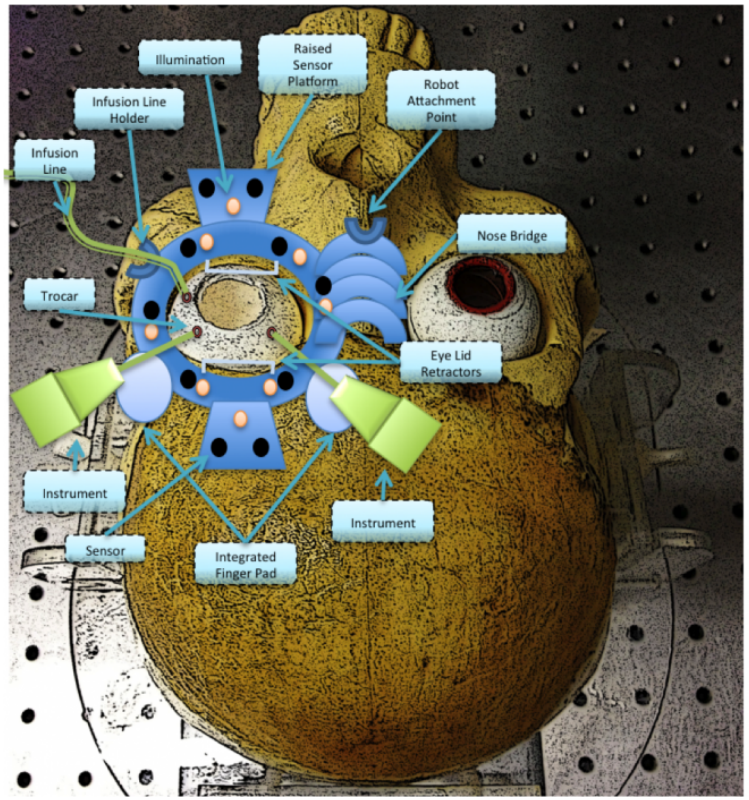

Figure provided by Marcin Balicki

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

Aims & Significance

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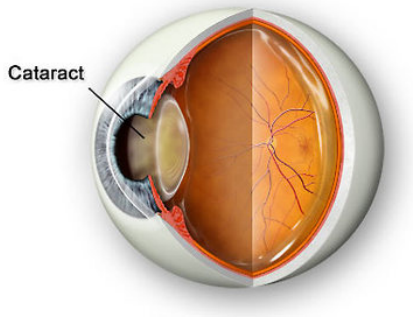
Significance/Future Directions
Monitor surgical protocols
Surgical skill assessment
Improve surgical safety
Robot-assisted surgery
Adaptation to other micro surgeries



Cornea image from [3]

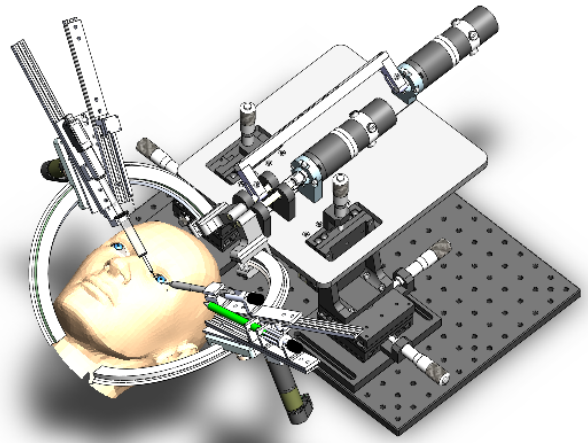


Image of IRISS system from [1]

Phase 1: Research

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Constraints for Camera
Type (IR vs. RGB)
Field of view
Focal length
Cost
Resolution
Placement/Orientation
Scale
Syncing Capabilities
Necessary Equipment

Computer Vision Techniques
Multi-Camera Calibration
Segmentation Methods
Tracking Algorithms
Libraries/Language Support

- Goal: due 3/11
  - Layout of Device & Equipment
  - Tracking System Design

Phase 2: Design & Build

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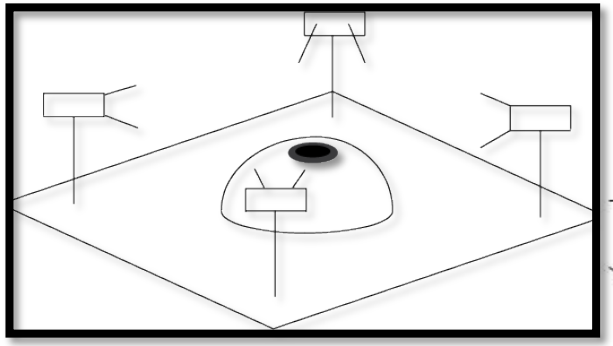
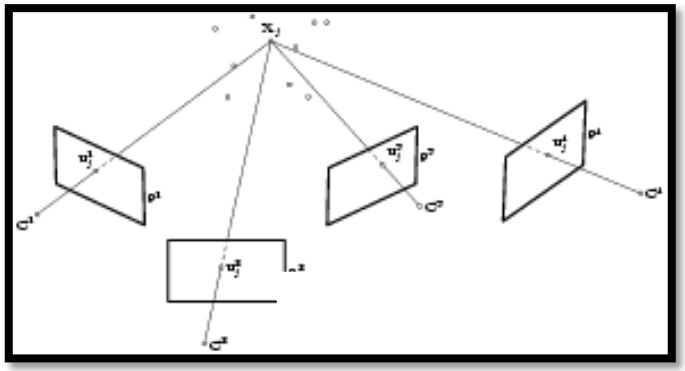


Proposed idea for initial prototype

Eye surgical tool from [2]



Multi-camera setup[4]

- Goal: due 4/26
  - Complete Mask Prototype
  - Tracking System Support

Phase 3: Evaluation

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- Design and run experiments for:
  - A static tool
  - A dynamic tool if system is online
  - Varied occlusion and illumination

- Goal: 5/13
  - Proof of Concept

Deliverables

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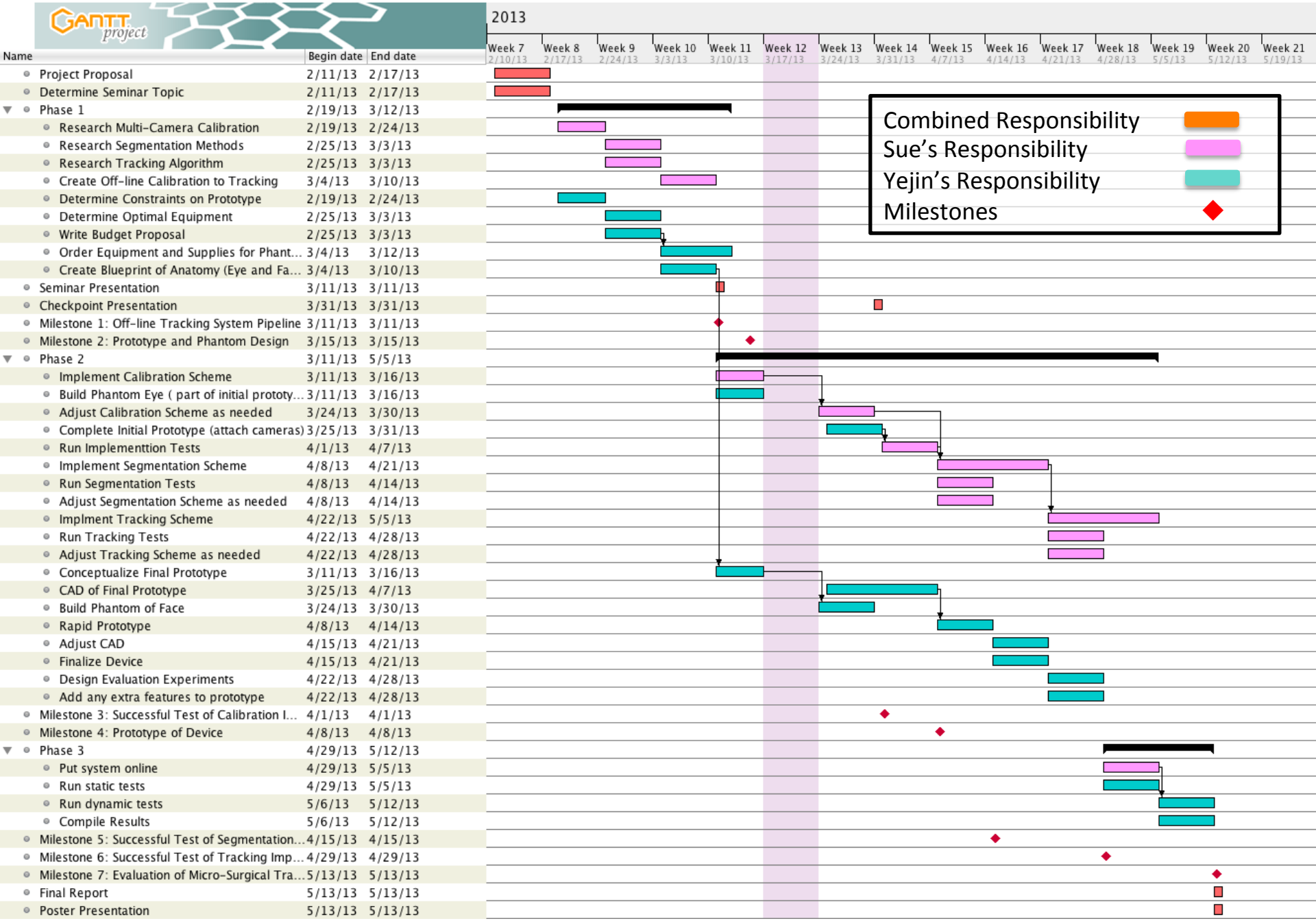
Minimum	Expected	Maximum
CAD design of prototype	A scaled prototype	Life-size prototype
Design of phantom	A scaled phantom	Life-size phantom
Specifications of equipment	Offline multi-camera calibration	Evaluation of tracking accuracy
Calibration scheme	Offline segmentation/ tracking algorithms	Real-time tracking
Segmentation/tracking scheme		



Name	Begin date	End date
Project Proposal	2/11/13	2/17/13
Determine Seminar Topic	2/11/13	2/17/13
Phase 1	2/19/13	3/12/13
Research Multi-Camera Calibration	2/19/13	2/24/13
Research Segmentation Methods	2/25/13	3/3/13
Research Tracking Algorithm	2/25/13	3/3/13
Create Off-line Calibration to Tracking	3/4/13	3/10/13
Determine Constraints on Prototype	2/19/13	2/24/13
Determine Optimal Equipment	2/25/13	3/3/13
Write Budget Proposal	2/25/13	3/3/13
Order Equipment and Supplies for Phant...	3/4/13	3/12/13
Create Blueprint of Anatomy (Eye and Fa...	3/4/13	3/10/13
Seminar Presentation	3/11/13	3/11/13
Checkpoint Presentation	3/31/13	3/31/13
Milestone 1: Off-line Tracking System Pipeline	3/11/13	3/11/13
Milestone 2: Prototype and Phantom Design	3/15/13	3/15/13
Phase 2	3/11/13	5/5/13
Implement Calibration Scheme	3/11/13	3/16/13
Build Phantom Eye (part of initial prototy...	3/11/13	3/16/13
Adjust Calibration Scheme as needed	3/24/13	3/30/13
Complete Initial Prototype (attach cameras)	3/25/13	3/31/13
Run Implementtion Tests	4/1/13	4/7/13
Implement Segmentation Scheme	4/8/13	4/21/13
Run Segmentation Tests	4/8/13	4/14/13
Adjust Segmentation Scheme as needed	4/8/13	4/14/13
Implment Tracking Scheme	4/22/13	5/5/13
Run Tracking Tests	4/22/13	4/28/13
Adjust Tracking Scheme as needed	4/22/13	4/28/13
Conceptualize Final Prototype	3/11/13	3/16/13
CAD of Final Prototype	3/25/13	4/7/13
Build Phantom of Face	3/24/13	3/30/13
Rapid Prototype	4/8/13	4/14/13
Adjust CAD	4/15/13	4/21/13
Finalize Device	4/15/13	4/21/13
Design Evaluation Experiments	4/22/13	4/28/13
Add any extra features to prototype	4/22/13	4/28/13
Milestone 3: Successful Test of Calibration I...	4/1/13	4/1/13
Milestone 4: Prototype of Device	4/8/13	4/8/13
Phase 3	4/29/13	5/12/13
Put system online	4/29/13	5/5/13
Run static tests	4/29/13	5/5/13
Run dynamic tests	5/6/13	5/12/13
Compile Results	5/6/13	5/12/13
Milestone 5: Successful Test of Segmentation...	4/15/13	4/15/13
Milestone 6: Successful Test of Tracking Imp...	4/29/13	4/29/13
Milestone 7: Evaluation of Micro-Surgical Tra...	5/13/13	5/13/13
Final Report	5/13/13	5/13/13
Poster Presentation	5/13/13	5/13/13

Milestones

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Date	Milestones	Responsibility
3/11	Offline Tracking System Design (Sue)	-Calibration Scheme -Segmentation Scheme -Tracking Scheme
3/18	Design of Prototype and Phantom (Yejin)	-Conceptual design of Eye and Face -CAD of the prototype
4/1	Build Phantom (Yejin)	-Build and attach eye to platform -Build and attach skull and nose to platform
4/1	Calibration Implementation (Sue)	-Implement single camera/multi camera calibration -Run test to verify success

Milestones

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Date	Milestones	Responsibility
4/8	Prototype of Device (Yejin)	-Rapid prototype goggle device -Rigidly attach cameras -Attach miscellaneous fixtures
4/15	Test of Segmentation (Sue)	-Implement Segmentation Method -Run test to verify success
4/29	Test of Tracking Implementation (Sue)	-Implement tracking algorithm -Run test to verify success
5/13	Evaluation of Micro-Surgical Tracker (Yejin)	-Static tool coordinate accuracy -Dynamic tool coordinate accuracy -Miscellaneous accuracy

Dependencies

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Dependency	Proposed Solution	Due Date
Ophthalmic Surgery Observation	Schedule through Marcin Balicki Acquire videos online	2/25 3/4
Access to Expertise	Weekly mentor meetings Survey literature	2/14 3/11
CISST Libraries	Training with Balazs Vagvolgyi If not, custom libraries as needed	3/4
Other Off-the-shelf Libraries	Research and plan accordingly Back-up plan: Implement on our own	3/11
Access to Steady Hand Eye Robot	Get initial plan approved Schedule through Marcin Balicki	3/11 4/8
Equipment	Evaluate constraints Purchase off-the-shelf components (OTC)	3/4 3/11
Funding	Propose budget plan to Dr. Taylor	3/4

Management Plan

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- **Yejin**: prototype development and funding
- **Sue**: tracking system, wiki page and communication
- Meet **weekly** with either Marcin Balicki or Balazs Vagvolgyi
- **Bi-weekly** team meetings on Monday and Wednesday
- Approximately **30 hours** per week combined

Reading List

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.
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4. M. Nasseri, E. Dean, S. Nair, and M. Eder, “Clinical Motion Tracking and Motion Analysis during Ophthalmic Surgery using Electromagnetic Tracking System,” in 5th International Conference on BioMedical Engineering and Informatics (BMEI 2012). 2012.
5. G. M. Saleh, G. Voyatzis, Y. Voyazis, J. Hance, J. Ratnasothy, and A. Darzi, “Evaluating surgical dexterity during corneal suturing,” Archives of ophthalmology, vol. 124, no. 9, pp. 12636, Sep. 2006.
6. K. Guerin, G. Vagvolgyi, A. Deguet, C.C.G. Chen, D. Yuh, and R. Kumar, “ReachIN: A Modular Vision Based Interface for Teleoperation,” in the MIDAS Journal - Computer Assisted Intervention, Aug. 2010.
7. Tomas Svoboda. A Software for Complete Calibration of MultiCamera Systems. Talk given at MIT CSAIL. Jan 25, 2005.
8. K. Zimmermann, J. Matas, and T. Svoboda. “Tracking by an Optimal Sequence of Linear Predictors.” IEEE Transactions on Pattern Analysis and Machine Intelligence. 31(4), 2009
9. A. Borkar, M. Hayes, and M. T. Smith, “A Non Overlapping Camera Network: Cali- bration and Application Towards Lane Departure Warning” IPCV 2011: Proceedings of the 15th International Conference on Image Processing, Computer Vision, and Pattern Recognition. 2011.

Questions?

References

[1] http://maclab.seas.ucla.edu/iriss.shtml

[2] http://www.dvice.com/archives/2012/10/new-surgical-to.php

[3] http://www.sharpervisionks.com/Cataracts/

[4] http://cmp.felk.cvut.cz/~svoboda/SelfCal/