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Prototype of a Microsurgical Tool Tracker

Team 5

Students: Sue Kulason, Yejin Kim

Mentors: Marcin Balicki, Balazs Vagvolgyi, Russell Taylor

600.466 Advanced Computer-Integrated Surgery

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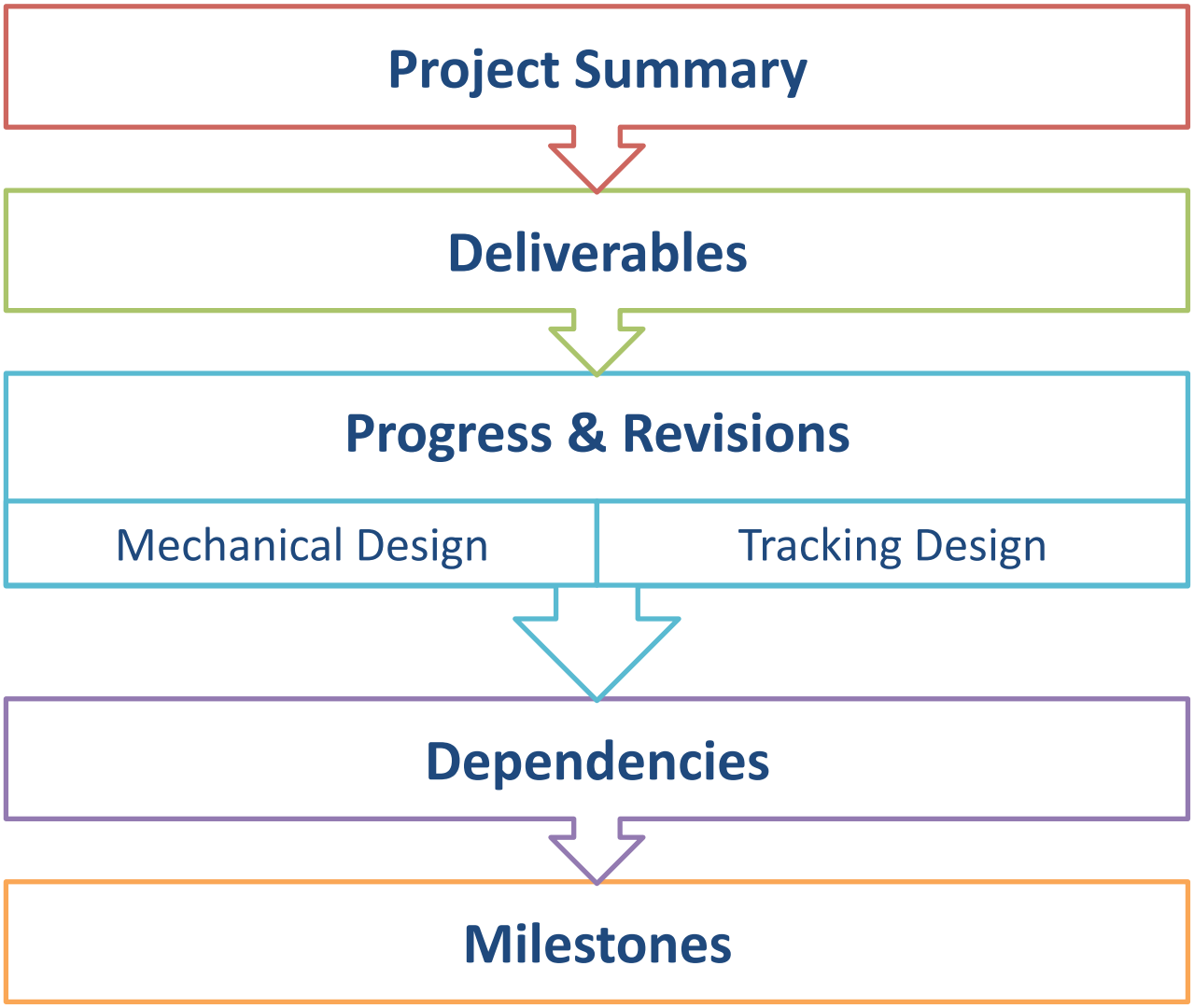
Outline



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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

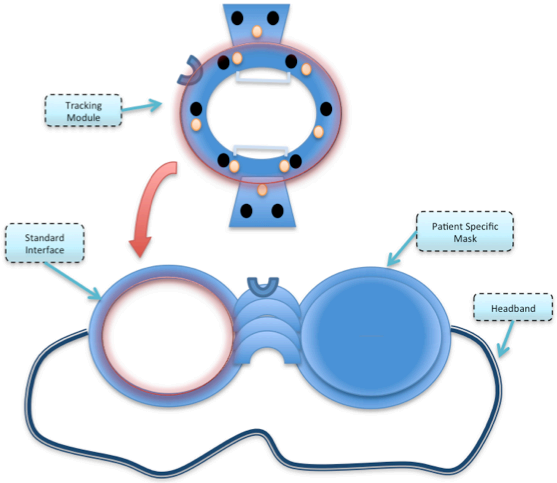

Figure 1. Idea proposed by Marcin Balicki

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Deliverables

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Minimum (3/18)	Expected (4/26)	Maximum (5/13)
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		

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Deliverables

Minimum ~~(3/18)~~ (4/18)		Expected ~~(4/26)~~ (5/3)		Maximum (5/13)	
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 detection/tracking algorithms		Real-time tracking	
Detection/tracking scheme	✔				

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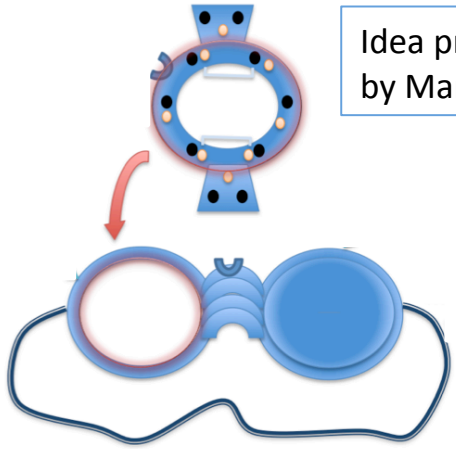
Progress: Mechanical Design

Plan from previous checkpoint:

- Create a mock up
- Determine optimized life-size design
- Build CAD design scaled 1.5x



Idea proposed by Marcin Balicki

Revision in prototype design goal:

- Design to avoid surgeon's motion
- Design to cover entire eye environment
- Scaled up to complement field of view of the camera
- Goggled shape is not necessarily implemented

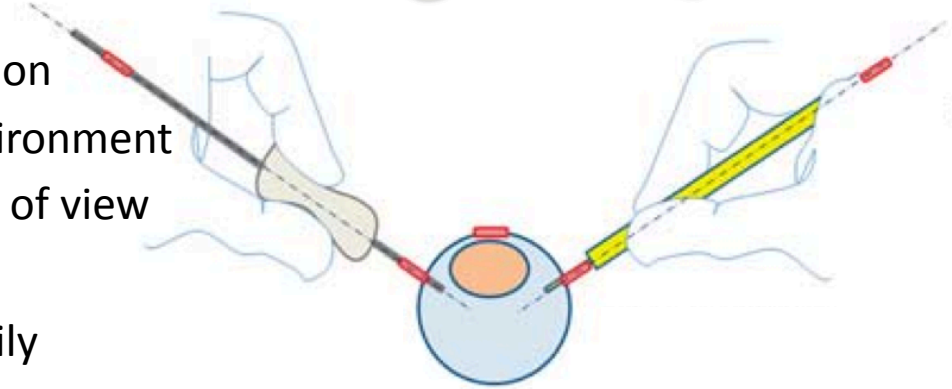


Figure from Hubschman et al

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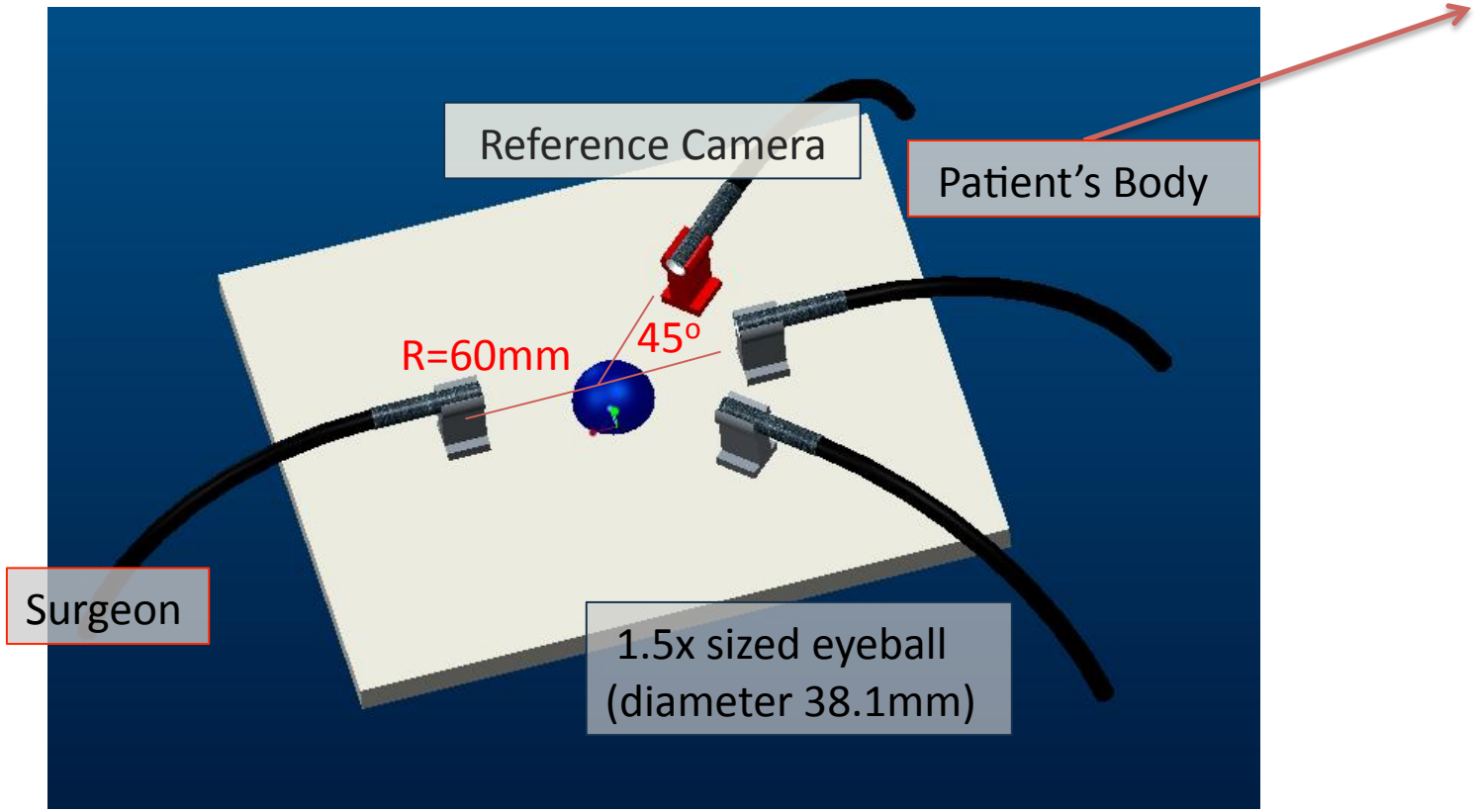
Mechanical Design

Previous computer-aided-design:



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Mechanical Design

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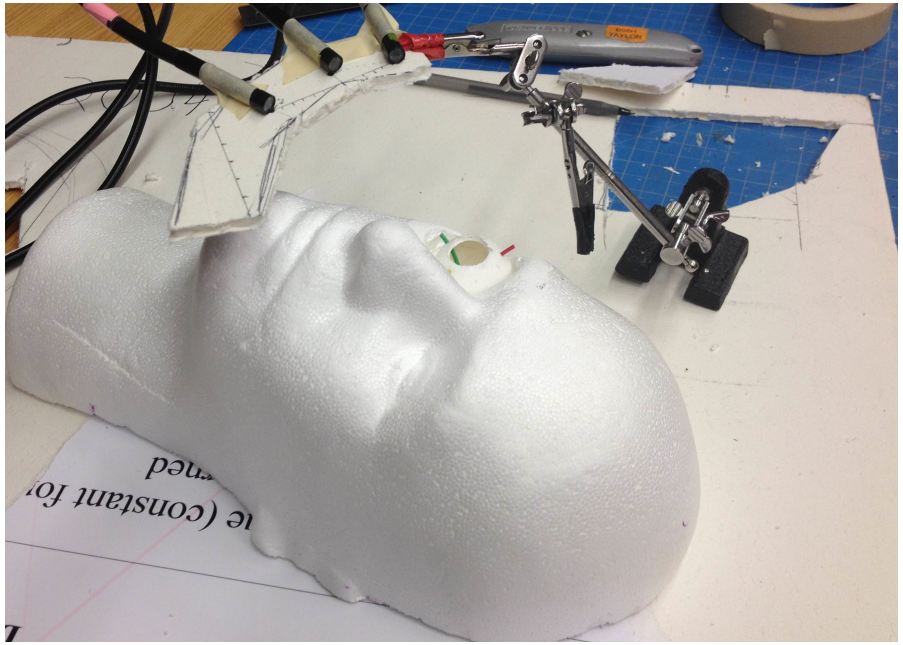
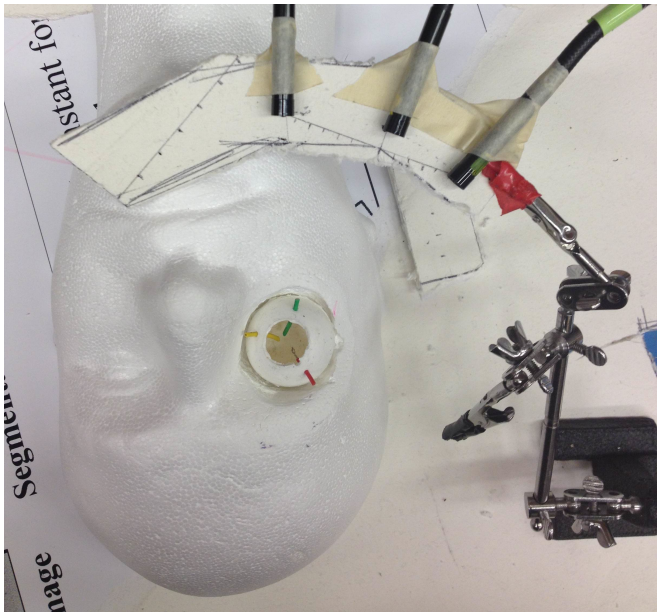
Progress:

1. Built a life-size phantom
2. Built a mock-up



Change:

1. Life-size eye phantom
2. Height and angle for each cameras
3. Angle between cameras



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Mechanical Design

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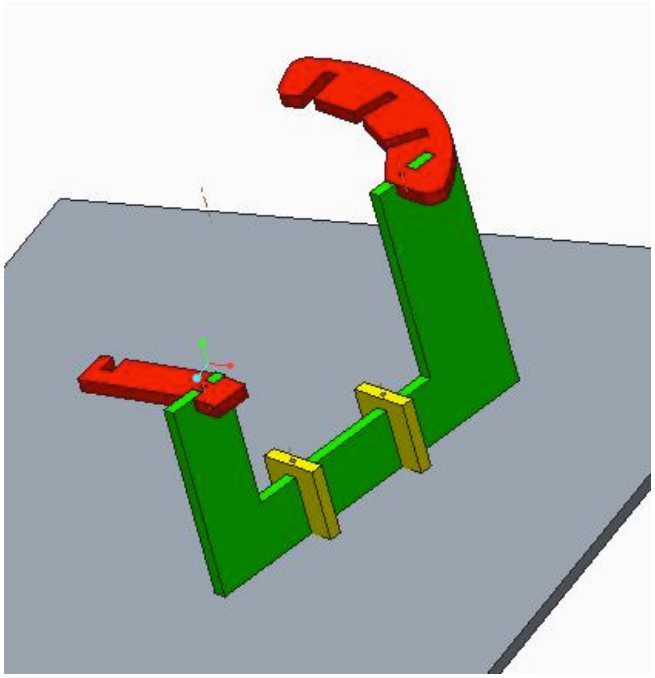
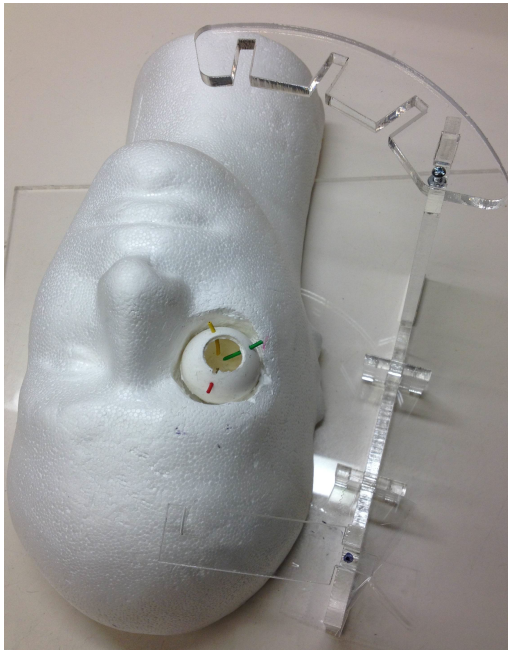
Progress:

3. Designed CAD platform
4. Built first platform



Next Step (4/29):

1. Make CAD modifications
2. Build rigid prototype
3. Install cameras



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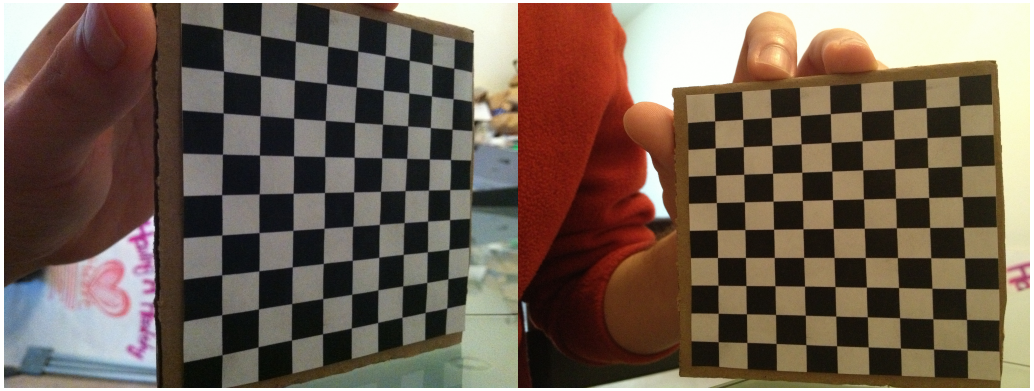
Progress: Tracking Design

Step 1: Calibration

Sources of Error:
- Warped Checkerboard
- Limited Field of View
- Placement Error



Next Steps: **5/1**
- Re-print Checkerboard
- Calibrate Device

	Error (45°)	**Error (135°)**
Translation	1.0 mm	2.2 mm
Rotation (Y)	0.2°	1.2°

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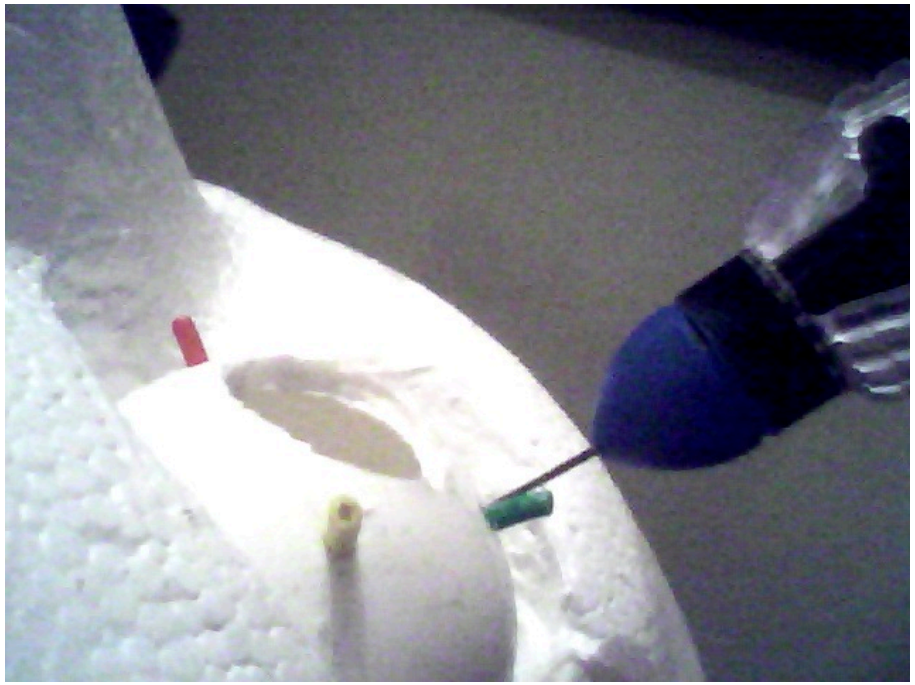
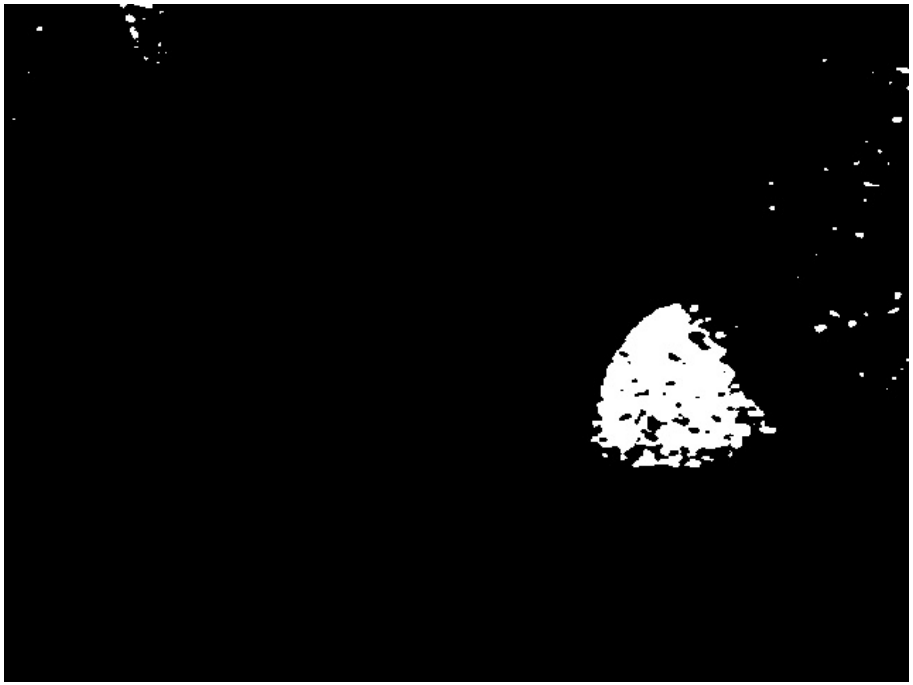
Progress: Tracking Design

Step 2: Detection





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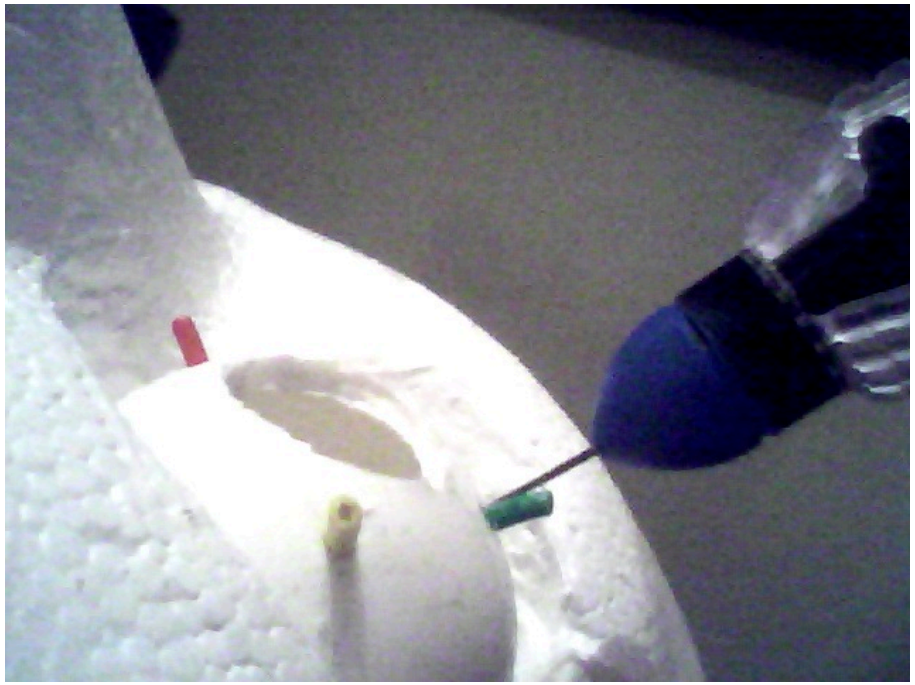
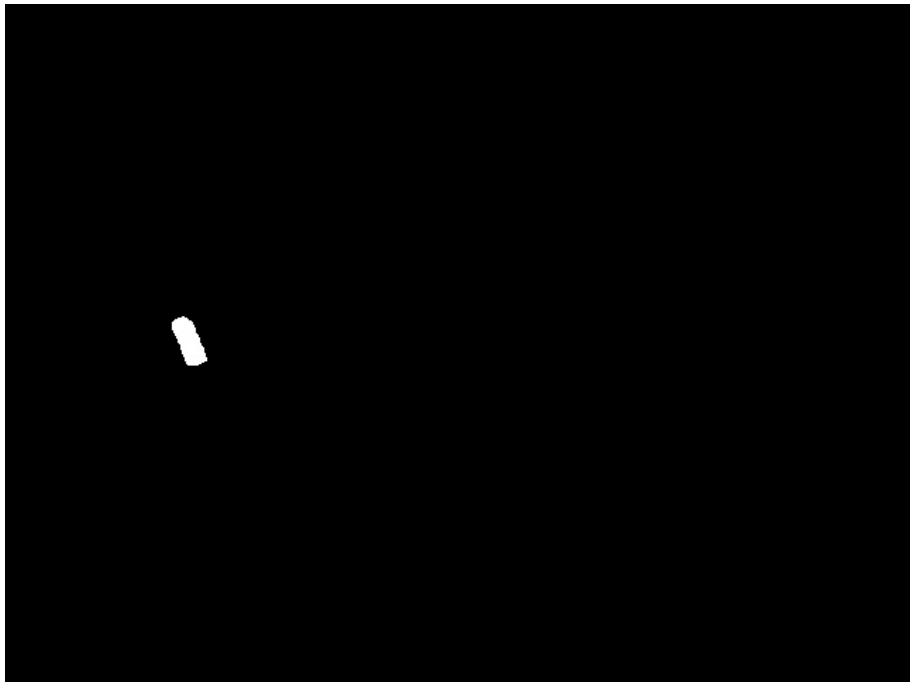
Progress: Tracking Design

Step 2: Detection





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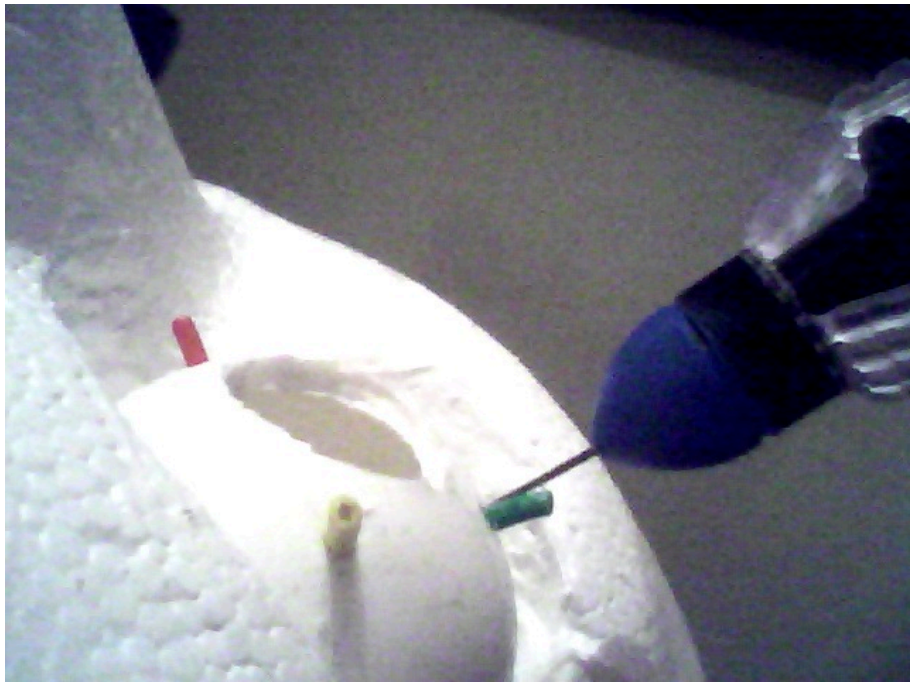
Progress: Tracking Design

Step 2: Detection



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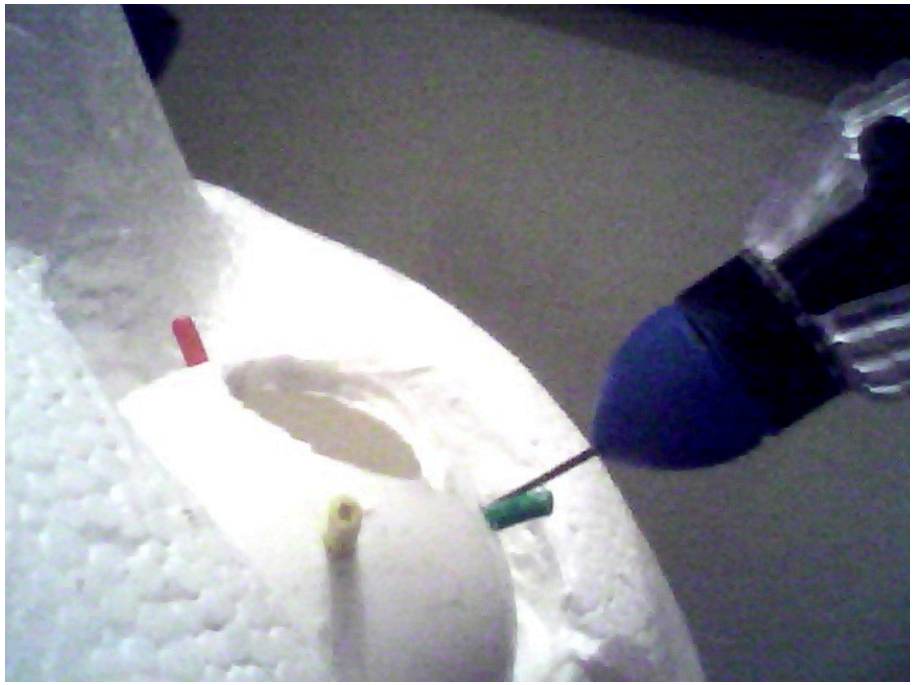
Progress: Tracking Design

Step 2: Detection



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Progress: Tracking Design

Step 2: Detection

Sources of Delay:

- Lack of final device due to broken laser cutter
- Lack of laptop with software due to hardware damage

Next Steps: **5/3**

- Prepare desktop with software ✔
- Modify code for real-time detection ✔
- Test segmentation with final device

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Progress: Tracking Design

Step 3: Tracking

Sources of Delay:

- Lack of final device due to broken laser cutter
- Lack of laptop with software due to hardware damage

Next Steps: **5/5**

- Finish implementation
- Run test on final device

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Dependencies

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 **OpenCV**	Research and plan accordingly Back-up plan: Implement on our own	~~3/11~~ ✔ **4/8**
Access to Steady Hand Eye Robot	Get initial plan approved Schedule through Marcin Balicki	3/11 ✔ ~~4/8~~ **4/21** ✖
Equipment	Evaluate constraints Purchase off-the-shelf components (OTC)	3/4 ✔ 3/11 ✔
Funding	Propose budget plan to Dr. Taylor	3/4 ✔

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~~CISST Libraries~~	~~Training with Balazs Vagvolgyi~~ ~~If not, custom libraries as needed~~	~~3/4~~
Other Off-the-shelf Libraries **OpenCV**	Research and plan accordingly Back-up plan: Implement on our own	~~3/11~~ ✔ **4/8**
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Equipment	Evaluate constraints Purchase off-the-shelf components (OTC)	3/4 ✔ 3/11 ✔
Funding	Propose budget plan to Dr. Taylor	3/4 ✔

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Dependencies

New Dependency	Proposed Solution	Due Date	
Parallel Camera Function	Determine cause and plan accordingly	~~4/1~~ 4/22	✔
Laser Cutter Machine	If not fixed, order from a company	4/27	✔
CV Software	Installed on desktop in Robotorium Hall	4/22	✔

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Milestones

Date	Milestones	Responsibility	Status
3/11	Offline Tracking System Design (Sue)	-Calibration Scheme -Segmentation Scheme -Tracking Scheme	Done
~~3/18~~ **4/15**	Design of Prototype and Phantom(Yejin)	-Conceptual design of Eye and Face -CAD of the prototype	Done
~~4/1~~ **4/8**	Build Phantom (Yejin)	-Build and attach eye to platform -Build and attach skull and nose to platform	Done
~~4/1~~ **4/8**	Calibration Implementation (Sue)	-Implement single camera/multi camera calibration -Run test to verify success	Done

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Milestones

Date	Milestones	Responsibility	Status
~~4/8~~ **4/29**	Prototype of Device (Yejin)	-Rapid prototype goggle device -Rigidly attach cameras -Attach miscellaneous fixtures	In Progress (Delayed)
~~4/15~~ **5/3**	Test of Segmentation (Sue)	-Implement Segmentation Method -Run test to verify success	In Progress (Delayed)
~~4/29~~ **5/5**	Test of Tracking Implementation (Sue)	-Implement tracking algorithm -Run test to verify success	In Progress (Delayed)
5/9	Evaluation of Micro-Surgical Tracker (Yejin)	-Static tool coordinate accuracy -Dynamic tool coordinate accuracy -Miscellaneous accuracy	Not Done

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Timeline

Milestones\Date	W4	W5	W6	W7	SB	W8	W9	W10	W11	W12	W13	W14	W15
M1: Offline Tracking System Design			3/11										
M2: Design of Prototype and Phantom				3/18									
M3: Build Phantom						4/1							
M4: Calibration Implementation						4/1							
M5: Prototype of Device								4/8					
M6: Test of Segmentation								4/15					
M7: Test of Tracking Implementation										4/29			
M8: Evaluation of Micro-Surgical Tracker												5/9	5/13

*W# : Week #, SB: Spring Break

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Timeline

Milestones\Date	W4	W5	W6	W7	SB	W8	W9	W10	W11	W12	W13	W14	W15
M1: Offline Tracking System Design			3/11										
M2: Design of Prototype and Phantom				3/18					4/15				
M3: Build Phantom						4/1		4/8					
M4: Calibration Implementation						4/1		4/8					
M5: Prototype of Device								4/8		4/29			
M6: Test of Segmentation								4/15			5/3		
M7: Test of Tracking Implementation										4/29	5/5		
M8: Evaluation of Micro-Surgical Tracker												5/9	5/13

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Questions?