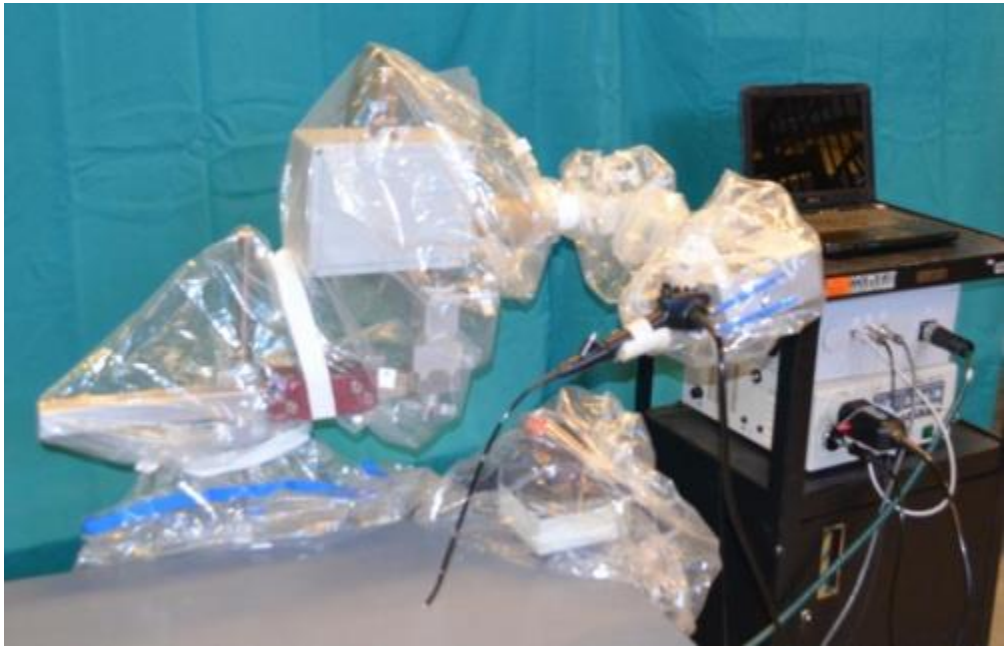
<Robo-ELF>

Human Subject Study, Controller, Computer Vision Tools

Checkpoint Presentation



Courtesy of Kevin Olds

Mentors

Kevin Olds

Dr. Richmon

Members

Jong Heun Kim (BME)

Tae Soo Kim (CS)

Steve Park (ME)

Project Goal

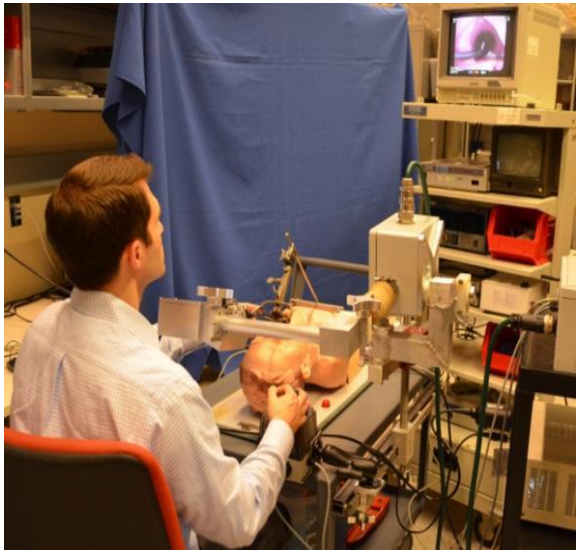
1. Program capable of providing quantitative endoscopic measurements from several monocular endoscopic images

1. Create ergonomic controller for the robot

1. Acquire clinical experimental data.

Background/Relevance

- Robo-ELF stands for **R**obotic **E**ndo-**L**aryngeal **F**lexible scope system
- Rigid Endoscope vs Flexible Endoscope
- Significances
  - Three active and two passive DOF
  - Keep the scope rigidly in place
  - Overcome line of sight constraints
  - Allows one or two handed operations



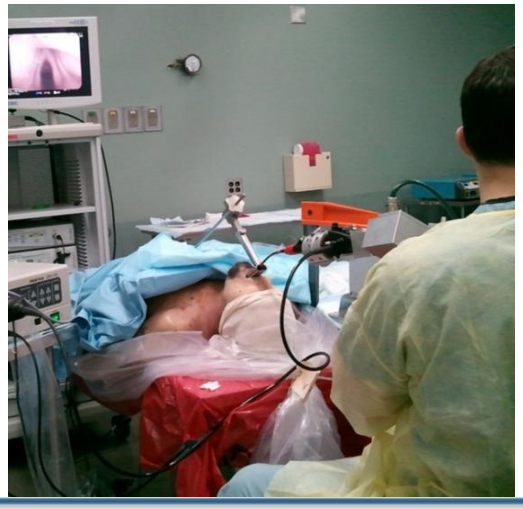
**Courtesy of Kevin Olds*

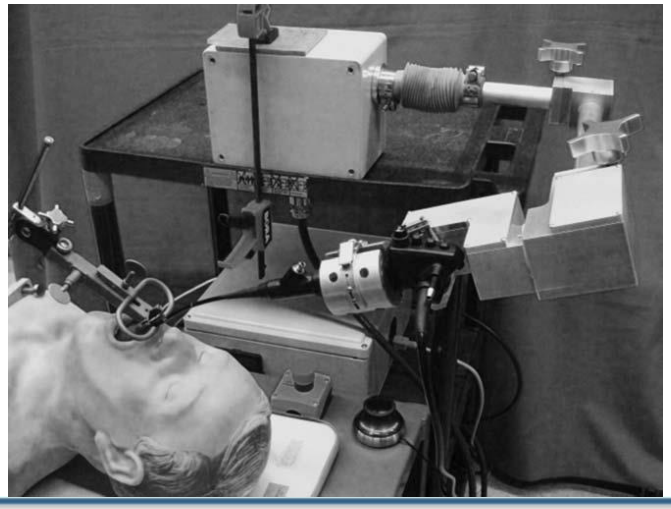
Background/Relevance (Cont.)

- Current Drawbacks
  - Bulky and not-so-ergonomic joystick
    - Digital (only On/Off states)
  - Endotracheal tube insertion for measurements.

Background/Relevance (Cont.)

- Current Drawbacks
  - ~~Bulky and not-so-ergonomic joystick~~
    Design a new intuitive and ergonomic controller.
  - ~~Endotracheal tube insertion for measurements.~~
    Endoscopic measurement software





Human Subject Study Goals

- To prove Robo-ELF as a superior system
- Knowledge of IRB protocols
  - tasks to test performance
- Full proficiency in setting up/ taking down of Robo-ELF
- Get appropriate training
- Tuning the robot for clinical use

HSS- Current State

- IRB approved ✔
- OR set up ✔
- Scope comparison test ⚠
  - Traditional rigid scopes have been updated
    - HD quality
  - Current Robo-ELF scope is outdated
  - In the process of obtaining a new version of flexible endoscope

Deliverables

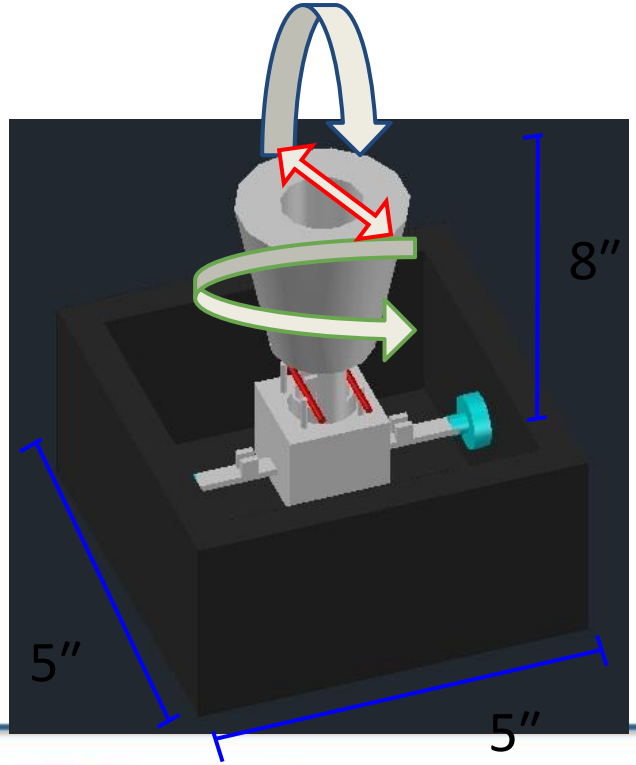
1) **Minimum (estimated March 26, 2014):**
   - ~~A. Assist Dr. Richmon in using the Robo-ELF Scope in the OR.~~
   - B. A fully designed ergonomic controller for the Robo-ELF Scope manipulation.
   - C. Documentation for the Robo-ELF Scope controller
   - D. Software to get real measurements from 2D scope images of an artificial setting + software documentation
1) **Expected (estimated April 30, 2014):**
   - A. Fully interfaced and functioning ergonomic controller with the Robo-ELF.
   - B. Software to get real measurements from 2D scope images of the larynx.
   - C. Software documentation
1) **Maximum (estimated May 07, 2014)**
   - A. Identify the disadvantages with the current prototype (feedback from surgeons) and produce an improved version of the controller.
   - B. Software that reconstructs a 3D model from the 2D scope images.

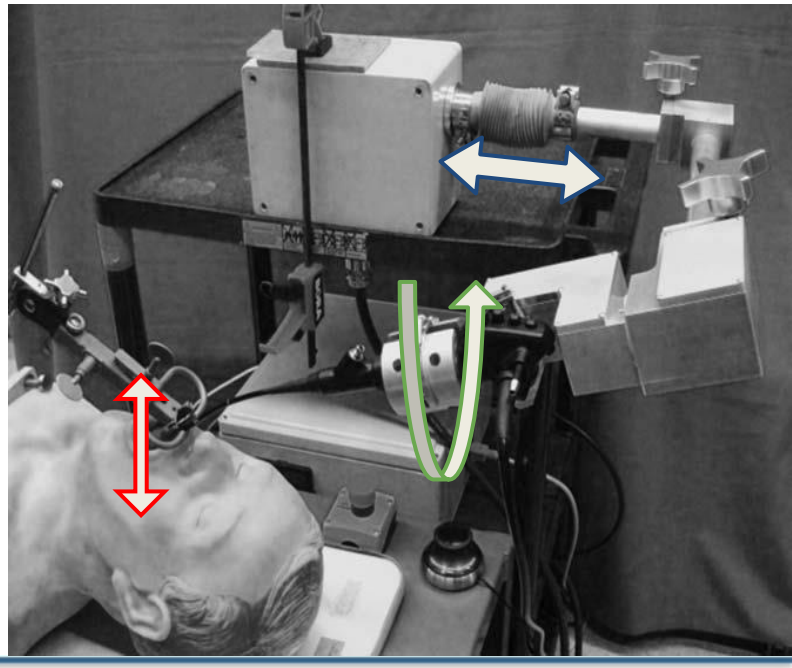
Technical Approach (Joystick)

- Characteristics of joystick design
  - Small and intuitive one-handed control interface
    - Overall design is compact (4″×4″×8″) and can be operated with only one hand.
    - The motion of joystick is parallel to that of scope.
  - Self reorientation and Haptic feedback
    - Gimbal system is implemented on each axis of rotation.
  - Analog sensing instead of digital
    - Linear potentiometers are used to sense the degree of rotation.

Technical Approach (Joystick)

- Small and intuitive one-handed control interface
  - Overall design is compact (5″×5″×8″) and can be operated with only one hand. The motion of joystick is parallel to that of scope.



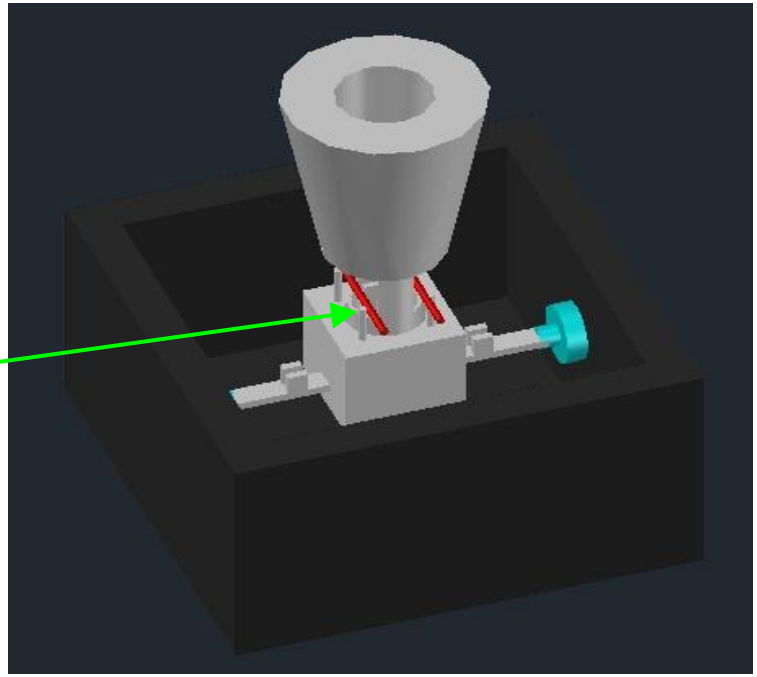


Technical Approach (Joystick)

- Self reorientation and Haptic feedback
  - Spring-tempered sheet metal is ordered from McMaster-Carr and expected to be arrived by this week.

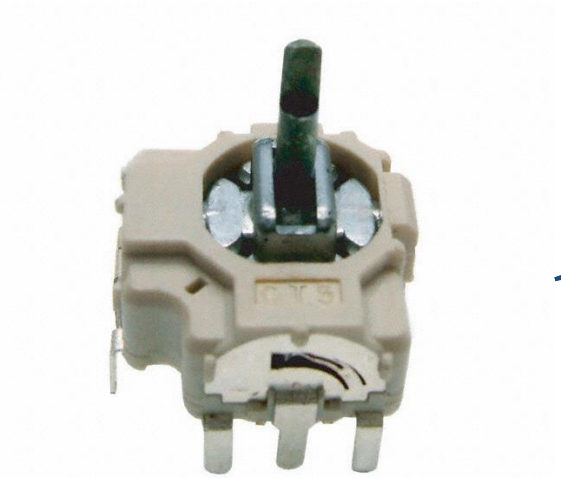
Gimbal System

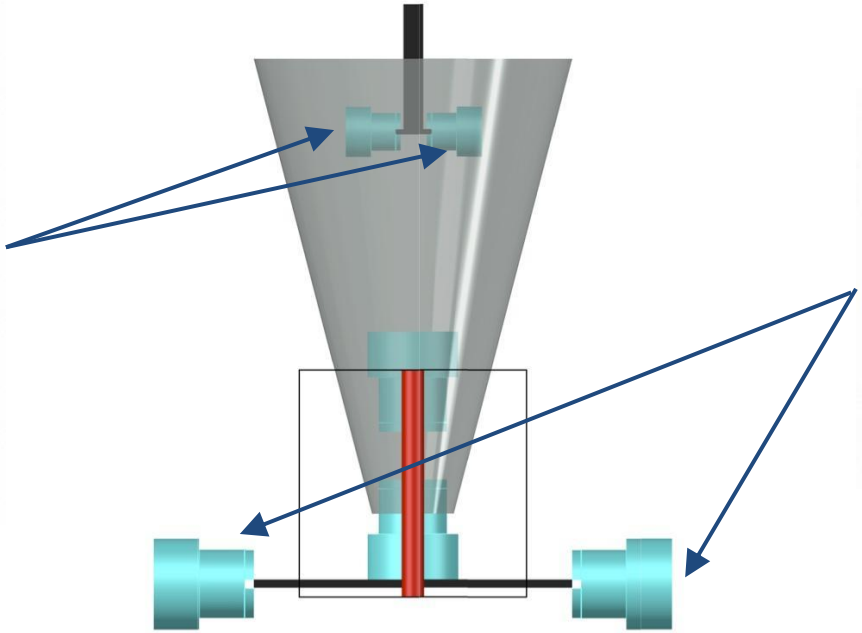
https://www.youtube.com/watch?v=zIc_aMcjkkA



Technical Approach (Joystick)

- Analog sensing instead of digital
  - Pair of Potentiometer for redundancy





Joystick- Current State

- Potentiometers ✓
- Arduino ✓
- Gimbal system components In progress
  - Spring-tempered metal sheets are expected to be arrived by this week.
- Digital Media Center MakerBot In progress
  - The body of the joystick is expected to be printed by this week.

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Work in progress

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Minimum Deliverable: 3D Distance Software

- Intuition: Stereo Vision

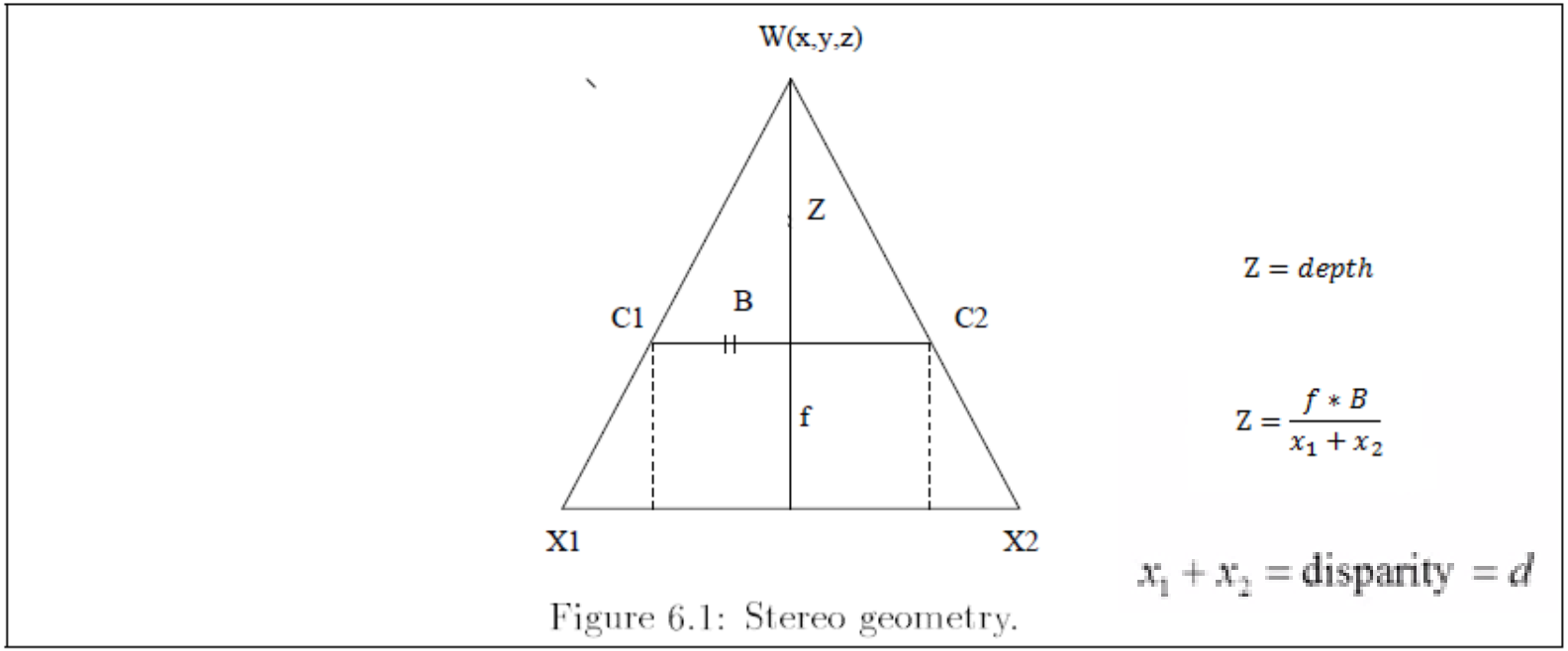
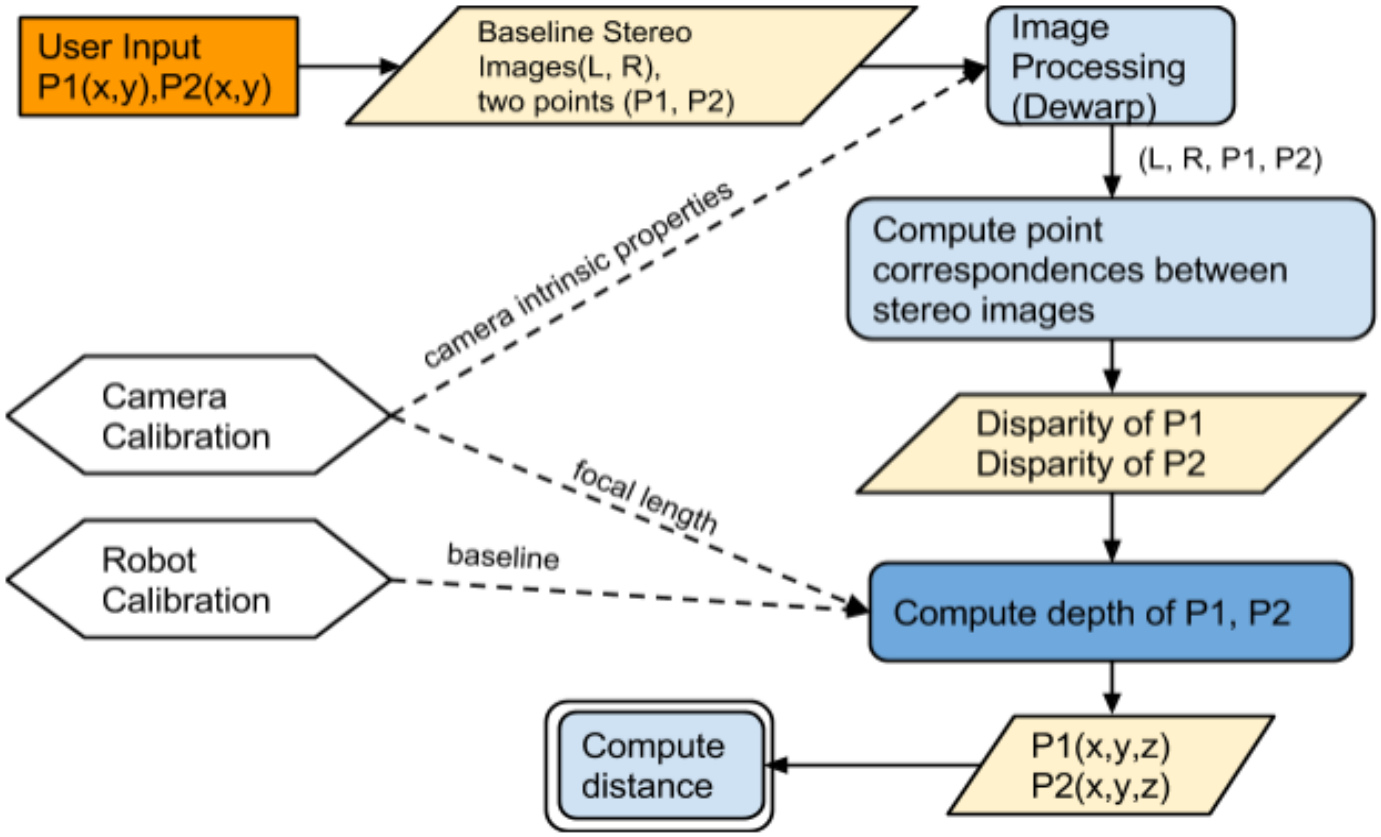


Figure 6.1: Stereo geometry.

Image courtesy of Prof. Mubarak Shah of University of Central Florida

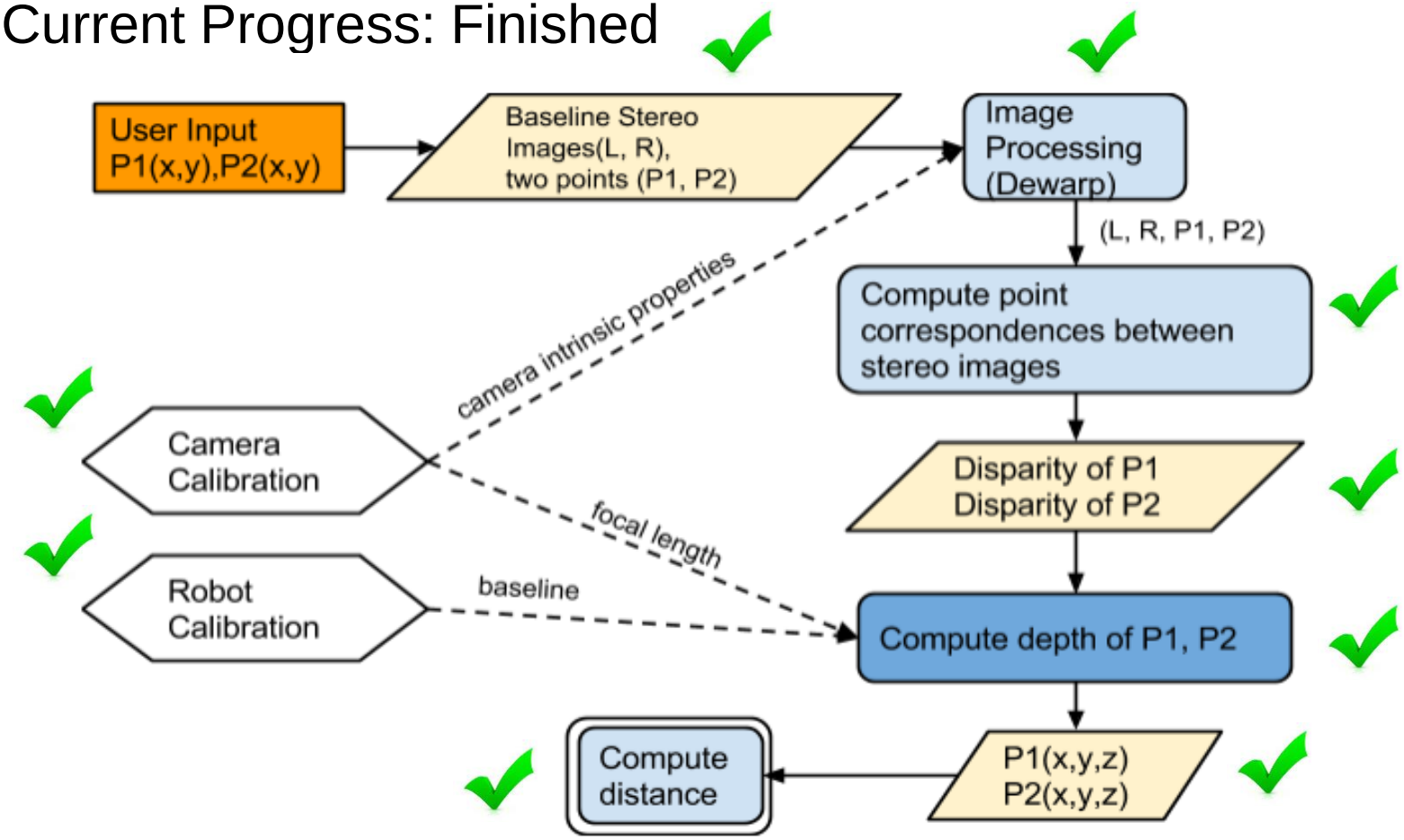
Minimum Deliverable: 3D Distance Software

- Workflow



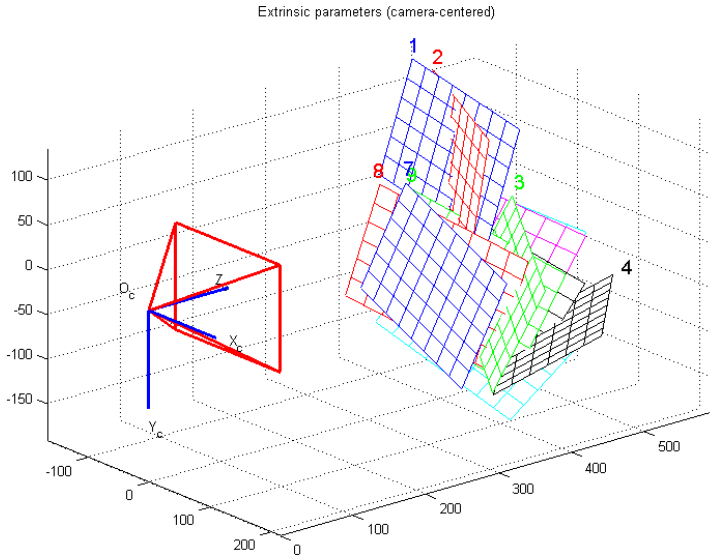
Minimum Deliverable: 3D Distance Software

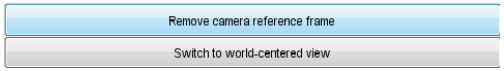
- Current Progress: Finished



Minimum Deliverable: 3D Distance Software

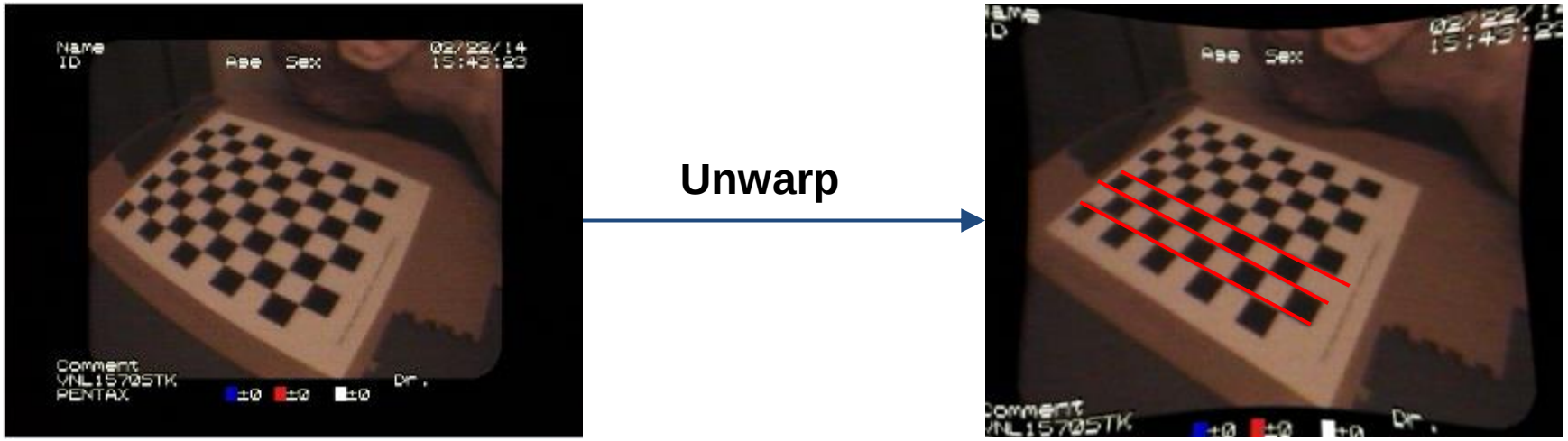
- Camera calibration → Camera parameters





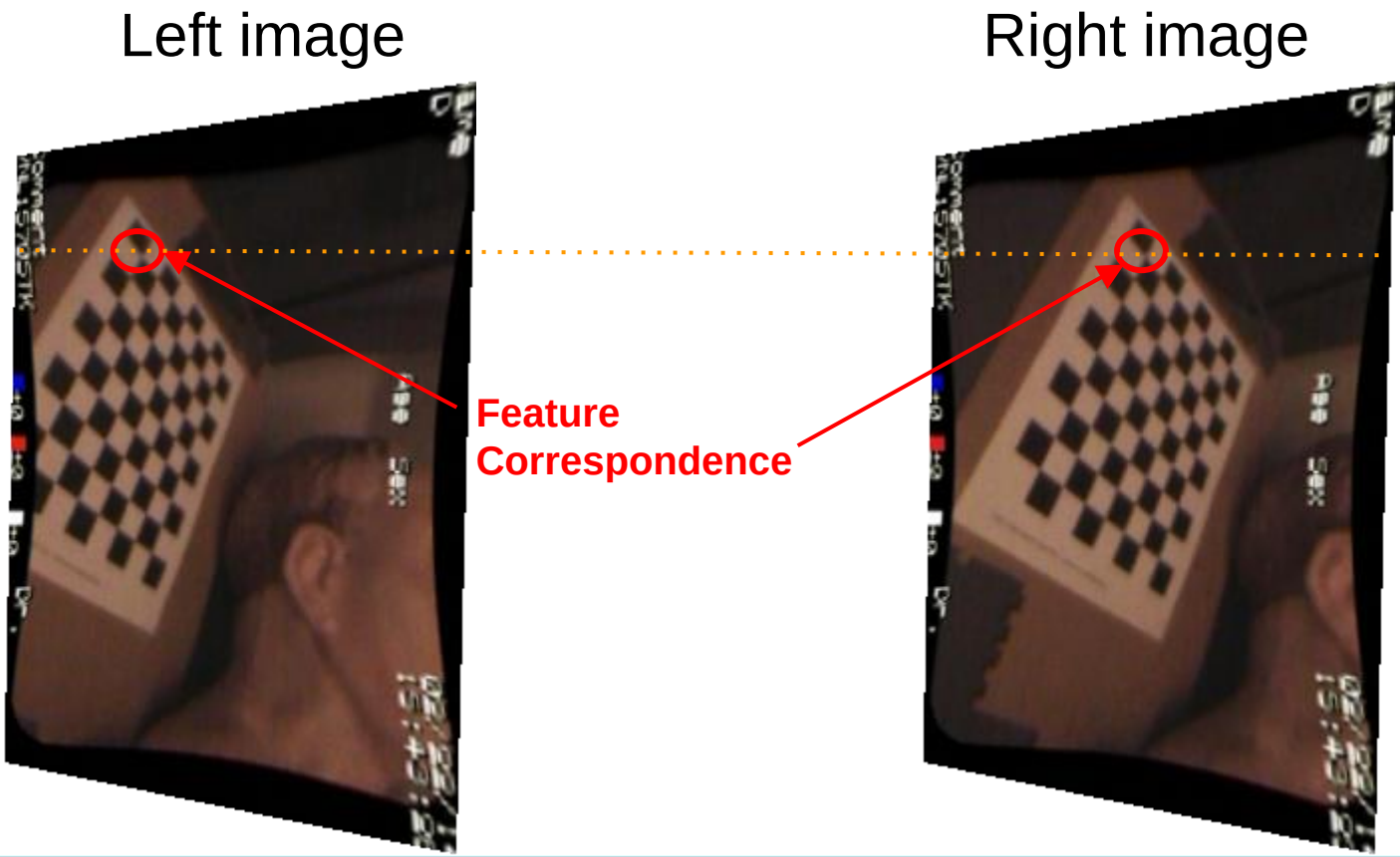
Minimum Deliverable: 3D Distance Software for an artificial scene

- Image unwarping using camera's intrinsic parameters



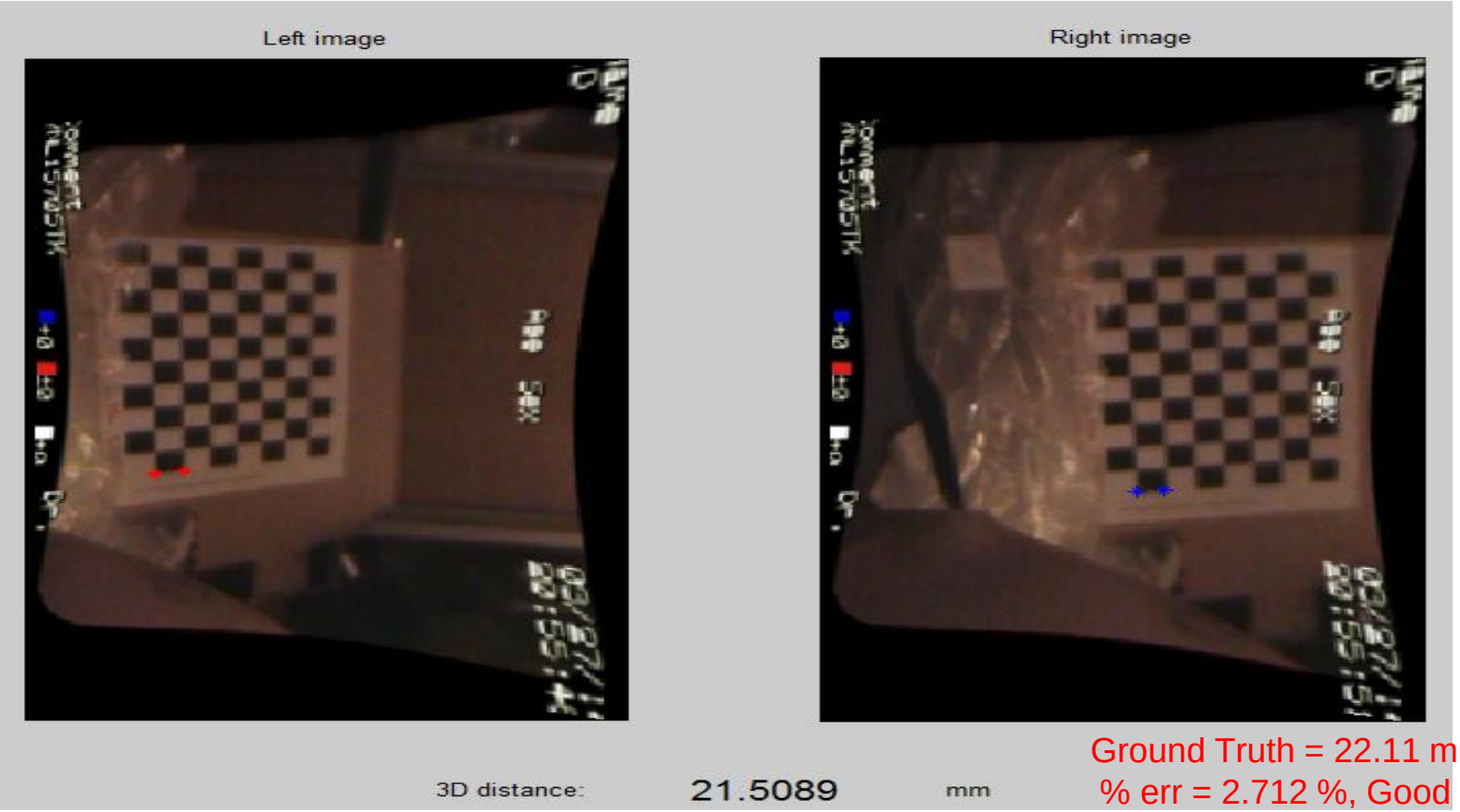
Minimum Deliverable: 3D Distance Software for artificial scene

- Stereo image rectification + correspondence



Minimum Deliverable: 3D Distance Software for artificial scene

- 3D distance measurement from a pair of 2D images



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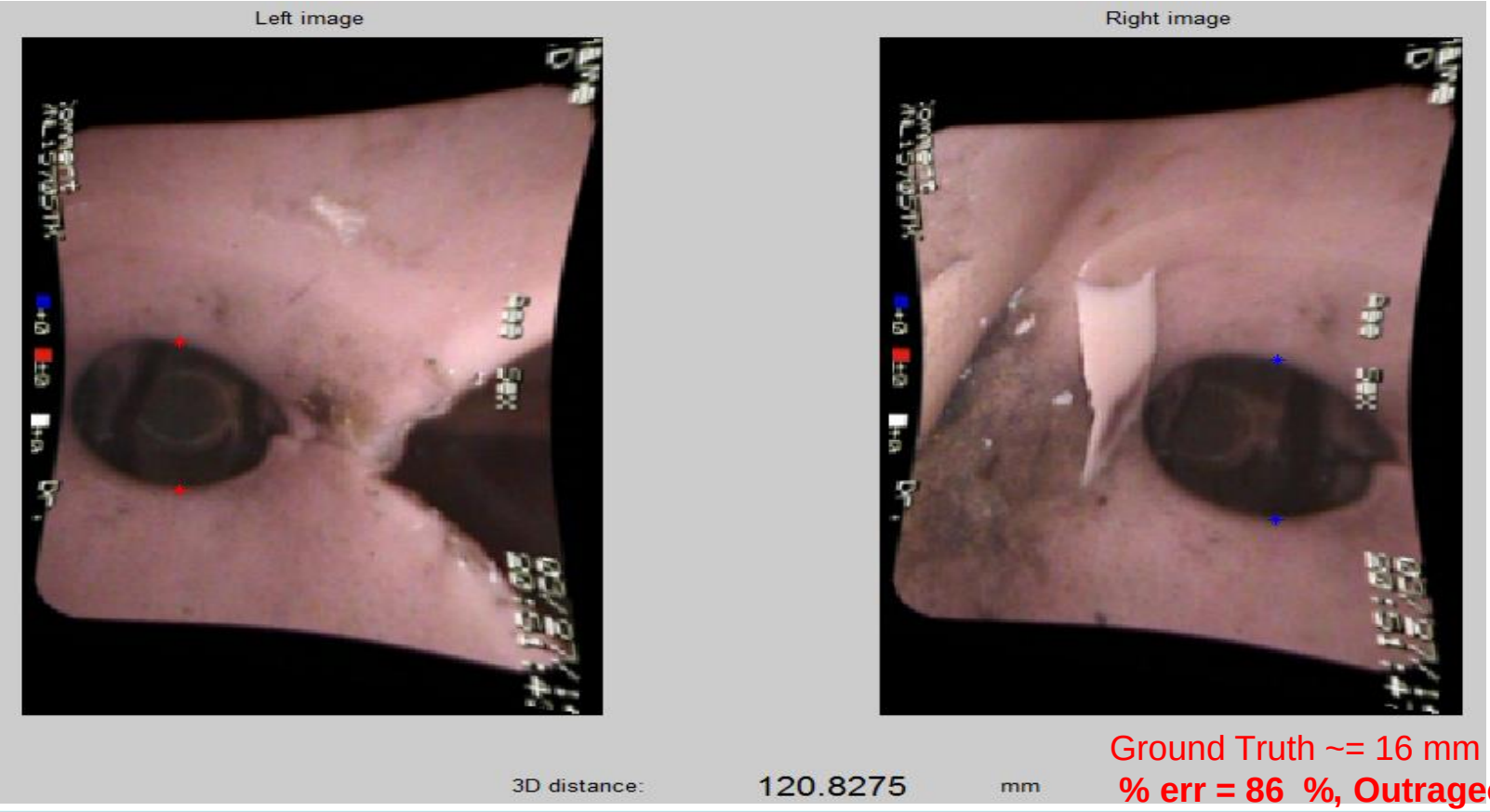
Expected Deliverable: 3D Distance Software for the Larynx

- Terrible results



Ground Truth ~= 16 mm

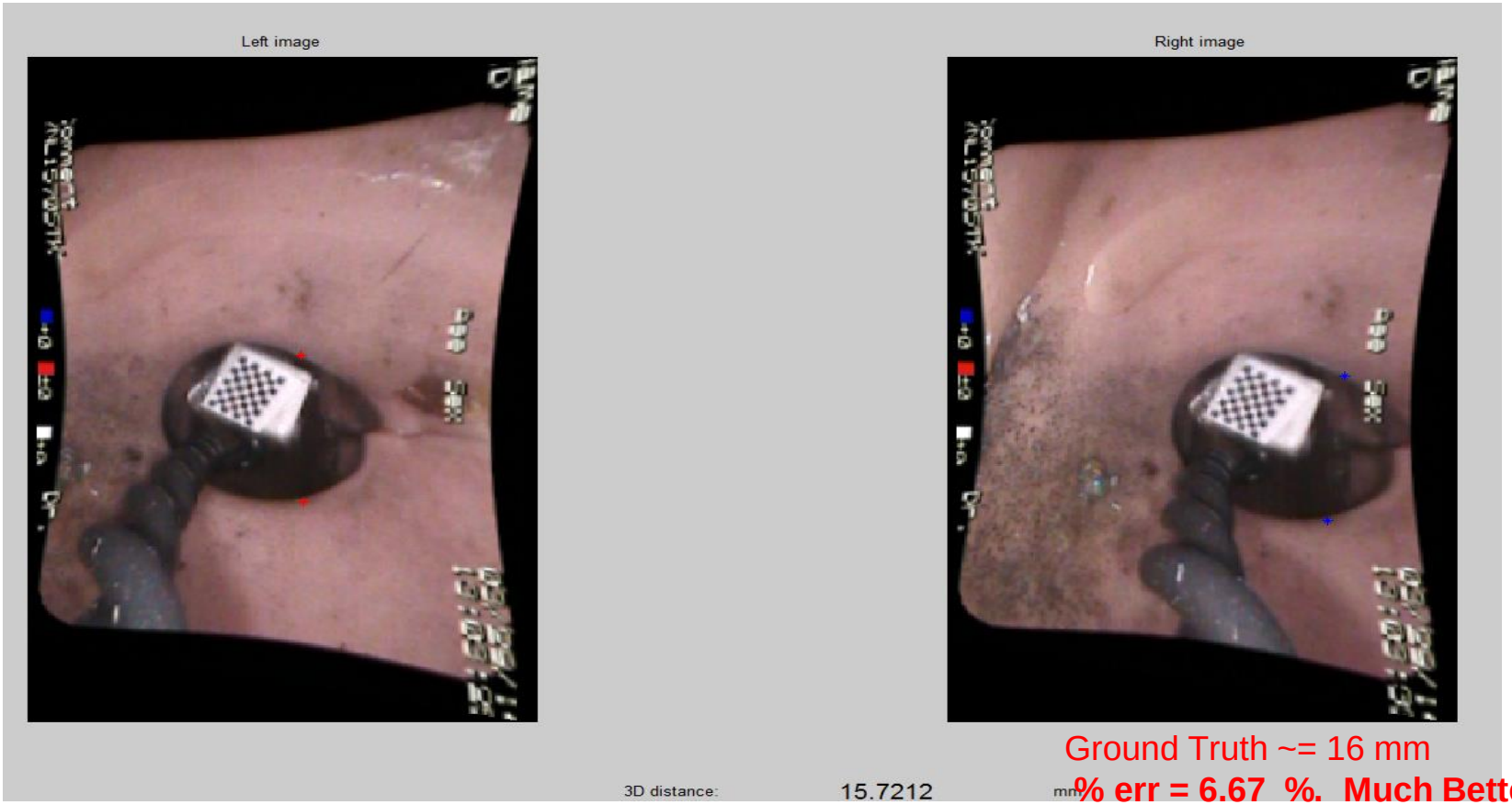
% err = 86 %, Outrageous

Expected Deliverable: 3D Distance Software for the Larynx

- Terrible results due to inaccurate baseline caused by interfered scope tip movement.
  - Confined workspace in throat compared to free space where everything was tested and calibrated.

Expected Deliverable: 3D Distance Software for the Larynx

- Re-calculated robot baseline in throat



Ground Truth ~= 16 mm

% err = 6.67 %. Much Better

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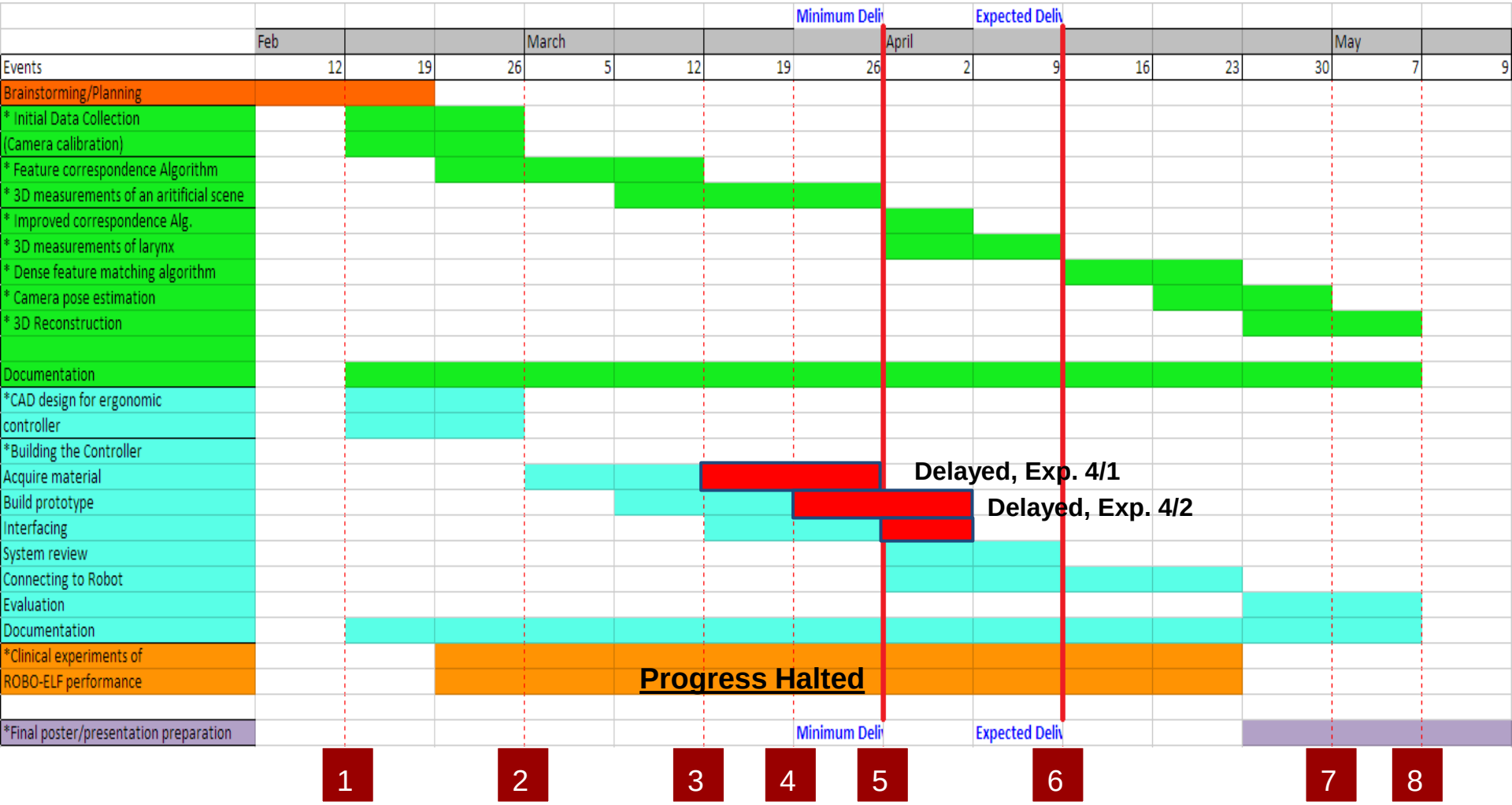
Dependencies

- ✔ **Access to Robo-ELF**
- ✔ **JHU IRB approval**
  - Just approved!
- ✔ **Medical consult & OR visit**
- ✔ **Images from the scope**
- ✔ **Software for 3D reconstruction**
  - OpenCV, Matlab
- ✔ **Cost**
  - The project is already funded by Johns Hopkins Hospital Department of Otolaryngology and Johns Hopkins University Internal Funds.
  - Will be funded up to $1000 (but most likely not have to spend over $300)
- ⚠ **Scope**

Milestones

	Milestone	Planned Date	Expected Date	Status
1	Scope image data collection	Feb. 12	Feb. 12	**Completed**
	Camera calibration	Feb. 26	Feb. 12	**Completed**
	Robot calibration	Feb. 26	Feb. 20	**Completed**
2	Initial CAD design of the controller	Feb. 26	Feb. 24	**Completed**
3	Order and acquire all controller parts	Mar. 12	Apr. 01	Delayed
4	Build prototype	Mar. 19	Apr. 09	In progress
	Interfacing with the robot	Mar. 26	Apr. 02	Delayed
5	3D distance from 2D scope images of an artificial scene	Mar. 26	Mar. 12	**Completed**
	Minimum deliverable met			
	3D distance from 2D scope images of the larynx	Apr. 09	Apr. 09	In Progress
	Expected deliverable met			
6	Get input from Dr.Richmon about the controller	Apr. 09	Apr. 09	
7	3D reconstruction of an artificial scene using the scope images	Apr. 30	Apr. 30	
8	3D reconstruction of the larynx	May. 07	May. 07	

Timeline



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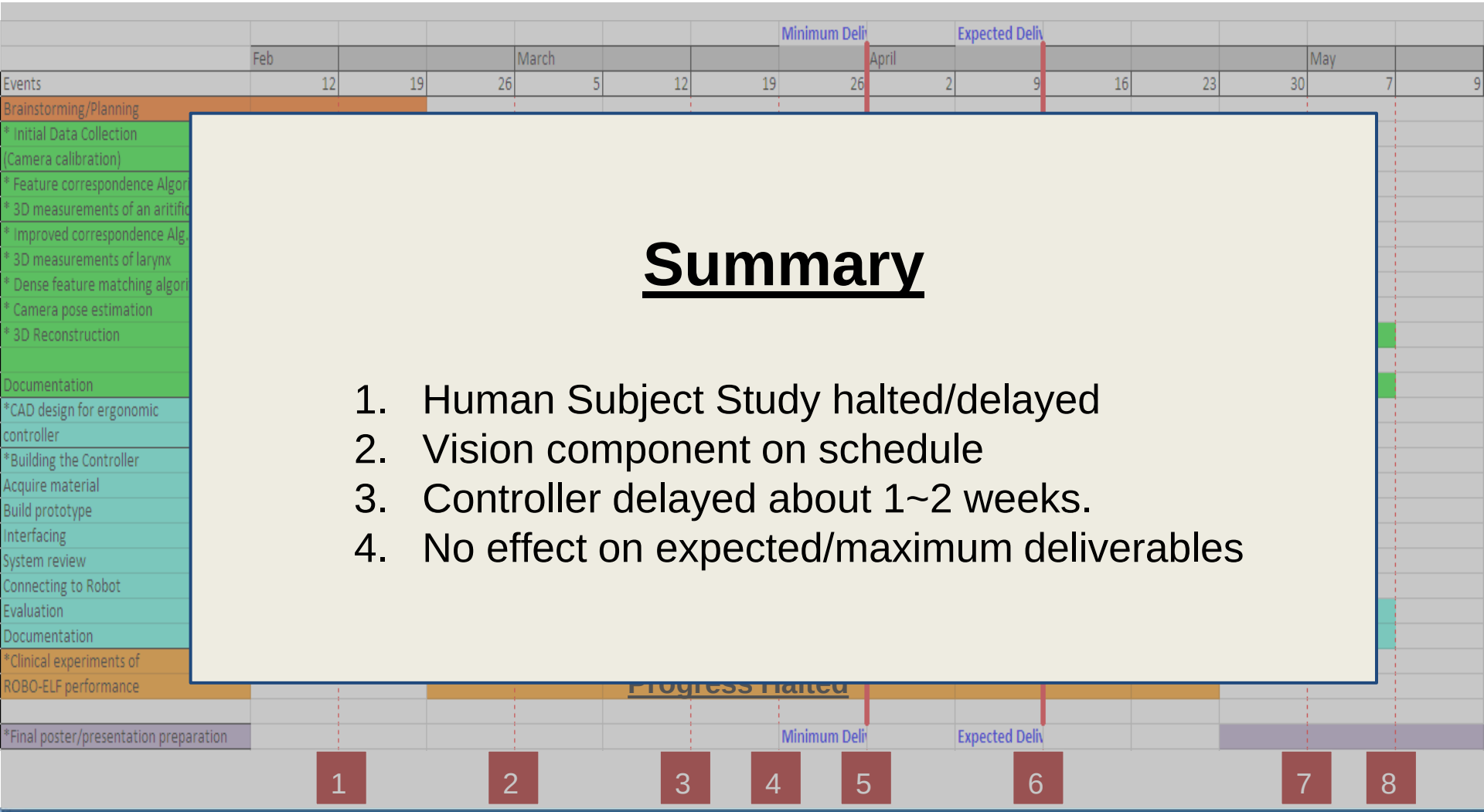
Timeline



Summary

1. Human Subject Study halted/delayed
2. Vision component on schedule
3. Controller delayed about 1~2 weeks.
4. No effect on expected/maximum deliverables

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Questions?