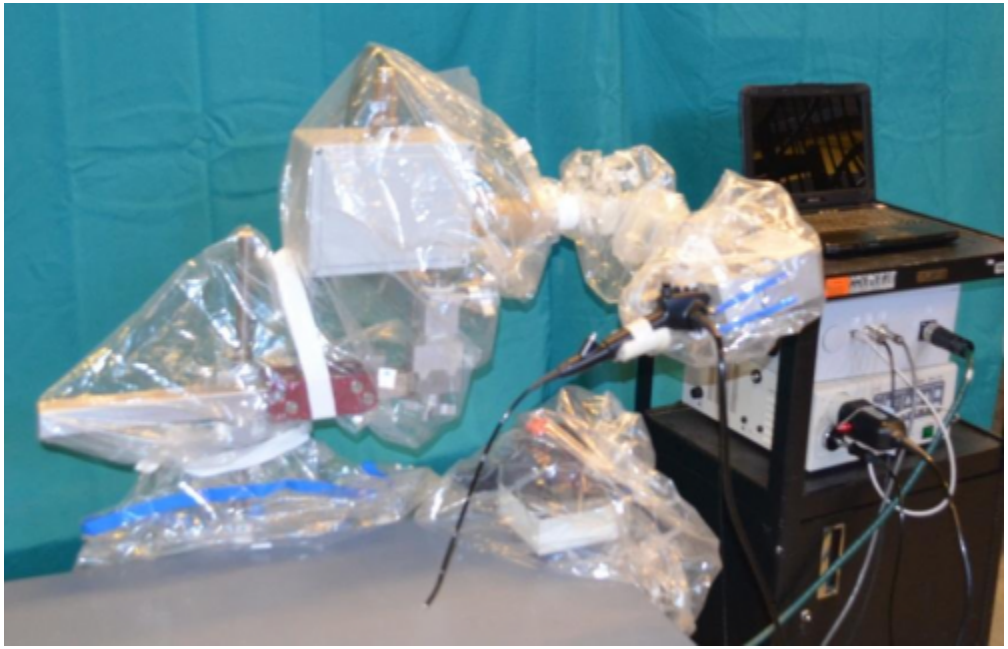
<Robo-ELF>

Human Subject Study, Controller, Computer Vision Tools

Mini-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

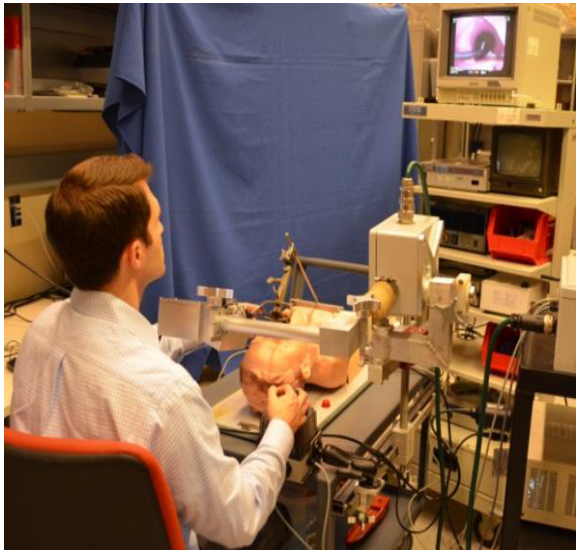
1. Program capable of providing quantitative endoscopic measurements from several monocular endoscopic images

2. Create ergonomic controller for the robot

3. Acquire clinical experimental data.

Background/Relevance

- Robo-ELF stands for **R**obotic **E**ndo-**L**aryngeal **F**lexible scope system
- Flexible Endoscope
  - Easier to navigate than rigid scope
- Significances
  - Three active and two passive DOF
  - Keep the scope rigidly in place
  - Overcome line of sight constraints
  - Require only one hand to control

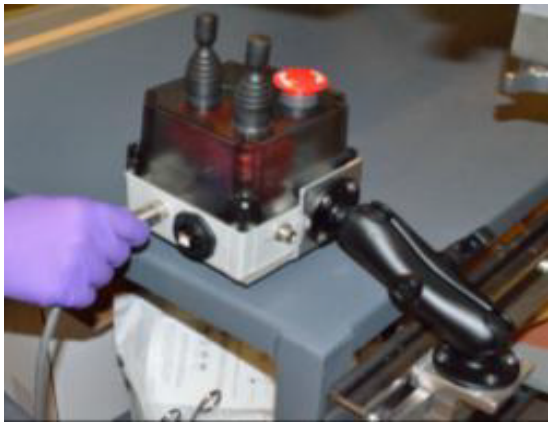


**Courtesy of Kevin Olds*

Background/Relevance (Cont.)

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

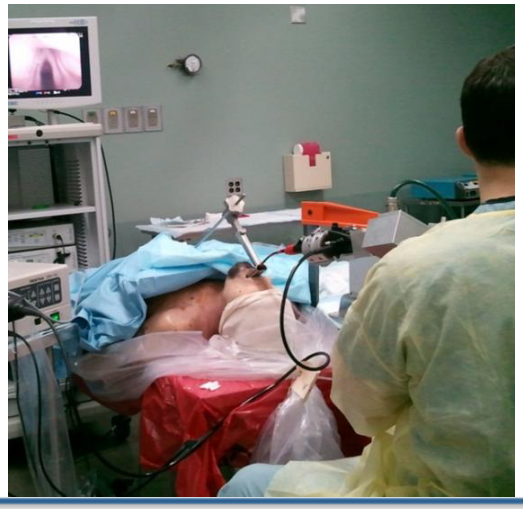
Prototype I

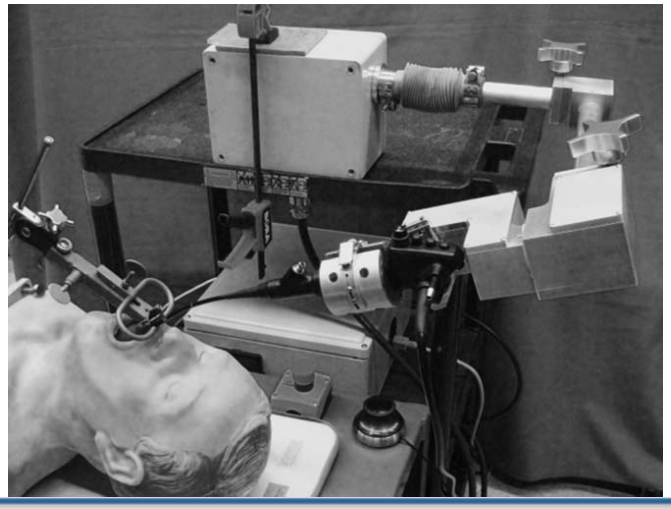


Prototype 2

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





Technical Approach (Joystick)

- Characteristics of joystick design
  - 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.
  - 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.
  - Redundant input for safety
    - Pair of potentiometer is mounted to ensure correct reading.

Technical Approach (Joystick)

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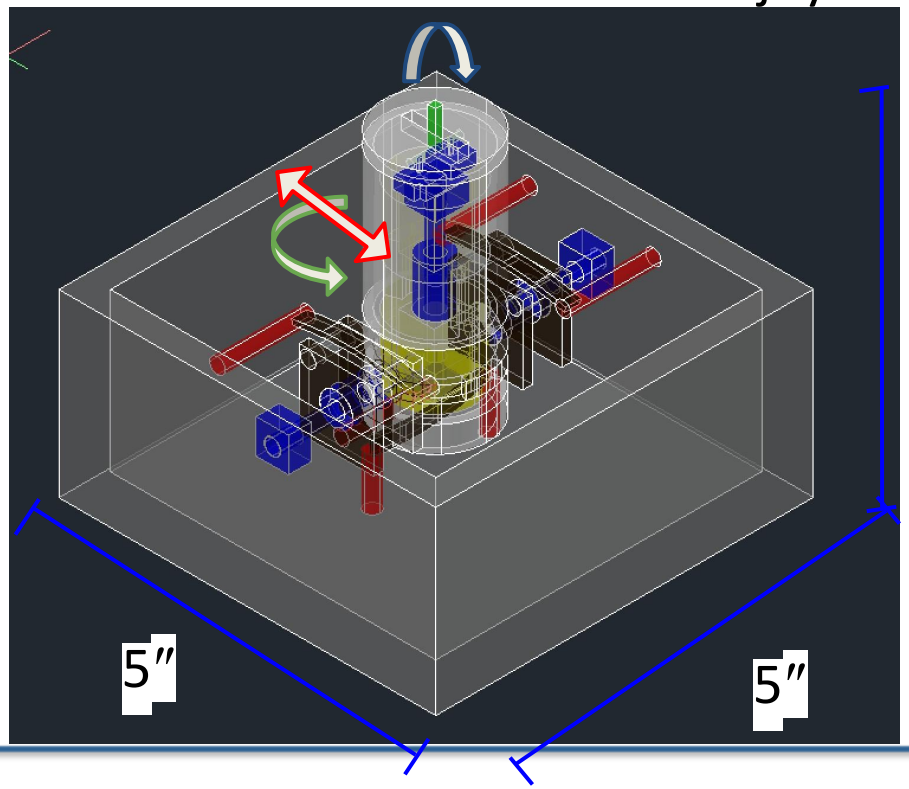
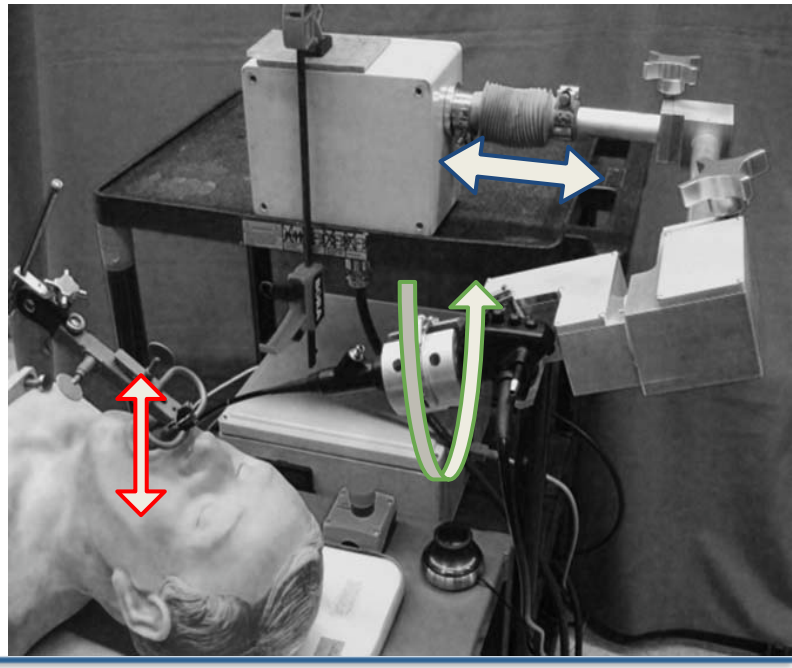


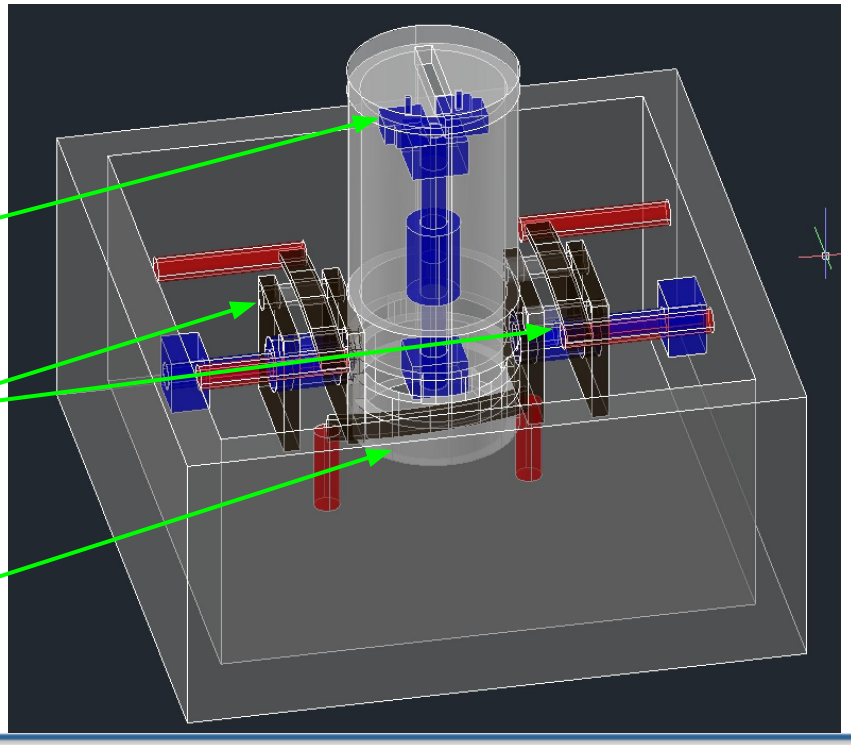


Technical Approach (Joystick)

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

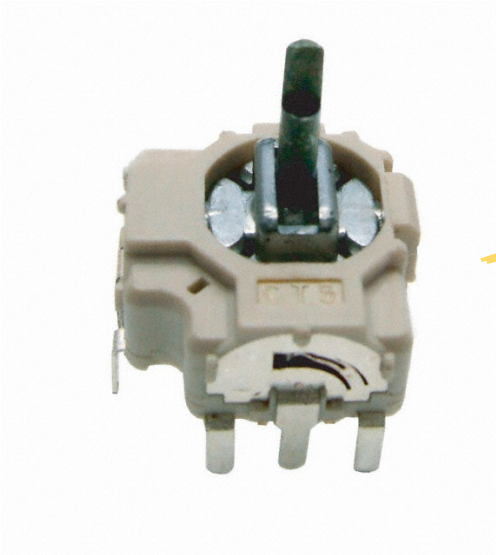
Gimbal System

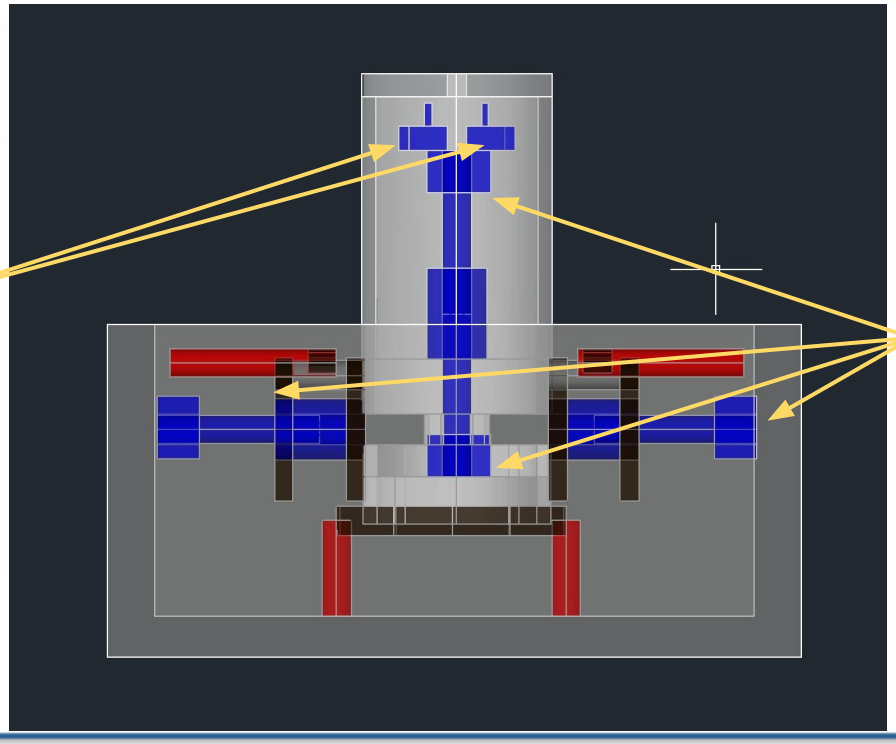
https://www.youtube.com/watch?v=zIc_aMcjkkA



Technical Approach (Joystick)

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





Joystick- Current State

- Potentiometers ✓
- Arduino ✓
- Gimbal system components ✓
  - Spring-tempered metal sheets
- Digital Media Center MakerBot
  - Printed parts had wrong dimension scale.
  - Re-printed parts with correct dimension had poor quality
- 3D print from Machine shop In progress
  - First design cost too much (~$150)
  - Improved design incorporating Gimbal system will be sent to Neil by end of this week.

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.

Work in progress C. Documentation for the Robo-ELF Scope controller

   D. Software to get real measurements from 2D scope images of an artificial setting + software documentation

2) **Expected (estimated April 30, 2014):**

Work in progress 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

3) **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.

Minimum Deliverable: 3D Distance Software

- Intuition: Stereo Vision

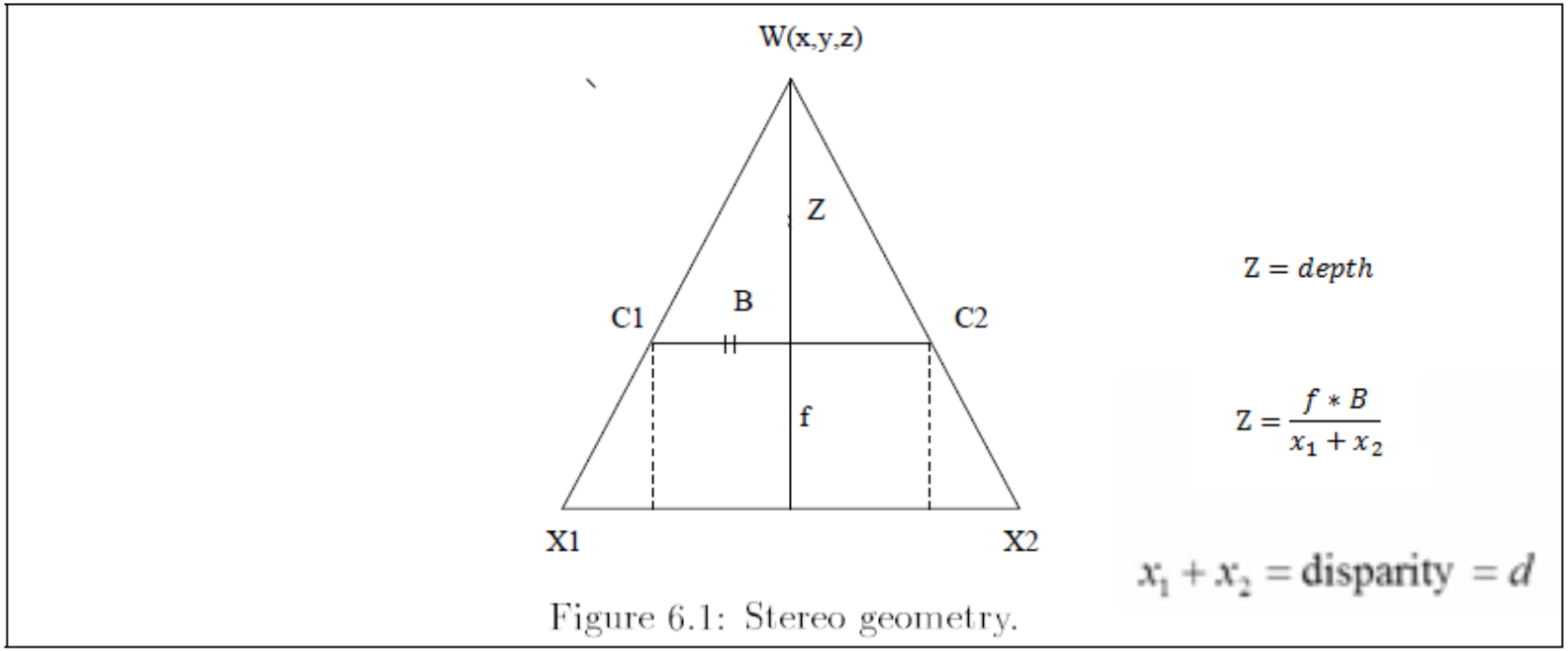
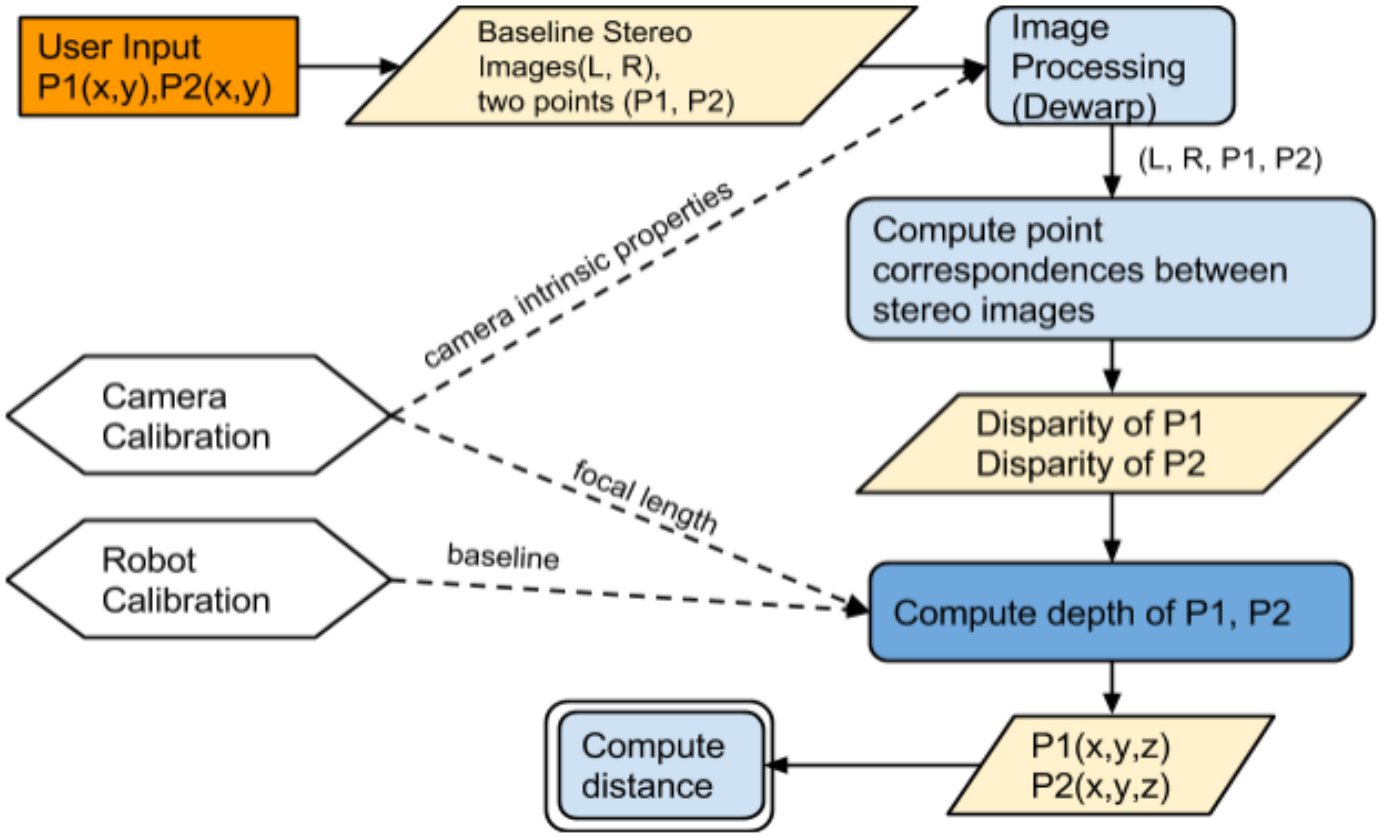


Image courtesy of Prof. Mubarak Shah of University of Central Florida

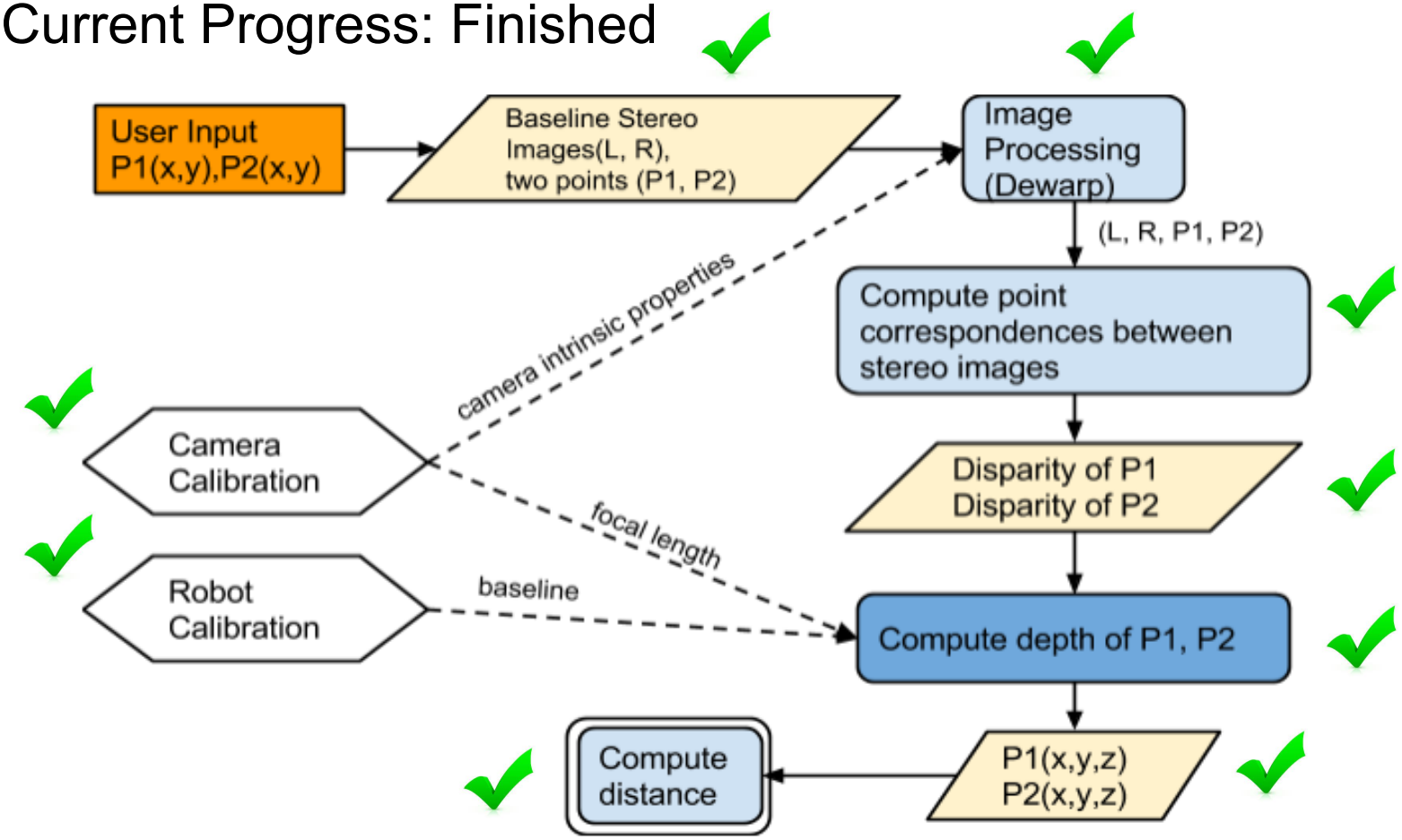
Minimum Deliverable: 3D Distance Software

- Workflow



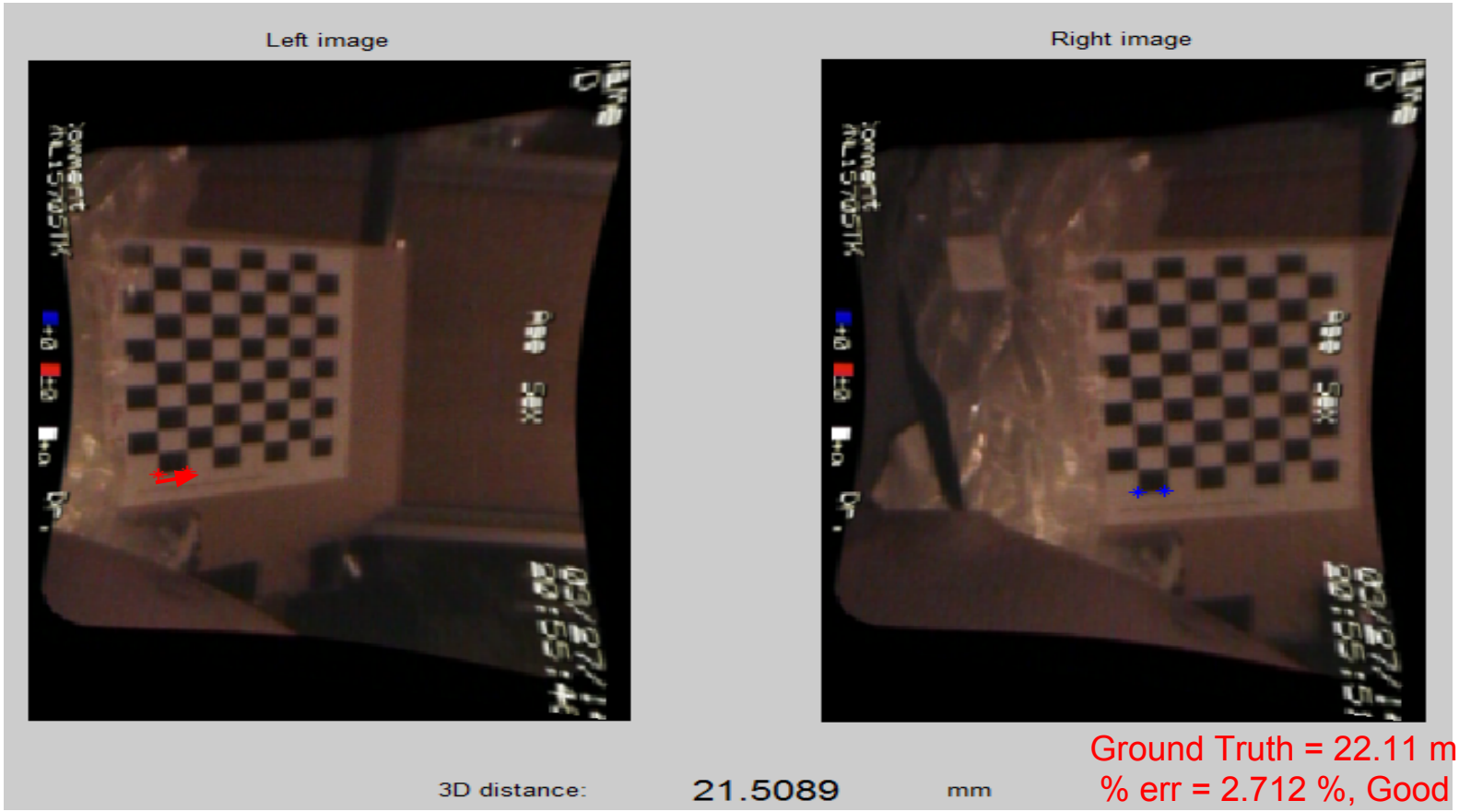
Minimum Deliverable: 3D Distance Software

- Current Progress: Finished



Minimum Deliverable: 3D Distance Software 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

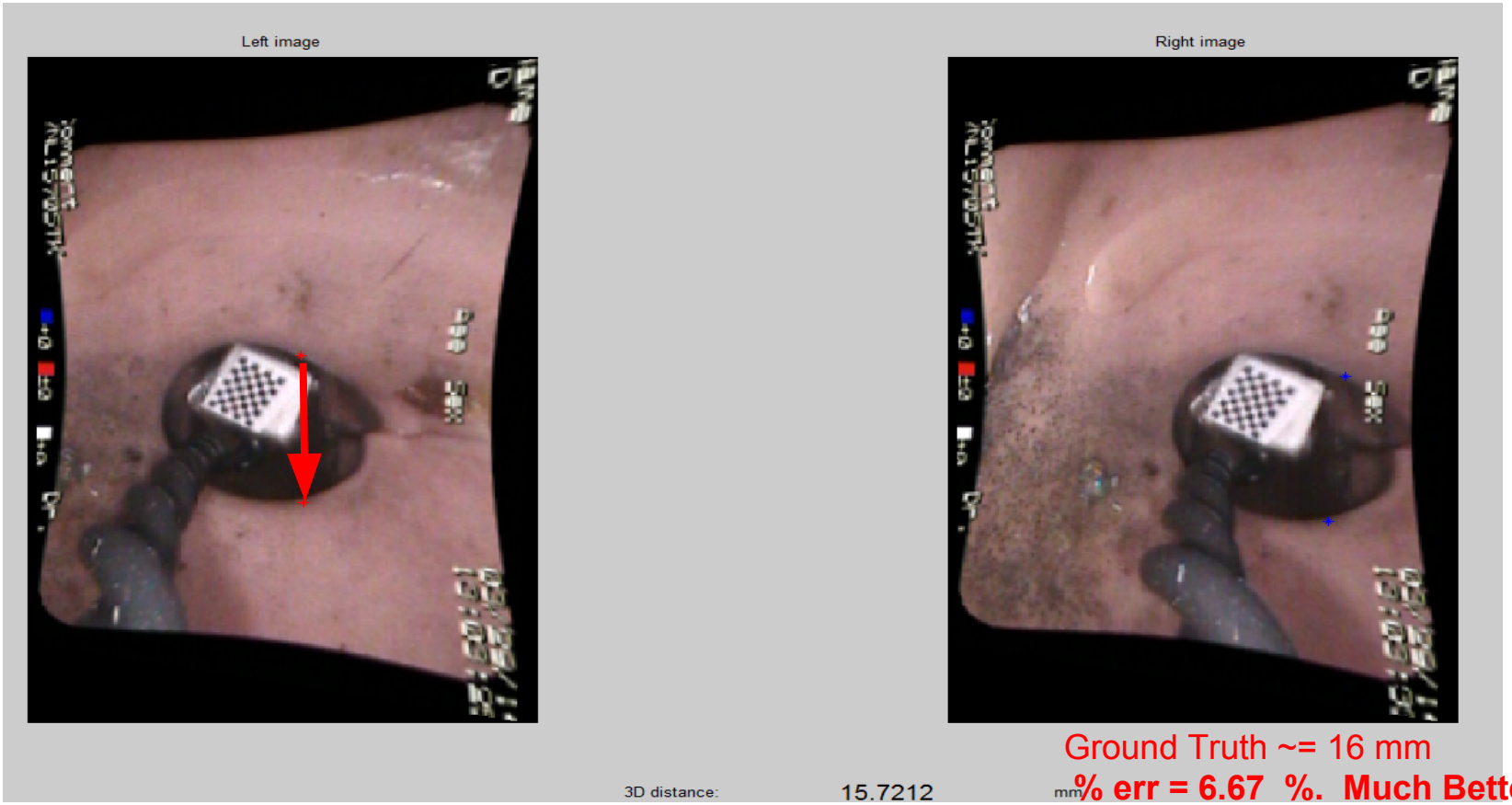
Ground Truth ~= 16 mm
% err = 86 %, Outrageous

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

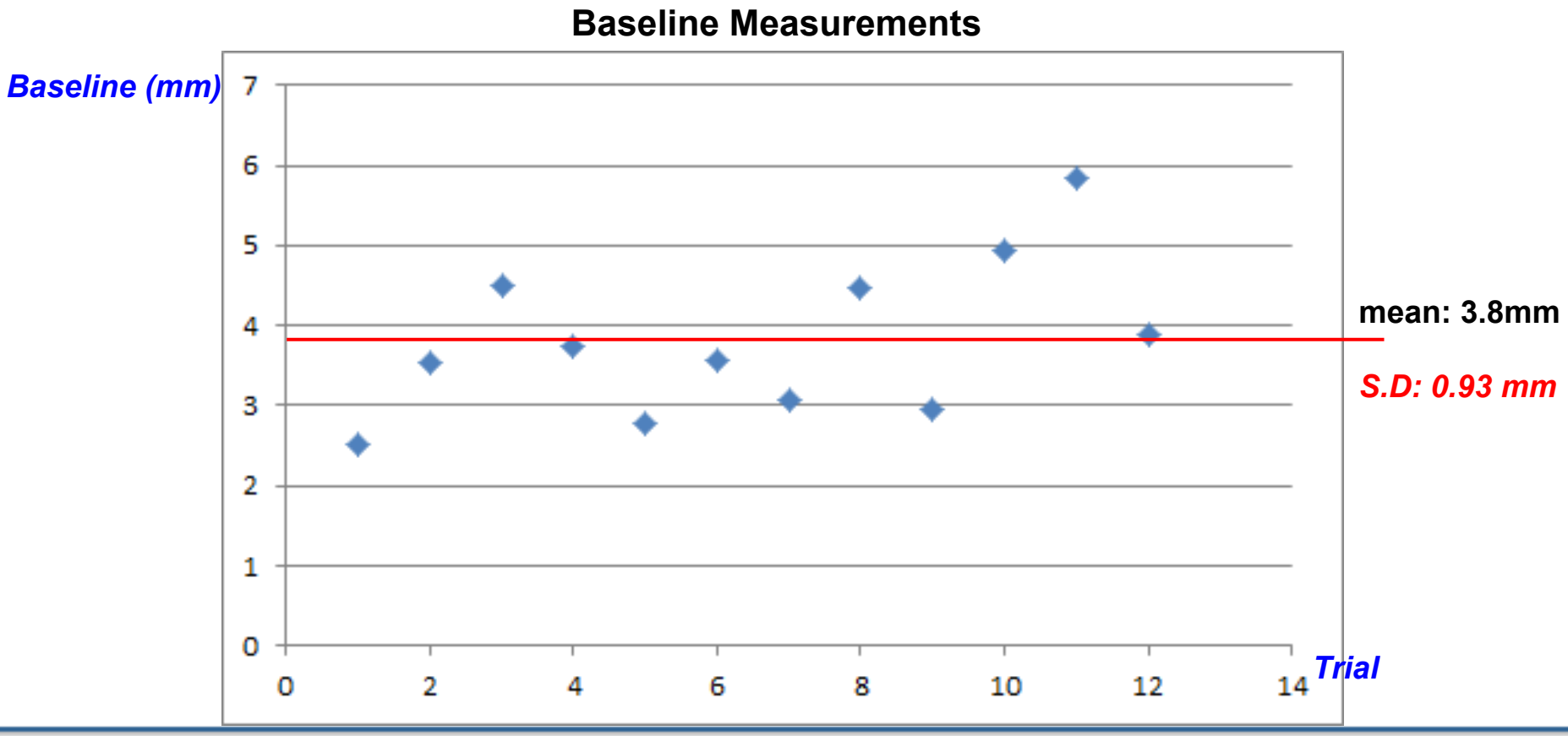


Ground Truth ~= 16 mm

% err = 6.67 %. Much Better

Expected Deliverable: 3D Distance Software for the Larynx

- *Still not good enough*: Inconsistent baseline



Expected Deliverable: 3D Distance Software for the Larynx

- Difficulties with current approach: Inconsistent baseline
- Large noise possibly due to:
  - Inconsistent configuration of the scope in throat
  - Inaccurate/inconsistent flexible endoscope manipulation
  - Backlash of the flexible scope

Measurement of the same scene

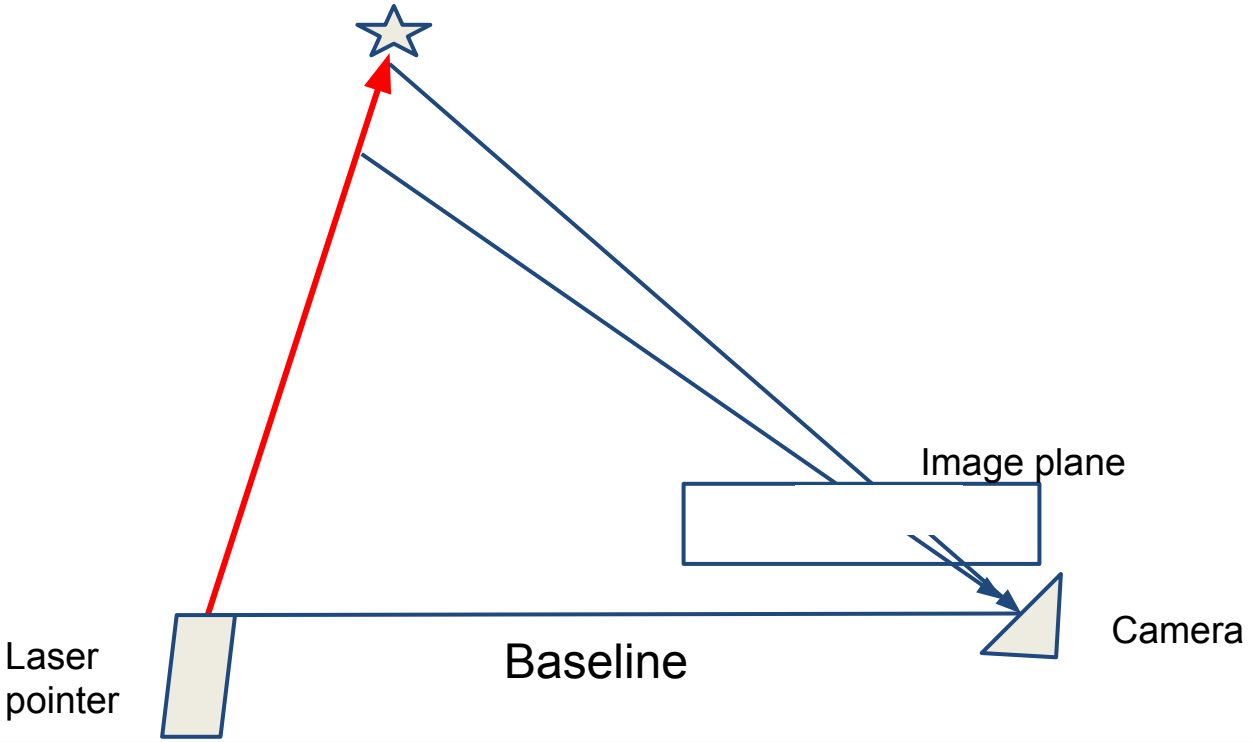
With minimum baseline: 1.87 mm
With maximum baseline: 5.08 mm

Unacceptable result

Expected Deliverable: 3D Distance Software for the Larynx

- Change of approach

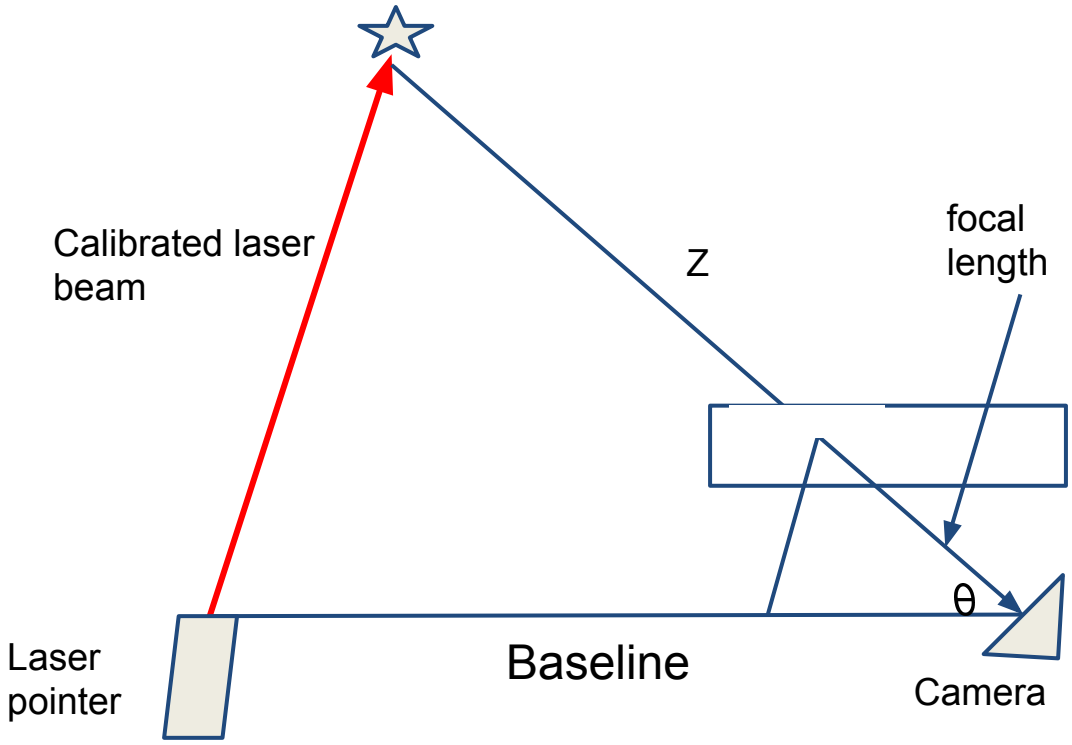
~~Passive stereo~~ → **Active stereo**



Expected Deliverable: 3D Distance Software for the Larynx

- Active stereo approach
  - Calibrate laser beam
  - Calibrate camera
  - Fixed baseline

Can compute depth (Z) by triangulation



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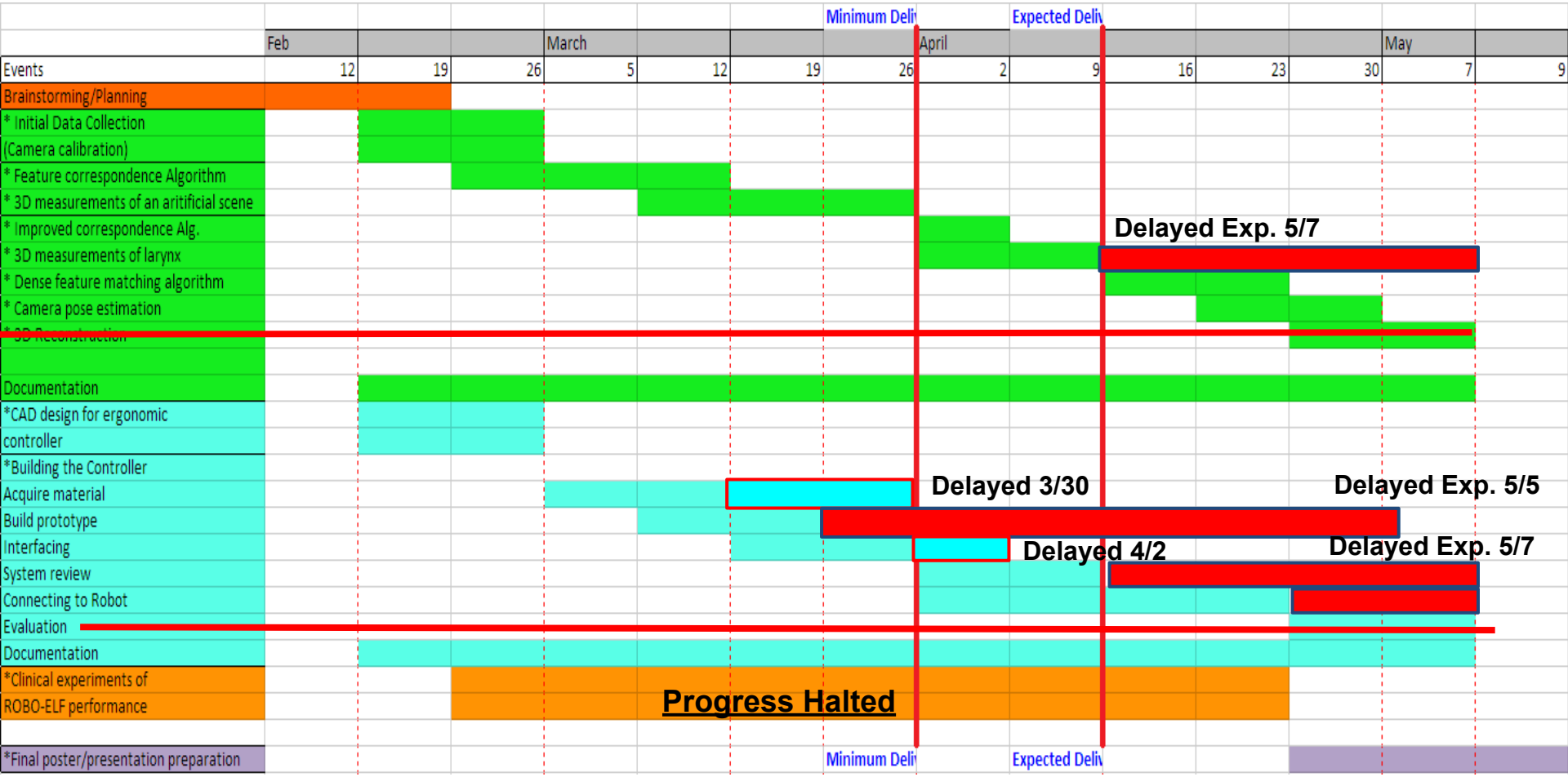
   - Work in progress C. Documentation for the Robo-ELF Scope controller
   - ✓ D. Software to get real measurements from 2D scope images of an artificial setting + software documentation
2) **Expected (estimated April 30, 2014):**
   - Work in progress A. Fully interfaced and functioning ergonomic controller with the Robo-ELF.
   - Upgrading B. Software to get real measurements from 2D scope images of the larynx.
   - ✓ C. Software documentation
3) **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.

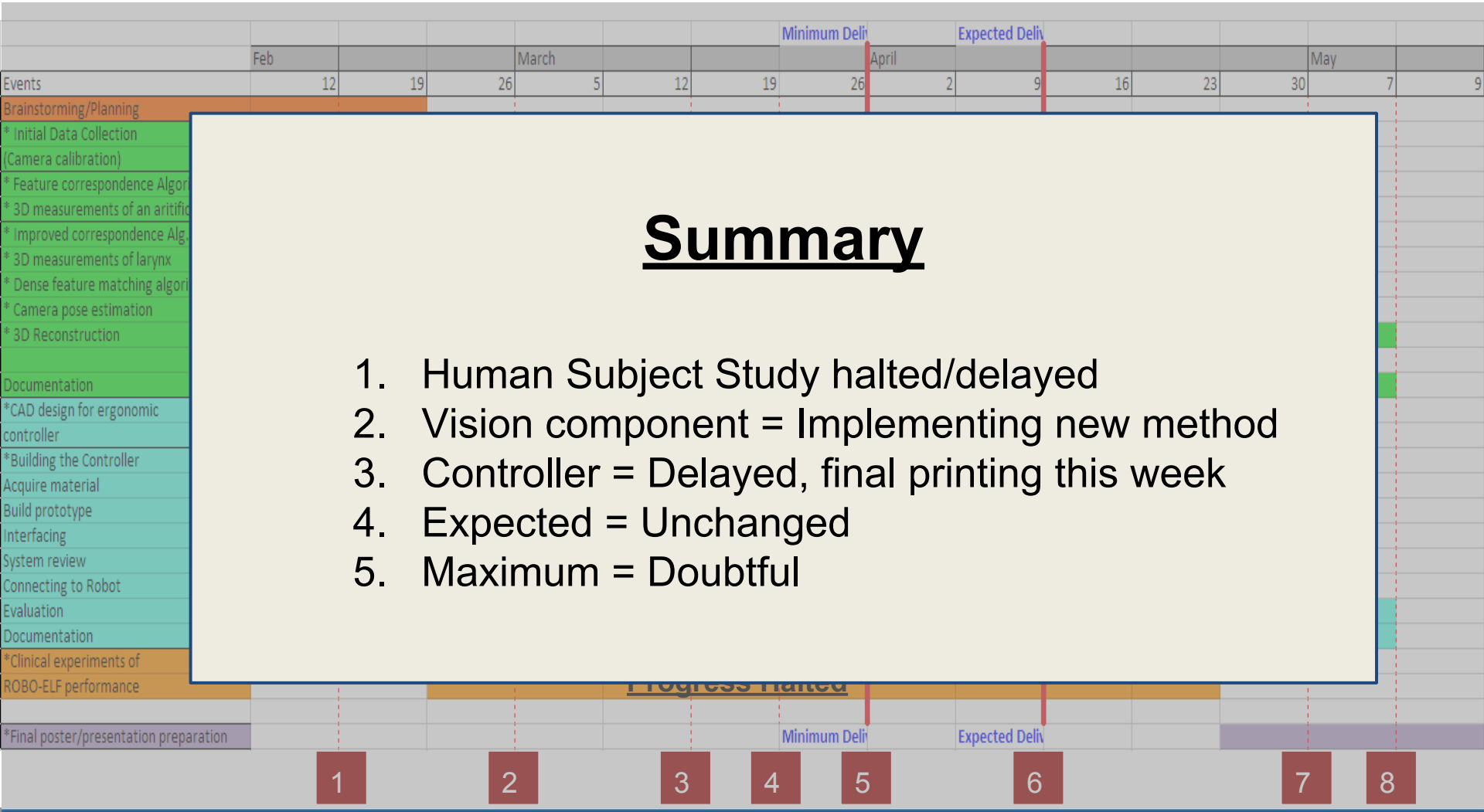
Dependencies

- ✔ **Access to Robo-ELF**
- ✔ **JHU IRB approval**
  - Just approved!
- ✔ **Medical consult & OR visit**
- ✔ **Images from the scope**
- ✔ **Software for 3D reconstruction**
  - OpenCV, Matlab
- ✔ **Cost**
  - Will be funded up to $1000 (but most likely not have to spend over $300)
- ✔ **Laser safety training**

Timeline


Minimum Deli
Expected Deliv
Feb
March
April
May
Events
12
19
26
5
12
19
26
2
9
16
23
30
7
9
Brainstorming/Planning
* Initial Data Collection
(Camera calibration)
* Feature correspondence Algorithm
* 3D measurements of an aritificial scene
* Improved correspondence Alg.
* 3D measurements of larynx
* Dense feature matching algorithm
* Camera pose estimation
Documentation
*CAD design for ergonomic
controller
*Building the Controller
Acquire material
Build prototype
Interfacing
System review
Connecting to Robot
Evaluation
Documentation
*Clinical experiments of
ROBO-ELF performance
*Final poster/presentation preparation
Delayed Exp. 5/7
Delayed 3/30
Delayed Exp. 5/5
Delayed 4/2
Delayed Exp. 5/7
Progress Halted
Minimum Deli
Expected Deliv

Timeline



Summary

1. Human Subject Study halted/delayed
2. Vision component = Implementing new method
3. Controller = Delayed, final printing this week
4. Expected = Unchanged
5. Maximum = Doubtful

Question?