Software for an Intra-Operative “Kinect” with a Flexible Endoscope

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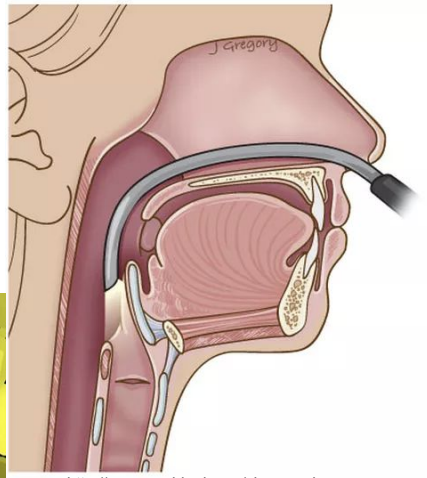
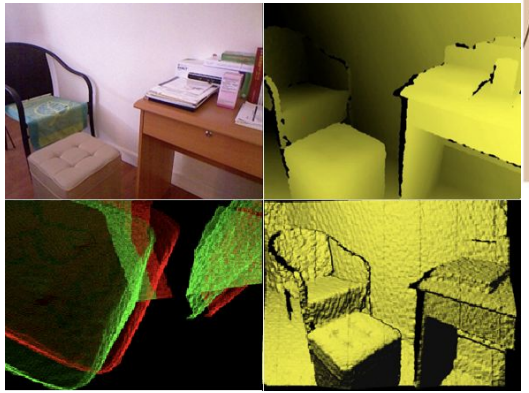
Relevance

- “Depth cameras” have spurred the popularity and approachability of real-time 3D reconstruction
- 3D reconstruction based on images captured by endoscope
- Small laser allows for structured light approach with endoscope

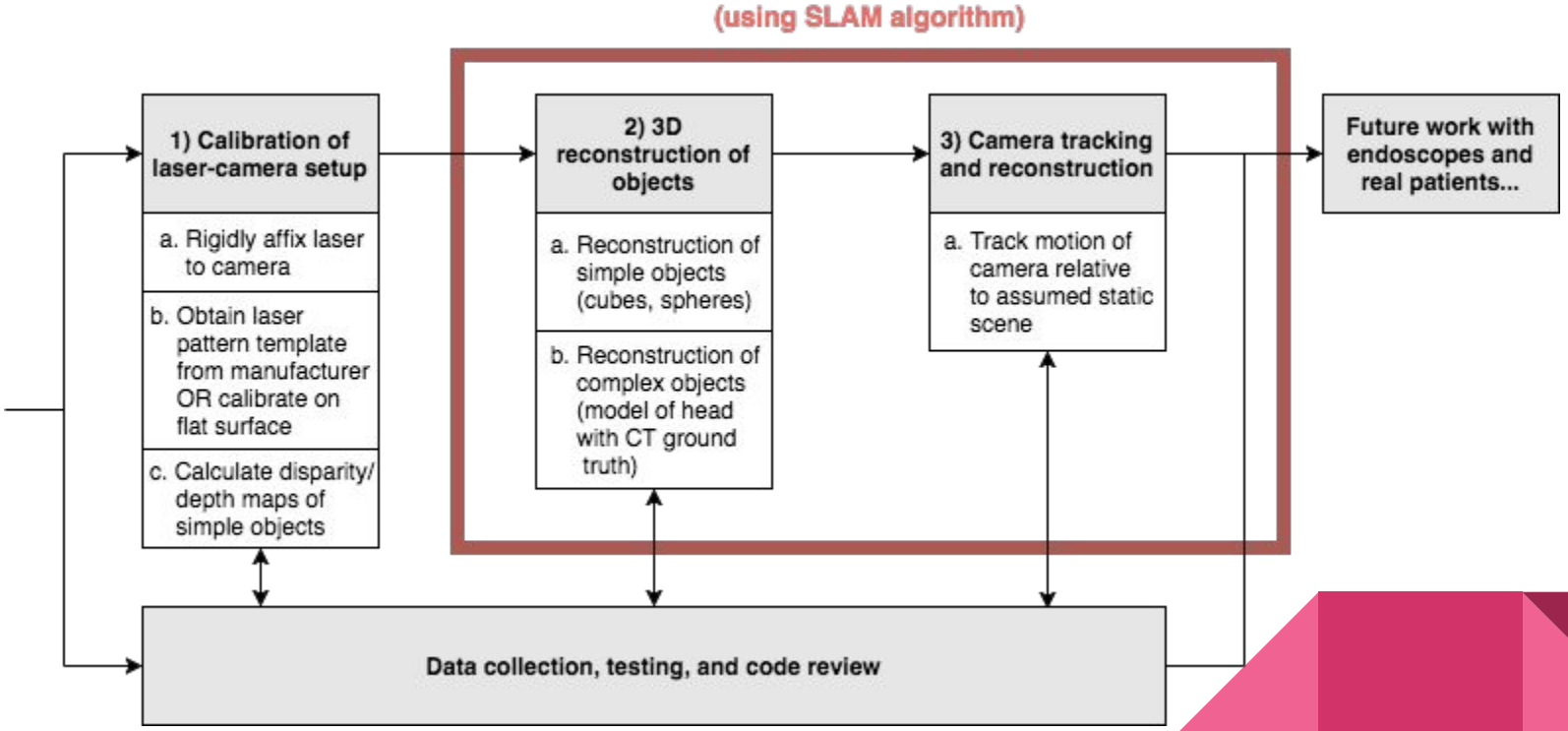


http://www.zaghimd.com/sleep-endoscopy



http://jiakaizhang.com/project/real-time-3d-reconstruction/

Technical Approach



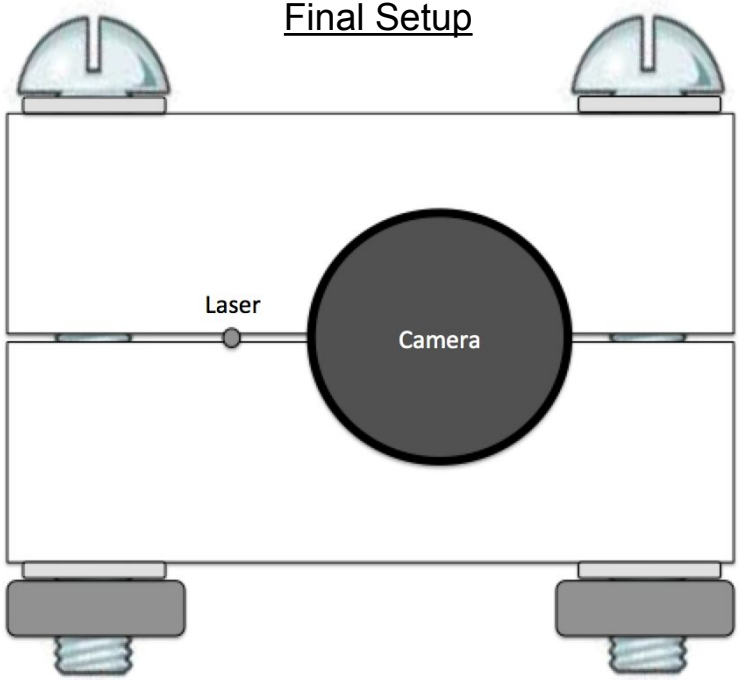
Technical Approach - Calibration

- Training
  - Collect “training” images of laser pattern on normal plane at known distances ranging from 12cm to 19cm
  - Identify each laser point in all training images
  - Determine how center point and radius of each laser point varies with distance of plane
- Testing
  - For new “test” images, identify each laser point then consider center point location and radius to estimate distance (linearly interpolate between training image distances)

Mechanical Fixation

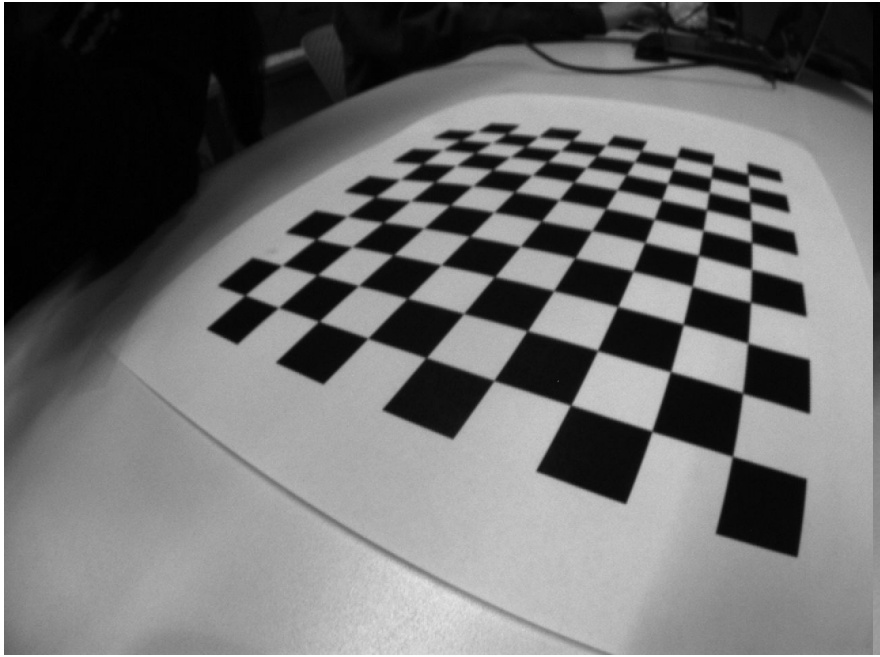
Current Setup

Final Setup

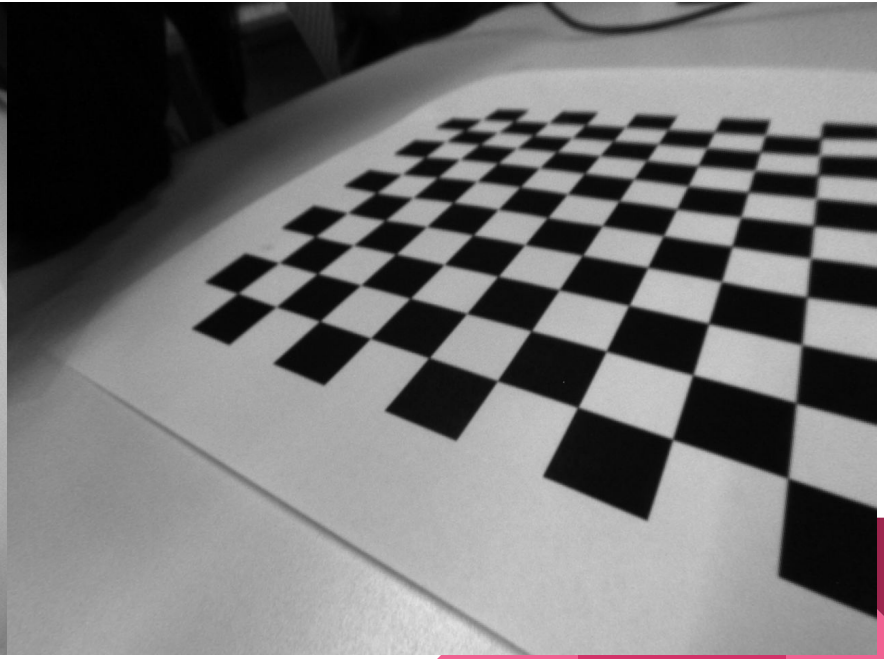


Camera Calibration & Distortion Correction

Original

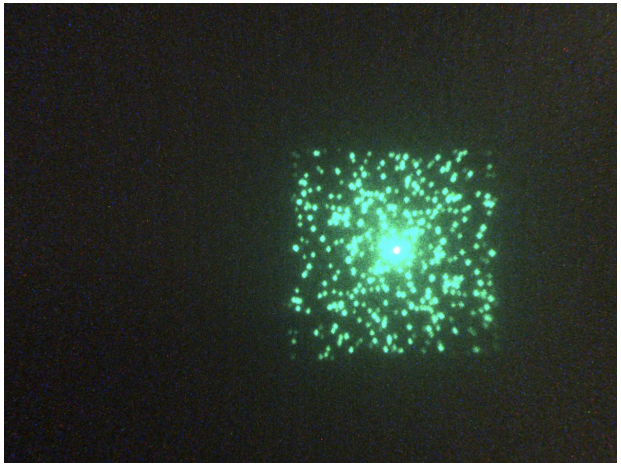


Distortion Corrected

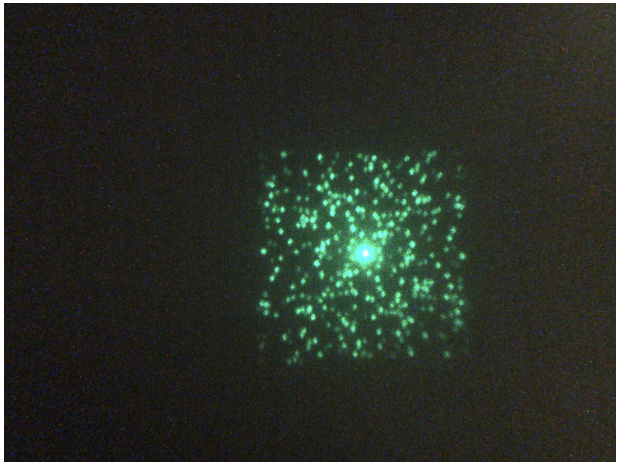


SampleData

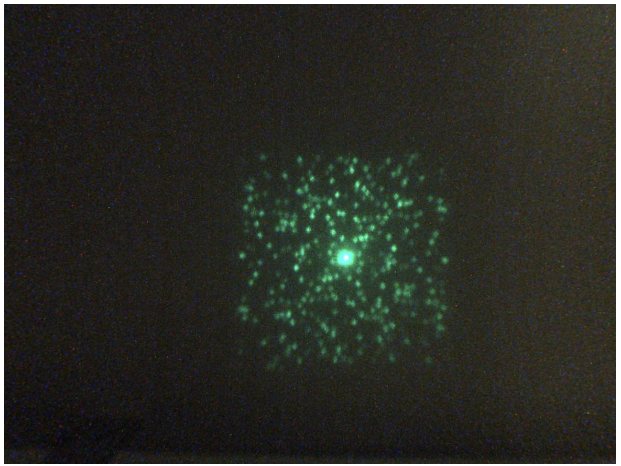
12cm



15cm

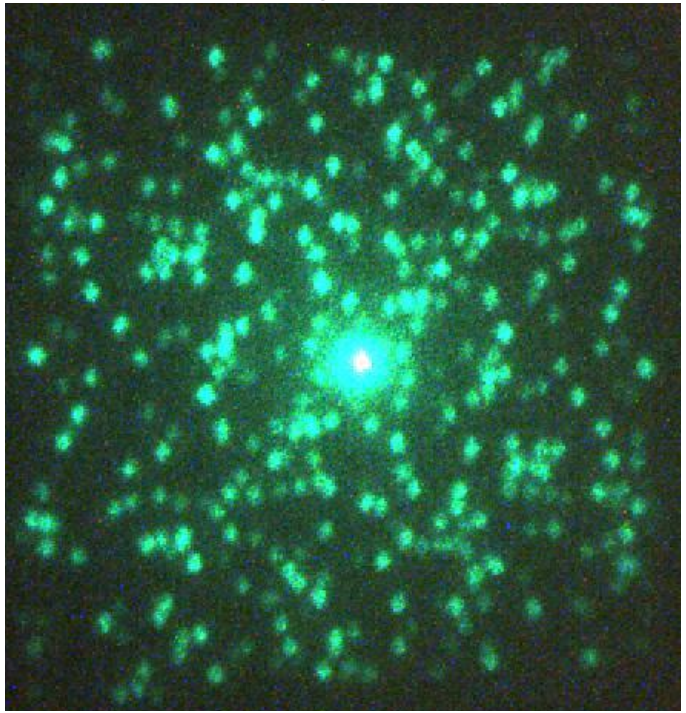


19cm

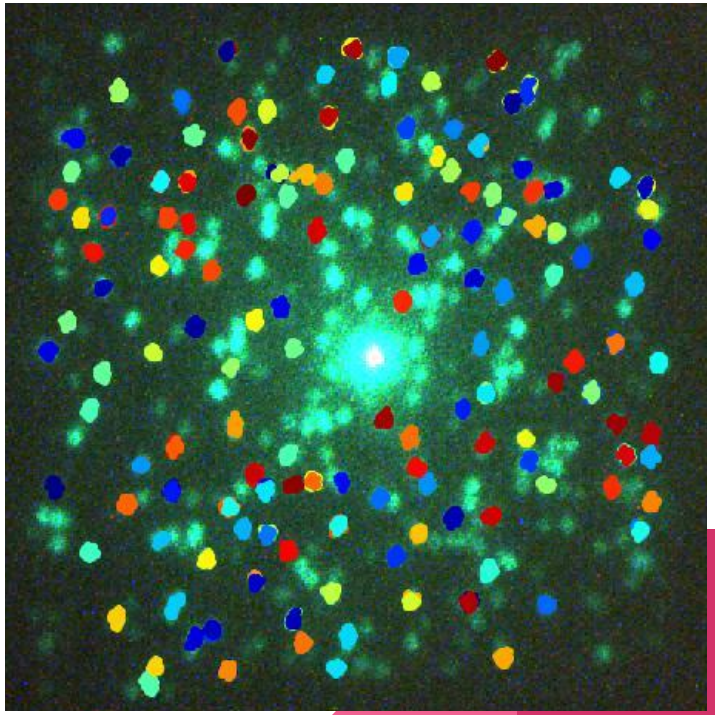


Segmenting Laser Points

Original



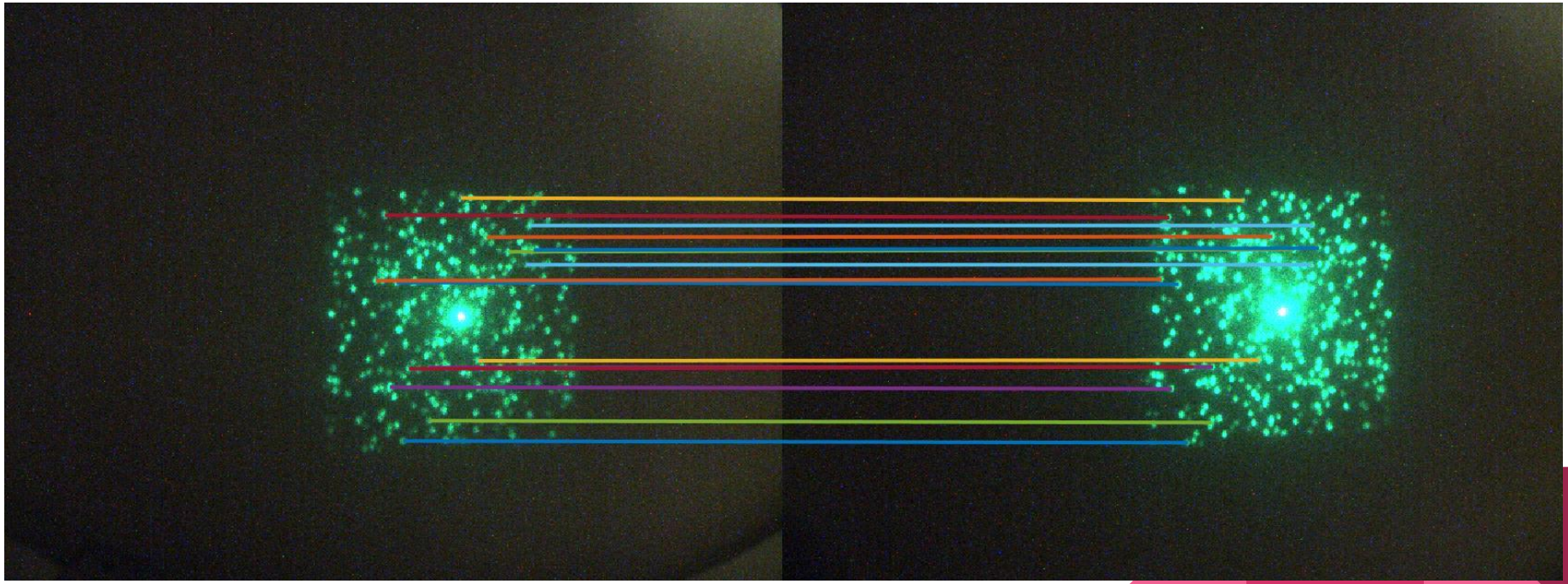
Labeled Laser Points



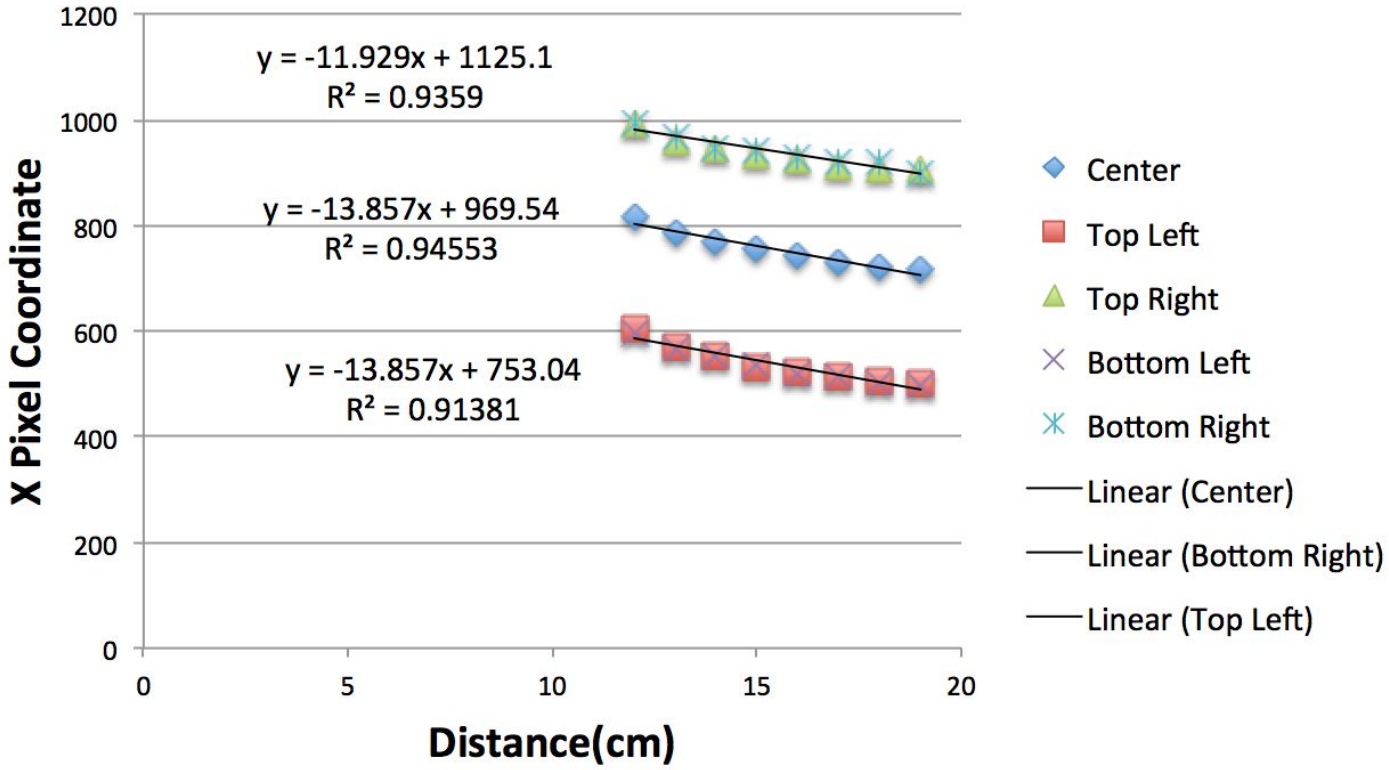
Matching Laser Points

15cm

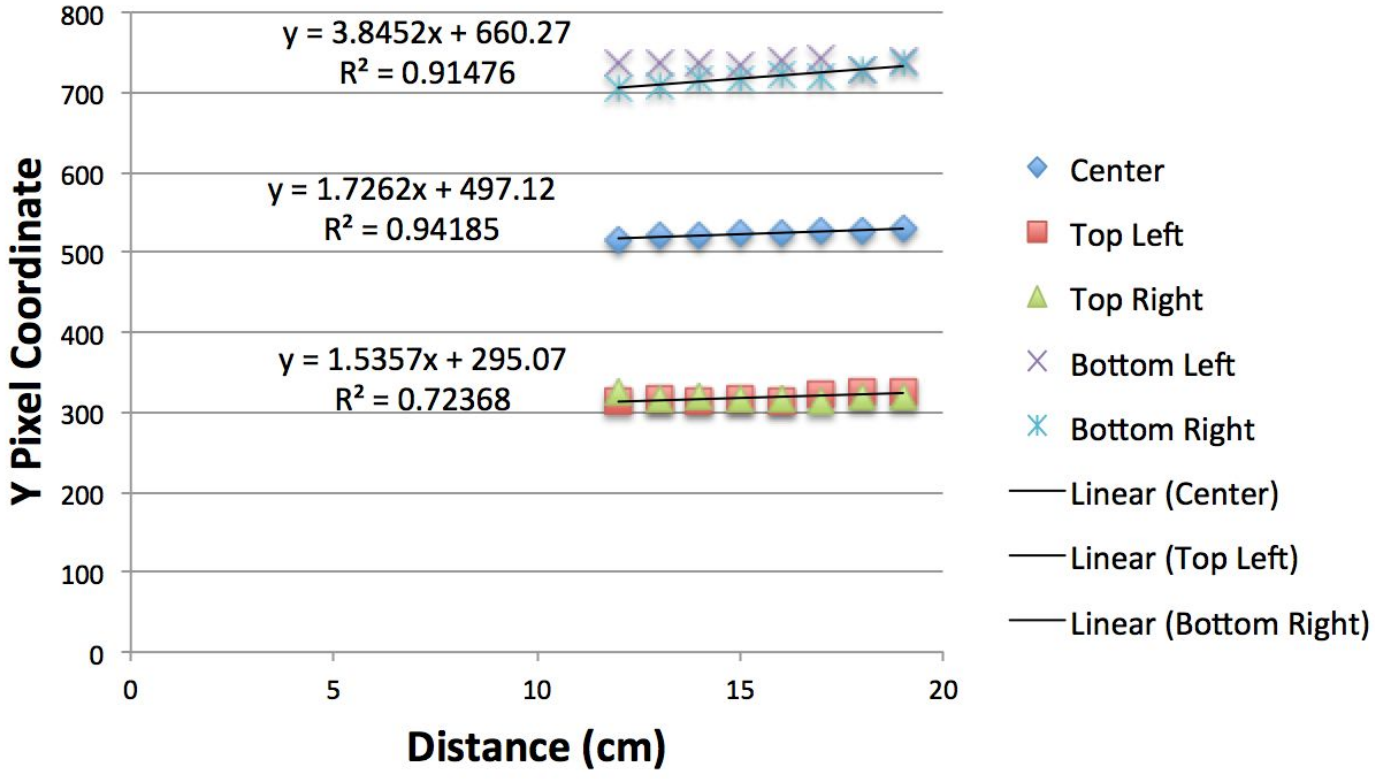
12cm



Initial Results for X Coordinate



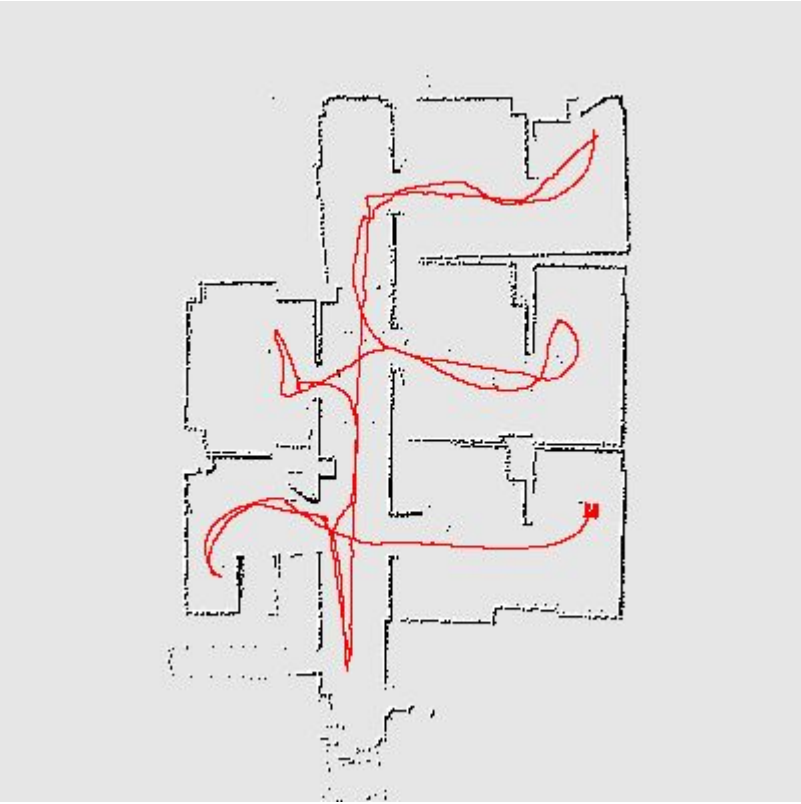
Initial Results for Y Coordinate



Calibration Testing Plan

- Collect “test” images at known distances and verify that our distance estimate is correct for:
  - Normal plane
  - Irregular surface
  - In varying lighting conditions
  - Against red background

Planned Approach for 3D Reconstruction



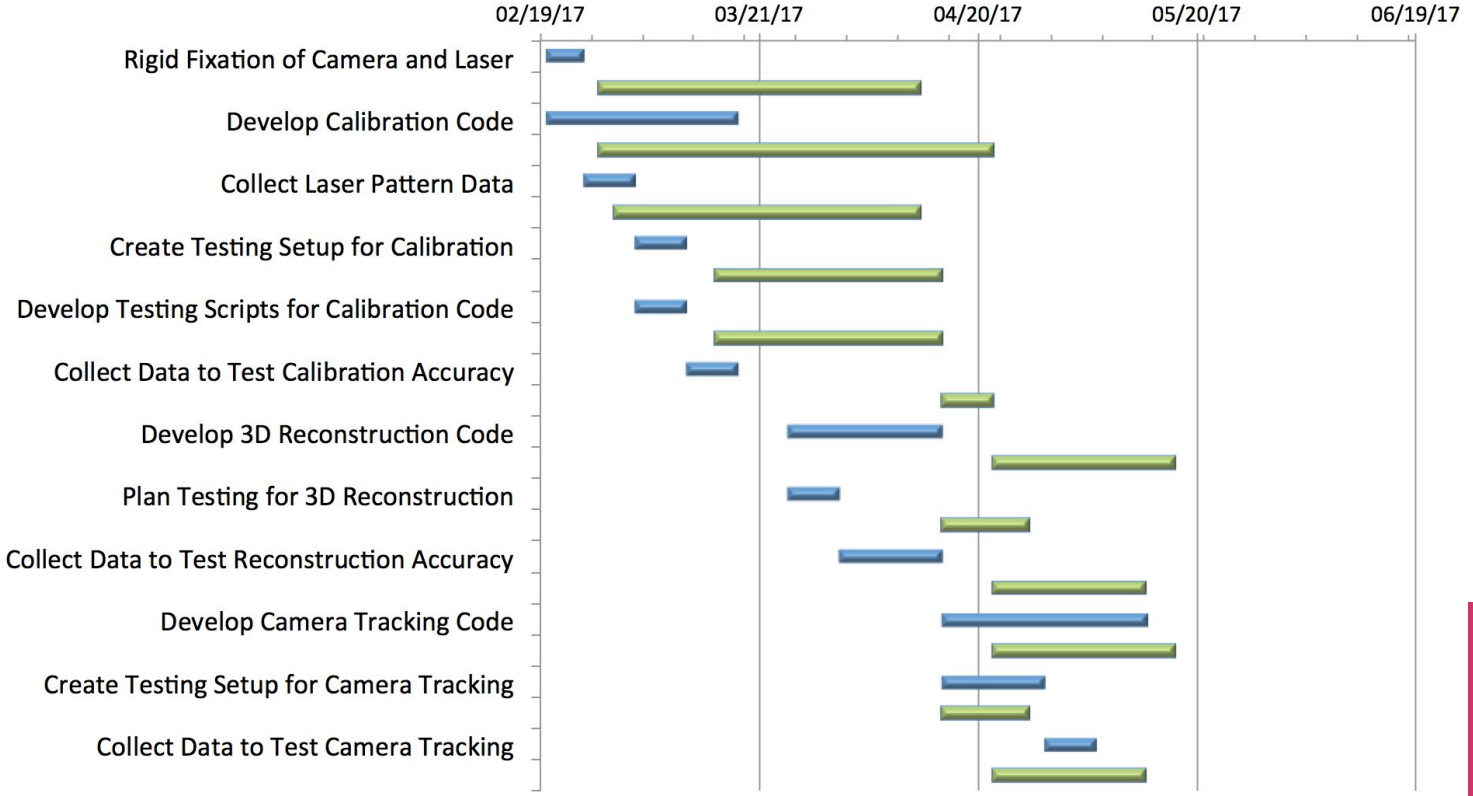
- Need to move camera to collect images for 3D reconstruction
  - Need many images because of sparse laser pattern
- SLAM (simultaneous localization and mapping)
  - BreezySLAM for MATLAB
- Test on simple and complex objects

Updated Deliverables

- Minimum
  - Rigid fixation method of camera to laser
  - Template for laser pattern in appropriate coordinates relative to camera
  - Code to compute depth map for camera's field of view**
- Expected
  - Code to create 3D reconstruction of simple objects and track camera movement relative to static scene**
- Maximum
  - Code to create 3D reconstruction of complex objects and track camera movement relative to static scene**

**Includes testing to verify mm accuracy

Updated Timeline



Obstacles

- Positioning of laser relative to camera and camera parameter settings
  - → Resolved
- Laser pattern dots detected are not always unique
  - Need efficient way to determine if MSER regions are overlapping significantly
- Matching laser pattern dots
  - Sparse laser pattern precludes window matching, need to match individual laser points
  - Radius varies with distance so cross-correlation ineffective
  - → Identify laser pattern dot by position relative to rest of pattern

Dependencies

Dependency	Plan for Resolving
Obtaining Tae Soo Kim’s prior work	Resolved
Obtaining calibration code	Not needed
Reliable fixation method for camera and laser	Will be resolved by 4/12
SLAM depends on calibration	Calibration code almost complete
Development of testing setup	Work with Dr. Taylor

Questions?