Vision Based 3-D Shape Reconstruction of Flexible Manipulators from Multiple Images

CS543 Spring 2016 Project

Guoyong Li, Zheng Li and Naveen Kumar Uppalapati

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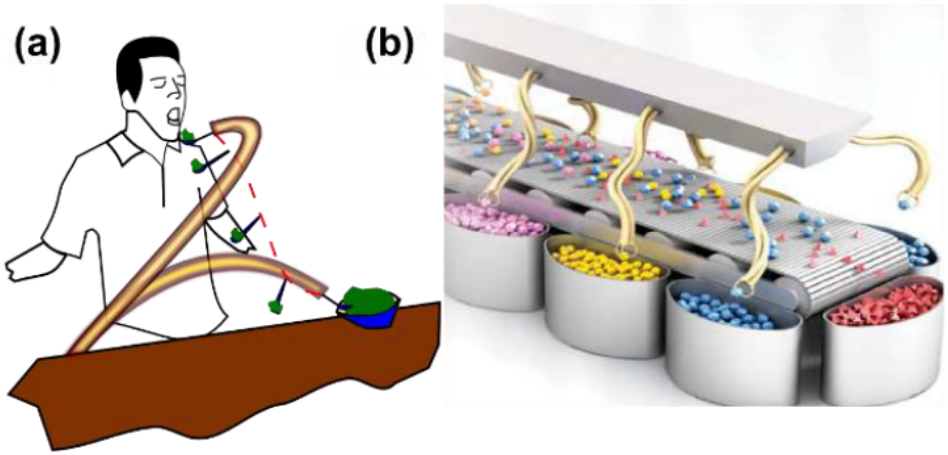
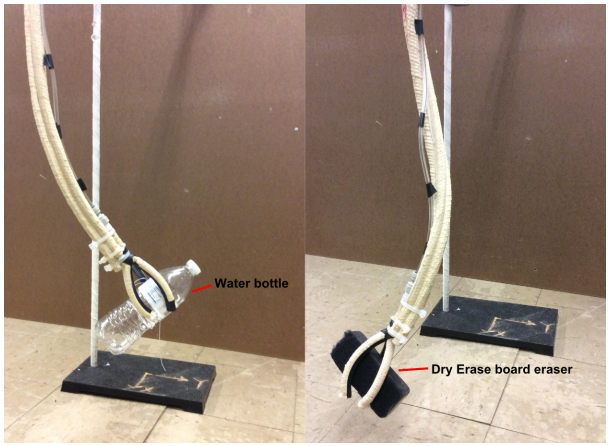
Motivation

- Continuum manipulators major limitation – **sensing**
- Few sensors developed – dependent on inaccurate models of the manipulator.
- Vision based sensing to get the shape of the manipulator.



Assistive feeding and human safe automation



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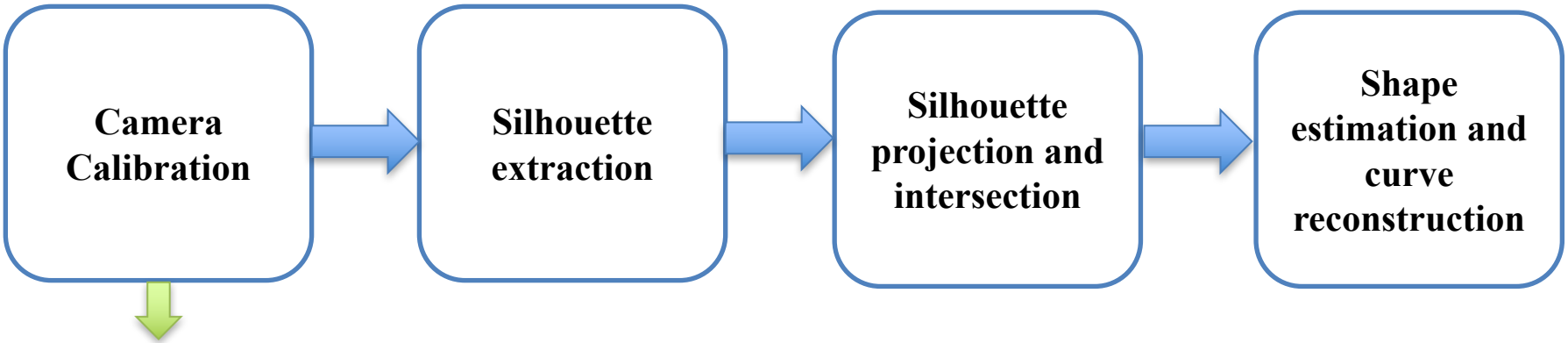
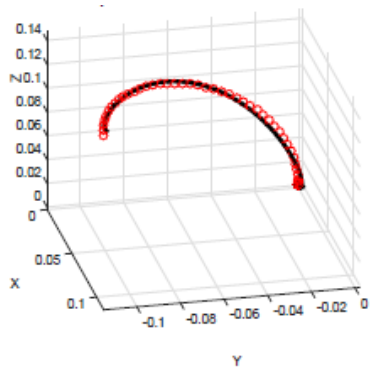
Shape Sensing Algorithm

- Uses shape from silhouette technique.





Synthetic data results

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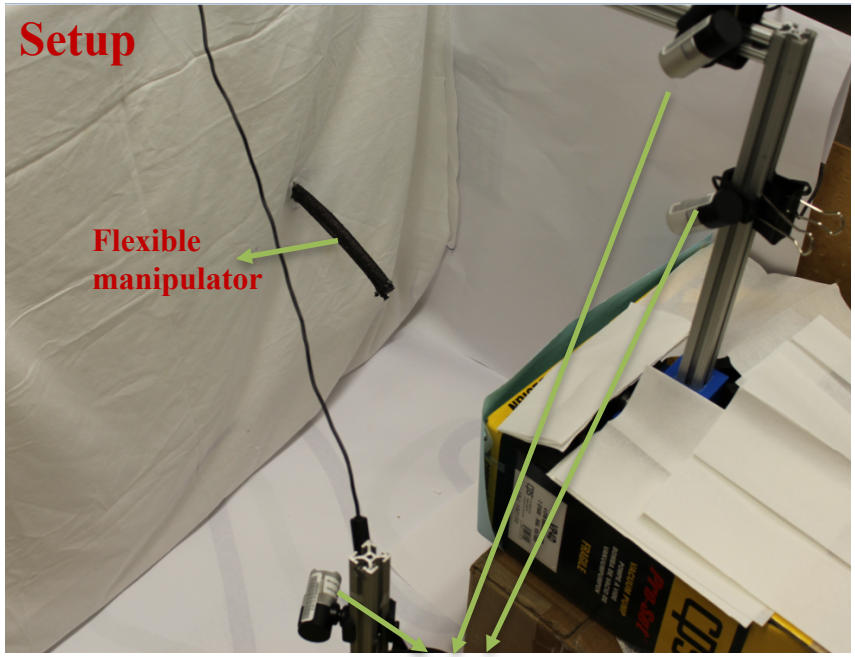
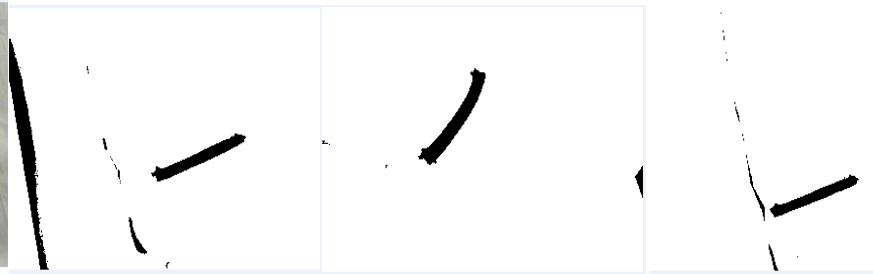
Camera Calibration and Silhouette extraction

- Used Matlab Single Camera calibration toolbox.
- Method to fix common world center for three cameras.
- Silhouette extracted by converting to a binary image.
- Resolution- 320x240



Microsoft lifecam studio webcam

Captured images



Extracted silhouettes

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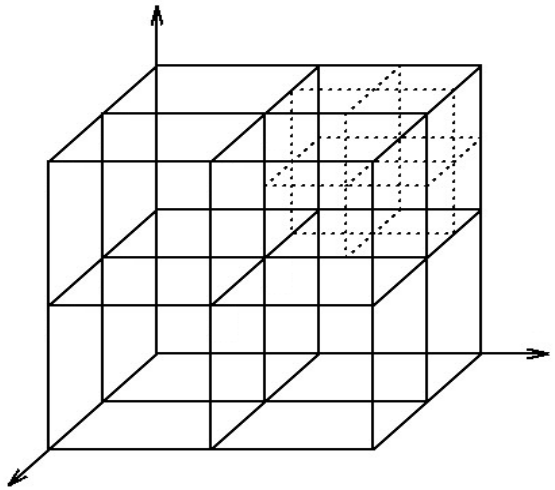
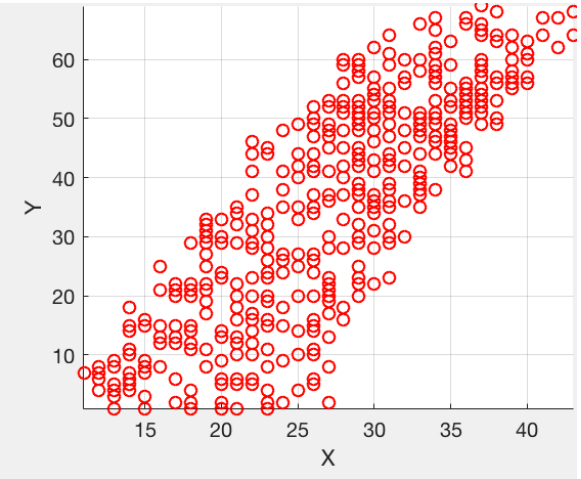
Point cloud from Silhouette intersections

- Divide the space into a cube
- Dimensions – 256x256x256
- Check the surface layer of a big cube before calculate a small cube





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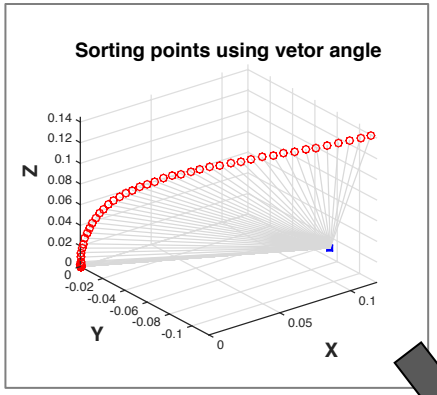
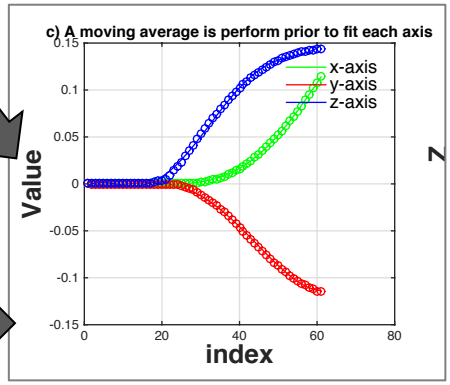
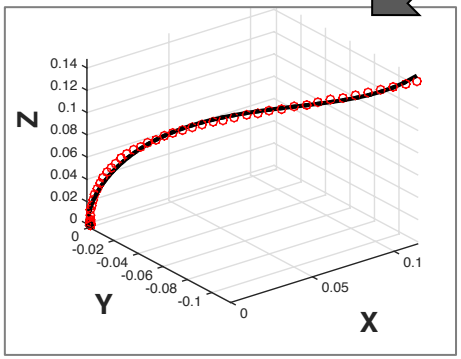
Shape estimation and Curve reconstruction

- Sphere fitting
  - Each point will be represented as **vector** using angle corresponding to a referenced vector
- Re-order point cloud (based on angle)
  - Relationship between axis **Index** ~ axis **Value**
- Fitting points as polynomial relationship between each axis
  - Reconstruct the spatial curve from ***f*(*Index*)~*Value***







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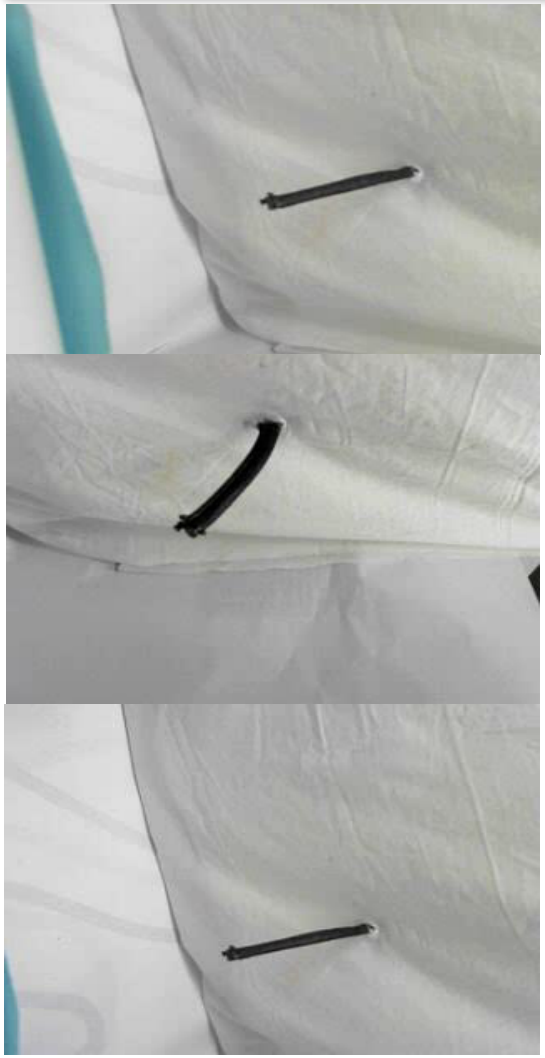
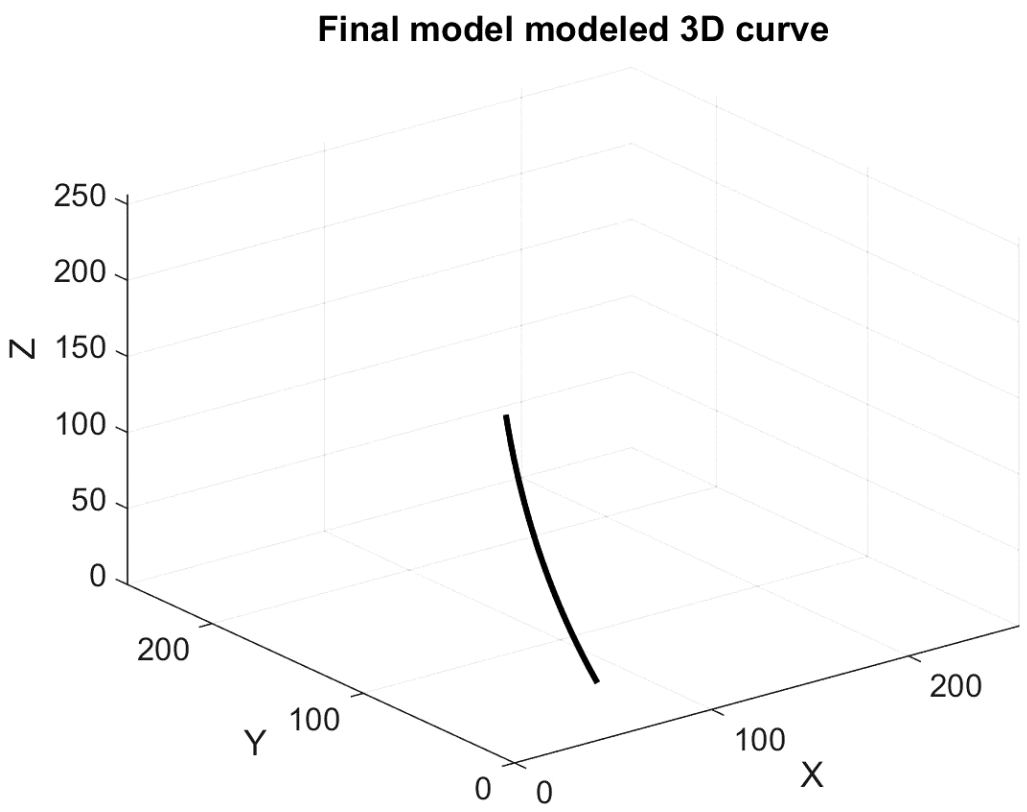
Results





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Improvements

- Capture rate: 30 frames/sec
- Reconstruction time per frame : 53 seconds
- 160 frames ~ 142 minutes
- Working on reducing this reconstruction time to try to make it real time.
- Error analysis

References

- Camarillo, David B., Kevin E. Loewke, Christopher R. Carlson, and J. Kenneth Salisbury. Vision based 3-D shape sensing of flexible manipulators. In Robotics and Automation, 2008. ICRA 2008. IEEE International Conference on, pp. 2940-2947. IEEE, 2008.
- Krishnan, Girish, Joshua Bishop-Moser, Charles Kim, and Sridhar Kota. "Kinematics of a Generalized Class of Pneumatic Artificial Muscles." Journal of Mechanisms and Robotics 7, no. 4 (2015): 041014.
- Trivedi, Deepak, Christopher D. Rahn, William M. Kier, and Ian D. Walker. "Soft robotics: Biological inspiration, state of the art, and future research." Applied Bionics and Biomechanics 5, no. 3 (2008):99-117.