Tool Localization for Robotic Manipulation

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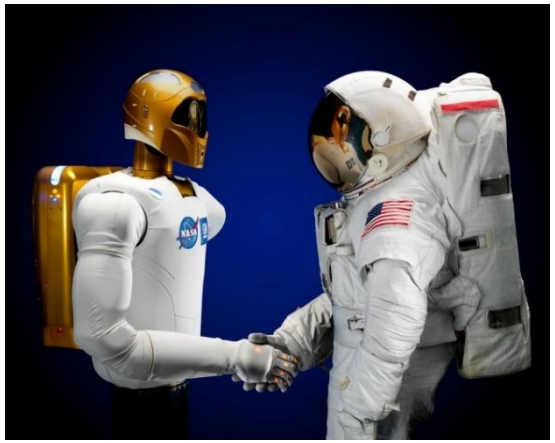
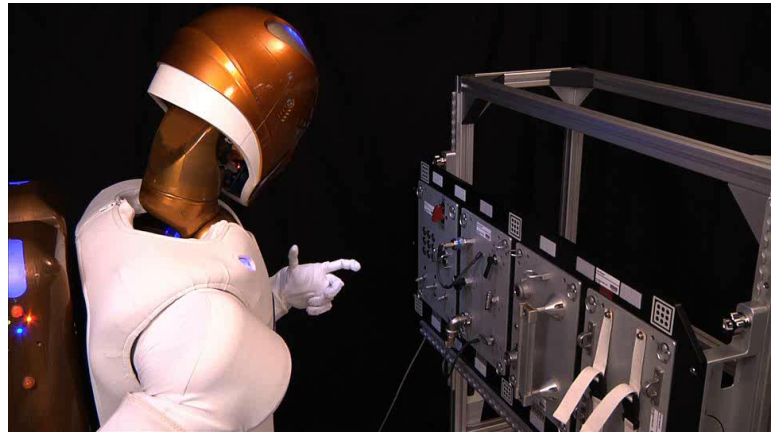
Background – Robonaut2

- Started in 2007 with GM
  - Leveraged Robonaut 1 technology
  - Launched R2B to ISS in 2011
- Common goals
  - Use humans' tools
  - Safety share humans' workspace
  - Do physical work
    - interact with the environment in meaningful ways
- Future objectives
  - Improve command modalities (speech, vision processing, haptic feedback, command interfaces)
  - Use model-based learning to quickly expand robotic capabilities (**identify tools, manipulation**)
- In order to create a useful robotic system, the robot must interact with tools
- To ***interact*** with a tool, the robot must first ***find*** the tool





Vision Pipeline Overview

Segmentation

- Break the input into smaller meaningful chunks
- Separate the foreground from the background, etc

Classification

- Identify what the chunks are, and what is important
- “Classic” techniques – local features like SIFT, SURF, etc.
- More modern Techniques - Deep Learning
  - Some DL techniques can simultaneously do **segmentation** AND **classification**

Localization

- Once you know ***what*** you are looking at, you need to know ***where*** is it in the environment
- Stereo pair, LIDAR, Depth Cameras, etc

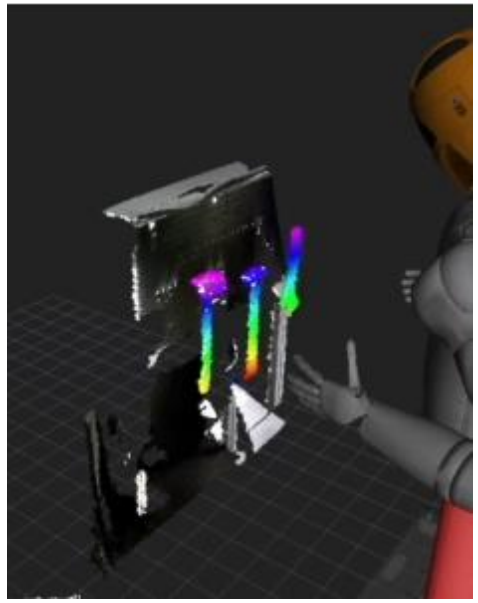
Segmentation and Classification

Segment Cloud into clusters (connected components)

Transform each cluster into a 2D image

Classify each image (Google Inception / Tensorflow)

RGBD Sensor (ASUS)



???

adjustable wrench

???

rubber mallet

???

ball peen hammer

Object Selection and Localization

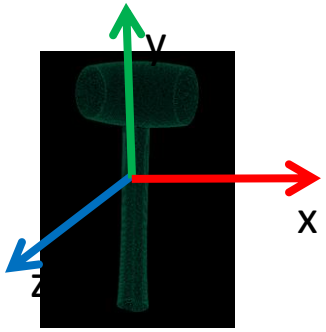
Voice recognition (Google Voice API)

Final localization using ICP

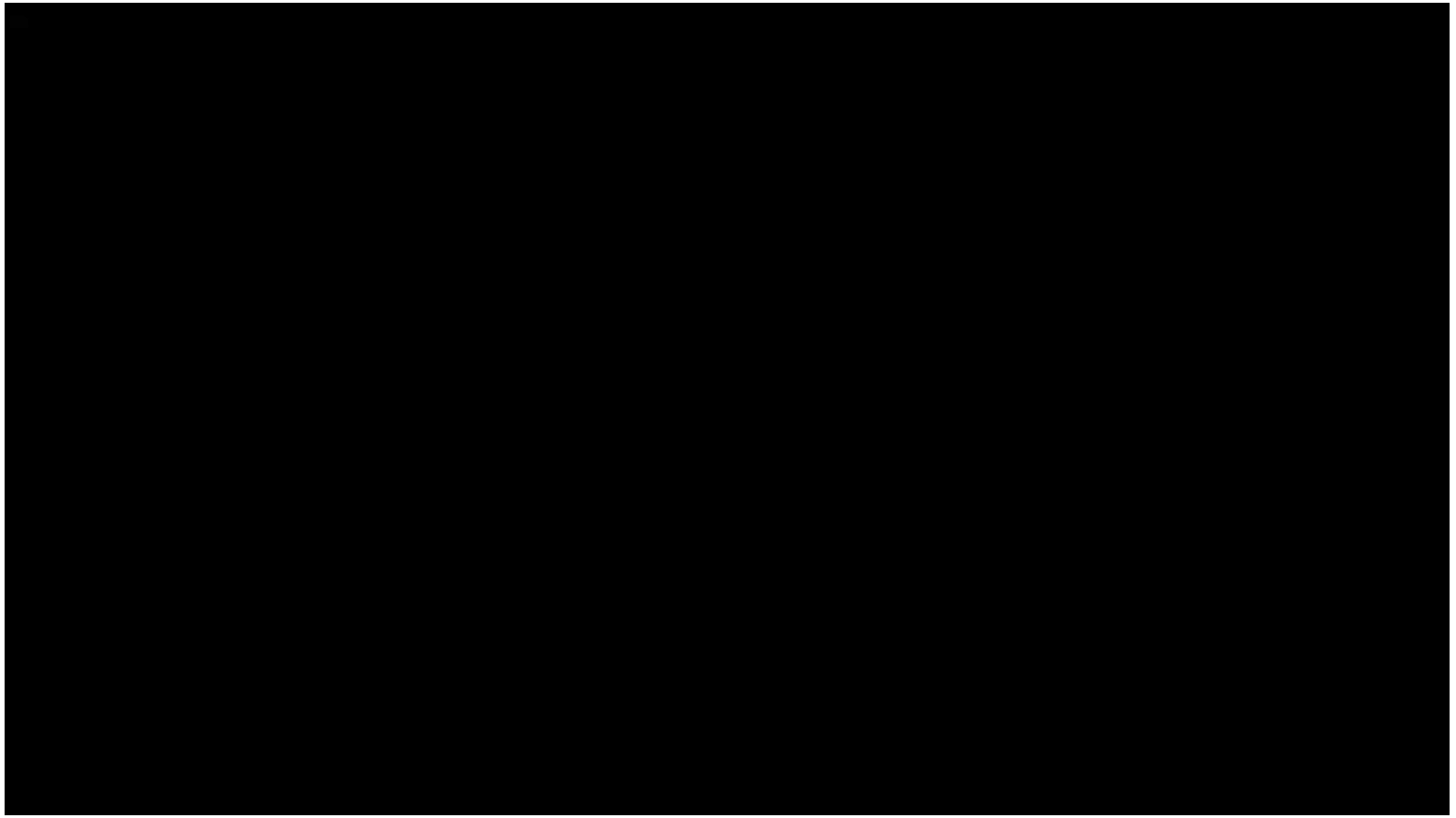
adjustable wrench

rubber mallet

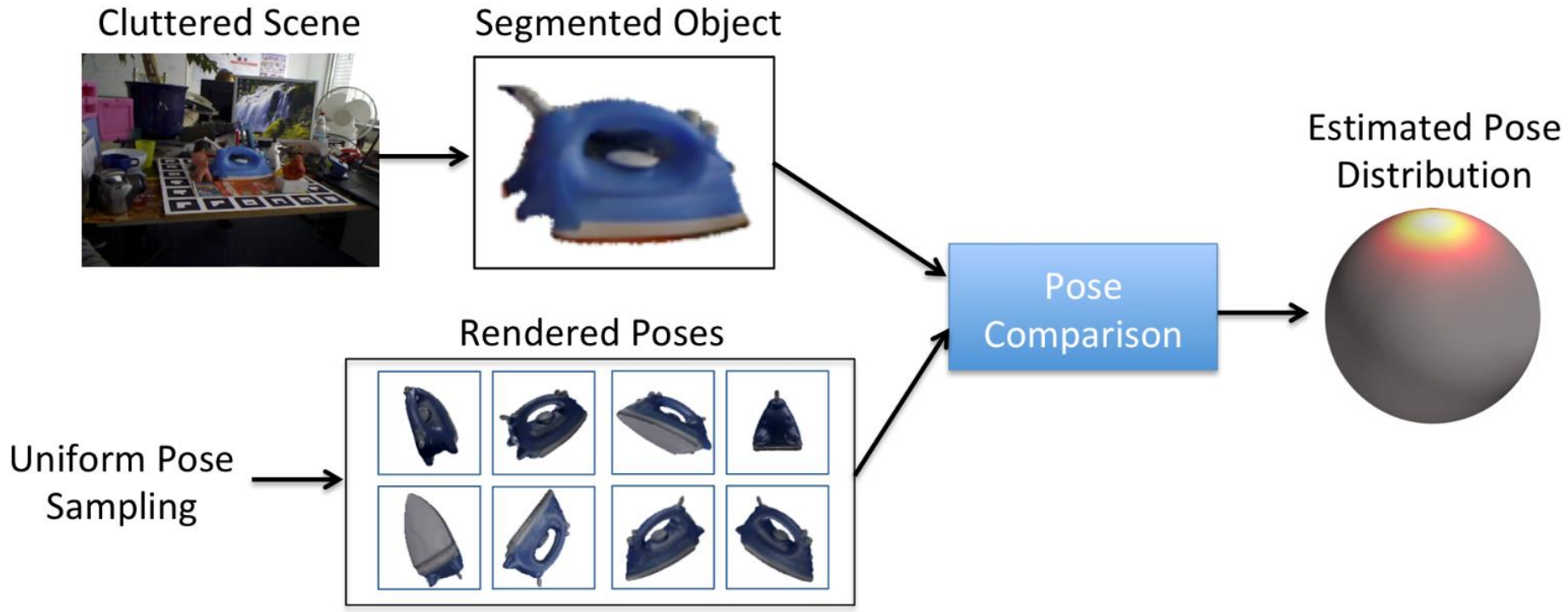
ball peen hammer



Interactive Tool Gather



Deep Pose Estimation



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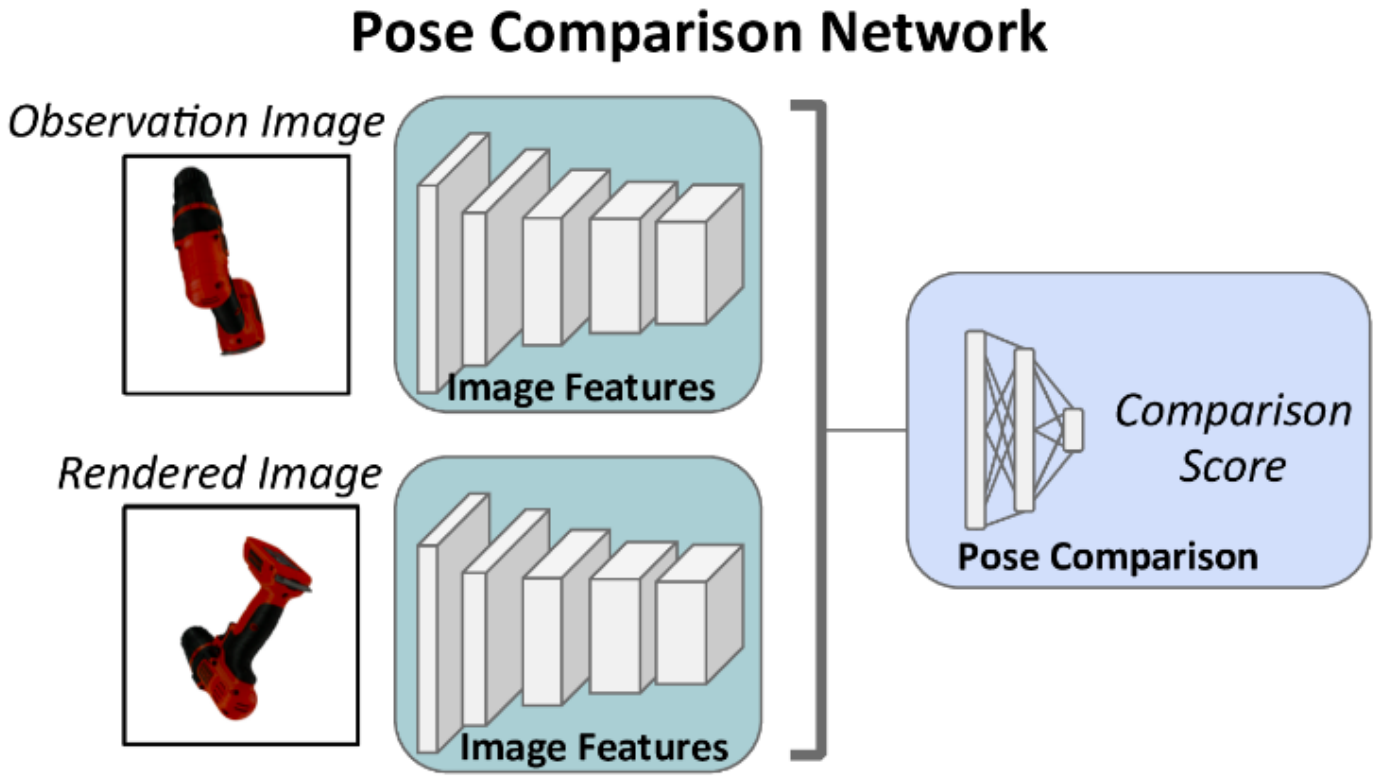
Network Architecture



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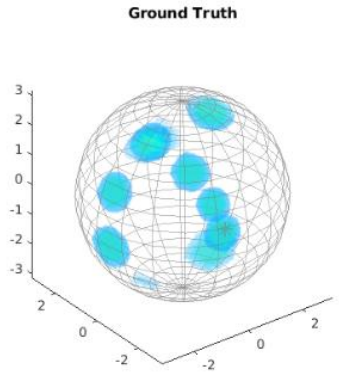
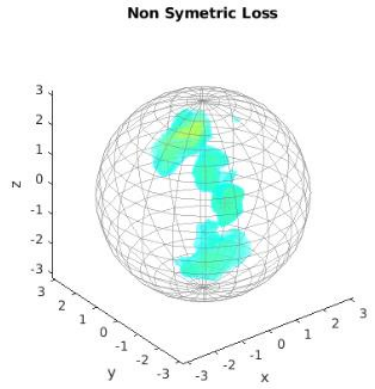
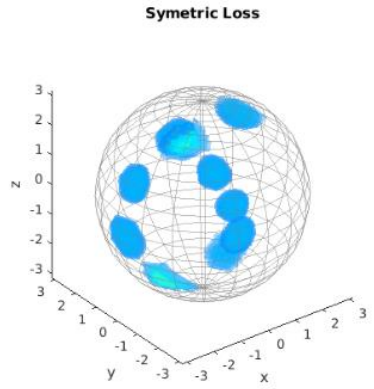
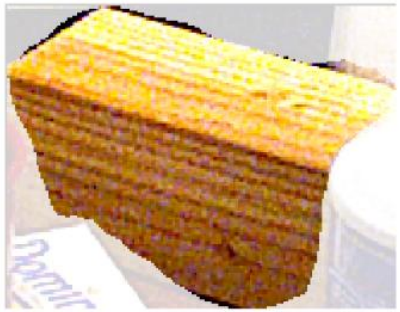
Symmetric Distributions









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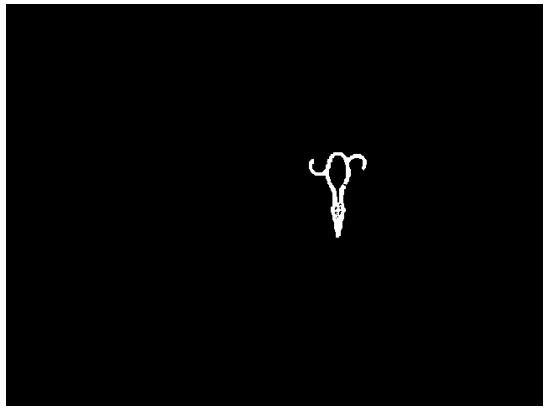
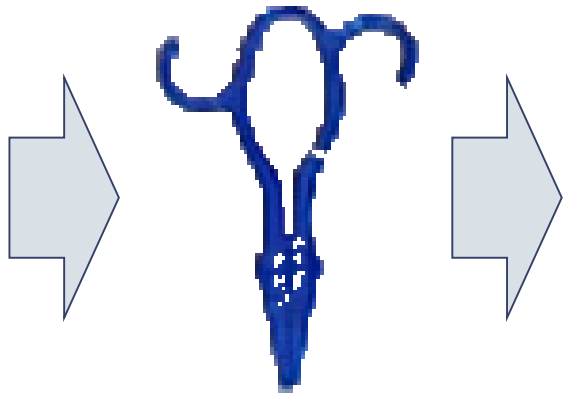
Preliminary Results





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Future Work

Surgical Tool Gathering

- Collaboration with University of Louisville to investigate identification and hand-off of simple surgical instruments
- This is part of a larger effort in how robots can assist as a medical assistant

Deep Learning pose estimation

Deep Learning for Semantic Segmentation

- Leverage advances in Deep Learning for a complete scene segmentation

Datasets

- Deep learning requires LOTS of data!
- Create / augment existing datasets with NASA-relevant data