“Kinecting” the Dots: How Bolt Sees the World

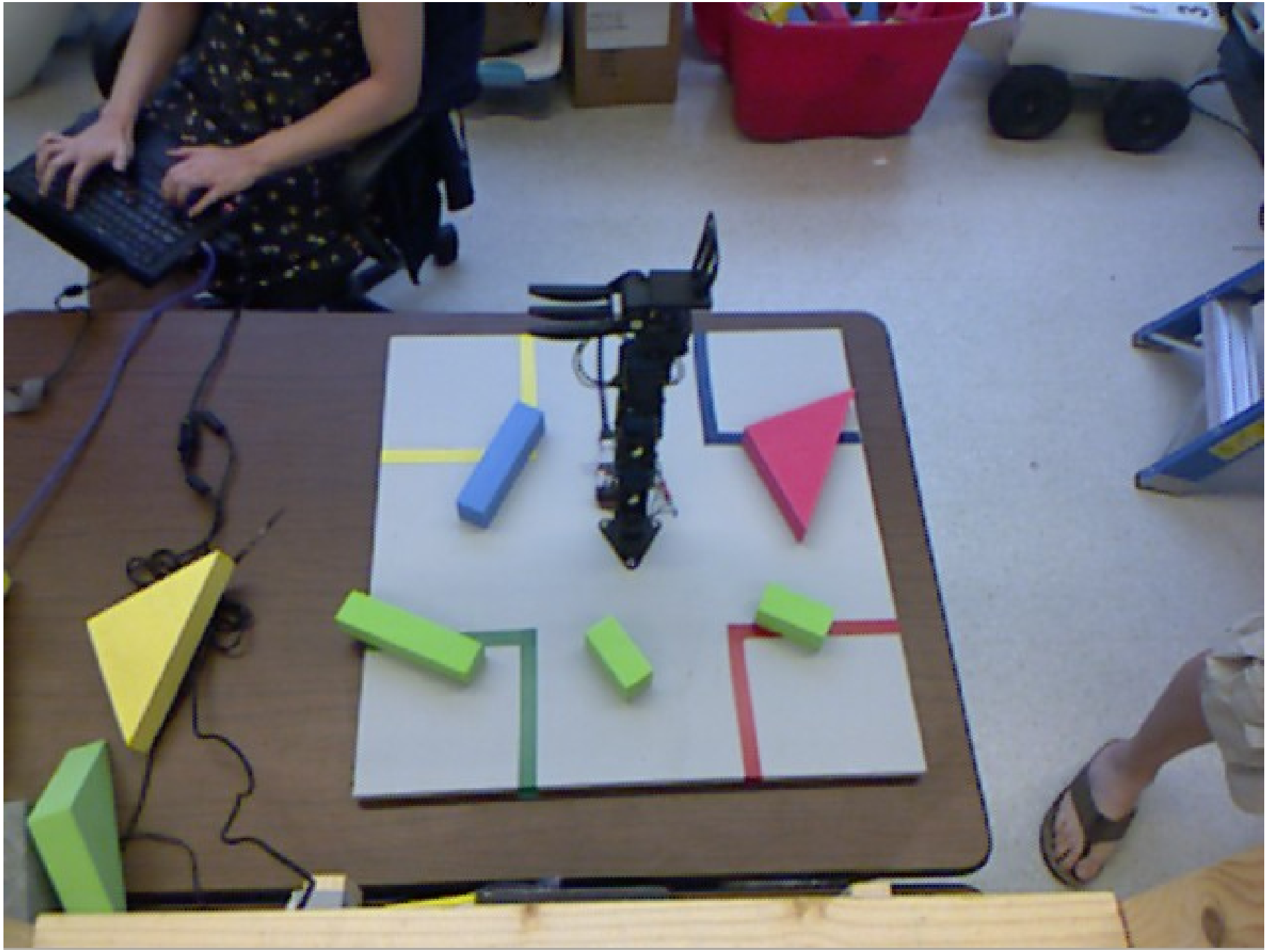
Rob Goeddel

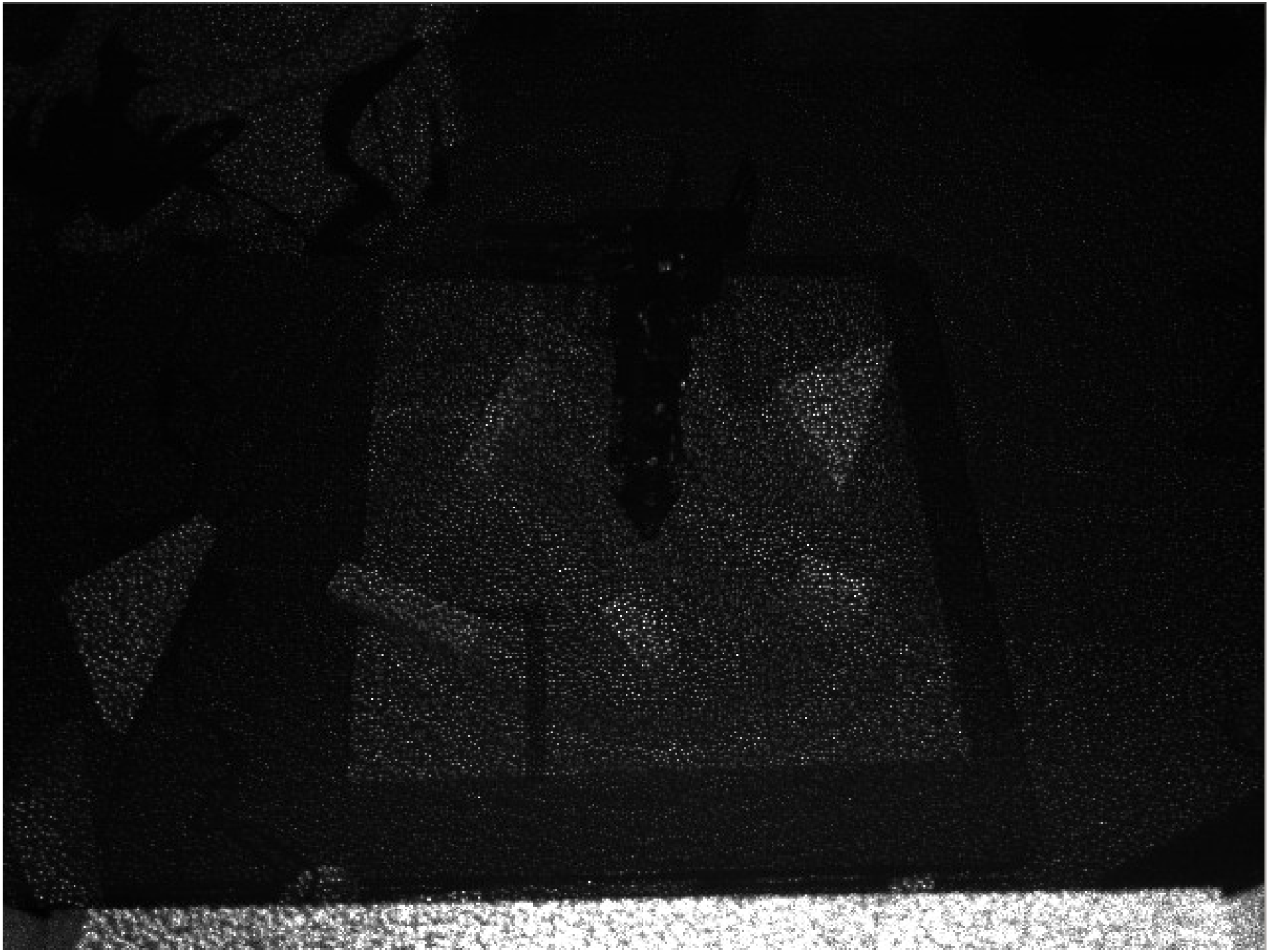
Overview

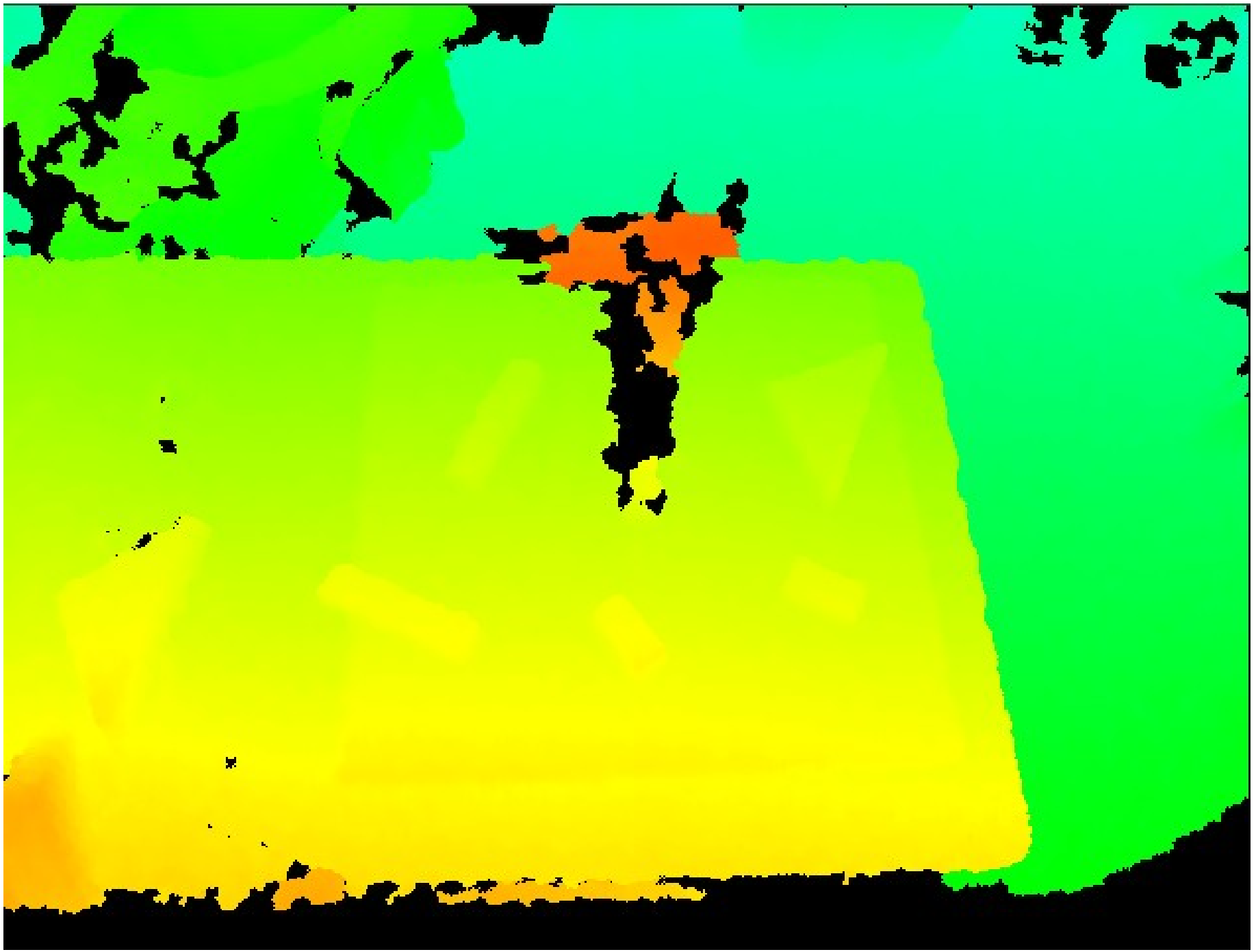
- Sensing the environment
- Interpreting the data
- Classifying objects
- Interacting with the environment

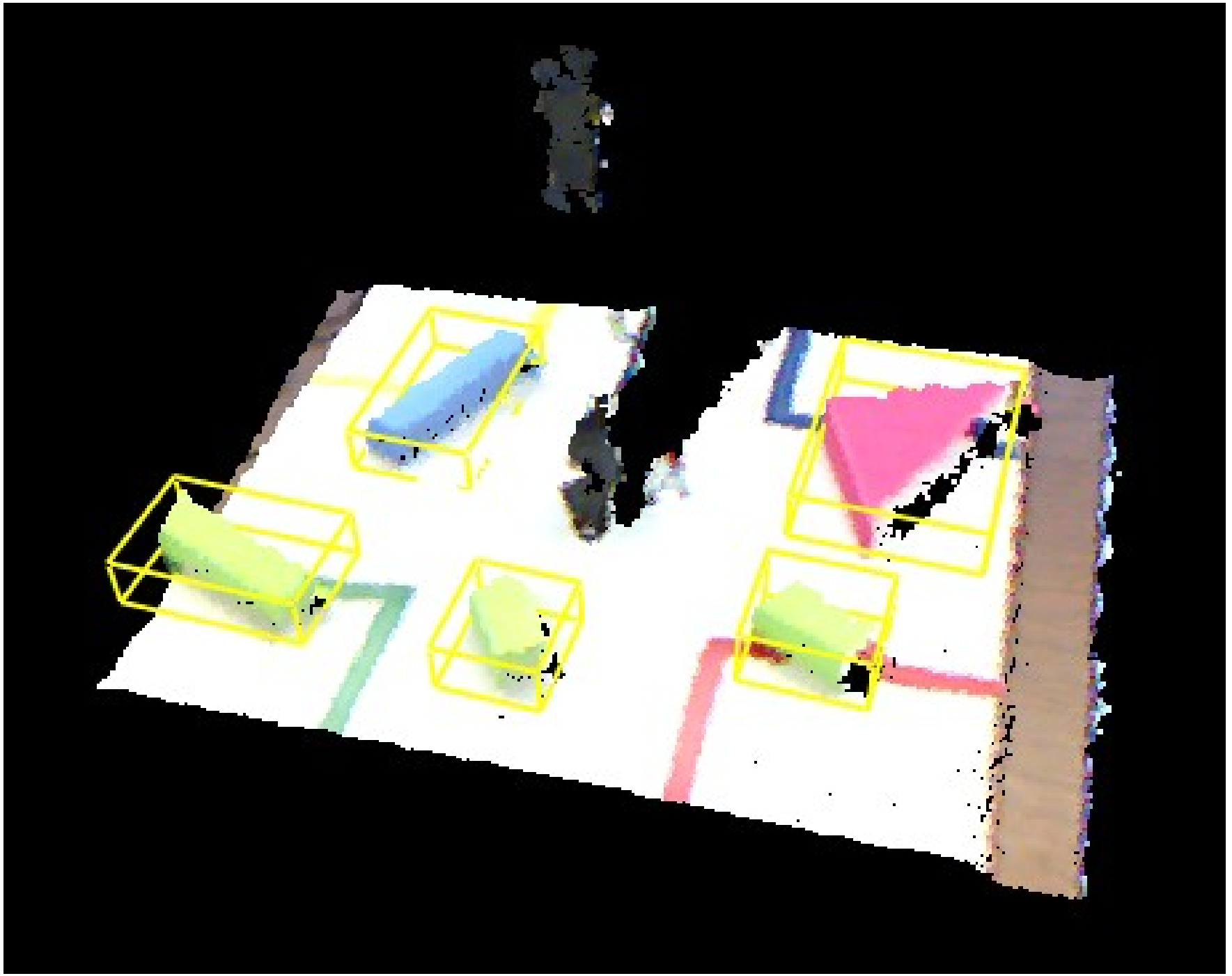
Sensing the Environment

- Kinect offers cheap RGB-D data
  - Fast (up to 30 Hz)
  - Open source support
- Returns a color 3D point cloud
  - Typically 500-1500 points per object



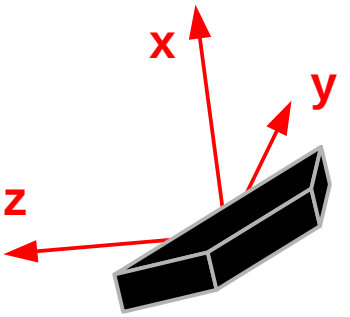


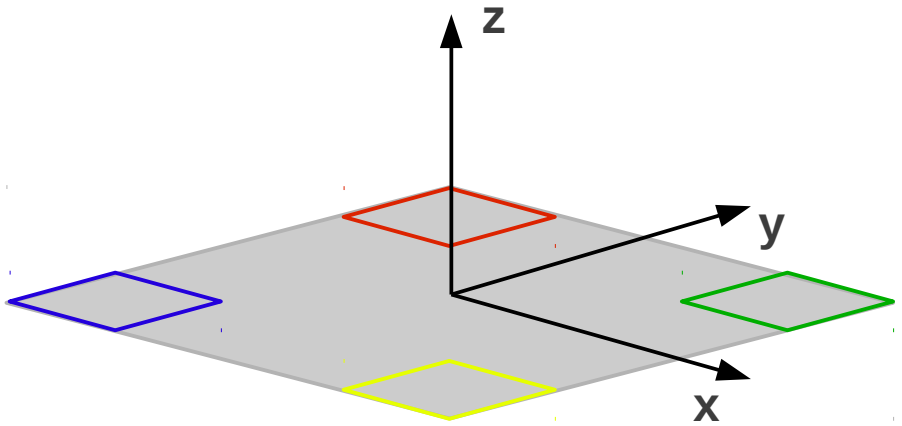




Sensing the Environment

- Kinect elevated beside workspace
- Quick calibration to align Kinect data to our world coordinates



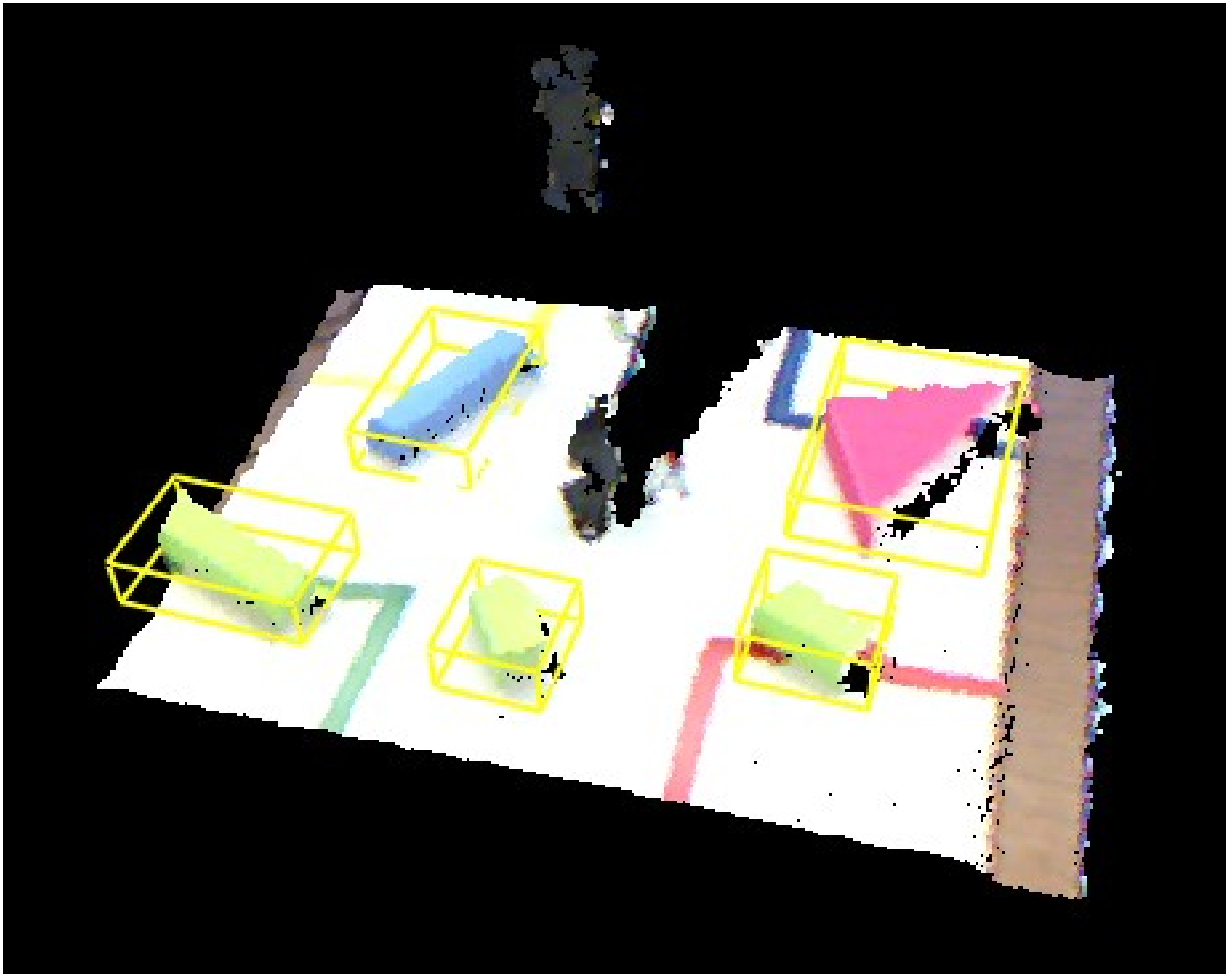


Interpreting the Environment

- Need to identify objects in the environment to
  - Describe them
  - Interact with them
  - Track them over time
- Segmentation based on color and distance separating points
  - Assumes solid color objects

Segmenting the Data

- Use RANSAC to fit floor plane
- Throw away points in/below the floor
- Cluster remaining points based on
  - Distance apart
  - Color similarity



Tracking the Objects

- Object tracking important for reasoning and action in the environment
  - Allows Soar to store persistent state
  - Soar and robot system can communicate about objects based on shared IDs
- Must be robust to being occluded by our own movements in the environment

Tracking the Objects

- Between frames
  - Match objects to objects from previous frame and short-term memory based on color and location
- If no object match is found for a new object, create a new ID
- If no object matches an object from the previous frame, store in in short-term memory
  - Allows us to deal with short occlusions

Classifying Objects

- Given point clouds for objects, we can extract features and classify them
- Currently classifying 3 categories
  - color, shape, size
- Human “instructor” supplies training examples, identifying an object and the applicable labels

Classification

- Classification via *k*-nearest neighbor (KNN)
  - Generalizes well to multi-class problems
  - No training time between examples
- Gaussian weighting discounts bad training examples

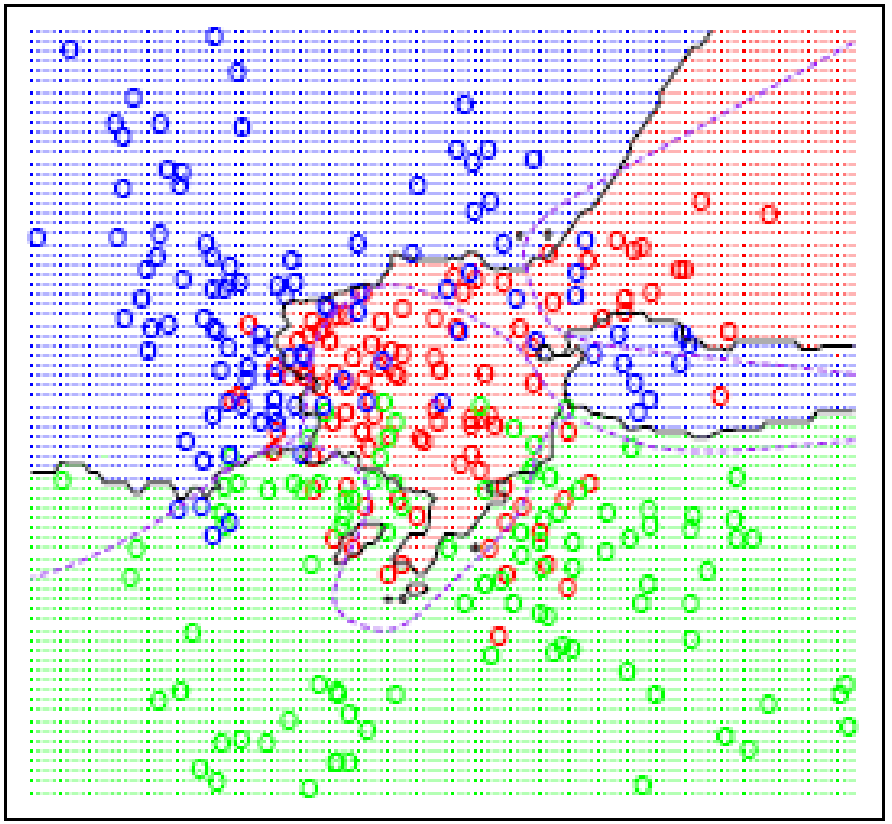
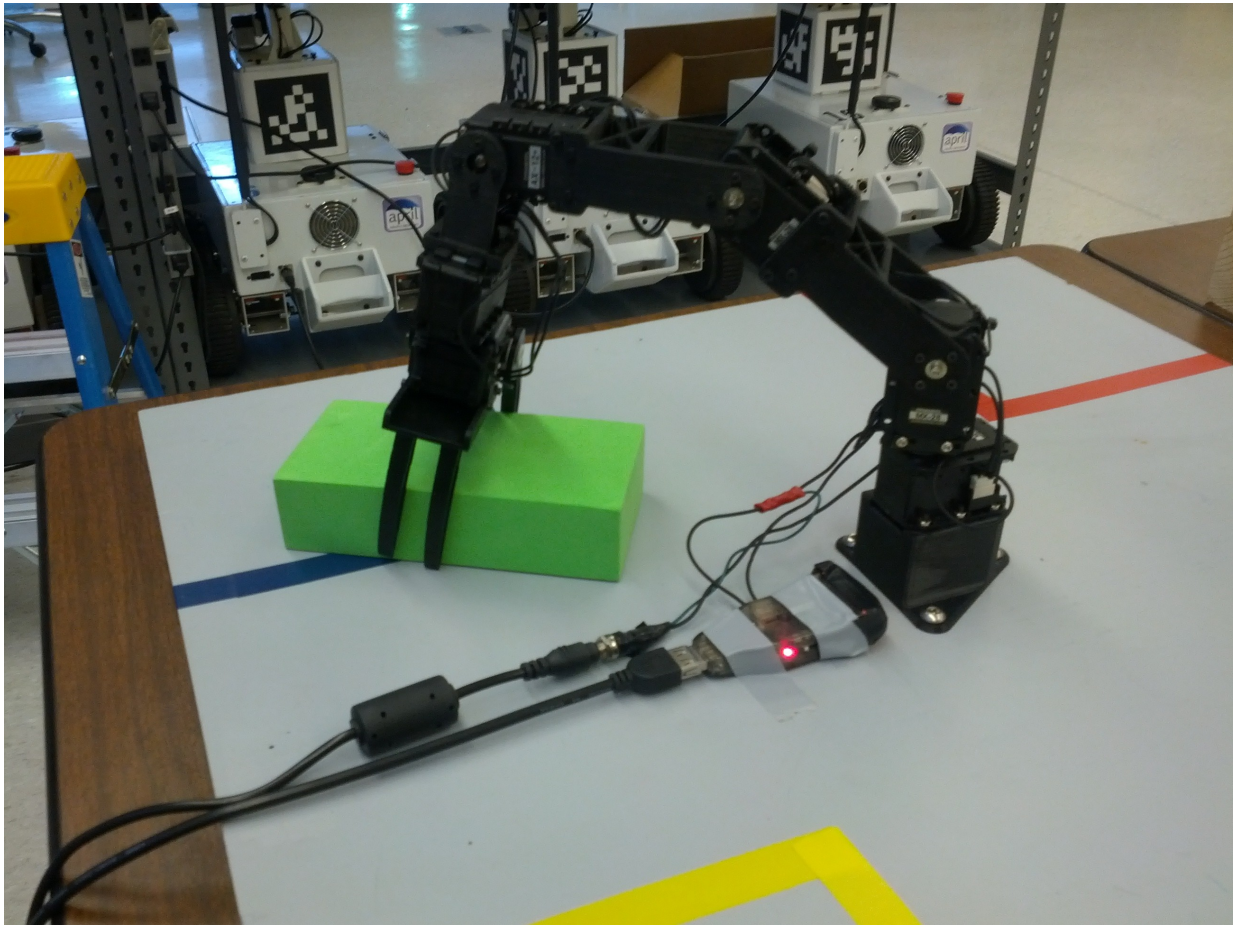


Image courtesy of Penn State University

Interacting with the Environment



Interacting with the Environment

- Robotic arm gives us manipulation capabilities
- Simple arm geometry allows for closed-form inverse kinematic solutions
- Arm executes several loosely scripted actions
  - POINT, GRAB, DROP

System Overview