Human Robot Interaction: Machine Vision and End Effector Control

Aresty Research Center for Undergraduates

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Motivation

- **Human-Robot Interaction** studies the interaction between humans and robots in a wide spectrum of environments.
- It is a multidisciplinary field that lies in the intersection of **artificial intelligence, robotics, computer vision, design and social science.**

Figure 1. The current spectrum of Robotics from Industrial Robots (left) to handheld robots (right).

- Governed by Isaac Asimov's **Three Laws of Robotics:**
  - A robot may **not injure a human being** or, through inaction, allow a human being to come to harm.
  - A robot must **obey any orders given to it by human beings**, except where such orders would conflict with the First Law.
  - A robot must **protect its own existence** as long as such protection does not conflict with the First or Second Law.
- Initially, robots were confined to highly controlled and large scale industrial environments, **interaction with humans was minimal**. Robots can now fit the palm of our hands (Figure 1).
- As robots percolate the boundaries of human working and living environments, **precise mapping and safe motion planning** become imperative.

Problem Statement:

- Evaluate **robotic arm trajectories** that move along a collision free path as well as optimise the end effector's (hand) grasping configurations.
- **Baxter** (Figure 2A) is a popular robot, designed to work in a human's world. With a pair of dextrous arms, a 360-degree sonar sensor and a force-sensing system that allows it to avoid harmful contact with humans, it is meant to slide up next to people and toil safely alongside them.

Figure 2. A)The Baxter Robot working on a conveyer belt. B) A robotic arm collaborating with a human, while working on pharmaceutical manufacturing.

Methods

Complete System Architecture for Environment Mapping and Object Grasping

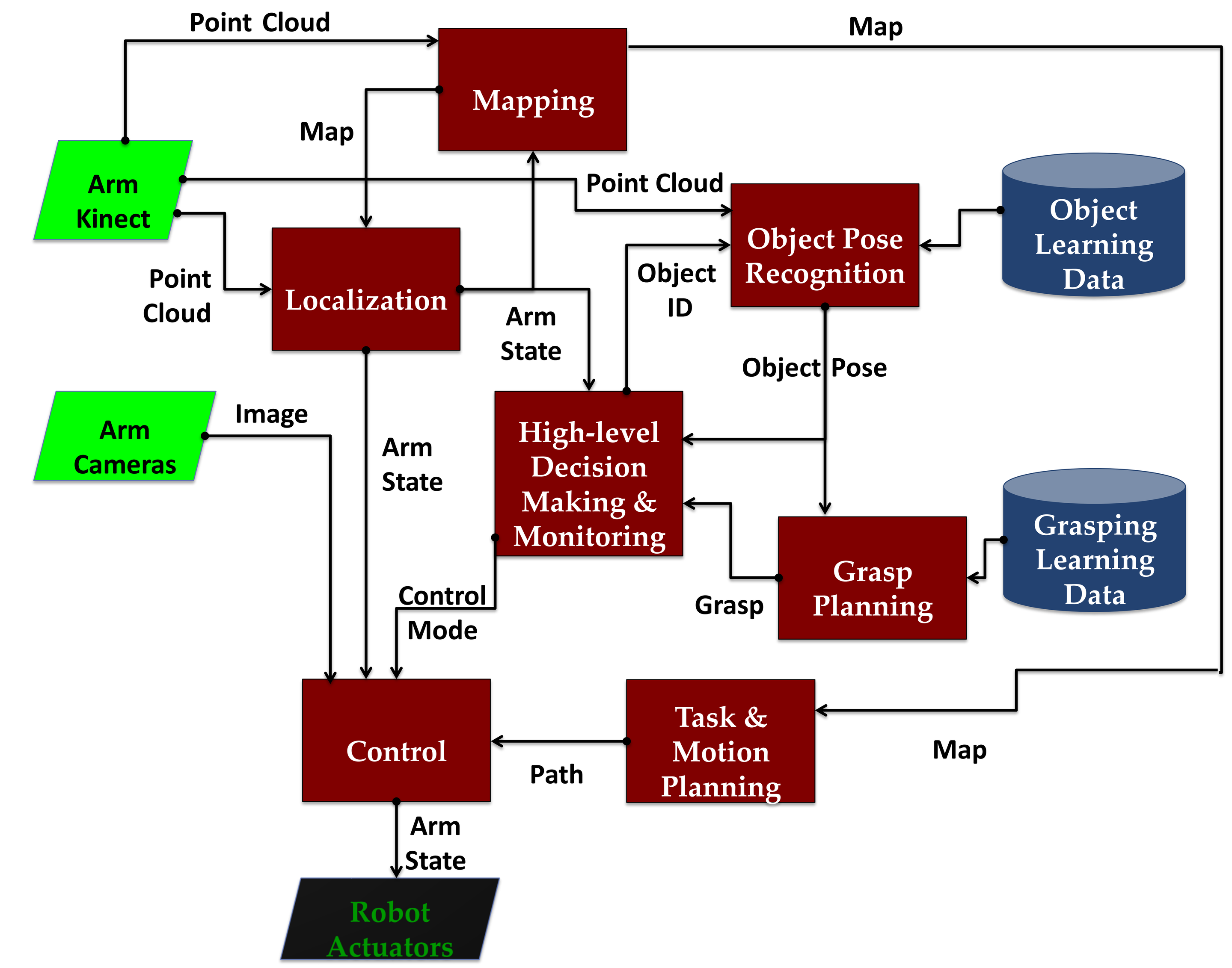

Figure 2. The diagram represents the control flow, starting from environment mapping to arm movements. The green boxes represent the sensors, the red boxes represent computation modules and the blue disks are the databases.

- In addition to the cameras on the wrist, we attached a **Microsoft Kinect Sensor** (Figure 3a) on the Baxter's arm.
- The Kinect's responsible for providing a **3D Point Cloud (PC)** of the environment (RGB + depth information).
- The PC is used **to map the environment and localize the position** of the Baxter with respect to the map.
- The same PC is utilized to **determine a collision free path** by detecting obstacles.
- The PC is also used to **detect objects in the environment** and recognize their pose and orientation, done by matching the object to an existing one in the database.
- Given the pose**, an optimal grasp is calculated,** keeping in consideration the type of gripper.
- The **high-level decision maker** determines which objects in the environment is to be grabbed and what is to be done with them.
- Finally, the **control module** takes as input the current arm state, the grasp configuration and a collision free path and determines the required end effector trajectory by solving an **inverse kinematics equation**.

Figure 3. A)The Kinect Sensor, B) The Vacuum Gripper and C) The Parallel Gripper used by Baxter.

Results

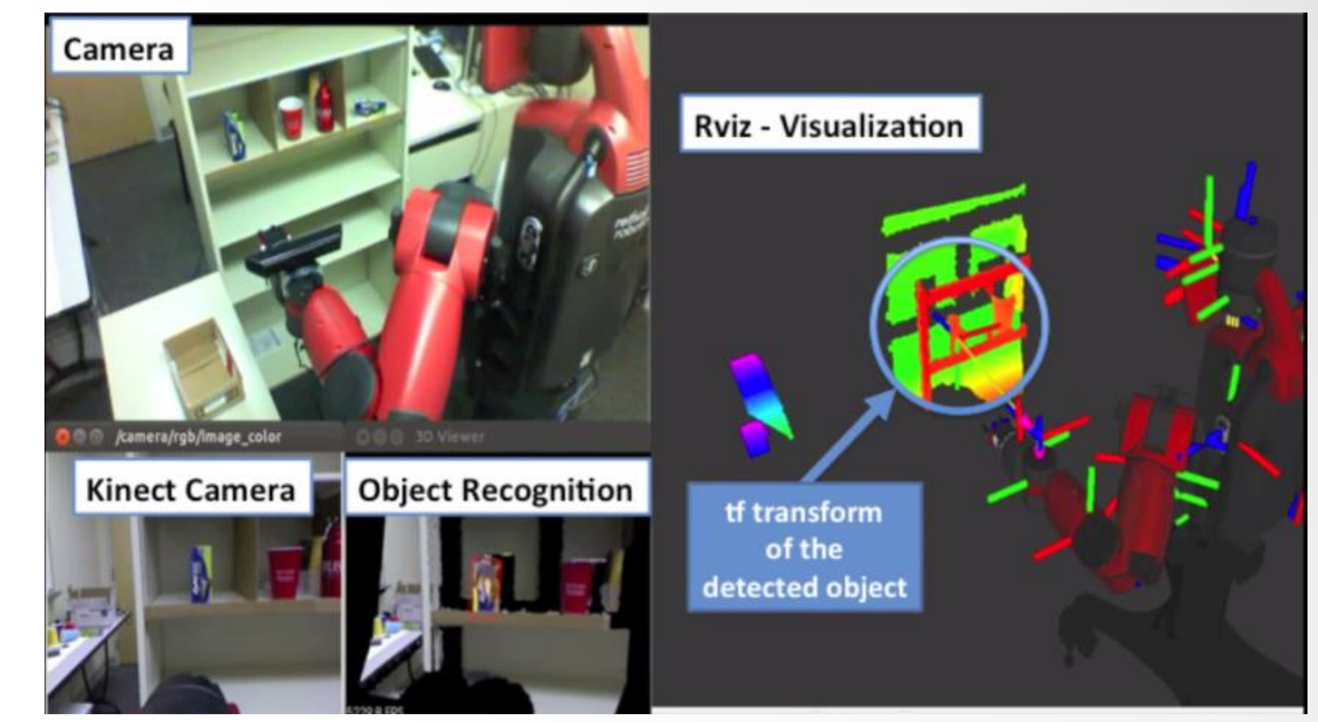

Figure 4. A) The setup viewed from a standard camera. B) The shelf as seen in the Kinect on the arm. C) Recognizing objects on the shelf. D) Mapping and pose estimation visualized in software.

Figure 5. A) Grasping in the computer simulation. B) Grasping in the real world. C) Recognizing a rectangular object placed on a plain surface

Conclusion

- Out of the box, a Baxter has primitive vision capability and an elementary control system.
- Our research has enabled complicated tasks and skilled labor accurately and securely, in a collaborative environment.
- The modules created are open source and can be utilized by anyone working with a similar system.

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