Andy Project

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Mentors

Special thanks to our mentors --

- Jean Oh -- Project Scientist, NREC
- Katharina Muelling -- Project Scientist, NREC

Autonomous Robotic Manipulation Lab, NREC
In this project, we worked on Andy, a two-arm robot. We extended Andy’s current capabilities to:

- understand verbal commands
- recognize specific objects
- execute manipulation tasks

as verbally instructed by the user.
Subsystems of the Project

- Perception
- Speech/Language
- Manipulation
- User Study
Perception Subsystem
Asus Xtion Pro Live
Block Detection

Visualization of the blocks in the GUI

RGB Camera Image
Block Detection

Depth Map

Contour Detected

Labelled Blocks
Color Detection

To detect the average color of each block --

- Calculate the enclosing contour for each image as shown below --
  - OUTPUT

- Calculate the average across all the 3 channels --
  - OUTPUT

\[ [R, G, B] = [34, 203, 43] \]
Color Reasoning

Convert the average color to from RGB color space to CIE Lab color space and rank based on Euclidean Distance from the desired colored block.

\[ d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2} \]

OCCAM’S RAZOR

**Why not just keep in RGB color space?**

Although RGB values are a convenient way to represent colors in computers, we humans perceive colors in a different way from how colors are represented in the RGB color space.
Language Subsystem
Andy + Alexa = Awesomeness :)
We wrote a package to integrate ROS with Amazon Echo.

We will be soon open-sourcing the code at [github.com/auto-pirates](https://github.com/auto-pirates).

We love Open Source!!
We used and extended capabilities of the TBS-Parser written by Jean.

“The Best Code is No Code At All”
High Level Idea

VOMA = (Verb, Object, Mode, Adverbial)

Modes are "quickly", "a little bit", "more" etc.  
Adverbials are "to the left", "up", etc.

Examples:
Rotate your right arm a little bit forward.  
Move your left arm more to the right.
Tactical Behavior Specification (TBS) language in BNF

```plaintext
<tbs> ::= <action><direct-obj>[<mode>][<action-constraints>]<goal>[<goal-constraints>]

[action] ::= navigate | search | observe | grasp

<direct-obj> ::= <named-obj>

<goal> ::= [ <relation> ] <landmark-object>

<goal-constraint> ::= <constraint-list>

<action-constraint> ::= <constraint-list>

<constraint-list> ::= <constraint-term> | <constraint-term> { <operator> <constraint-term> }

<constraint-term> ::= [not] <relation> <named-object> [<constraint-list>]

<mode> ::= "quickly" | "covertly" | "safely"

<relation> ::= "to" | "left" | "right" | "behind" | "front" | "around" | "near" | "away"

<landmark-object> ::= <named-object>

<operator> ::= and | or

<named-object> ::= "Robot" | "Building" | "Wall" | "Door" | "Grass" | "Asphalt" | "Concrete" | "Person" | "TrafficBarrel" | "Car" | "GasPump" | "FireHydrant"
```
Manipulation Subsystem
New Actions added

- Rotations
  - Rotate Left
  - Rotate Right
  - Rotate Up
  - Rotate Down
- Relative Placement
  - Place on top
  - Place on left
  - Place on right
- Slight Movement
  - Move little in left
  - Move little in right
  - Move little up
  - Move little down
- Put down
For motion planning, we used **Covariant Hamiltonian Optimization for Motion Planning (CHOMP)**. The advantage of CHOMP over other sampling based planners is that it very smooth trajectories. **Smooth motion makes the robot's actions look more natural to the people around it.**

Co-authored by our very own SID :)
User Survey
Thanks for participating folks; We really appreciate it :)
Shivam attempting the survey !! [VIDEO]
Inference

**SAMPLE USER COMMAND**

1. Pick the blue block, place it vertically with the side with the largest surface area facing yourself.
2. Pick the green block. Place it vertically with the side with the largest surface area towards yourself, along the blue block just beside it with the corners touching each other.
3. Now move the green block until the contact is just about to be removed.
4. Now pick the pink block and do the same thing on the other side of the blue block.
5. Move the pink block back so that the edges are changed, touching some other side of the blue block. Do it again.
6. Now pick the purple block and place it next to the green block, just touching it.
7. Place it vertically facing yourself.
8. Pick up this one. Put it just touching the pink in line with the purple and blue block. Vertically with the largest surface area facing yourself.

**INFERENCE**

1. There was a lot of intuition involved.
2. Confusing actions (Actions not necessary, because can be expressed otherwise or hard to code):
   a. Bring
   b. Use
   c. Separate
   d. Leave
   e. Stack = Put on top of
3. Synonyms:
   a. Shift: Push
   b. Take: Pick up
4. Repeat:
   a. Repeat: Do the same thing
   b. Undo the previous
   c. Do it again
   d. Repeat the same thing
   e. Once more
Andy in Action !! [VIDEO]