Robot For Assistance

Master Project

ME-GY 996

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Presented To:

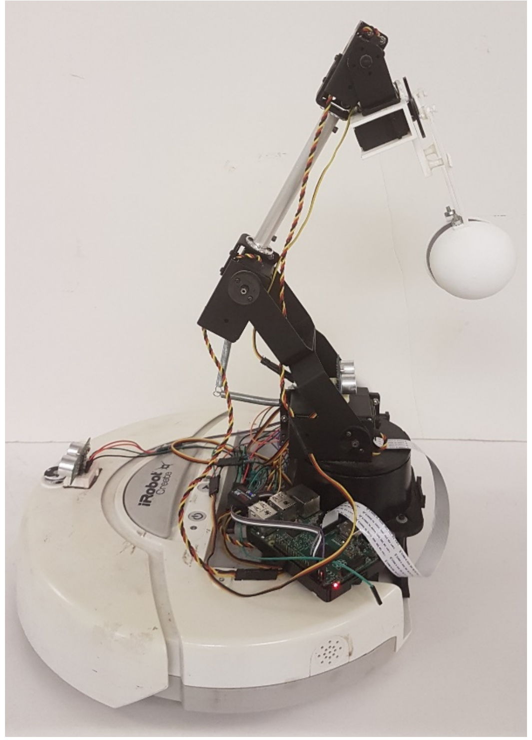
Dr. Vikram Kapila

Project Description

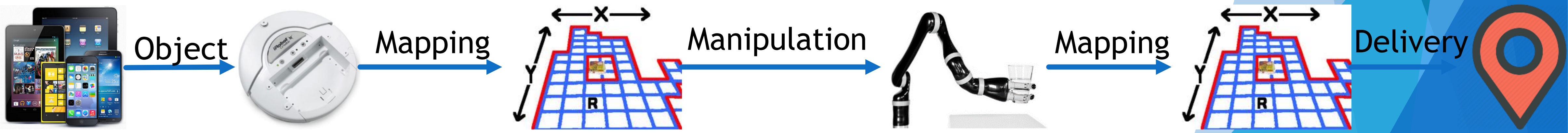
Building a robot with an assistance duty.

Goals:

- Build a cheap and independent robot.
- Assist seniors, children or people with disabilities.
- Make use of mobile technology.



How It Works?:



Available Solutions

Toyota Human Support Robot (HSR)

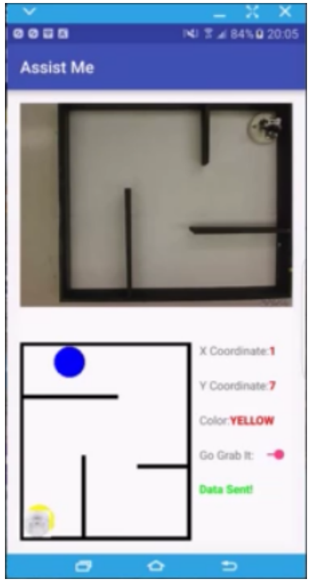
Project Description

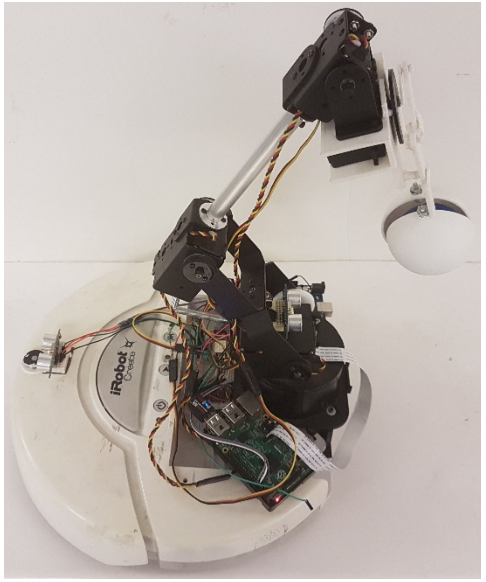
Robot For Assistance

Mobile Application

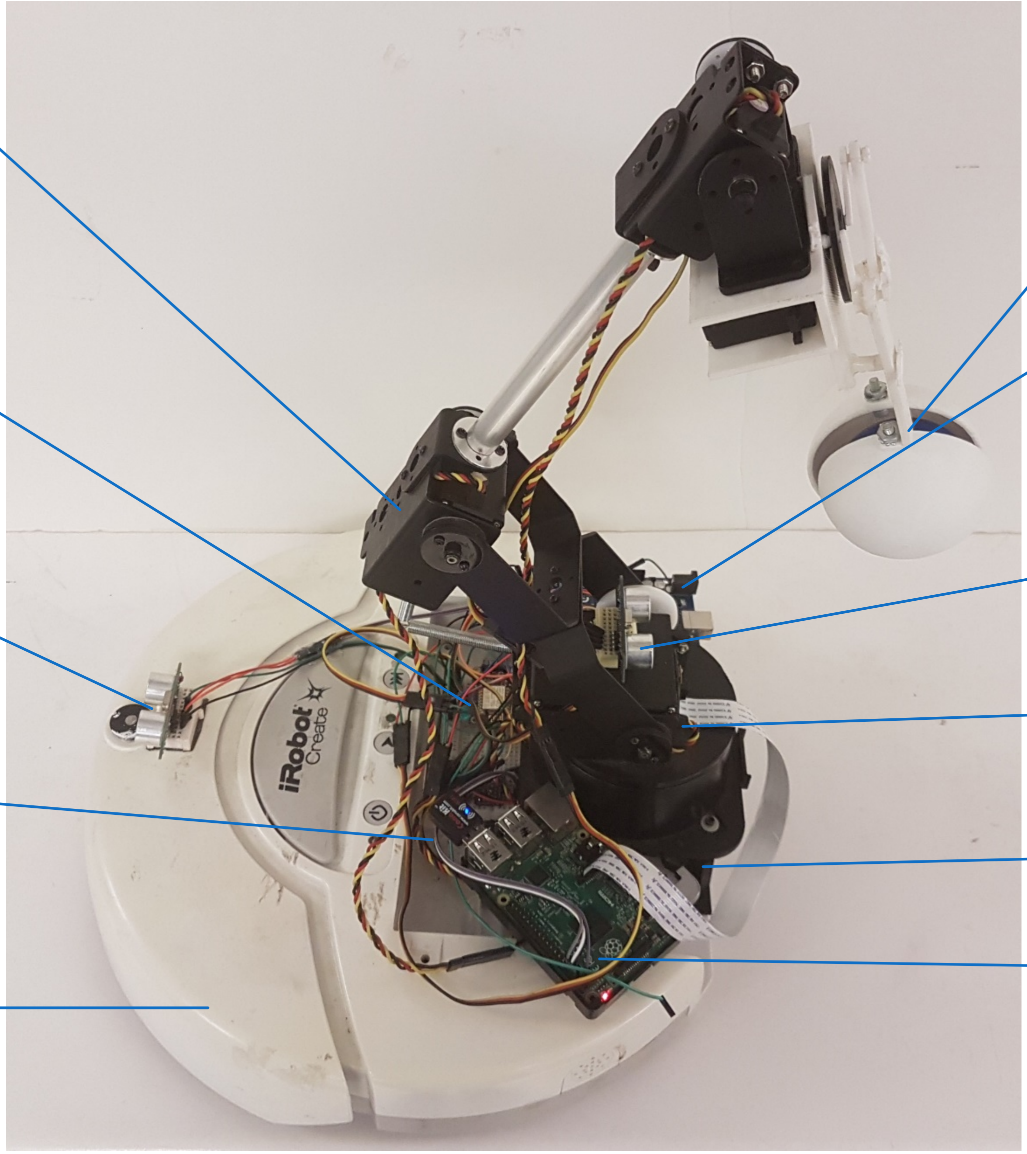
Mobility

Manipulation

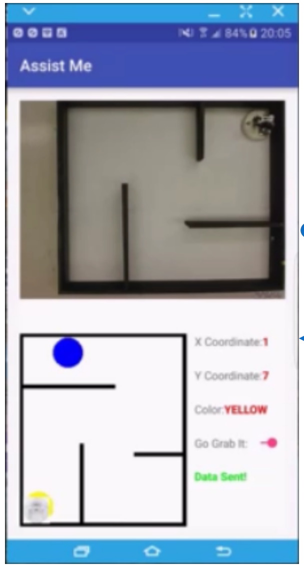




System Description



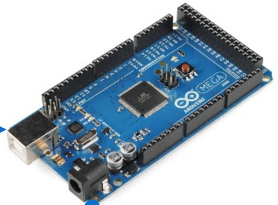
Communication Protocol



TCP sender

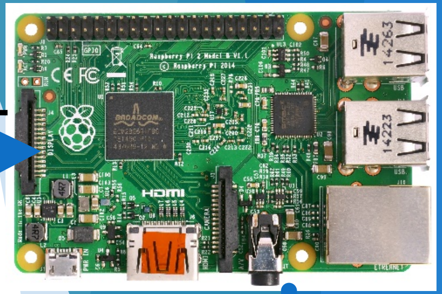
TCP receiver

USART

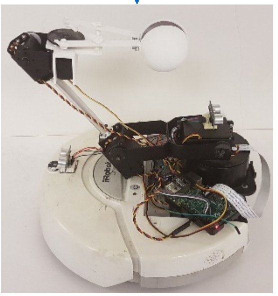


USART

USART



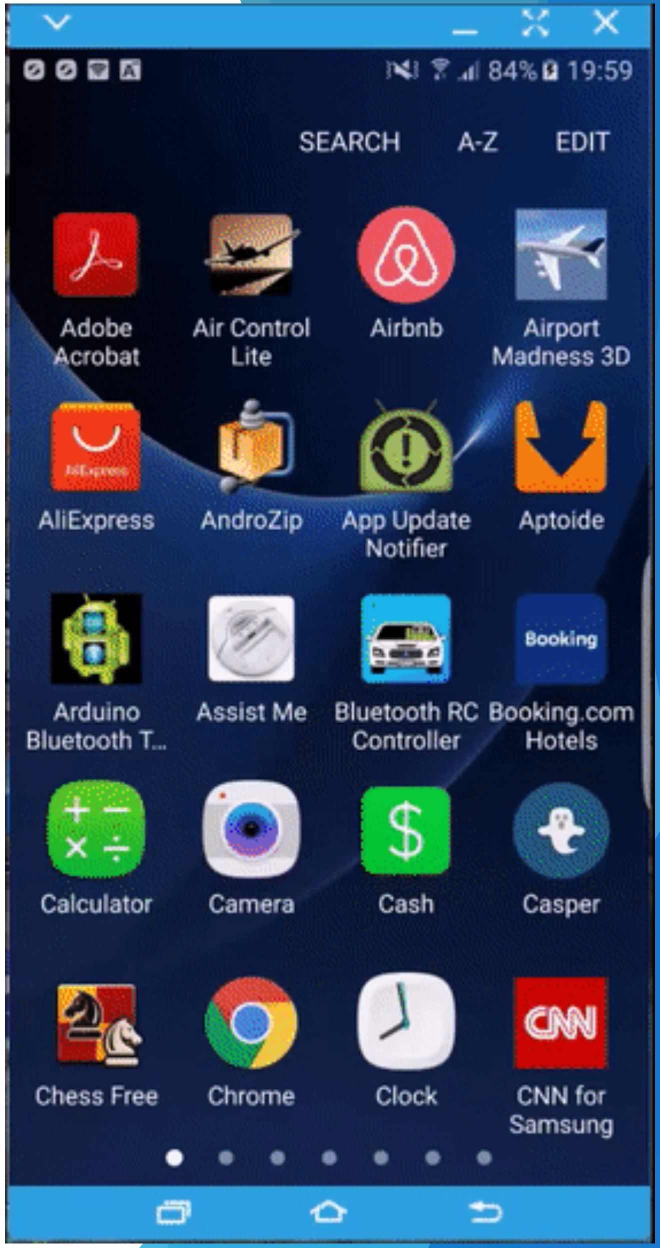
USART



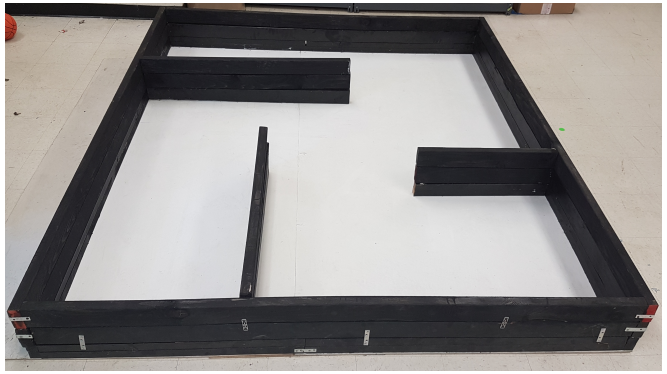
Command Type	Character	Action
	f	Forward
	b	Backward
	r	Right 45 Degrees
	e	Right 90 Degrees
	l	Left 45 Degrees
Steering	k	Left 90 Degrees
	t	Rotate 180 Degrees
	s	Stop
	v(0-1)	Accept Encoder Distance
	o	Return Ultrasonic Distance

Mobile Application (Assist Me)

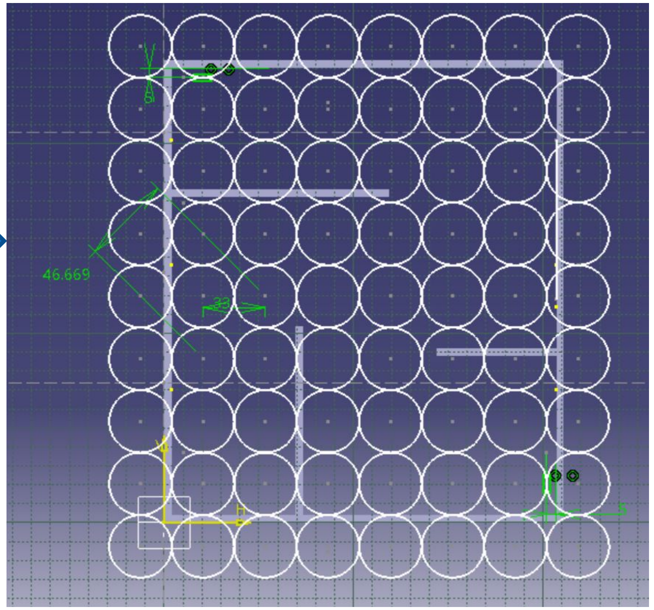
- Design of a mobile application capable of communicating with the robot via server protocol.
- User friendly application:
  - User will select an object at a particular position.
  - User will visualize the process as the robot move towards the object.



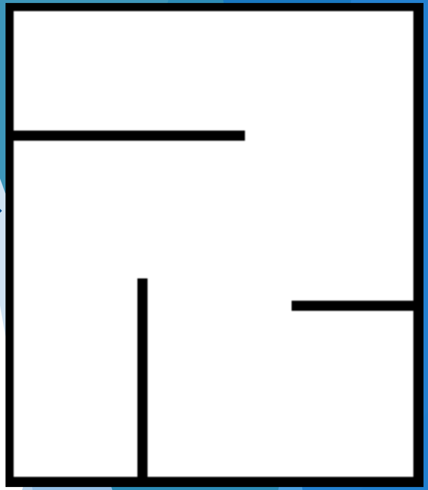
Mobility



Cad Software



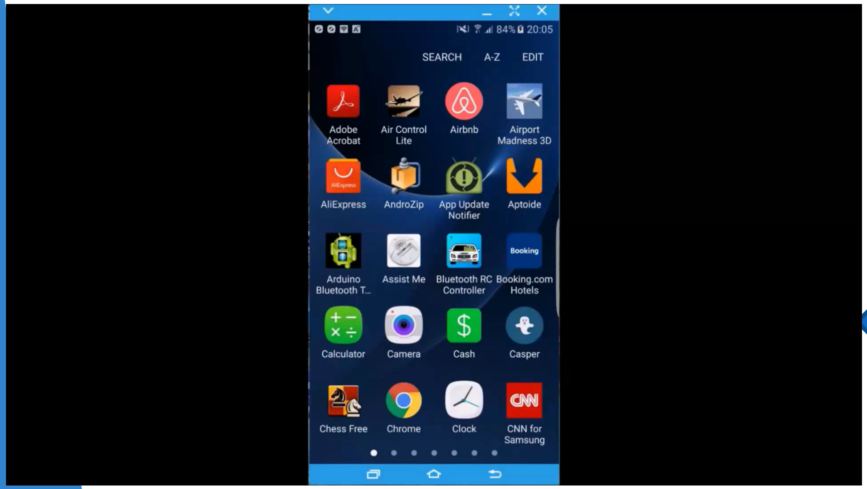
Map Design



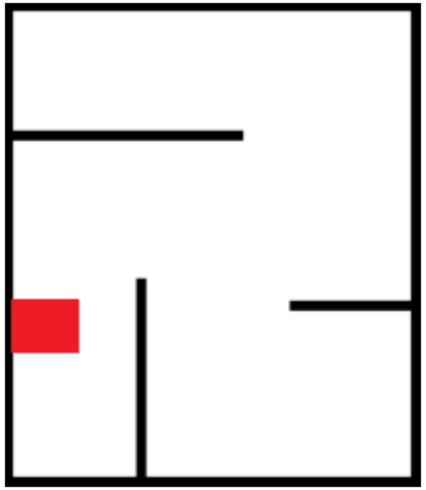
Mapping

```
O O O O O O O O
O . . . . . . O
O O O O O . . O
O . . R . . . O
O . R O R . . O
O R . O R O O O
O R . O . R . O
O F . O . . S O
O O O O O O O O
```

Outcome



Mobility
(Obstacle Avoidance)

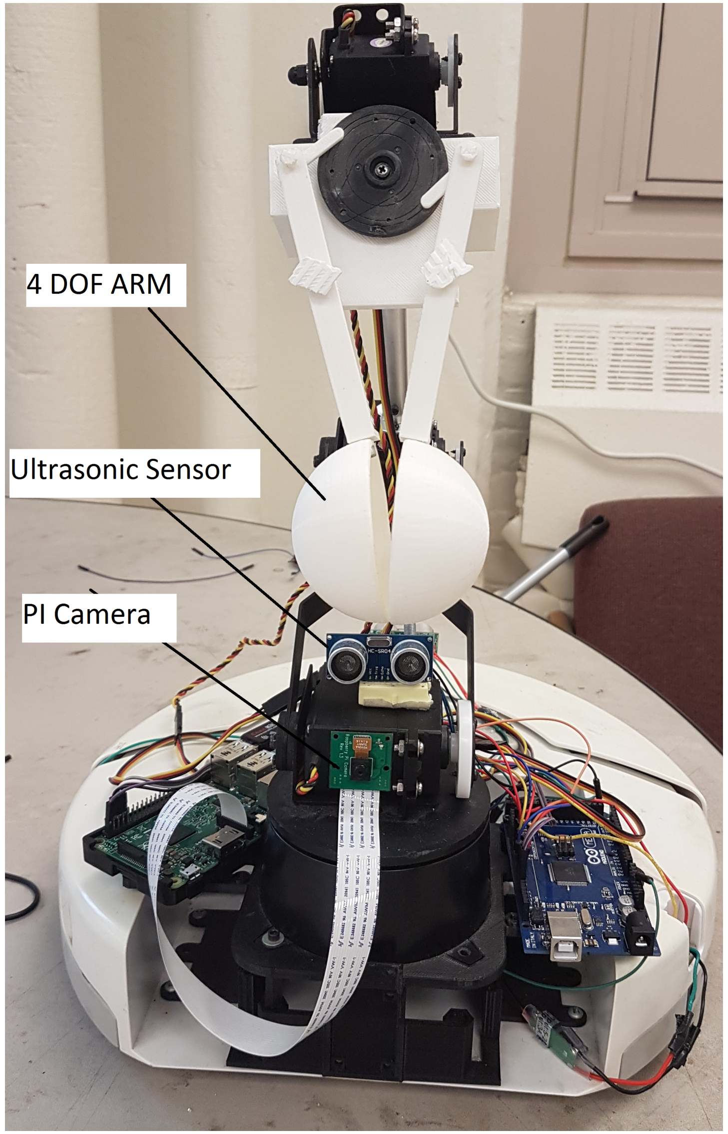


```
O O O O O O O O
O F R R R . . O
O O O O O R . O
O . . R R . . O
O . R O . . . O
O R . O . O O O
O R . O . . . O
O S . O . . . O
O O O O O O O O
```

Reinitializing Map

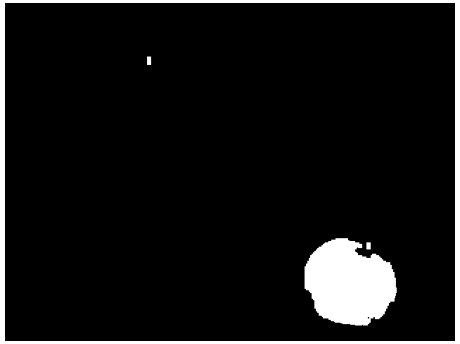
```
O O O O O O O O
O F R R R . . O
O O O O O R . O
O . . R R . . O
O . R O . . . O
O O R O . O O O
O S . O . . . O
O . . O . . . O
O O O O O O O O
```

Manipulation

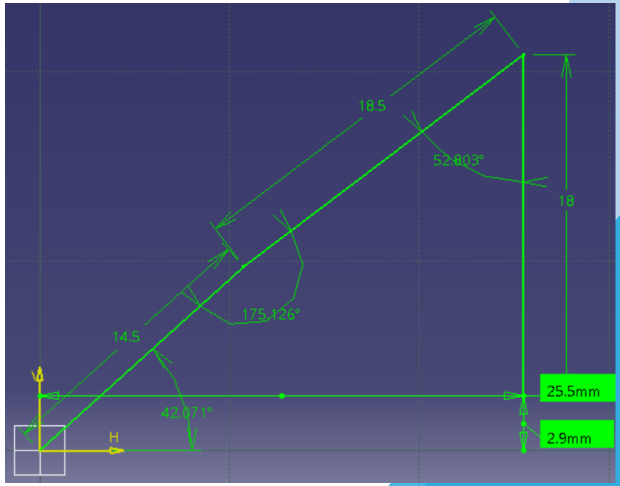


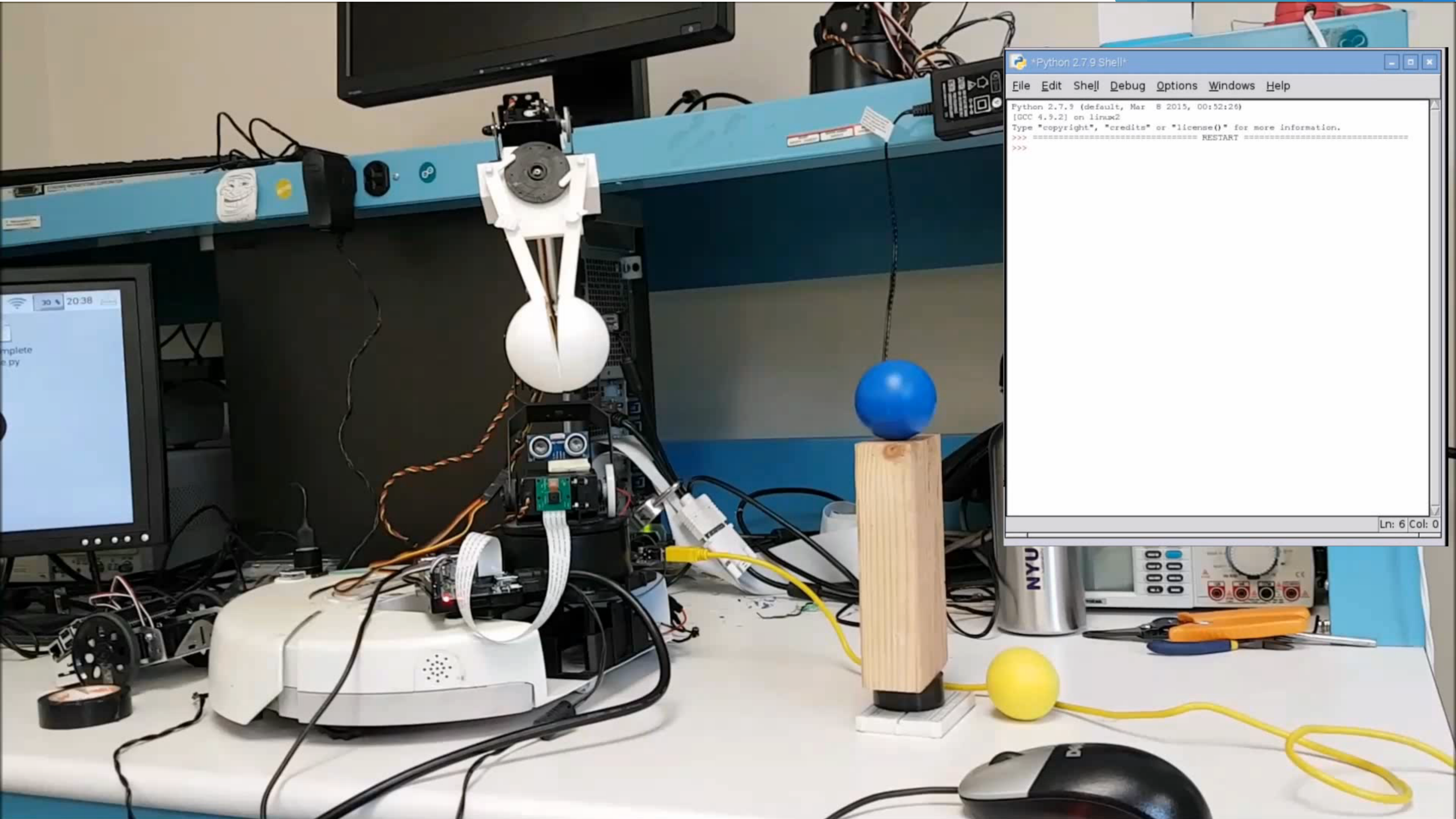
Depth Measurement

Image Processing



Inverse Kinematics

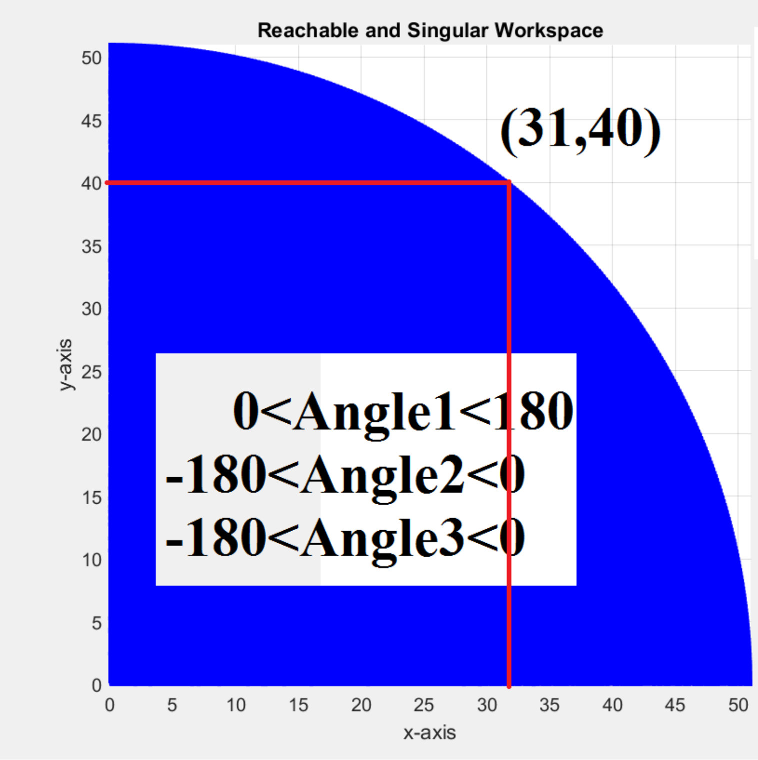


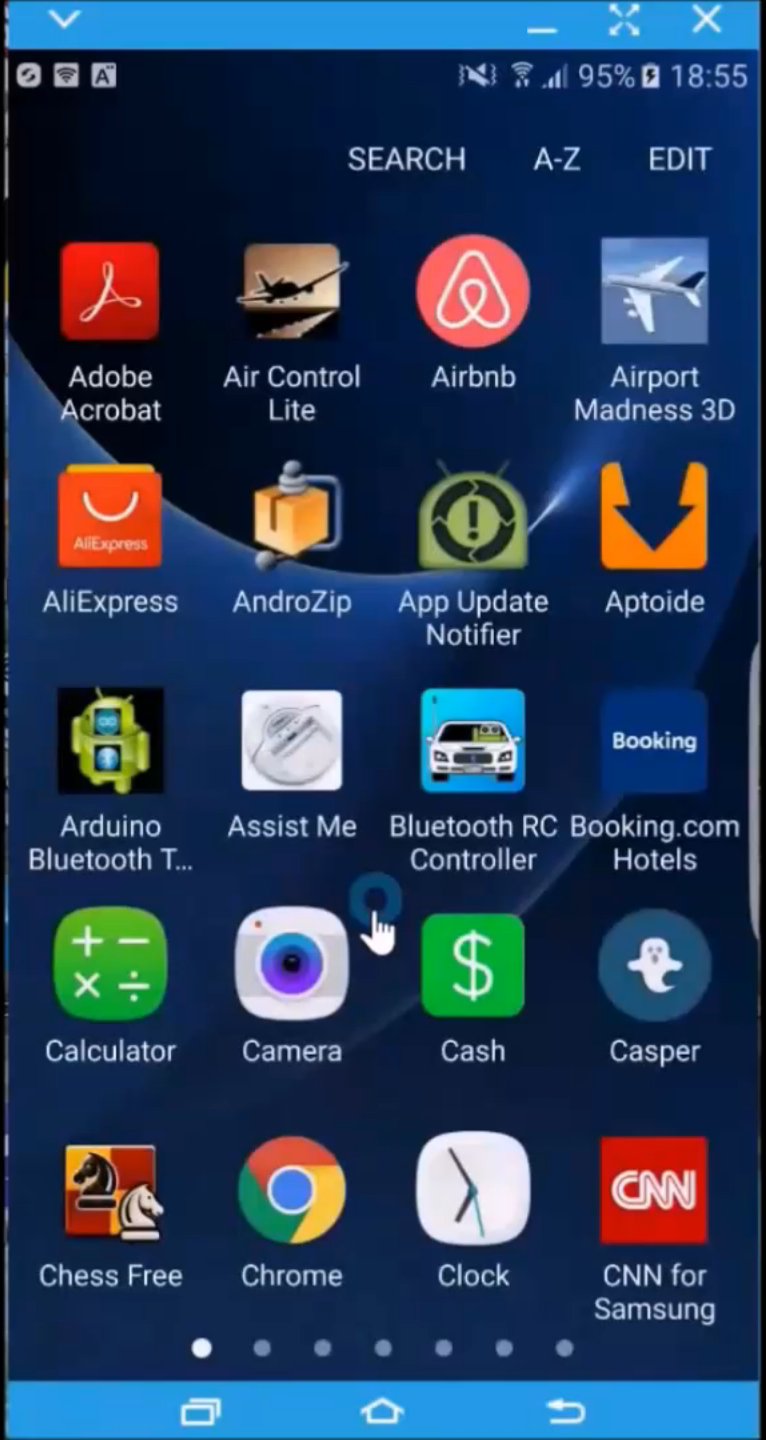

Python 2.7.9 Shell
File Edit Shell Debug Options Windows Help
Python 2.7.9 (default, Mar 8 2015, 00:52:26)
[GCC 4.9.2] on linux2
Type "copyright", "credits" or "license()" for more information.
>>> ================================ RESTART ================================
>>>
Ln: 6 Col: 0
20:38
NYU

Manipulation (Inverse Kinematics)

Link	a	α	d	θ
1	14.5	0	0	$\Theta(1)$
2	18.5	0	0	$\Theta(2)$
3	18	0	0	$\Theta(3)$

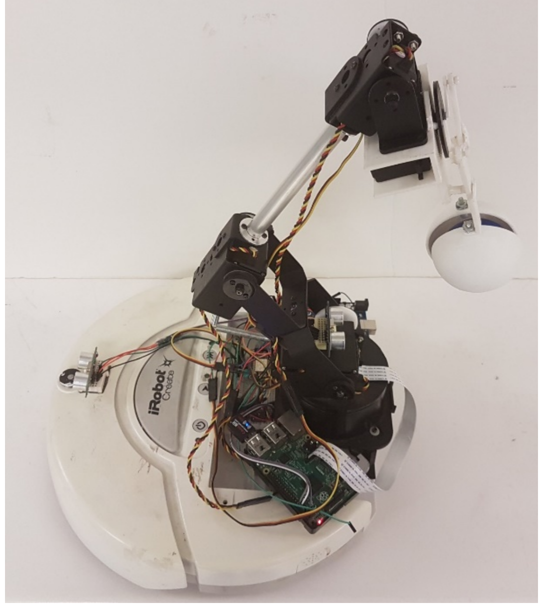
```
[ cos(q1 + q2 + q3), -sin(q1 + q2 + q3), 0, 18*cos(q1 + q2 + q3) + (37*cos(q1 + q2))/2 + (29*cos(q1))/2]
[ sin(q1 + q2 + q3),  cos(q1 + q2 + q3), 0, 18*sin(q1 + q2 + q3) + (37*sin(q1 + q2))/2 + (29*sin(q1))/2]
[                 0,                  0, 1,                                                              0]
[                 0,                  0, 0,                                                              1]
```



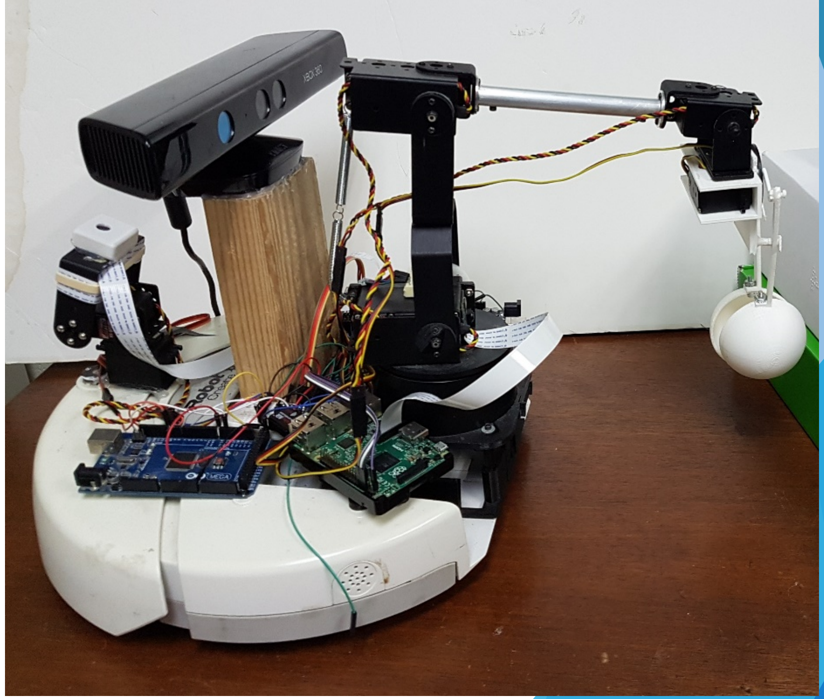

95% 18:55
SEARCH
A-Z
EDIT
Adobe Acrobat
Air Control Lite
Airbnb
Airport Madness 3D
AliExpress
AndroZip
App Update Notifier
Aptoide
Arduino Bluetooth T...
Assist Me
Bluetooth RC Controller
Booking
Booking.com Hotels
Calculator
Camera
Cash
Casper
Chess Free
Chrome
Clock
CNN
CNN for Samsung

Enhancing Manipulation

- Enhancing manipulation by considering the full 4-DOF range of the manipulator.
- Implementing a Kinect in order to measure the depth of the object with respect to the manipulator.
- Obtaining a faster and more efficient mode of pick up.



Adding a Kinect



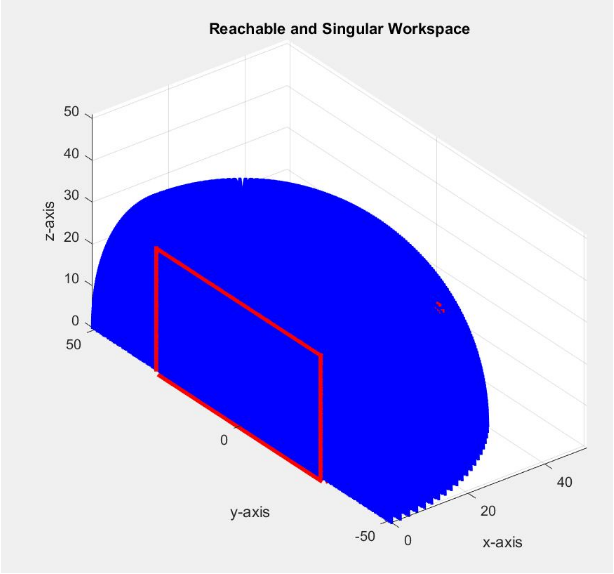
Enhancing Manipulation

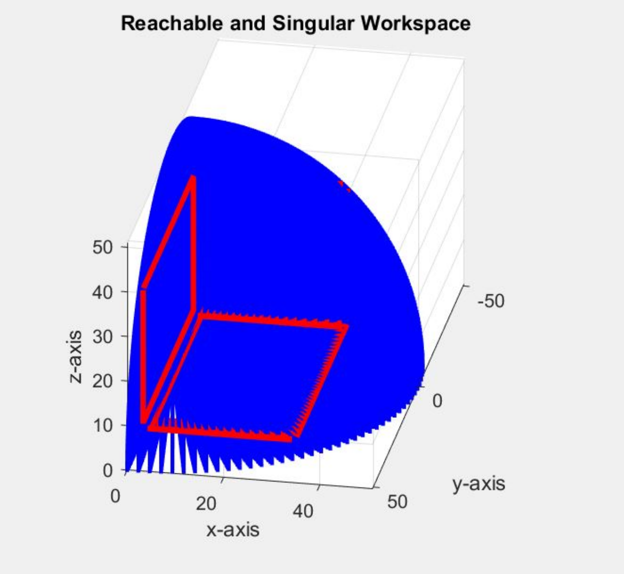
DH-Parameters

DH Table

Link	a	α	d	θ
1	0	90	0	$\Theta(1)$
2	14.5	0	0	$\Theta(2)$
2	18.5	0	0	$\Theta(3)$
3	18	0	0	$\Theta(4)$

Workspace Modeling





Workspace Limits

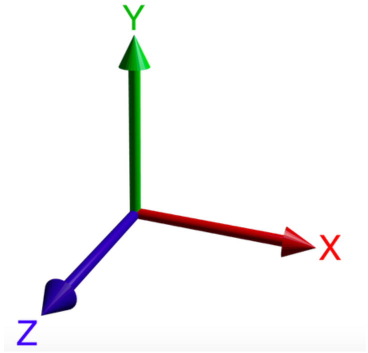
0<X(cm)<30

-28<Y(cm)<28

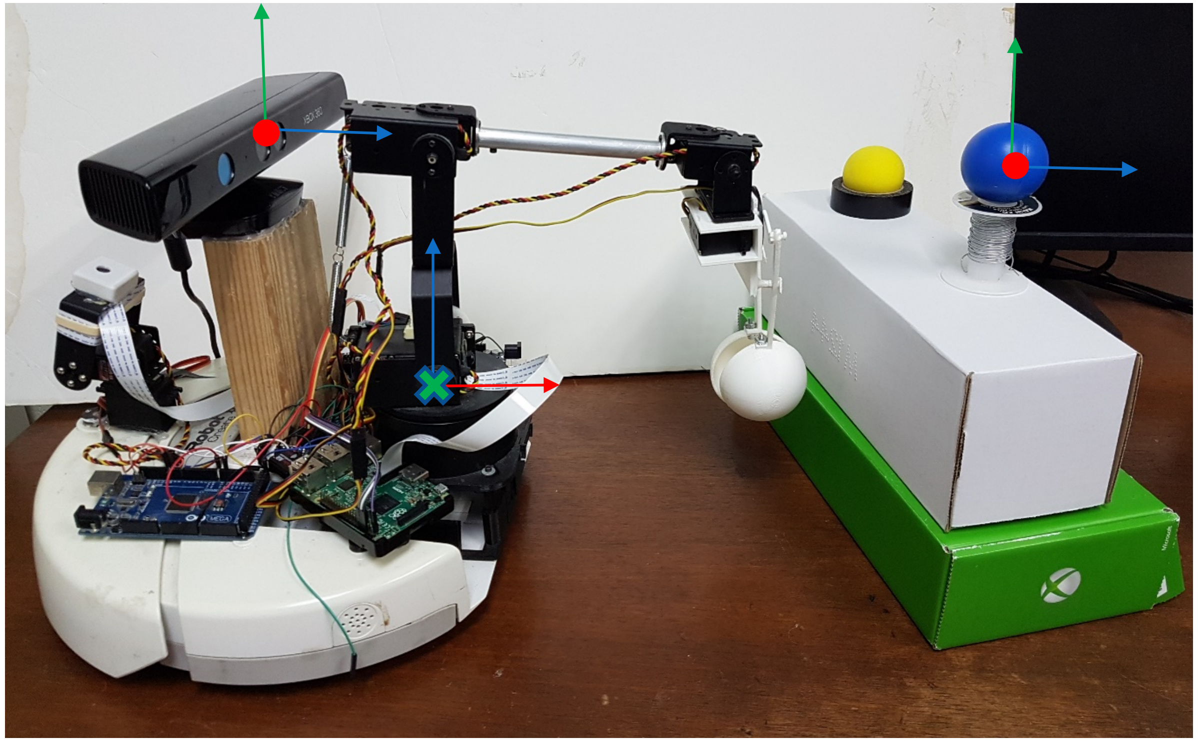
0<Z(cm)<30

Enhancing Manipulation

Coordinate Transformation



Reference Frame



$$
{}^{M}H_{B} = ({}^{K}H_{M})^{-1} \times {}^{K}H_{B} = \begin{bmatrix} 0, & 0, & 1, & \mathtt{zbwrtk - zmwrtk} \\ -1, & 0, & 0, & \mathtt{xmwrtk - xbwrtk} \\ 0, & 1, & 0, & \mathtt{ybwrtk - ymwrtk} \\ 0, & 0, & 0, & 1 \end{bmatrix}
$$

Enhancing Manipulation
Obtaining Position of an Object

- **Major Steps:**

1. Obtain rgb and depth frame from the Kinect.
2. Defining the HSV range representing the color of the object.
3. Applying OpenCV techniques such as: Blurred, hsv and mask(Erode and dilate).
4. Track the centroid of the ball and identify it's pixel location in the rgb and depth image.
5. Apply the necessary equations:

```
x = (i - w / 2) * (z + minDistance) * scaleFactor
y = (j - h / 2) * (z + minDistance) * scaleFactor
z = 100/(-0.00307 * rawDisparity + 3.33).
```

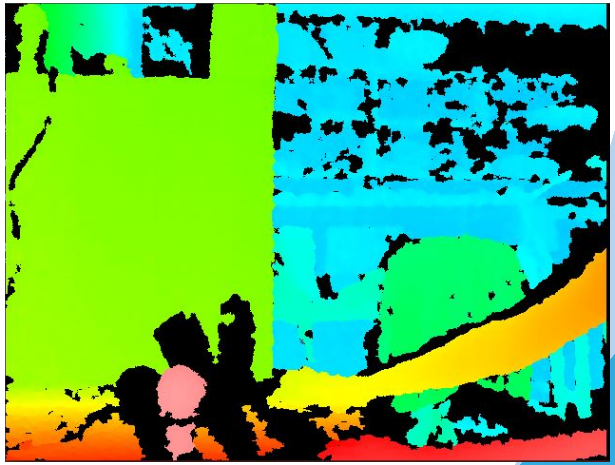
6. Coordinate transformation between different frames.

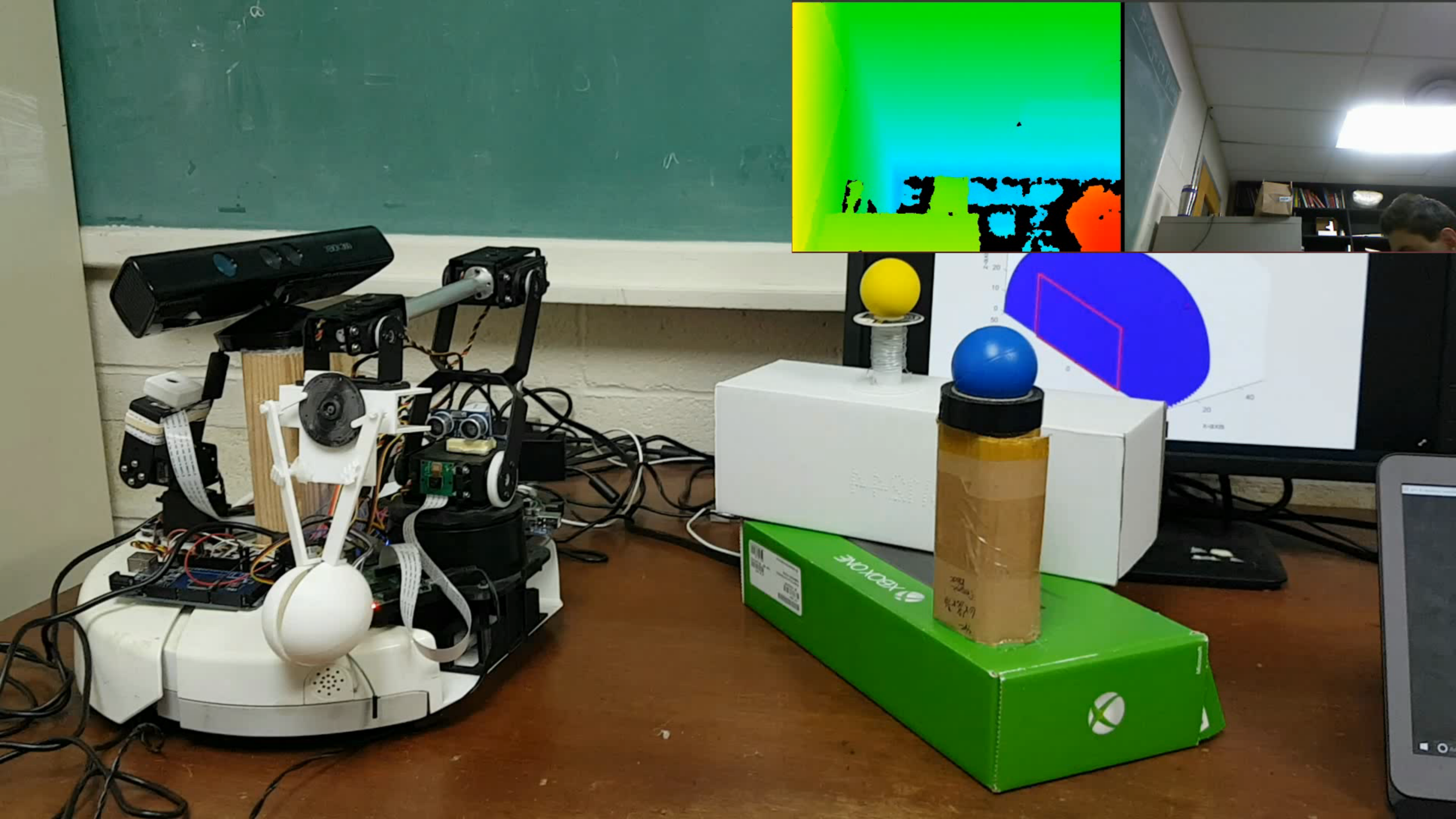
Enhancing Manipulation
Recording with a Kinect


RGB image


Grayscale depth


Filtering


RGB depth



Enhancing Mobility

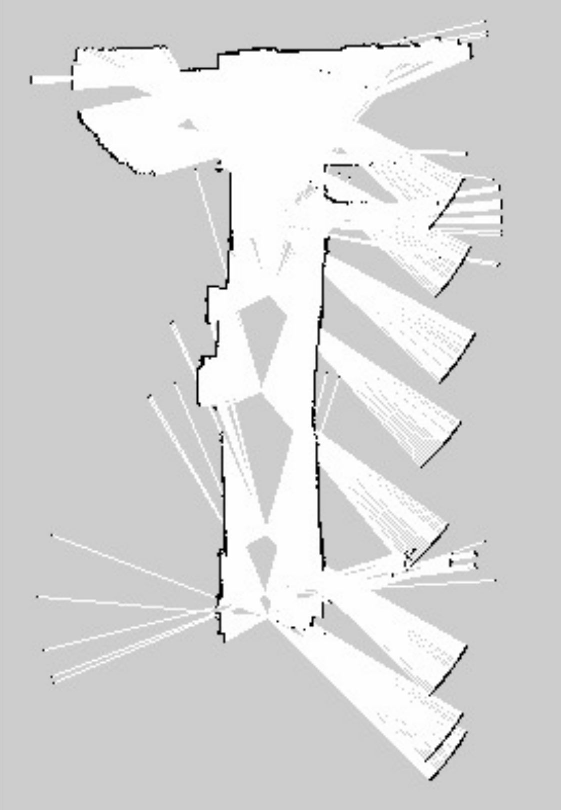
- Improving mapping techniques
- Mapping in a real environment.
- Using **ROS** packages for mapping:"gmapping".
- Experimenting with LIDAR sensor and a Kinect.

Area to be mapped

Enhancing Mobility
LIDAR

- Experimenting with a LIDAR attached to a mockup robot.
- Hokuyo URG-04LX LIDAR used for mapping
- ROS parameters adjusted with respect to the location of the LIDAR.

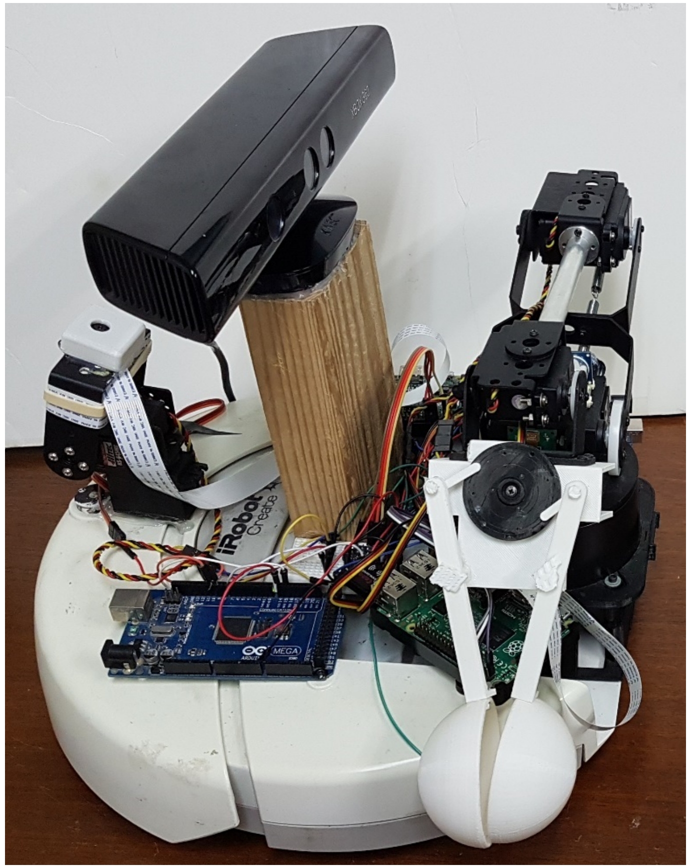
Mapping



Enhancing Mobility

Kinect

- Mapping using the Kinect onboard.
- Aiming to achieve accurate results with less noise.



Mapping

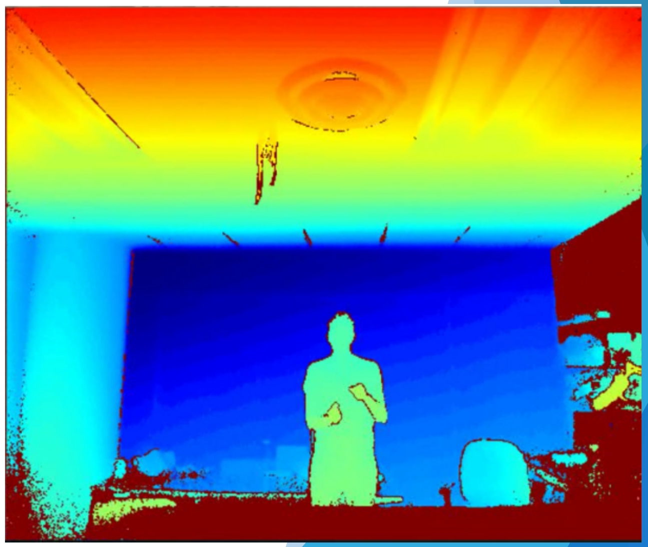

MEGA


Manual Control

- Making use of a standalone Kinect one in order to manually control the robot.
- Driving the robot using a virtual steering wheel.
- Actuating the manipulator and picking up objects using our right arm.

Kinect one

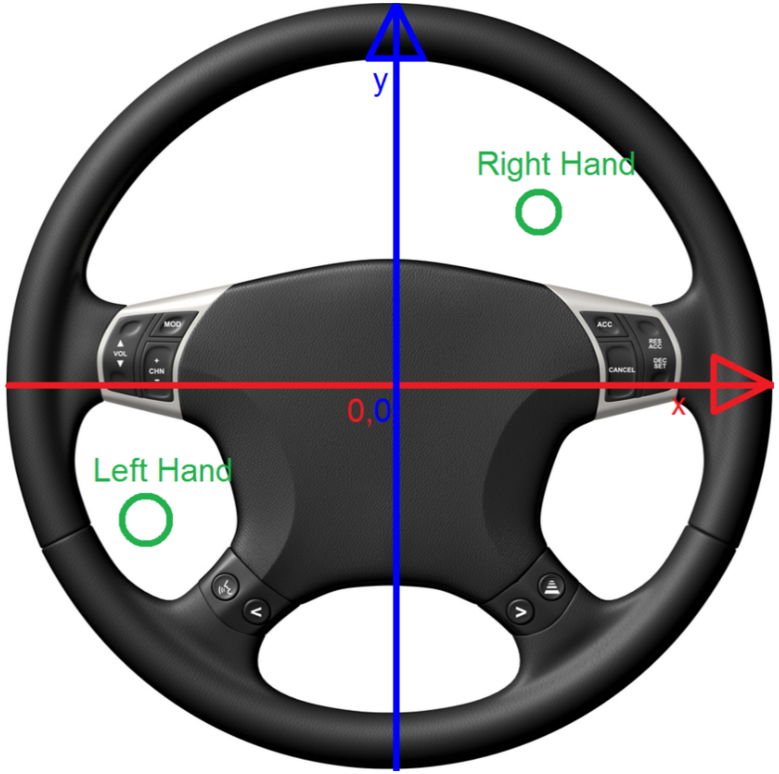
RGB image



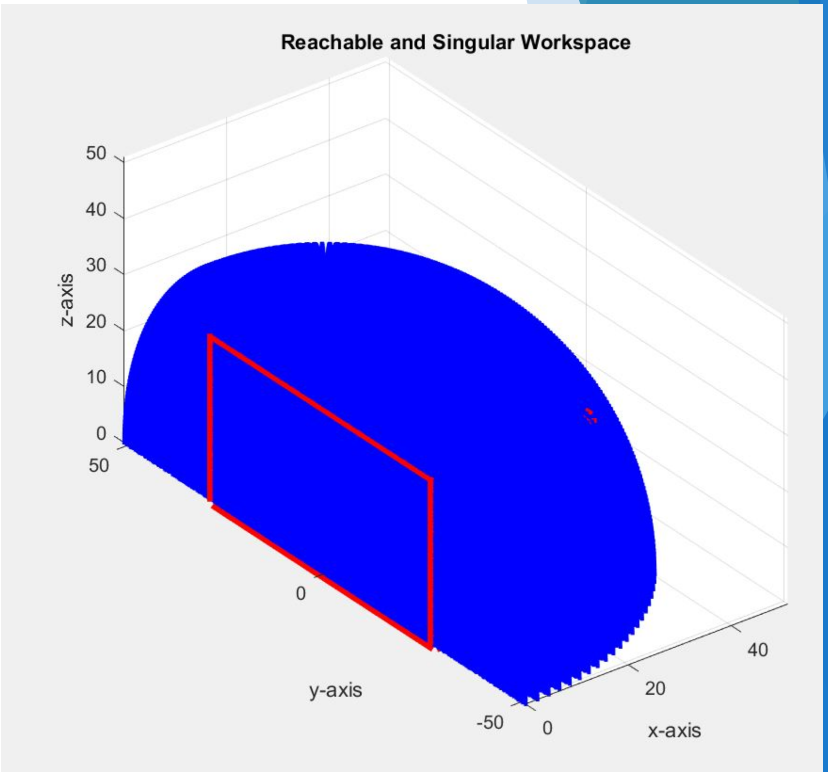
Depth image

Manual Control

- **Virtual steering:** Keep track of the right and left hand position in order to solve for the **angle** of rotation and well as the **speed** depending on the depth.
- **Arm control:** Keep track of the right hand and limit the control of the manipulator within it's workspace boundary



Virtual steering



Arm control

Conclusion

- Provided a robotic solution in order to assist people and pick up objects for them.
- Hacked and transformed the iRobot create into an assistive robot.
- Enhanced manipulation using a Kinect.
- Enhanced the mapping techniques using ROS packages.
- Extended the work and overrode the robot manually using a standalone Kinect.

Thank You

Questions ?