

EINSTEIN TURTLEBOT

PROJECT #1

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INTRODUCTION

The Einstein TurtleBot is comprised of a Kobuki base and two arms and head that all have the ability to move. The arms utilize ten servos with four in each arm and two in the head. There is a range of limits that you must adhere to for the arms and head of Einstein so that the servos are not damaged. You must follow the RoboPlus Dynamixel Wizard, to allow for the degrees of operation of the servos. In the arms, the servers are located at the shoulder, elbow, and wrist and in the head there is a servo for the pan of the head and a servo for the tilt of the head. There are raw values that must be accounted for they are the minimum and maximum value that can be sent to the servo. If these values are not accounted for and followed, the commands that are sent to Einstein can damage him. You also must account for the torque. Using precise calculations we also need to calculate the torque before administering commands to the servos. We have the individual components of Einstein working but we need to mount our Raspberry pi to the robot to have him successfully perform. We can run all of his acting capabilities but the cords are getting tangled as he spins and raises his arms.

BEHAVIOR

Our goal was to make our Einstein Turtlebot an experienced actor with funny behavior and profound arm and head gestures. After the setup and discovery of all the materials that we needed to learn to accomplish this took many hours we decided to have Einstein navigate his surroundings and wave his arms when he discovered an obstacle. We plan on expounding on this behavior for the next project as we are finally becoming comfortable with Einstein's hardware and Software.

SETUP

We used our own host machine to set up our Einstein Turtlebot and there are several configuration steps, following each of the steps in the links below:

1. <http://wiki.ros.org/kinetic/Installation/Ubuntu>
2. <http://wiki.ros.org/ROS/Tutorials/NavigatingTheFilesystem>
3. <http://wiki.ros.org/ROS/NetworkSetup>

Now implement this Command as one command:

```
$ sudo apt install ros-kinetic-turtlebot* libudev-dev ros-kinetic-find-object-2d  
ros-kinetic-rtabmap-ros roskinetic-  
moveit ros-kinetic-octomap-ros ros-kinetic-manipulation-msgs  
ros-kinetic-controller-manager  
Python-wxgtk3.0
```

Setup TurtleBot2i Source Code & Catkin Environment:

```
$ source /opt/ros/kinetic/setup.bash  
$ cd ~
```

SETUP

```
$ mkdir -p ~/turtlebot2i/src
$ cd ~/turtlebot2i/src
$ git clone https://github.com/Interbotix/turtlebot2i.git .
```

Setup TurtleBot2i Source Code & Catkin Environment Cont:

```
$ git clone https://github.com/Interbotix/arbotix_ros.git -b turtlebot2i
$ git clone https://github.com/Interbotix/phantomx_pincher_arm.git
$ git clone https://github.com/Interbotix/ros_astra_camera -b filterlibrary
$ git clone https://github.com/Interbotix/ros_astra_launch
$ cd ~/turtlebot2i
$ catkin_make
$ bashrc setup
```

ROS:

1. Place the following at the bottom of your ~/.bashrc file
2. Replace example.hostname with your computer's hostname

```
$ source /opt/ros/kinetic/setup.bash
$ alias goros='source devel/setup.sh'
$ export ROS_HOSTNAME=example.hostname
$ export TURTLEBOT_3D_SENSOR=astra
$ export TURTLEBOT_3D_SENSOR2=sr300
$ export TURTLEBOT_BATTERY=None
$ export TURTLEBOT_STACKS=interbotix
$ export TURTLEBOT_ARM=pincher
```

Dialout permission

```
$ sudo usermod -a -G dialout <username_of_host>
```

CONNECT

Run Commands:

- ```
$ goros
$ roscore
```
1. Open another terminal/tab in terminal #2

```
$ goros
```
  2. Now run the demos in the second terminal window terminal #2

### Choose one of the following to establish Map:

Start robot and create a new map (erasing data from previous sessions):

```
Run: $ roslaunch turtlebot2i_bringup turtlebot2i_demo1.launch new_rtabmap:=true
```

## CONNECT

To resume mapping:

Run: `$ roslaunch turtlebot2i_bringup turtlebot2i_demo1.launch`

To use existing map for localization purposes only:

Run: `$ roslaunch turtlebot2i_bringup turtlebot2i_demo1.launch localization:=true`

### ARM DEMO:

1. Run: `$ cd turtlebot2i`
2. Run: `$ goros`
3. Run: `$ roslaunch turtlebot2i_block_manipulation block_sorting_demo.launch`

### KEYBOARD NAVIGATE & CONNECT:

Run: `$ cd turtlebot2i`

Run: `$ goros`

Run: `$ roslaunch turtlebot_teleop keyboard_teleop.launch`

### SERVO MOTORS SETUP:

1. Ubuntu 16.04 on the pi from <https://downloads.ubiquityrobotics.com/pi.html>. I selected the build 2019-06-19-ubiquity-xenial-lxde
2. Connected the Kokuki base to the pi.
3. Connected the motors to the adapter and then to the pi.
4. SSH into the pi.
5. Followed the steps in <https://github.com/philiparola/ece478-turtlebot> - starting at 'Building the project' section.
6. Built their project with the following commands

```
$ source /opt/ros/kinetic/setup.bash
```

```
$ cd <repository_dir>/catkin_ws
```

```
$ source devel/setup.bash
```

```
$ catkin_make
```

7. After building

```
$ sudo chmod a+rw /dev/ttyUSB0
```

```
$ roslaunch my_dynamixel_tutorial controller_manager.launch
```

this will initialize all the motors

```
$ roslaunch y_dynamixel_tutorial start_all_motor_controller.launch (this will start all the motors)
```

## CONNECT

```
$ roslaunch face_detection face_detection.launch
```

```
$ roslaunch gesture_controls gesture_controls.launch
```

Note: Script have the port hard coded to have the servos connected to USB0. Make sure the Kokuki base is not enumerated to USB0. You can connect servo USB first and then the base USB.

### TURTLEBOT BASE SETUP:

```
Run: $ goros
```

```
Run: $ roscore
```

**Map Base, start with new map**

```
Run: $ roslaunch turtlebot2i_bringup turtlebot2i_demo1.launch new_rtabmap:=true
```

**Set Keyboard Controls**

```
Run: $ roslaunch turtlebot_teleop keyboard_teleop.launch
```

### Dependencies:

```
$ sudo apt-get install libgl1-mesa-dev-lts-trusty
```

### Environment setup:

```
$ echo "source /opt/ros/indigo/setup.bash" >> ~/.bashrc
```

```
$ source ~/.bashrc
```

### Ros Tools:

```
$ sudo apt-get install python-rosinstall
```

```
$ sudo sh -c 'echo "deb http://packages.ros.org/ros/ubuntu `lsb_release -sc` main" > /etc/apt/sources.list.d/ros-latest.list'
```

```
$ wget http://packages.ros.org/ros.key -O - | sudo apt-key add -
```

```
$ sudo apt-get update
```

```
$ sudo apt-get install ros-indigo-turtlebot ros-indigo-turtlebot-apps
```

```
ros-indigo-turtlebot-interactions ros-indigo-turtlebot-simulator ros-indigo-kobuki-ftdi
```

```
ros-indigo-rocon-remocon ros-indigo-rocon-qt-library ros-indigo-ar-track-alvar-msgse
```

```
$ sudo apt-get install python-catkin-tools
```

### Workspace Setup:

```
$ mkdir ~/rocon
```

```
$ cd ~/rocon
```

```
$ wstool init -j5 src
```

```
https://raw.githubusercontent.com/robotics-in-concert/rocon/release/indigo/rocon.rosinstall
```

```
$ source /opt/ros/indigo/setup.bash
```

```
$ rosdep install --from-paths src -i -y
```

```
$ catkin_make
```

```
$ mkdir ~/kobuki
```

## CONNECT

```
$ cd ~/kobuki
$ wstool init src -j5
https://raw.githubusercontent.com/yujinrobot/yujin_tools/master/rosinstalls/indigo/kobuki.rosinstall
$ source ~/rocon/devel/setup.bash
$ rosdep install --from-paths src -i -y
```

### Workspace Setup:

```
$ catkin_make
$ mkdir ~/turtlebot
$ cd ~/turtlebot
$ wstool init src -j5
https://raw.githubusercontent.com/yujinrobot/yujin_tools/master/rosinstalls/indigo/turtlebot.rosinstall
$ source ~/kobuki/devel/setup.bash
$ rosdep install --from-paths src -i -y
$ Catkin_make
```

### NTP setup:

```
$ sudo apt-get install chrony
```

### Colcon install:

```
$ sudo sh -c 'echo "deb http://packages.ros.org/ros/ubuntu `lsb_release -cs` main" >
/etc/apt/sources.list.d/ros-latest.list'
$ sudo apt-key adv --keyserver 'hkp://keyserver.ubuntu.com:80' --recv-key
C1CF6E31E6BADE
$ sudo apt update
$ sudo apt install python3-colcon-common-extensions
```

### AWS polly Install:

```
$ sudo apt-get install python3-pip
$ pip3 install -U boto3
$ sudo apt-get install -y ros-$ROS_DISTRO-tts
```

### AWS polly for newer builds:

```
$ cd ~/ros-workspace/src
$ git clone https://github.com/aws-robotics/tts-ros2.git
$ cd ~/ros-workspace && sudo apt-get update
$ rosdep install --from-paths src --ignore-src -r -y
$ cd ~/ros-workspace && colcon build
$ source ~/ros-workspace/install/local_setup.bash
$ colcon test --packages-select tts && colcon test-result --all
```

### AWS robomaker install:

```
$ cd /opt/robomaker/cross-compilation-dockerfile/
$ sudo bin/build_image.bash
```

## CONNECT

```
$ cd ~/environment/HelloWorld/robot_ws
$ sudo docker run -v $(pwd):/ws -it ros-cross-compile:armhf
$ cd ws
$ apt update
$ rosdep install --from-paths src --ignore-src -r -y
```

### **AWS robomaker install Cont:**

```
$ colcon build --build-base armhf_build --install-base armhf_install
$ colcon bundle --build-base armhf_build --install-base armhf_install --bundle-base
```

## VISION PROCESSING

We found that we needed to use a simple webcam to start the vision processing for the Einstein Turtlebot. At first we set up the kinetic camera but we all kinds of issues processing the images since the kinetic camera has a more advanced algorithm to process the images. We were able to have Einstein process the images and adjust his position based on obstacles he encountered.

## WHAT WE LEARNED

We learned that the setup for the hardware and the software take a great deal of time even when you have the right tools. It seems to be a rule that for every hour of set up there are three hours of debug time. Once that we established communication with Einstein, there were hurdles to climb debugging the commands and their order. We learned that the reading and studying of what it takes to get our robot going needs to be done early and quickly, as you can fall behind very quickly when the project and the robot needs to be functional.

We would also change the orientation of Einstein's movements, we would base it on vision processing of humans instead of based on processing objects. We would also like to refine the movements of Einstein as they are not smoothly in order. Possibly making several movements with both arms and head at the same time. We would also like to refine our facial recognition abilities of Einstein and fine tune his vision processing.



## CHALLENGES

When we first pulled Einstein off the shelf in the lab we discovered it was just the base and servo motors. It took awhile to find a battery, and at one point we contemplated constructing our own from Tyson's personal stock of recycled 18650 lithium cells. Fortunately a battery and charging cable miraculously appeared in the lab the following week and saved us the additional work.

The netbook or joole computer had also been removed, and after several attempts with one of our raspi2 boards, had to purchase a raspi3 to get the hardware capabilities required to do everything we needed.

After some searching we found a github repository with a previous students project documentation and source code which was helpful, although it was difficult to follow the steps to setup our robot from the previous teams coursework. It was unclear what steps were vital for functional operation. A great amount of time was spent before we were able to establish the proper hardware and software but it still took substantial debugging to get satisfactory results.

The app for the kinetic camera crashed because the kinetic camera needs extra configuration in OpenCV. We then had to bring a simple webcam in order for the vision application to successfully process. We were able to get the app for the vision processing running but we were unable to control any of Einstein's gestures. Another hurdle was the network setup between the master and secondary IP address that needed to be used between the robot, our host machine, and the raspberry pi.

We also had a difficult time collaborating together using the same software. The catkin software behaved differently on each of our hosts and it took a little bit of a different twist for each host machine to get them all working. Due to the nature of Catkin workspace sourcing it was a definite challenge working individually but together on the same project. Having a VPN SSH tunnel to the lab would really help for team situations with conflicting work schedules like ours.

## ROLES

- Tyson: Speech Synthesis/Voice Recognition/Hardware
- Ruben: Servo motors/ROS Software/Robot vision
- Todd: Software/scripts/artistic improvements
- Nick: Hardware repair/functionality/Low level Control

## PROJECT 2 TO DO LIST

- Establish Einstein as the accomplished performance artist he really is
- Create a stable version of ROS that can move cross platforms
- Make arm and head movements based on facial recognition
- Establish Head, Arm, and Base movements work together with added artistic components
- Einstein raise and waive arms dancing based on voice commands
- Have Einstein follow scripts for the robot theater with added artistry
- Have custom gestures Einstein preforms based on spoken commands

## APPENDIX

### Resources:

<http://wiki.ros.org/kinetic/Installation/Ubuntu>  
<http://wiki.ros.org/ROS/Tutorials/NavigatingTheFilesystem>  
<http://wiki.ros.org/ROS/NetworkSetup>  
<https://github.com/philiparola/ece478-turtlebot>

### Project Link:

<https://github.com/DrFoz/ECE478>

### Video Link:

Arm Movement:

[https://drive.google.com/open?id=1lr8Mg7wSTL5JatylwD7\\_JFDlo8uyXj9Z](https://drive.google.com/open?id=1lr8Mg7wSTL5JatylwD7_JFDlo8uyXj9Z)

Base Movement:

<https://drive.google.com/open?id=1gPx3vRITreGPHsqcNhCVngxRq7ifiBCf>

Actors Studio: (We still need to mount Raspberry Pi for cord freedom)

<https://drive.google.com/open?id=1m7QQjQ-6lbZp1LXzcxQstcScWiaj6BCF>

Intent Request/Speech Synthesis:

[https://drive.google.com/open?id=1mEtL2i5\\_8z4l8SRj9xwE46y-nDbxKwf9](https://drive.google.com/open?id=1mEtL2i5_8z4l8SRj9xwE46y-nDbxKwf9)