CSCE 496/896: Robotics: UAS, Fall 2020
Homework 1

Started: Monday, Aug 24
Video Submission 1: Friday, Aug 28
Video Submission 2: Friday, Sept 4
Video Submission 3: Friday, Sept 11
Due: Sunday, Sept 13

Instructions: This homework is an individual assignment collaboration is not allowed. If you discuss any problems with others, please note this on the assignment as described in the syllabus. Also note any materials outside of lecture notes, course textbooks, and datasheets that you used. Show your work and describe your reasoning to get partial credit if your solution is incorrect.

You should also make sure that you properly label and **describe** any figures or plots that you include in your writeup. You will not receive full credit if you do not explain these. In addition, you should refer to your code where needed to answer the questions (e.g. say "See file mynode/launch/test.launch for this problem, which ...").

You must turn in a pdf of your assignment on Canvas. Make sure to answer questions in complete sentences and explain answers as needed. **You must also turn in your code for all parts of this problem on Canvas.** Failing to electronically turn in your code will result in a 10 point penalty on this assignment. Points may also be deducted for coding errors, poor style, or poor commenting.

If you use any code from an online or other source you must cite the source in the comments. Otherwise it is considered plagiarism, which we check for!!

Note Regarding Video Submissions: There are a number of video submissions associated with this assignment. You must submit a short video to the associated video assignment on Canvas showing your system in action by the specified video submission date to receive credit for this. Using your phone to record a video of your computer with you narrating is sufficient for this.

Name:

Problem 1. *(5 pts)*[1] *(To be completed at end of assignment) Approximately how much time did the total assignment take? Which sub-problem took longest and how much time did it take? Are there any questions that need clarification?*

[1]Each HW counts equally in your overall grade, even if homeworks have different point totals. This one is out of 125 points for 496 and 125+10 points for 896.

Problem 2. *(0 pts) Prerequisite of Installing ROS*[2]*. A VMware image of Ubuntu 18.04 and ROS Melodic already setup is available here:* `https://unl.box.com/shared/static/05lil2hn70lahw40kq2h8yqs8kwai3co.zip`*. This is a 7GB file zip file that extracts to a 17GB image. You can download a copy of VMware by going to* `https://unl.onthehub.com/WebStore/Welcome.aspx` *and signing in*[3] *or download the free VMware Player software. You can login to the* `robot` *account with the password* `robotsrule!` *(please change it).*

As an alternative, you can manually install **ROS Melodic** *(one of the ROS releases). I would either recommend installing Ubuntu 18.04 natively on your computer and then install ROS or you can do all of this inside of a virtual machine such as VirtualBox (open source) or VMWare (free to CoE students or the free vmware-player can be used). You will also need to go through the gazebo and px4 setup. Ask the instructor or TA for pointers to do this if you are interested.*

Problem 3. *Turtle Sim. Complete section 1.1 the beginner tutorials found at* `http://www.ros.org/wiki/ROS/Tutorials`*. This goes through a "turtle" tutorial that you will need to use to answer the below questions.*

Note 1: *If you downloaded the VMWare image step 1.1.1 is complete and there is already a catkin_ws directory with other source files in there.*

Note 2: *The tutorials use* `catkin_make`*, but some of the packages we use require* `catkin build`*. So use* `catkin build` *to compile instead of* `catikn_make`*. They are more or less equivalent.*

a). *(5 pts) Use* `rostopic pub` *from the command line to write your two-letter initials with your turtle (e.g. I would write "CD"). Attach a picture showing your initials as drawn in TurtleSim.*

b). *(5 pts) Give all the commands you used to write your initials in TurtleSim.*

c). *(5 pts) Show the* `rqt_plot` *of x position, y position, speed, linear velocity, and angular velocity (so five lines) of your turtle as it writes your initials. Augment the plot to show where drawing of each of the letters occurred.*

Video Submission: (10 pts) *This is due by Friday, Aug 28. You must submit a video showing commands to write your initials. Narrate the video to say what you are doing.*

[2]You should explore `http://www.ros.org` as there are many more helpful hints and documentation that are not referenced in this homework.

[3]If you do not have an onthehub account or if it does not allow you to download vmware, you can log in to https://cse.unl.edu/account with your CSE account credentials and going to the Account Settings link on the left. From there, check the box for VMware Academic Subscription, and click the Save button. This will create a request to get an account for you.

Problem 4. *Creating New ROS Nodes*

a). *(10 pts) Now create a new ROS node (see* `http://www.ros.org/wiki/ROS/Tutorials` *for details, you can use either C++ or Python) that publishes messages to write your initials (similar to the manual* `rostopic pub` *from problem 3a). Include a picture of the results. Also, describe how you dealt with the delays between sending messages. Remember that you need to comment the code appropriately for full credit (and include it in the zip file when submitting on* `Canvas`*).*

b). *(5 pts) Create a launch file that starts both the TurtleSim node and your new node. Include a copy of the launch file in your report.*

c). *(5 pts)* **839 Only:** *Create* **one** *new node that writes your initials using two different turtles. Include a picture of the results.*

d). *(5 pts)* **839 Only:** *Create two different nodes (or they could be one node instantiated two times) that each control a different turtle to write your initials (one turtle per letter). Include a picture of the results. The result should be the same as for the prior question.*

Problem 5. *In this class we will be using ROS with Gazebo. Gazebo is a physics simulator that will allow us to simulate flying around a drone. In this part of the problem we will start out using QGroundControl to fly the drone. This is the ground station that can be used to configure and operate drones that have a pixhawk-type flight controllers (or more generally any drone that supports the MAVLink protocol). You can use it to plan missions and do a bunch of other stuff. We won't use it much in this class as we will quickly move to using ROS to program and control our drones. But it is good to know how to use QGroundControl.*

a). *(5 pts) To get started, run the command* `roslaunch px4 posix_sitl.launch` *in one terminal and* `QGroundControl.AppImage` *in another. The first command should start up Gazebo and the second command will start QGroundControl. QGroundControl should show the drone on the ground and allow you to see battery status and other features. If it says "Communication Lost" in the upper right, something is wrong. Try relaunching/restarting and ask the TA or instructor if you continue to have trouble. Note: After closing Gazebo you might need to do a ctrl-c in the terminal where you launched it to get it to close.*

Include an image of Gazebo and QGroundControl running. If you had problems, include a description and how you fixed it.

b). *(5 pts) Review the QGroundControl user guide at* `https://docs.qgroundcontrol.com/master/en/index.html` *and pay close attention to the "Plan" section. Figure out how to create a flight plan to (yes, you guessed it) to draw your initials with the drone in a flight plan.*

In Gazebo if you go to the "Models" under the "World" tab and right click on the "iris" (name of the drone) you can select "Follow" to make Gazebo follow it around as you fly.

Describe how you did this in the text answer to this question. Include a description of any challenges you had and how you overcame them.

Video Submission: (10 pts) *This is due by Friday, Sept 4. You must submit a video showing how your drone writes your initials in QGroundControl. Narrate the video to say what you are doing.*

c). *(5 pts) What ROS topics are available?*

d). *(5 pts) Find where the launch file* `posix_sitl.launch` *is located and give the complete path to it. Hint: You can use* `roscd` *to get close.*

e). *(5 pts) The directory* `~/px4sim/src/Firmware/Tools/sitl_gazebo/worlds` *contains other "worlds." Copy the launch file and edit the copy so that you launch the* `ksql_airport.world`*. Describe how you did this and include a copy of the new launch file.*

f). *(5 pts) On your computer, how long (in seconds or minutes) did it take to launch the original launch file versus the ksql one? How do you explain the difference?*

Problem 6. This problem will take a while, so plan accordingly!
Now we are going to use ROS to control the drone instead of QGroundControl.

a). *(5 pts) Start by launching* `roslaunch px4 mavros_posix_sitl.launch`. *What ROS topics are available?*

b). *(5 pts) What is the battery voltage and how may "cells"*[4] *are there in the battery? How did you find this out?*

c). *(10 pts) Read about how to use ROS to control the drone at this site:* `https://dev.px4.io/v1.9.0/en/ros/mavros_offboard.html`. *Follow this tutorial to launch your drone using just ROS. Note, the tutorial is a bit sparse, so you will have to use all your ROS skills learned in class and in the prior problems. Describe the steps you took and any problems you encountered.*

d). *(10 pts) Now create the code to (yes, you guessed it) draw your initials with the drone. Now you are a ROS and drone master, congratulations! Describe the steps you took and any problems you encountered.*

Video Submission: (10 pts) *This is due by Friday, Sept 11. You must submit a video showing the initial takeoff from the tutorial (Problem c)) and also writing your initials (Problem d)). Narrate the video to say what you are doing.*

[4]See `https://rogershobbycenter.com/lipoguide/` and `https://en.wikipedia.org/wiki/Lithium_polymer_battery` for some info on LiPo batteries if you are unfamiliar with them.

Do not forget to fill in the amount of time you spent on this assignment in Question 1.