Module M02_RCDP - Remote Control & Data Processing

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Deadline: Sunday Feb 28, 2016, 11:59pm

Feedback and discussion about this module belong to the Slack channel **#m02-RCDP**, or **comment** directly here. Please **do not** edit directly (even if you can), because sudden changes might be very confusing for other students. If you find inconsistencies, please use the comment function. Instructors: please clearly mark the changes in a different color.

List of exercises:

TA grading guide: 100/7 points for each exercise.

RCDP0: Setup the repository to work on the lab branch

Background: please read the chapters in the Git book mentioned in Pointers to Reference Materials for Git, ROS, etc..

For this module, please work on the branch M02_RCDP:

```
duckiebot $ git pull
duckiebot $ git checkout M02_RCDP
duckiebot $ catkin_make
```

Please do not commit to M02_RCDP.
(Advanced students: please submit pull requests to M02_RCDP.)

Create your own branch from M02_RCDP:

```
duckiebot $ git branch M02_RCDP-<handle>
duckiebot $ git checkout M02_RCDP-<handle>
```

Feel free to *commit* to this branch.

Please do not *push* the branch to the remote repository just yet. (We will explain in the next lectures what you need to know about Git to move your work to a private fork.)

Do you now know about the difference between “commit” and “push”? Time to read the Git book mentioned in Pointers to Reference Materials for Git, ROS, etc. We guarantee that you will have to learn Git properly -- better do it now and save yourself lots of trouble later.

This is the expected output:

```
duckiebot $ git status
On branch M02_RCDP-<handle>
nothing to commit, working directory clean

duckiebot $ ls ~/duckietown -t
YES-THIS-IS-THE-RIGHT-ONE  RPi2-Ubuntu   circuits
LICENSE.md                 bootstrap.sh  duckietown_install_car.sh     ros_diagram     setup
README.md                  catkin_ws     duckietown_install_laptop.sh  scuderia.yaml
```

TA grading guide: assume this was done correctly.

RCDP1: Remote control

Learning objective: Basic Duckiebot operation; video documentation; access to Dropbox.

1) Create the folder in Dropbox:

    `Dropbox:duckietown-data/logs/20160210-M02_DPRC/<handle>/`

2) Setup the Duckiebot in RC mode, using the instructions in Setup Step 2.1 Joystick + camera output in remote laptop.

3) Make sure your Duckiebot is in the CCC (current conforming configuration).
    - Reminder: the CCC includes the cuteness constraint (Duckie on top).

4) Drive your Duckiebot and take a video of it using an external camera.
    - The Duckiebot should do a nontrivial trajectory that excites all degrees of freedom.
        - The trajectory corresponding to (velocities v = 0, omega) = 0 is trivial
    - Length: 10-15s are enough.
    - Cell phones are great cameras.
    - Our Creative Director Chris Welch hates vertical video. Therefore, vertical video is not valid.
    - Given the dynamic constraints, it is impossible for a Duckiebot in CCC to do wheelies; videos with wheelies are therefore evidence of the duckiebot being not in the CCC.
    - You might want to use a friend to drive the robot or to take the video, unless you have a tripod, three arms, or another robot that you programmed to hold the camera while it takes a video of the Duckiebot.

5) Put the video in *mp4* or *mov* format on Dropbox, with file name:

`../20160210-M02_DPRC/<handle>/201602DD-<handle>-<robot>-RCDP1-external.[mp4|mov]`

TA guide: Check that the file above exists in the Dropbox, that it is named appropriately, and that it contains what it should contain.

RCDP2: Logging

Learning objective: Take a log (called "bag") with your Duckiebot.

To learn how to record a bag, refer to the tutorial in 160219 - Lab 03 - ROS tutorial.

Instructions:

1) Start RC mode on your Duckiebot (with camera output).
2) Start a log with rosbag and subscribe to all channels (use the -a option).
3) Drive around for at least 1 minute of continuous motion.
4) Open the log using rqt_bag to check that the data got recorded correctly.
5) Put the bag in Dropbox, and name the file (DD = day of month):

```
../20160210-M02_DPRC/<handle>/201602DD-<handle>-<robot>-RCDP2.bag
```

TA guide: Check that the file above exists, that it is named appropriately, and that it contains what it should contain using rqt_bag.

RCDP3: ROS Basics

Learning objective: creating ROS modules.

If you were in Lab 03 (Beaverworks Feb 19) **<u>and</u> you completed up to Step 2.3**: you are done - please move on to the next exercise.

1) node

If you have not already completed up to Step 2.3, you should replicate the lab **using your robot and your laptop** instead of the ones used in the lab, which were called “Wolverine” and “megaman”, respectively.

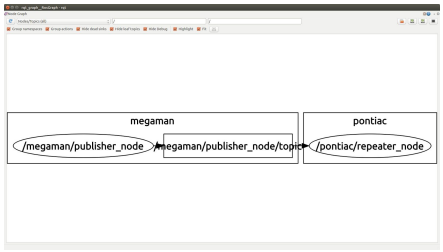
These are the differences between the lab setup and your individual setup:

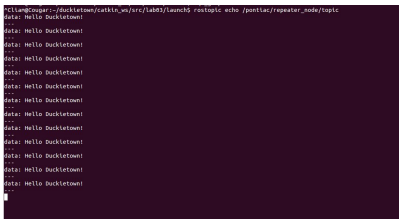
1) Your laptop should be “publisher”.
2) Your robot should be the “repeater” / “subscriber”.
3) Set the ROS_MASTER_URI to be your laptop.
4) Complete the steps in 160219 - Lab 03 - ROS tutorial.
5) Add ‘1’s to the columns in 160219 - Lab 03 - progress status.
6) In Exercise 2.3, run the publisher on your laptop with **veh:=megaman**
7) Run the repeater on your robot with **veh:=your_robot_name**

Take a screenshot of
1) the graph created by rqt_graph; and
2) the output of running this on your laptop:

```
laptop $ rostopic echo /your_robot_name/repeater_node/topic
```

The screenshots should look something like this:





Post both of these to the Slack channel #lab03-feb19.

TA guide: Check that either:

1) they were present at the lab and completed the exercise; or
2) the two screenshots were posted to the Slack channel.

RCDP4: Basic Data Processing

Learning objective: creating a node that can receive and republish data.

The simplest example of a data processing node is a node that receives an image, makes a little modification to it, and then republishes it. Let us call this node "virtual_mirror-<handle>".

1) Create virtual_mirror-<handle> according to the conventions in the ROS tutorial. The package should be in:

   `duckietown/catkin_ws/src/virtual_mirror-<handle>`

2) This is the specification of the functionality.

   Let H,W be the height and width of an image. The array has thus size H x W x 3.

   Let rgb_in[u1,v1,w1] be the image received by the module (pixel y=u1, x=v1, channel w1) and let rgb_out[u2,v2,w2] be the image published by the module. (pixel y=u1, x=v1, channel w1).
   vi
   Then this should be true for all u,v in the range of the image:

   ```
   rgb_out[u, v, w] == rgb_in[u, W - v, w]
   ```

   (Note: `W` ≠ `w`) This corresponds to flipping the image along the horizontal axis (virtual mirror).

3) Create a launch file that makes the node subscribe to the Duckiebot image. Please refer to the ROS Diagram in the Duckietown-public:design/ folder for the name of the topic.

   The launch file is in

   `duckietown/catkin_ws/src/virtual_mirror-<handle>/launch/virtual_mirror_node.launch`

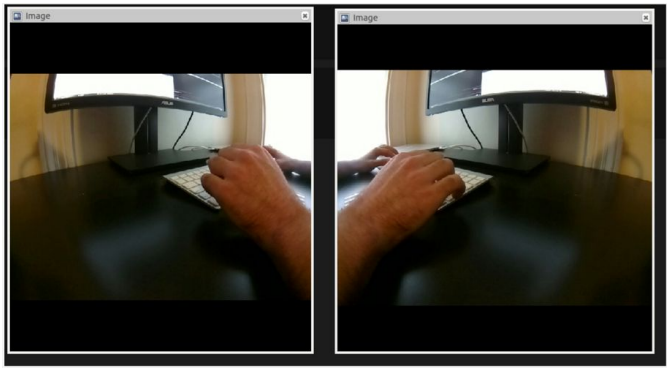
   (Note: You will have to run the camera launch file separately) The node should be launchable using:

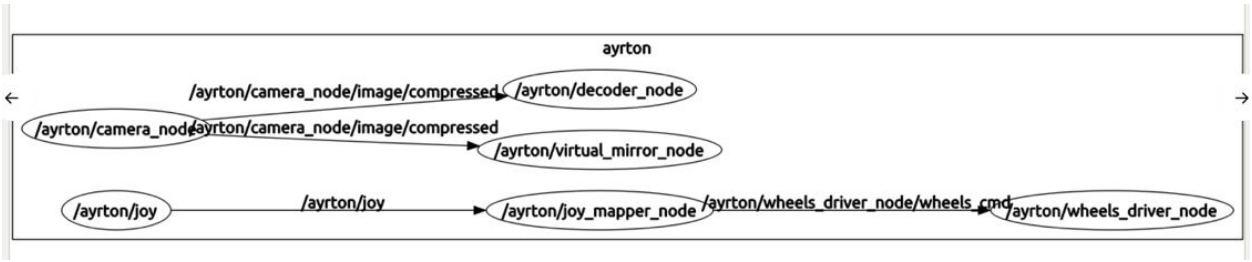
   `$ roslaunch virtual_mirror-<handle> virtual_mirror_node.launch veh:=<duckiebot>v`

4) Run this node and subscribe to both images from RViz in your laptop.
5) Take a screenshots and post to #m02-RCDP:
   a) the rqt_graph
   b) the two images in RViz

TA grading guide: Check that the two screenshots were posted to the Slack channel.

Food for thought: Why do mirrors reverse left and right, but not top and bottom?
Expected result (from Takke):





RCDP5: Processing data from a log.

Learning objective: ability to process data from a log.

In exercise RCDP2 you created a bag file, by the name:

```
[...]/20160210-M02_DPRC/<handle>/201602DD-<handle>-<robot>-RCDP2.bag
```

Call this “log_in”. In bash (it needs to be the full path):

```
log_in=[...]/20160210-M02_DPRC/<handle>/201602DD-<handle>-<robot>-RCDP2.bag
```

In this exercise we will create another bag file, which we are going to call “...**-RCDP5-log_out**.bag”:

```
log_out=[...]/20160210-M02_DPRC/<handle>/201602DD-<handle>-<robot>-RCDP5-log_out.bag
```

Create a launch file `virtual_mirror_test.launch`.

This launch file should use two variables, log_in and log_out, such that when we run

```
$ roslaunch virtual_mirror-<handle> virtual_mirror_test.launch veh:=<duckiebot>
log_in:=$log_in log_out:=$log_out
```

this is what happens:

1) The recorded image data in $log_in is pushed through virtual_mirror
2) All the topics are saved in $log_out.

Hint: have a look in `~/duckietown/catkin_ws/src/duckietown_unit_test/launch` *for some launch files that run rosbag in this way.*

Consequently, log_out contains two image streams: the initial one and the flipped one.

Deliverable: the resulting file log_out in
`20160210-M02_DPRC/<handle>/201602DD-<handle>-<robot>-RCDP5-log_out.bag`

Update (Feb 24): You should know that ``rqt_bag`` has a bug for which the colors are not decoded right. If you use ``rqt_bag`` in our logs, the logs look blueish, but in fact, the image inside the log is correct.

TA grading guide: Check that the file exists and that it contains the two streams of images.

RCDP6: Stateful data processing

Learning objective: learn how to create a module that does data processing in a stateful way (i.e. with an internal state).

Create a package “image_average-<handle>” according the the conventions. This package reads an image rgb_in and cpwrites an image rgb_out.

The image rgb_out in this case is the temporal average of rgb_in. Formally:

> rgb[u,w,v] at time t1 == average of rgb_in[u,w,v] between t0 and t1

Create a launch file that takes log_in and log_out as parameters.

Run this on the bag file provided in

> 20160210-M02_RCDP/censi/20160122-censi-ferrari-RCDP2.bag

Put the output bag file in

> 20160210-M02_DPRC/<handle>/20160122-censi-ferrari-RCDP6-<handle>.bag

Open the bag using rqt_bag and take a screenshot of the last image; post it on Slack in #m02-rcdp.

TA grading guide: Check that the file above exists and that it contains the two streams of images; look for the screenshot in Slack.