Challenge 1 – Sensor fusion with Kalman Filters

These instructions will lead you through setting up a turtlebot and running your code on it, for the first robotics challenge. Be sure that the launch file you wish to run does not have a rosbag node, does not have an rviz node, and does not have the "use_sim_time" parameter set to true.

To prevent conflicts with the live robot, you should also modify your EKF node to add the following argument:

```
<param name="publish_tf" value="false"/>
```

Part 1: Robot OS setup

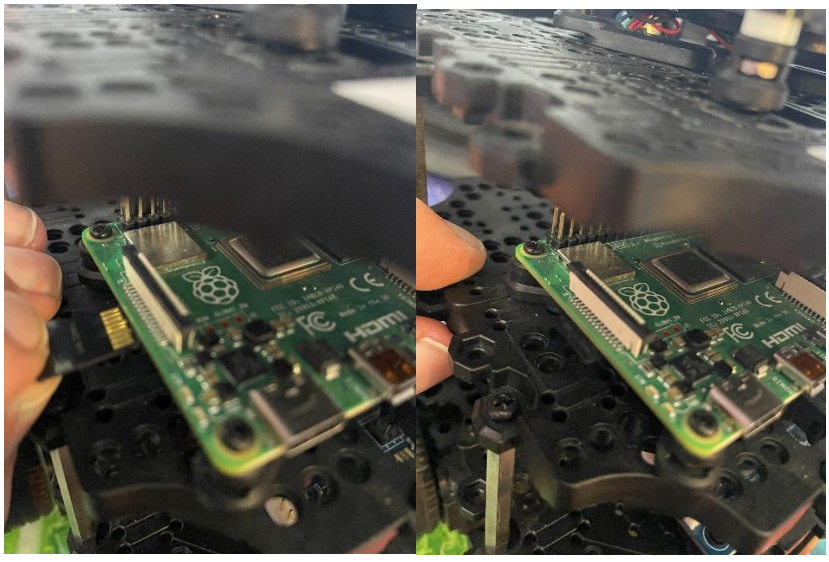
At least one person in each group will need to have their own laptop available (either windows, linux and MacOS should be fine). One other person from each group should grab the following supplies from the trolley and find a computer for your group to work at:

- 1 turtlebot
- 1 display cable
- 1 SD card
- 1 power pack

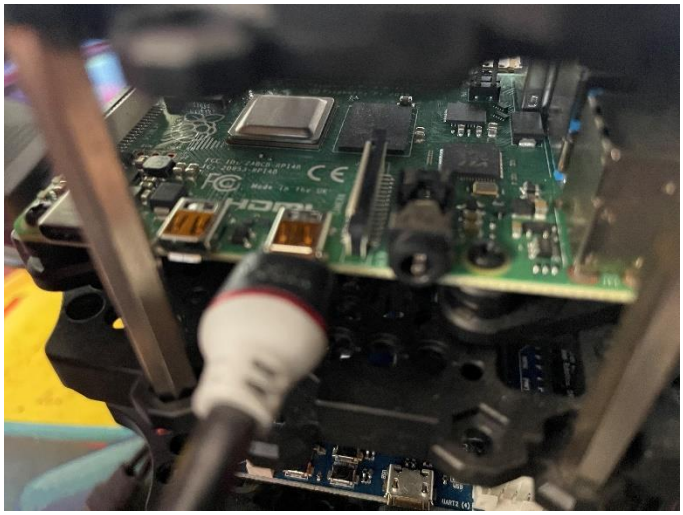
Hopefully the group from last year left everything in a good state. For now proceed to Part 2, but if you encounter any software setup issues while completing the challenge, look at the appendix at the end of the document for instructions on flashing the SD card.

Part 2: Robot connectivity

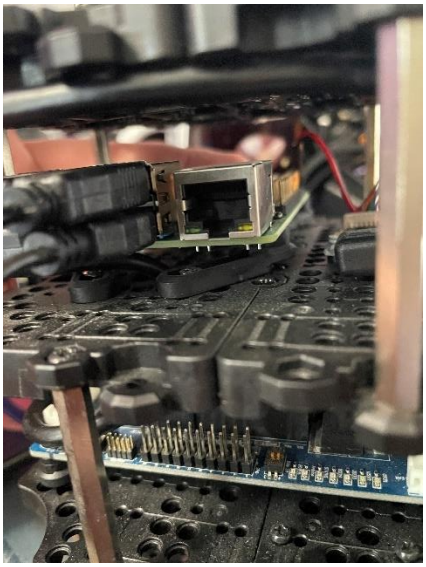
Next we will setup the turtlebot to connect to the network, and talk to your laptop and the lab machines. First, insert the SD card into the turtlebot as shown below.



Next plug the display cable into one of the micro HDMI ports as shown below, and connect the other end to the monitor on your desk.



Disconnect the keyboard and mouse from the same computer, and plug them into the turtlebot as shown below.



Finally, connect your power pack to the blue controller board (not the green raspberry pi) and switch it on, as shown below.

During the challenge if your robot beeps and no longer responds to commands, it is likely that the battery is about to run out. Please turn off your robot, remove the battery and connect it to one of the chargers next to the trolley, then collect a new battery put it in your robot and resume.

You should now see an ubuntu login screen. Log into the account with username “bot” using the password “bot” (without quote marks). We are now logged into the raspberry pi inside the turtlebot.

It is likely that you will see a blank desktop with no taskbar, because the turtlebot considers this a secondary display. If not, proceed to the next paragraph. If so, to resolve it press ctrl + alt + t to open a terminal and run gnome-control-centre, go to devices -> display click mirror and click apply.

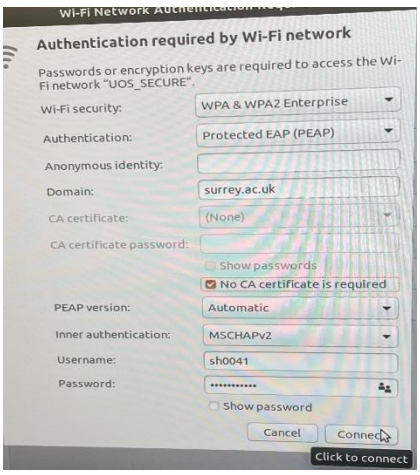
Open a terminal and run the following command, where **Z** is the number of your turtlebot (shown on it’s label). It will prompt you for the password again, which is bot

```
sudo hostnamectl set-hostname turtlebotZ
```

Next update the turtlebots firmware by running

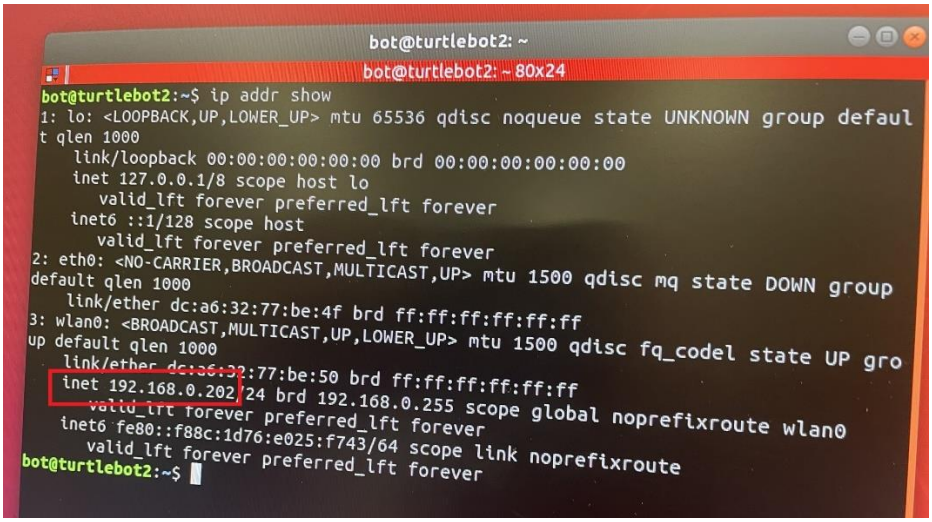
```
cd ./opencr_update
./update.sh $OPENCR_PORT $OPENCR_MODEL.opencr
```

Next, click the wifi icon in the top right of the screen, and choose “wifi settings”. We will use the eduroam network. If it seems like it is already connected, click the gear icon and go to security, otherwise simply double click on it. Either way, you should fill in the options as shown below, using your own university username and password.



You should now be connected to the wifi. Next, run the following command and make a note of the resulting IP address, as highlighted in the picture below.

```
ip addr show
```

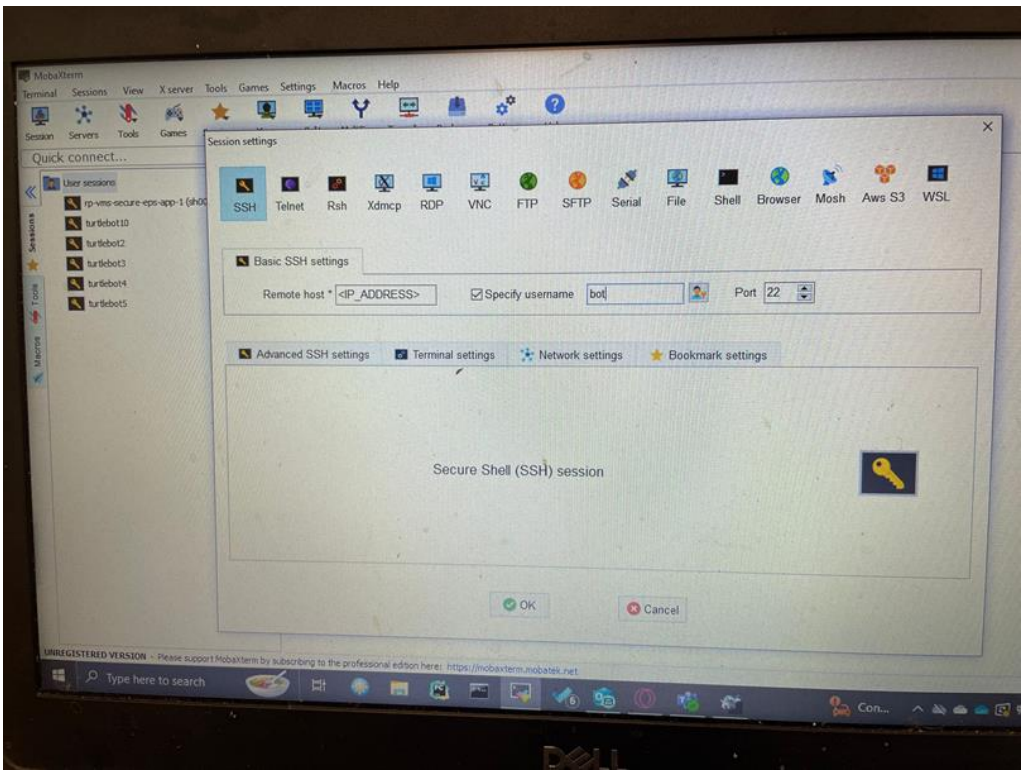


Part 3: Connecting to the robot and setting up the workspace

Connect your group's laptop to eduroam, then we will open a remote terminal on the robot. If your laptop is running ubuntu you can use the following command (password is bot) using the IP address of your turtlebot which you recorded above:

```
ssh -X bot@<ip_address>
```

If you are running windows install mobaxterm then create a new session using the username bot and the ip address found above.



Any commands you run in this terminal will now execute on the robot, not on your computer.

First mount a network space by entering the following command, using your university username, and where **W** is the number of the lab machine you are sat next to (shown on its label or in a terminal). You will probably have to accept the ECDSA fingerprint and enter your university password. If you restart your robot you will probably need to rerun this command.

```
sshfs <username>@heronW.eps.surrey.ac.uk:/vol/vssp/signsrc /vol/vssp/signsrc
```

Next, we will remove any older versions of the challenge code, and ensure the robot has the latest version.

```
rm -R ~/turtlebot3_ws
mkdir -p ~/turtlebot3_ws/src
cd ~/turtlebot3_ws/src
git clone https://gitlab.surrey.ac.uk/eee3043/eee3043.git
echo "source /home/bot/turtlebot3_ws/devel/setup.bash" >> ~/.bashrc
```

Next we will close and reopen the terminal to ensure that the new space is sourced correctly (on windows close and reopen the mobaxterm session, on mac/linux use the following command)

```
exit
ssh -X bot@<ip_address>
```

It will prompt for the password again which is bot, then we rebuild the ROS workspace with

```
cd turtlebot3_ws
catkin_make
source ./devel/setup.bash
```

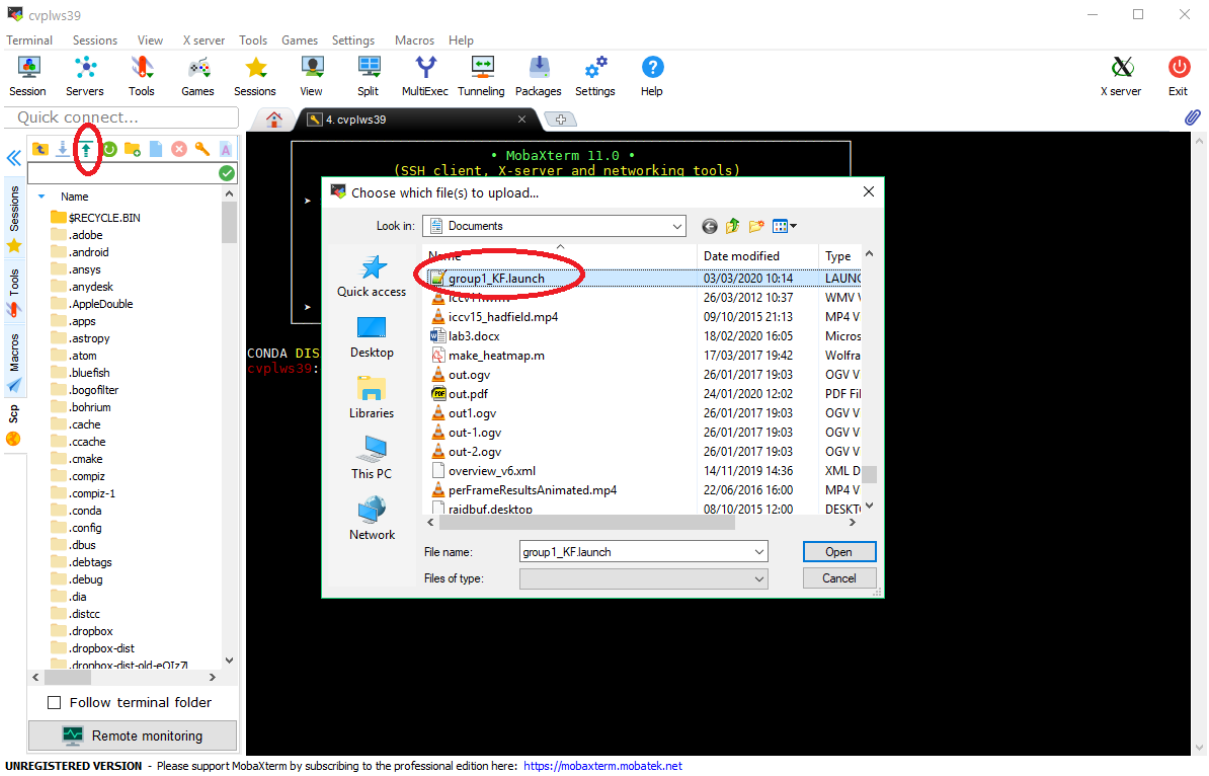
Part 4: Copying your code to the robot

Name your launch file group**X**_kf.launch (where **X**) is your group number.

If you are using a linux/mac laptop place your launch file in your home space. Then open a new local terminal (not on the robot), and run the following command to copy it onto the robot (remember the password is bot and the ip address for your robot was recorded above) :

```
scp ~/groupX_KF.launch bot@<ip_address>:~
```

If you are using a windows laptop click the “upload” button as shown below, and select your launch file and click OK.



From now on, if you wish to modify your launch file on the robot ssh into it using the command from section 3, and then run the following:

```
gedit ~/groupX_KF.launch &
```

Note that editting the version of the launch file in your own laptop will not affect the robot's behaviour unless you copy it to the robot again.

Part 5: Running your code on the robot

First, disconnect the keyboard, mouse and display cable from the turtlebot. Make sure your robot is on the floor with around 1.5m of empty space in every direction. Then, to run your code simply execute the following command in a remote terminal, where **X** is your group id and **Y** is the route number (between 1 and 6):

```
roslaunch eee3043 challenge1.launch group:=X route:=Y
```

The robot should execute a trajectory (which one depends on the value of Y) while running your kalman filter. After execution a number should be written to the terminal. This number represents the accuracy of your Kalman filter output with respect to the "ground-truth" (the pseudo-GPS signal before noise is added).

After a route has been run, the code will print a number to the terminal which is the accuracy of your Kalman filter's output. You can also look at a plot of your estimate versus the "true" trajectory by running the following command in the terminal (where X is your group ID and Y is the route):

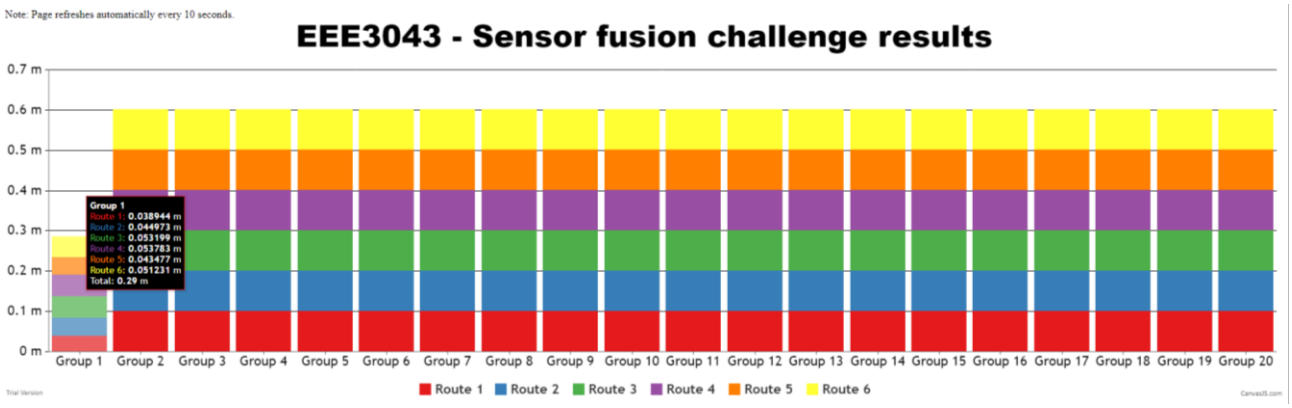
```
eog /vol/vssp/signsrc/challenge1/X_Y_plot.png
```

Before running the next route, ensure you return your robot to a clear starting position, including making sure it faces the correct direction. This will help to avoid crashing into the walls when you run the next route.

Part 6: Competing on the leaderboard!

You can check your performance compared to that of other groups by looking at the online leaderboard displayed on the screens around the lab.

The leaderboard should look something like the following picture. Note that you will see a score of 0.1 for every route that you have not yet completed. If you complete a route more than once, the most recent score will be used to populate the leaderboard.



When you have completed all 6 routes and are happy with the results you are done! However, please note that the system will save rosbags of your predictions so that they can be rerun and verified later if your team wins.

Part 7: Cleanup

Before leaving the challenge, we need to clear your saved details from the SD card. Connect the robot to the keyboard, mouse and monitor again. Bring up a terminal and run

```
sudo hostnamectl set-hostname turtlebot000
```

Then click the wifi icon in the top right corner, click select network, click the gear icon and press “forget connection”.

You can then turn off the robot, remove the SD card, and return your supplies (turtlebot, SD card, display cable, powerpack) to the correct boxes on the trolley.

Finally, please ensure that your desktop computer is left setup correctly (monitor, keyboard and mouse all connected) or IT will be upset with me!

APPENDIX: Flashing the SD card

Only follow the below instructions if you have a problem during the challenge and are advised to re-flash the SD card.

We don’t have permission to flash the SD card on the lab machines, so you will have to use the provided laptop. Assuming now card is already being flashed, remove any cards that have been left in the machine and return them to the box. Then insert your SD card into the laptop, and run the

following command; when prompted the password will be ‘bot’

```
sudo ~/burn_turtlebot_image.bash
```

While it is flashing, grab a new SD card from the box and return to your group.