COMP-4510-Project-3

This file contains logic to construct and test a navigation system for wall following generated through reinforcement learning.

On a high level, this either exploits or finds a mapping between robot states and actions, that result in some consistent or learned behavior.

Intended is to learn a type of wall following behavior that prevents the robot from crashing while maintain a constant distance to a wall on the right of the robots frame.

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- /launch/wallfollow.launch
  - Launch file containing model and world information
- /src/q_learning.py
  - Primary navigation software.
    - Is used to train new RL models, either using SARSA or Q learning
    - Demos Q tables in simulation
- /src/Optimal_Q_Table_TD.JSON
  - The best Q table for Temporal Difference Learning (try demoing)
- /src/Optimal_Q_TABLE_SARSA.JSON
  - The best Q table for SARSA learning (try demoing)
- /src/known_states_tracker.JSON
  - List of states and actions that are used to track the behavior during training.
  - Informs the learning convergence plots.
- /src/Test_Q_table.JSON
  - File placeholder for training throwaway Q tables (You can write over this)

Watch the video for task 1

[Watch the video for part 1]

Run Setup Files

First in its own terminal start the launch file.

```
$ roslaunch wallfollowing wallfollow.launch
```

If this throws an error, you may need to resource the terminal

```
$ cd catkin_ws
$ source devel/setup.bash
$ roslaunch wallfollowing wallfollow.launch
```

Navigation Software

The file

```
/src/q_learning.py
```

Here you can train a new model, or demo a pre-saved Q table (behavior)

Run

```
$ rosrun wallfollowing q_learning.py --help
```

For more information about how to start training/testing cycles.

Training a new RL model

The simplest way to train a new model is with

```
$ rosrun wallfollowing q_learning.py --train
```

This will launch a training cycle with all default parameters.
However, it is more useful to specify some of your own parameters.
Try running,

```
$ rosrun wallfollowing q_learning.py --train --num_epocs=100 --out_filename Test_Q_table --p
```

This will launch a training cycle for 100 episodes, and save the final q table to the file 'Test_Q_table'
Note, all files are saved to the file location where the .py script is running and will write over any existing files. (Run carefully)
Code Breakdown
- num_epocs <—- Number of episodes in a learning cycle - out_filename <—- File name to save Q table - plot_out_file <—- file name to save convergence plots - strategy <—- this is a mode section that can be 'Temporal Difference' or 'SARSA'

Testing a model

Here the behavior of a Q table is tested in simulation,
The Q table is note updated during this mode.
The fastest way to demo a Q table is to run,

```
$ rosrun wallfollowing q_learning.py --demo
```

This will automatically select the optimal Q table for temporal difference and demo it over 25 cycles.
However, you can also select a different Q table.
run

```
$ rosrun wallfollowing q_learning.py --demo --in_filename 'Optimal_Q_Table_TD'
```

to demo the the best Q table for temporal difference
Run

```
$ rosrun wallfollowing q_learning.py --demo --in_filename 'Optimal_Q_Table_SARSA'
```

I think the SARSA Q table has better performance.
to demo the best Q table for SARSA
Finally, run

```
$ rosrun wallfollowing q_learning.py --demo --in_filename 'Test_Q_table'
```

to demo the Q table you made in the previous section.

Connecting to the Robot (Turtlebot 3 Waffle Pi)

Ensure the following is installed

```
$ sudo apt-get install ros-kinetic-dynamixel-sdk
$ sudo apt-get install ros-kinetic-turtlebot3-msgs
$ sudo apt-get install ros-kinetic-turtlebot3
```

Export the waffle pi model,

```
$ echo "export TURTLEBOT3_MODEL=waffle_pi" >> ~/.bashrc
```

SSH into the robot in its own terminal.

```
ssh ubuntu@192.168.9.{Robot Number}
```

Or turtlebot 1 and 2,

```
ssh pi@192.168.9.{Robot Number}
```

Next, run the bring up software,

```
$ roslaunch turtlebot3_bringup turtlebot3_robot.launch
```

In a new terminal
Find your wifi IP address under inet Addr, ###.###.#.###

```
$ ifconfig
```

Update ./bashrc with the correct ROS master IP

```
$ vim ~/.bashrc
```

The last line has the form,

```
export ROS_MASTER_URI=http://192.168.9.{Robot Number}:11311
export ROS_HOSTNAME={Your Computers Host IP}
```

For help with vim, see the help with vim section.
After updating and saving ~/.bashrc, source the terminal

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

You can try to teleop the robot with,

```
roslaunch turtlebot3_teleop turtlebot3_teleop_key.launch
```

Or run the navigation software by following the next section.

Running on the robot

After connecting to the ROS master on the robot, run the command,

```
rosrun wallfollowing q_learning.py --robot --in_filename Optimal_Q_Table_SARSA
```

For best result, place robot near a wall before starting.

Troubleshooting

It is likely you will need to resource every terminal you enter.

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

Help With VIM

Start by entering insert mode by pressing ‘I’.
Make the necessary changes to the document.
To save, press,
‘esc’
‘:’
‘wq’
Then press ‘enter’
The document is now saved, don’t forget to resource the terminal after.