EXPERIMENT 1: INTRODUCTION TO QBOT 3 FOR QUARC

The objective of this introductory exercise is to explore the hardware and software related to Quanser QBot 3 Mobile Platform. You will learn how the QBot 3 is actuated, what types of sensors are available, and how you can communicate with the device in order to send commands and receive sensory data.

Topics Covered

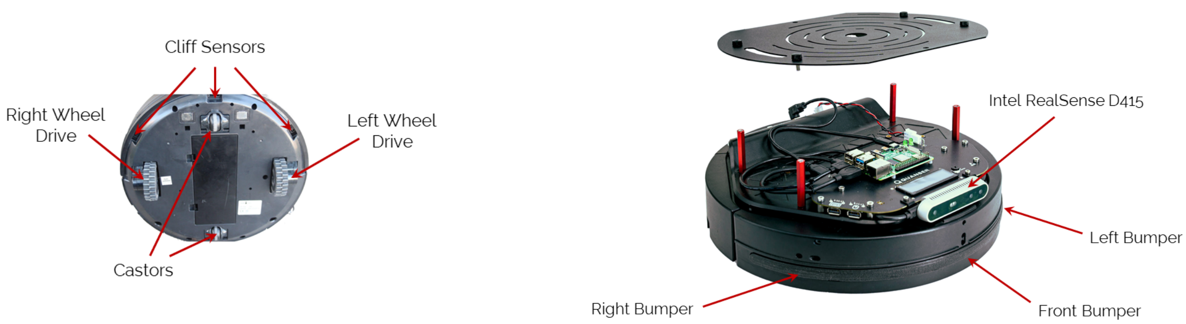
- QBot 3 Hardware Components
- QBot 3 Software and Communication

1 Background

The purpose of this lab is to get you started with the Quanser QBot 3 Mobile Platform and familiarize you with the basic concepts related to the product including sensors, actuators, and the QBot 3 software components.

1.1 QBot 3 Main Hardware Components

The Quanser QBot 3 Mobile Platform consists of two central drive wheels mounted on a common axis that bisects the robot as shown in Figure 1.1a. This drive configuration is known as differential drive. Castors at the front and back of the robot stabilize the platform without compromising movement. The two drive wheels are independently driven forward and backward in order to actuate the robot. This approach to mobile robot wheel geometry is very common due to its simplicity and maneuverability.



(a) Bottom View

(b) Front View

Figure 1.1: Main QBot 3 Hardware Components

The motion of each wheel is measured using encoders, and the robot's orientation, or yaw angle, are estimated using the integrated gyro. For more information on the Kinematics of the QBot 3, and how you can generate wheel commands to achieve specific motion trajectories, refer to the Forward/Inverse and Differential Kinematics laboratory experiments. You will also learn how the measured sensory information is used for odometric localization.

In addition to the encoders and gyro, the QBot 3 comes with an Intel RealSense D415 camera for vision, shown in Figure 1.1b, that outputs color image frames (RGB) as well as depth information. You can process RGB and depth data for various purposes including visual inspection, 2D and 3D occupancy grid mapping, visual odometry, etc. For more information on these concepts and more, refer to the Computer Vision laboratory experiments.

The QBot 3 also comes with integrated bump sensors (left, right and central), and cliff sensors (left, right, and central) as shown in Figure 1.1a and Figure 1.1b. These sensors can be used in a control algorithm to avoid obstacles, or prevent damage to the robot.

1.2 QBot 3 Software and Communication

The QBot 3 for QUARC leverages Quanser QUARC Rapid Control Prototyping software which seamlessly integrates with MATLAB/Simulink Software to provide real-time communication and interfacing to the components of the QBot 3. QUARC extends the code generation capabilities of Simulink to the QBot 3 as an external real-time target. Using QUARC, you can rapidly prototype any algorithm and quickly evaluate it on the device.

To communicate with the QBot 3, the following QUARC blocks are used:

1. Hardware In the Loop (HIL) Initialize block: The HIL Initialize block configures the drivers and hardware interface for the QBot 3
2. HIL Read/Write: The HIL Read/Write blocks are used to read sensory data and drive the motors
3. Video3D Initialize: Used to initialize the Intel RealSense sensor. Maximum frame-rate and resolution are set in this block.
4. Video3D Capture: Captures RGB data from the Intel RealSense sensor with the RGB stream.
5. Video3D Capture: Captures depth data from the Intel RealSense sensor with the Depth stream.
6. Video Compressed Display: Transmits compressed input data (RGB or depth) from QBot 3 to the PC and displays them on the monitor.

Other than the aforementioned blocks, the “Host Initialize” block can be used to make use of external input devices such as a keyboard (Host Keyboard) or joystick (Host Game Controller). These blocks can be seen in the supplied model for the In-Lab portion of this laboratory experiment.

2 In-Lab Exercise

2.1 Wheel Drive Mode

In this experiment, you will command the left and right wheels independently and observe the motion of the robot and vision data from the Kinect sensor. The supplied model for this part of the lab is called `QBot3_Keyboard_Teleop_Wheel.mdl`, shown in Figure 2.1. In this model, we use the HIL Initialize block to configure the interface options for the QBot 3, Video3D Initialize for the Intel RealSense sensor, and Host Initialize for the keyboard interface. If you double click on the *QBot 3 Basic Motor Commands and Sensor Measurement* subsystem, and then *QBot3_IO_Basic*, you will find *HIL_Write* and *HIL_Read* blocks used to drive motors and read from the sensors. Take time to explore the model. You can right-click on the blocks and select help to find more useful information regarding each block.

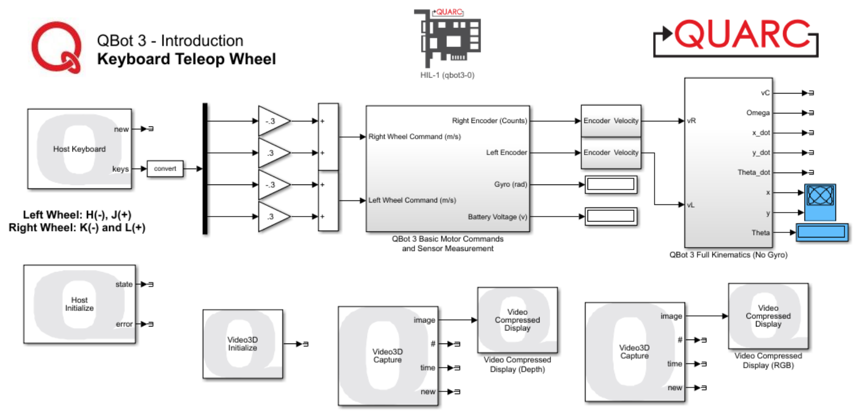


Figure 2.1: Snapshot of the `QBot3_Keyboard_Teleop_Wheel.mdl` model.

The *Video3D Capture* block is used to read the depth and RGB data from the Intel RealSense sensor, based on the stream selected. We then use the *Video Compressed Display* blocks to display these images.

The keyboard controls for this experiments are as follows:

- Left wheel command: H (-) and J (+)
- Right wheel command: K (-) and L (+)

After turning on the device, and connecting to the *Quanser_UVS-5G* wifi network, follow these steps:

1. Compile the supplied model and run it.
2. Double-click on the *XY Figure*, *Video Compressed Display (Depth)* and *Video Compressed Display (RGB)* blocks.
3. Use the keyboard to command the robot.
4. Describe how the motion of the left/right wheels relate to the actual motion of the robot (forward/backward motion, left/right turn, etc.)
5. Stop the model.

2.2 Normal Vehicle Drive Mode

In this experiment, you will drive the robot in a conventional manner where the robot commands correspond to move forward/backward, and turn left/right, similar to the way you would control any vehicle. The controller model for this exercise, shown in Figure 2.2, is called `QBot3_Keyboard_Teleop_Normal.mdl`. The QUARC blocks used in this model are similar to the ones described above.

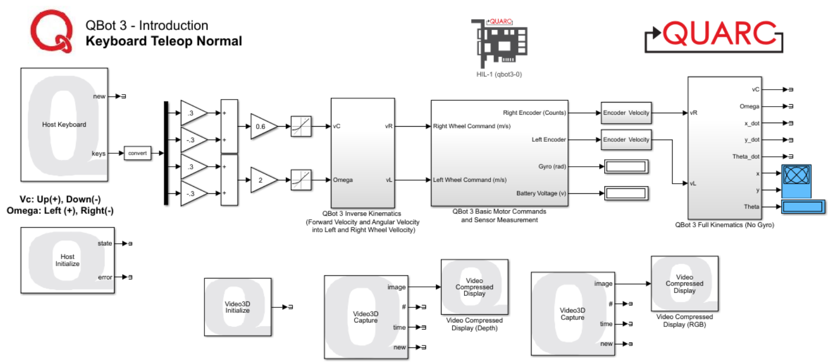


Figure 2.2: Snapshot of the `QBot3_Keyboard_Teleop_Normal.mdl` model.

Two customized blocks are also used that apply the inverse kinematics and forward kinematics models of the device, the details of which are presented in the Kinematics laboratory experiment. Keyboard controls for this model are as follows:

- Linear velocity command:Up (+) and Down (-)
- Angular velocity command: Left (+) and Right (-)

After turning on the device and connecting to the *Quanser_UVS-5G* wifi network, following these steps to run the model:

1. Open the supplied model, compile the model and run it.
2. Double-click on the *XY Figure*, *Video Compressed Display (Depth)* and *Video Compressed Display (RGB)* blocks.
3. Use the keyboard keys to command the robot. Up arrow to move forward, down arrow to move backward, left arrow to turn left, and the right arrow key to turn right.
4. Observe the RGB and depth images, as well as the XY figure, and report your observations.
5. Describe the benefits of controlling the vehicle in normal mode.
6. Stop the model.

Quanser Inc.
119 Spy Court
Markham, Ontario
L3R 5H6
Canada
info@quanser.com
Phone: 1-905-940-3575
Fax: 1-905-940-3576

Printed in Markham, Ontario.

For more information on the solutions Quanser Inc. offers, please visit the web site at:
http://www.quanser.com