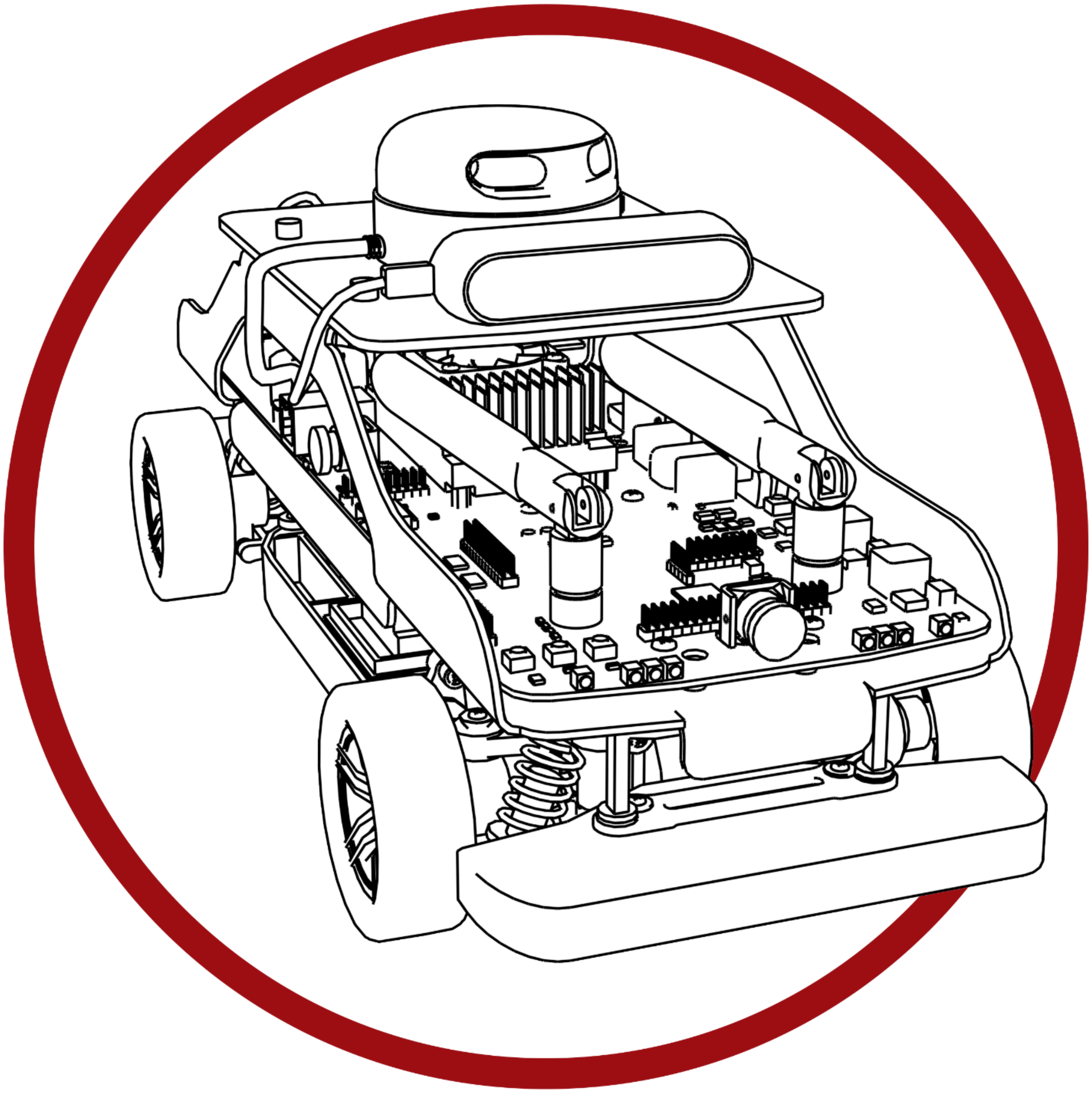
Self-Driving Car Research Studio



Gyro Heading Estimation - Simulink

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I. System Description

In this example, we will build on the manual drive example to read the IMU and estimate the heading of the car. The IMU is a full 9-axis device. Each internal device (accelerometer, gyro, and magnetometer) has their advantages and disadvantages. The accelerometer is a high-bandwidth linear device, but will also easily pickup vibrations in the car adding to the noise floor. The magnetometer can give us an absolute angular heading, but it is relatively slow device and it can be affected by other environmental factors such as rebar in concrete floors. The gyro has a bandwidth between the accelerometer and magnetometer. It isn't as sensitive to vibrational noise and it's relatively immune to environmental factors, but it is subject to small steady-state errors that can cause drift in our heading measurement when integrated.

In this example, we will only be using the Z (vertical) axis of the gyro to estimate the QCar heading. The Simulink implementation is displayed in Figure 1 below.

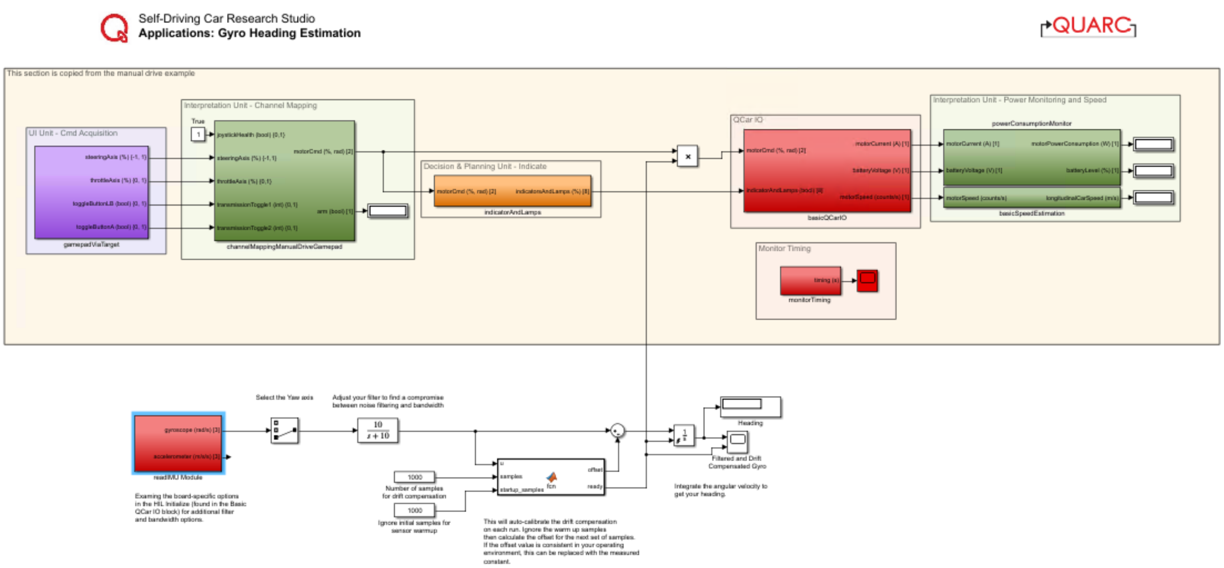

Figure 1. Simulink implementation of the Gyro Heading Estimation

The manual drive example has been left unaltered except for the addition of a ready signal multiplied by the motorCmd signal to block the car from moving until the self-calibration is complete.

The readIMU block gets the gyroscope measurement and we select only the yaw axis. The result is put through a low-pass filter that is above the expected bandwidth of our QCar angular velocity to reduce the signal noise. This is combined with the Board-Specific Options set in the HIL Initialize block (inside the basicQCarIO subsystem) to also provide some filtering to the gyro by selecting a lower full-scale range of 250 deg/s.

The filtered result is fed into a Matlab Function block that ignores an initial set of samples to account for startup conditions, then averages the result of the next 1000 samples to estimate the gyro drift factor. This is stored as a persistent variable to be subtracted from future gyroscope readings. Finally, the angular velocity of the gyroscope measurement is integrated to give the heading of the QCar.

Inevitably, the gyro heading will drift eventually, but when a technique like this is combined other sensors in the IMU or other QCar sensors such as the cameras or LIDAR, it can be corrected periodically. In between corrections, it can estimate the heading to provide high-frequency updates in between slower sensor measurements or when confidence in other sensors is reduced.

II. Running the example

Check the user guide **IV - Software - Simulink** for details on deploying Simulink models to the QCar as applications.

Before running this example, connect the **Logitech F710 Gamepad** (provided with the **Self-Driving Car Research Studio**) USB dongle to one of the USB 3.0 ports on the QCar.

III. Details

1. Driving manually is mapped to the following gamepad sticks/buttons:

    a. **Left Button LB** for Arm - QCar will be armed when this is pressed (**1**), and steering/throttle will not respond when it is released (**0**).

    b. **Left Stick** for steering - stick all the way to the left position is +ve, steering the wheels left as well.

       Note: The LED light next to the **MODE** button on the gamepad must be **OFF** to use the Left Stick for control. If that LED light is on, press the MODE button again to toggle it OFF.

    c. **Right Throttle RT** for throttle - pressed all the way represents 100% command. Let the throttle go for 0% command.

       Note: Throttle is scaled by 20% for better manual control then saturated to 20% in the **basicQCarIO** subsystem for safety.

    d. **Button A** for reverse - hold this button and use the steering/throttle commands to drive backwards.

   NOTE: The switch at the back of the F710 gamepad must be in the **X** position for the above mentioned control to work. If the switch is in the **D** position, move the switch back to the **X** position.