UTRA Robosoccer

Robot Modeling for WeBots

For RoboCup 2021 Qualification

List of Changes/Revisions:

Date	Revision	Editor(s)	Changes
2021-04-23	0.1	Shahryar Rajabzadeh	First Draft - IMU Section
2021-04-23	0.2	Jonathan Spraggett	Added Actuator Section
2021-05-09	0.3	Shahryar Rajabzadeh	Changed the LUT unit for Gyro from deg/s to rad/s

Actuators

We are planning to use MX28 motors from Dynamixel set at 14.8V with characteristics and positional sensor resolution found in the MX28 datasheet. We used the exact values from the sample actuators listed in robot modeling specification document v1.01 from RoboCup Humanoid League Organizing Committee.

IMU Sensor

We are [Here]planning to use the LSM6DSOX IMU from STMicroelectonics. The sensor is set to be operated in high-performance mode and sampled at 104Hz.

Noise Modeling

We considered the noise inherent to the IMU and modeled the drift-due-to-temperature effect as a random variable obeying normal distribution. We also assumed that the sensor is calibrated to offset the zero-level bias by taking measurements of the sensor at still condition and we did not include its effect within our webots modeling.

Accelerometer

Sensor Range and Raw Output

The sensor is set to measure from -2g to 2g linear accelerations in each axis. The raw output of the sensor is 16 bits represented in 2's complement, the same scheme used to store signed integers in the C/C++ language variables. (Refer to pages 10, 72-73 of the IMU datasheet)

Noise Components

Inherent Noise

The accelerometer's noise density (An) is 70 (micro-g / √Hz) for the sensor reading range we defined earlier. A sample rate of 104Hz is considered as it is the closest sample rate to our control-loop frequency. If sampled at 104 Hz, we will have ±700 (micro-g) noise. (Refer to page 10 of the IMU datasheet)

Temperature Noise

The IMU datasheet reports the LA_OffDr, the coefficient for the temperature drift as ±0.1 (mili-g / C). Considering a temperature difference of 40 degrees (assuming operating range of 10C - 50C), we will have ±4 (mili-g) variation in the sensor readings. To overestimate the noise, the value of 4 mg is used as the std-dev of the gyro sensor readings. This value is 0.2% of the ±2 (g), the boundaries of the sensor readings.

Combined Noise

Without knowing about the internals of the sensor, we assumed the two components of noise are independent from one another. Therefore the combined noise standard deviation would be 4.06. This value is 0.203% wrt to the sensor reading boundaries.

Gyro

Sensor Range and Raw Output

The sensor is set to measure from -500 (deg / s) to 500 (deg / s) angular velocities in each axis. The raw output of the sensor is 16 bits represented in 2's complement, the same scheme used to store signed integers in the C/C++ language variables. (Refer to pages 10, 70-71 of the IMU datasheet)

Noise Components

Inherent Noise

The gyro's noise density (Rn) is rated at 3.8 ((mili-deg / s) / √Hz). A sample rate of 104Hz is considered as it is the closest sample rate to our control-loop frequency. If sampled at 104 Hz, we will have 0.039 (deg / s) noise. (Refer to page 10 of the IMU datasheet)

Temperature Noise

The IMU datasheet reports the G_OffDr, the coefficient for the temperature drift as ±0.01 ((deg / s) / C). Considering a temperature difference of 40 degrees (assuming operating range of 10C - 50C), we will have ±0.4 (deg / s) variation in the sensor readings. To overestimate the noise, the value of 0.4 deg/s is used as the std-dev of the gyro sensor readings. This value is 0.8% of the ±500 (deg / s), the boundaries of the sensor readings.

Combined Noise

Without knowing about the internals of the sensor, we assumed the two components of noise are independent from one another. Therefore the combined noise standard deviation would be 0.402. This value is 0.804% wrt to the sensor reading boundaries.

LUTs for Webots

Using g = 9.81(m/s^2), the following are the look-up tables (LUTs) for the gyro and accelerometer:
[
-19.62 -32768 0.00203
19.62 32767 0.00203
]

And for the Gyro:
500 deg/s is converted to 8.7266 rad/s(Refer to Gyro for Webots)
[
-8.7266 -32768 0.00698
8.7266 32767 0.00698
]

Refer to the LUT API for Webots to understand the placement of each number. Note that the resolution field for both Gyro and Accelerometer should be set to 1 to reflect the digitized nature of these sensors. (Refer to Accelerometer and Gyro API for Webots)

References

MX28 specs for WeBots:
https://cdn.robocup.org/hl/wp/2021/04/v-hsc_model_specification_v1.01.pdf

IMU Sensor's datasheet from: https://www.st.com/en/mems-and-sensors/lsm6dsox.html

Accelerometer API for Webots: https://cyberbotics.com/doc/reference/accelerometer

Gyro API for Webots: https://cyberbotics.com/doc/reference/gyro

LUT API Guide for Webots: https://cyberbotics.com/doc/reference/distancesensor#lookup-table