EE565: MOBILE ROBOTICS

LAB # 6: INERTIAL ODOMETRY USING AR DRONE'S IMU AND CALCULATING MEASUREMENT'S COVARIANCE

DESCRIPTION & MOTIVATION

In this lab students shall implement an inertial odometry algorithm using AR-Drone IMU. They will fly a real quadrotor (See Lab 5 for help on how to run an AR-Drone), read the IMU data and calculate odometry information from this raw sensory data. Furthermore they shall calculate the noise statistics of the IMU data. **Quadrotors are really dangerous devices; be very careful and don't try to touch rotating propellers! If it fails in the air let it fall!**

IN-LAB TASKS

1. Start the AR Drone, make wireless connection, use ardrone/navdata topic to acquire sensor information.
2. Write code for a node that reads the AR Drone navdata. You'll get linear acceleration, gyro-rate and magnetometer readings about x, y and z axes.
3. Now place the quadrotor in a static state. Ideally your IMU readings should give constant values.
4. Estimate Euler angles (orientation) upon each callback (accelerometer + magnetometer):
    a. Using the linear acceleration (accelerometer) readings, find the Roll and Pitch angles (ϕ_a, θ_a). [See Class Lecture 6]
    b. Once you have the Roll and Pitch angles, find the Yaw angle (ψ_m) using Magnetometer readings. [Slide 44]
5. Use Gyro readings (p, q, r) to get fused Euler angles (ϕ, θ, ψ), upon each callback. Here you'd need values of $(\phi_a, \theta_a, \psi_m)$ upon each iteration. Basically, implement the following equations (E.g. choose $\alpha = 0.8$) : [Slide 33]

$$\begin{bmatrix}\phi\\ \theta\\ \psi\end{bmatrix}_t = \alpha\begin{bmatrix}\phi\\ \theta\\ \psi\end{bmatrix}_{t-1} + (1-\alpha)\begin{bmatrix}\phi_{am}\\ \theta_{am}\\ \psi_{am}\end{bmatrix}_t \quad for \quad 0 < \alpha < 1$$

$$\begin{bmatrix}\phi\\ \theta\\ \psi\end{bmatrix}_t = \begin{bmatrix}\phi\\ \theta\\ \psi\end{bmatrix}_{t-1} + \left(\begin{bmatrix}1 & \sin\phi\tan\theta & \cos\phi\tan\theta\\ 0 & \cos\phi & -\sin\phi\\ 0 & \sin\phi\,/\cos\theta & \cos\phi\,/\cos\theta\end{bmatrix}\begin{bmatrix}p\\ q\\ r\end{bmatrix}\right)_t \Delta t$$

   Δt can be found using timestamps.
6. Publish fused Euler angles as an odometry message and visualize in RViz. Assume position to be $(0, 0, 0)$. Verify your implementation by moving and rotating the quadrotor by hand.

Remember to record a bagfile having IMU data, it will be used in Lab Assignment.

LAB ASSIGNMENT

INERTIAL ODOMETRY

1. Estimate the position (pose) along the three axes from accelerometer:
   a. Convert the accelerometer readings from body frame to inertial frame. Use the Euler angles found in-Lab. [Lecture 6, Slide 22]
   b. Implement rectangular integration step to find linear velocities from linear accelerations (in inertial frame). You'd need to find Δt using timestamps.
   c. Once you have linear velocities from accelerometer readings, find the position along the three axes by integration again.

MEASUREMENT COVARIANCE

2. Estimate the covariance matrix for estimated Roll, Pitch and Yaw. For this, run your code while keeping the robot in a static state. Record readings for about 60 seconds, and find all entries of the mean vector (3 x 1) and covariance matrix of the Euler angles statistically.
3. Take a few different values of α and see which gives most certain estimates.