Problem Statement and Goals
Attitude Check: IMU-based Attitude Estimation

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Table 1: Revision History

Date	Developer(s)	Change
2024/01/15	Adrian Sochaniwsky	Initial document creation.

1 Problem Statement

The problem of attitude estimation is to determine the rotation of an object relative to a reference frame using sensor measurements. Attitude estimation is essential for many applications, such as navigation and control of spacecraft, drones, or robots. Once only possible with expensive hardware, advances in Micro-Electro-Mechanical systems (MEMS) allow an inexpensive Inertial Measurement Unit (IMU) to provide the necessary measurements for attitude estimation. However, challenges arise from the presence of noise, bias, drift, and uncertainty in the sensor data, as well as the nonlinearity of the object dynamics [1].

1.1 Problem

Given imperfect measurements, estimate the attitude of the IMU sensor.

1.2 Inputs and Outputs

Inputs to the software is data produced by a 9 degree-of-freedom (DoF) IMU

$$\text{input} = [\vec{\text{accel}}, \vec{\text{gyro}},]$$

where $\vec{\text{accel}}$ is the acceleration vector, $\vec{\text{gyro}}$ is the angular rotation vector, and $\vec{\text{mag}}$ is the magnetic field vector.

The output of this software is the attitude of the IMU sensor with respect to time.

1.3 Stakeholders

A stakeholder for such an attitude estimation algorithm could be anyone who is interested in or affected by the performance, accuracy, and reliability of the algorithm [2]. Some possible stakeholders are:

- The developers and engineers who design, implement, and test the algorithm.
- The customers and users who rely on the algorithm for their applications, such as navigation and control.
- The researchers and scientists who use the algorithm to study the dynamics and behavior of the object.
- The competitors and collaborators who offer or seek alternative or complementary solutions to the algorithm.

1.4 Environment

Ubuntu 20.04 is officially supported. However, any system that can compile C++17 should work.

2 Goals

- Validate input data, out-of-range checks, etc.
- Convert imperfect measurment data into an attitude estimate.
- Provide a sensor calibration procedure.
- Provide a method to visualize the attitude with respect to time.

3 Stretch Goals

- Use labelled data to validate the software
- Port software to microcontroller for online attitude estimation.

References

[1] Bing Chat with GPT-4 "can you create a problem statement for a attitude estimation project". https://sl.bing.net/hakggcilB2y. Accessed: 2024-01-16.

[2] Bing Chat with GPT-4 "who would be a stakeholder for a attitude estimation algorithm?". https://sl.bing.net/dnfjOHJSXDg. Accessed: 2024-01-16.