SRS Presentation

Attitude Check: An IMU-based Attitude Estimator

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Introduction

- Many robotics and aerospace applications require knowledge of their attitude (orientation)
- Inertial Measurement Units (IMUs) are popular measurement devices, but can add noise and bias to the signal
- Attitude estimation aims to find the orientation relative to a reference frame

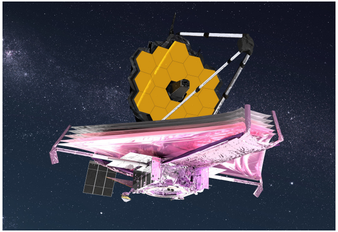

Figure 1: NASA's James Webb Telescope.

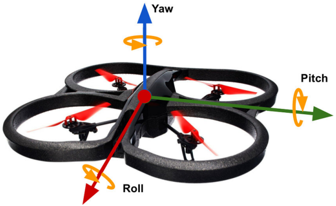

Figure 2: Quadcopter with labelled Euler angles.

Reference Material

Table 1: Table of Units

symbol	unit	SI
m	length	metre
rad	angle	radian
s	time	second
Hz	frequency	hertz
T	magnetic field	tesla

Table 2: Table of Symbols

symbol	unit	description
v	$\mathrm{m/s}$	linear velocity
a	$\mathrm{m/s^2}$	linear acceleration
ω	$\mathrm{rad/s}$	angular velocity
g_0	$\mathrm{m/s^2}$	gravitational constant
b	T	earth's magnetic field

- Current state of the reference tables.
- Must be careful, in the literature, v, represents a vector of $[x, y, z]$, and v is velocity, and $\mathbf{v}$ is the velocity vector.

Introduction - Scope and Reader

Scope of Requirements

- Dynamics models of this project will only consider a flat local earth, and the effect of the Earth's rotation will be ignored.
- MEMS sensor modelling, we will simplify the measurement error characteristics. Additionally, we will assume there are no local magnetometer disturbances.
- The IMU is assumed to be mounted to a rigid body, the IMU orientation will be the orientation of the object it is attached to.
- All measurements are assumed to be in the range of the sensors.

Characteristics of Intended Reader

The reader should have an understanding of university-level math including matrix and vector operations, numerical methods, and state estimation.

General System Description

System Context

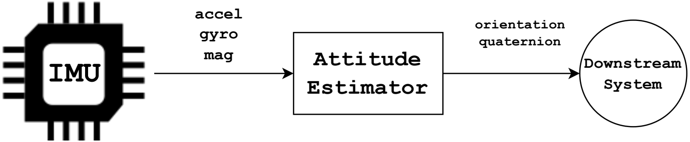

Figure 3: System Context

- User Responsibilities:
  - Provide IMU measurements.
- Attitude Check Responsibilities:
  - Detect data type mismatch, such as a string of characters instead of a floating point number.
  - Return orientation value for each set of measurements.

General System Description

User and Constraints

User Characteristics

- High-school kinematics.
- Understand what attitude estimation is, and has an expectation of the inputs and outputs.
- Designed for users looking to process IMU data.

System Constraints

- Attitude check should be able to maintain $100+$ Hz and consume minimal memory and CPU cycles.
- Expected to function on embedded systems with constrained resources.

Specific System Description

Problem Description

Attitude Check is intended to estimate the attitude of an IMU sensor, given noisy measurements.

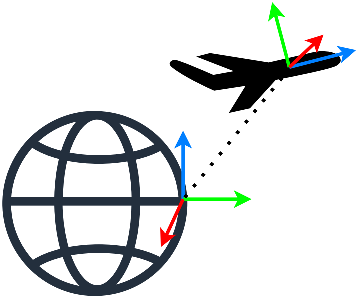

Figure 4: Physical System

Physical System Description

PS1a: Magnetometer measurement model: $\mathbf{m} = \mathbf{R}^T\mathbf{h} + \mathbf{B}_m + \mu_b$

PS2: Kinematic Model: $\mathbf{v} = \mathbf{v}_0 + \mathbf{a}t$

PS3: Orientation representation (quaternion): $\mathbf{q} = w + xi + yj + zk$

PS4: World Magnetic Model, North East and Down (NED)

Goal Statements

GS1: Convert sequential IMU measurements into an orientation relative to the Earth.

The End

Questions?