3D Motion Visualization for 6-axis IMU Sensor Data
Hexagon | NovAtel

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Abstract

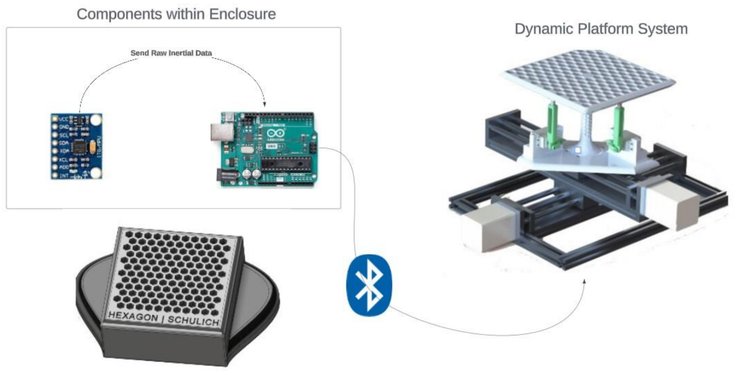
Inertial data is a very complicated concept to visualize. This project aims to provide a visual tool to help bridge the knowledge gap between the theory and application for customers and colleagues. This tool has been developed as an interactive device that the user can control with a proprietary handheld device. The motions of the handheld unit will be utilized to compute changes in position, roll angle, and pitch angle, which are reflected by the system. The changes in position are reflected by two linear actuators in the x-y system while the changes in roll and pitch are reflected by the articulating platform.

Introduction

This project seeks to address the absence of a visual representation of 6-axis IMU sensor data for Hexagon | NovAtel's GNSS and INS products. The raw inertial sensor data, processed by the handheld microcontroller, is utilized to generate a simultaneous portrayal of the controller's movements by the dynamic platform. In an application scenario, the system could be used to create a level surface upon which a UAV could safely land. For example, it could be used when landing a drone on a moving vehicle or, on a larger scale, landing a helicopter on a ship in rough seas.

Inertial Solution

- IMU data consists of accelerations and rotation rates in x, y, and z inertial frames. This data is filled with errors, biases, and is not within a frame that is useful to real world applications.
- Corrections, filters, and rotation matrices can be applied to the data to obtain viable and usable predictions of the motion.
- Change in Position: $\Delta \mathrm{d} = \mathrm{V_o T} + \frac{1}{2} a_d \mathrm{T}^2$
- Change in Angle: $\Delta \Theta = \omega \mathrm{T}$



Conclusions

- The development of this system provides an innovative solution to the visualization of inertial data. The intuitive approach that our system provides aids in the interpretation and research of IMU systems and principles.
- Further testing, refinement, and access to advanced sensors and actuators will allow for greater system utility in potential future iterations.

Handheld Controller

- Contains power supply, inertial measurement unit, Bluetooth module, and Arduino Uno microcontroller
- Raw data is received on the microcontroller where bias estimation can begin
- Once the biases are removed from the data, the mechanization of the inertial solution begins, and the results are transmitted to the dynamic platform system.
- The enclosure was designed to have an ergonomic feel for the user while also providing ample space within the enclosure to securely mount all components.
- PLA was selected for the material to provide the sponsor with an easily replaceable and light final prototype.

Dynamic Platform System

- The articulating platform consists of a sturdy base with two perpendicular arms, each capable of independently manipulating the pitch and roll of the system, respectively.
- Each arm is driven by a high-torque Servo motor, chosen for their integrated feedback control systems, continuously allowing accurate IMU data reflection.
- A combination of pin and universal joints are used to restrict the mobility of the system to strictly pitch and roll.
- The closed-loop kinematics of the platform is solved within the Arduino code. Based on the attitude input from the IMU, the system determines the precise angular position of each Servo motor to satisfy the pitch/roll requirement.
- The base is comprised of two linear actuators stacked in a perpendicular fashion, allowing for the display of translations in the x and y axis.
- The base is supported by aluminum V slot rails which provide stability to the lower actuator. Additionally, custom rollers are mounted to the top actuator. These utilize the support rail V slots to transfer force and moments from the driving screw of the bottom actuator.
- A 3D printing manufacturing process was selected to attain rapid iterative prototyping of parts. Additionally, the lightweight and durable properties of PLA are well suited for our application requiring both structural integrity and portability.

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