IMU-based Orientation Estimation and Trajectory Optimization

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***Abstract* - This project focuses on tracking the orientation of the camera system built. In this project, angular velocities and accelerations captured by the IMU were first converted to quaternions representing the object's pose, estimating the pose in the next timestamp, and finally use gradient descent algorithm to minimize the difference of its estimations with the data gathered by the VICON camera. The optimized quaternion data was then used in generating panorama pictures to represent the rotations of the camera**

***Index Terms* - Orientation tracking, Projected gradient descent, Inertial Measurement Unit, Optimization**

I. Introduction

Orientation tracking and pose estimation are the bases for almost all robotic problems in the autonomous robot industry. Whether for drones or autonomous vehicles, the ability to accurately determine its current state is essential for effective control and navigation. In this project, we address the specific challenge of estimating the 3-D orientation of a rigid body using noisy measurements from an Inertial Measurement Unit (IMU).

Inertial Measurement Unit (IMU) is one of the mostly used sensors in the robotics field. Its affordability and robustness has made it widely used in pose estimations. Typical IMU sensors consists of three accelerometers and three gyroscopes to measure the linear acceleations and angular velocities with respect to their corresponding axes. In this project, the IMU used track 6 datas at the same time and represent them in the following format:

Unix Time Stamps	A_x	A_y	A_z	W_x	W_y	W_z

With the provided data, we can get the converted quaternion to utilize the motion model and observation model for estimations. We implemented a projected gradient descent algorithm to minimize a cost function, while strictly enforcing the unit-norm constraints. Finally, to validate the accuracy of our orientation estimates, we construct a panoramic image by stitching together RGB camera frames captured by the rotating body.

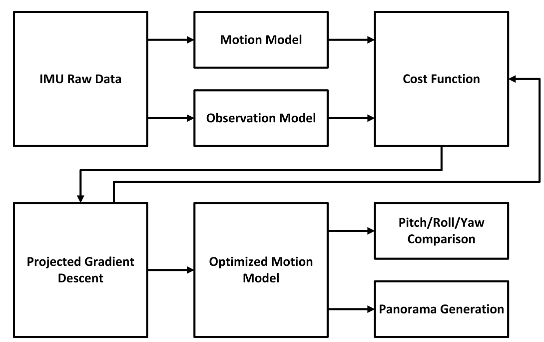

Figure 1: Orientation Tracking and Optimization Flowchart