Satellite/Inertial Navigation and Positioning System (SINAPS)

Functional Description And Block Diagram

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Introduction

The goal of this project is to integrate inertial sensors and a GPS unit into a unified, low-cost navigation system. The inertial measurement unit (IMU) will have nine degrees of freedom from magnetometers, accelerometers, and gyroscopes with respect to each axis in $\mathbb{R}^3$ (x, y, z). Cheaper IMU devices are built with MEMS sensors which constantly accumulate errors, resulting in a position 'drift' that will give increasingly incorrect solutions. On the other hand, a standalone GPS unit can be error prone as well if there is anything blocking the open sky (such as tall buildings or mountain ranges). The motivation for this project is that the fusion of both devices can produce accurate, robust navigation at a low cost.

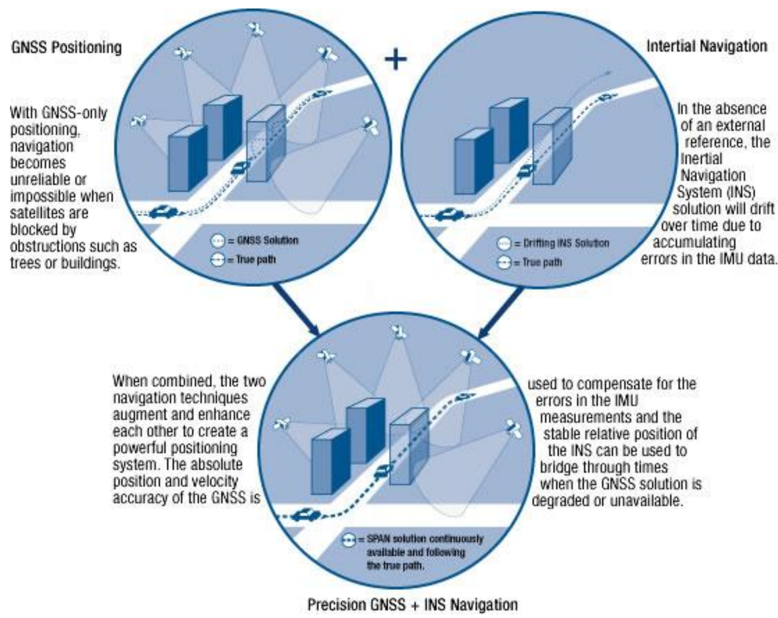

Figure 1: GPS IMU Overview [1]

Functional Description

As stated in Figure 1, the GPS's ability to track absolute location can correct the drift errors of the MEMS-based IMU. The IMU can, in return, maintain the ability to navigate when the satellite signal is lost or distorted. Another goal of this project is to explore the robustness of the IMU+GPS solution, such as how long the IMU navigates well before the accelerometer drift makes the system useless. The overall system efficiency, cost, tracking accuracy, and limitations need to be explored as well.

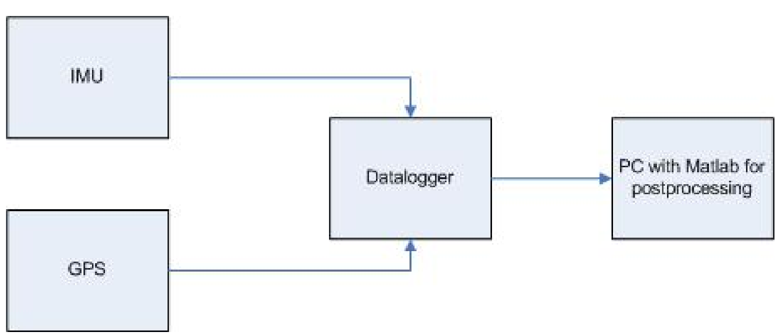

Figure 2: Hardware Overview

The GPS and IMU system is shown in Figure 2. The GPS unit and IMU unit will both feed data into a logger which can send that data to a PC, where it can be processed in MATLAB or C.

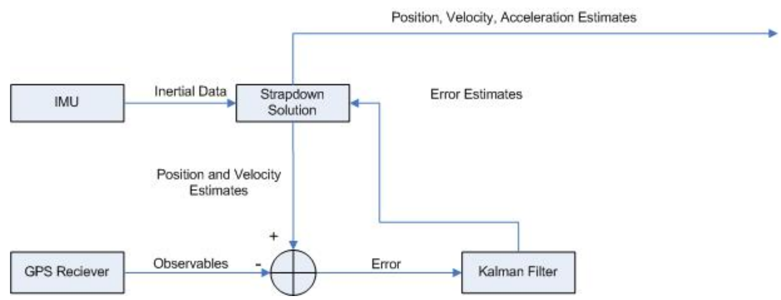

Figure 3: System Block Diagram [2]

The overall GPS/IMU relationship is shown in Figure 3. The IMU will produce very fast, highly sensitive updates that need to be processed by the strapdown solution software and compared to the GPS output data. This comparison will produce an error signal that will be fed into a Kalman Filter which will process the error and be fed back into the strapdown solution to correct the IMU drift.

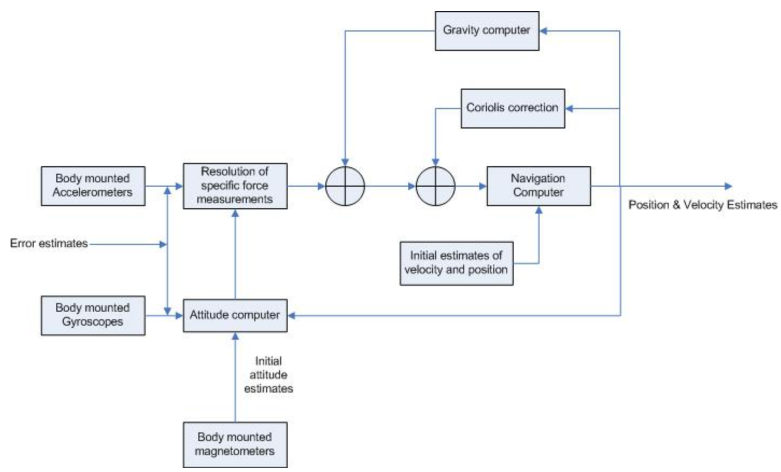

Figure 4: Strapdown Solution Software Diagram [3]

Figure 4 details the strapdown solution. The strapdown solution is named like it is because it is rigidly attached to a body, experiencing the same movement dynamics as the body itself [4]. From each component position, velocity, and acceleration information can be extracted with reference to earth's gravity and with the motion of the unit. The position and velocity estimates will have to be converted to the coordinate system of the GPS in order to be accurately compared.

References

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[4] C. Verplaetse, *Strapdown Systems*, Created Friday, May 26, 1995, [Online], Available: http://xenia.media.mit.edu/ verp/projects/smartpen/node8.html