EE 570: Location and Navigation

Navigation Equations: An Overview

Stephen Bruder[1] Aly El-Osery[2]

[1]Electrical and Computer Engineering Department, Embry-Riddle Aeronautical Univesity
Prescott, Arizona, USA
[2]Electrical Engineering Department, New Mexico Tech
Socorro, New Mexico, USA

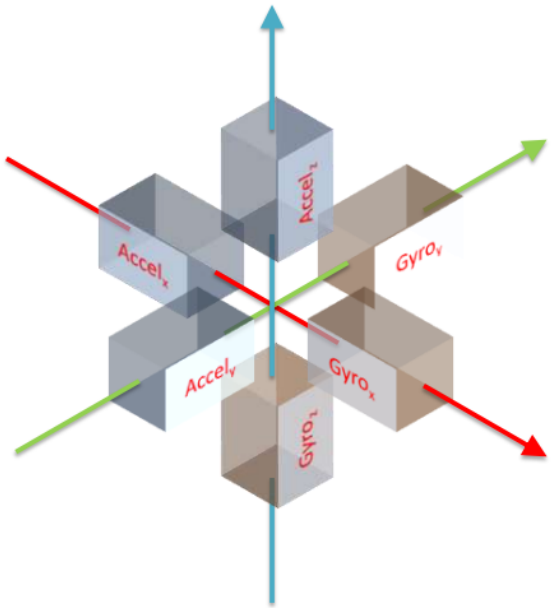
February 11, 2014

The Fundamental Problem

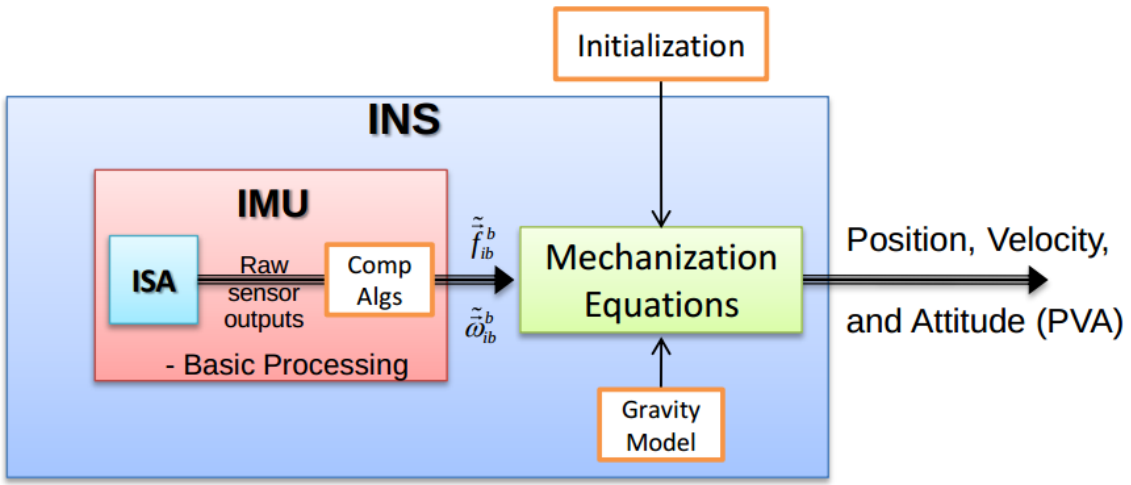
- The fundamental inertial navigation problem:
  - Using inertial sensors (accels & gyros) and an initial position and orientation, determine the vehicle's (i.e., body frame) current position, velocity, and attitude (PVA)
  - Assumptions:
    1. Know where we started (initial PVA: $\vec{r}_{?b}^{\,?}$, $\vec{v}_{?b}^{\,?}$, & $C_b^?$)
    2. Inertial sensors ($\vec{\omega}_{ib}^{\,b}$ and $\vec{f}_{ib}^{\,b}$)
    3. Have a gravity ($\vec{g}_b^{\,?}$) and/or gravitational ($\vec{\gamma}_{?b}^{\,?}$) model
  - Where am I? Current PVA?
    - With respect to which frame?

Inertial Navigation

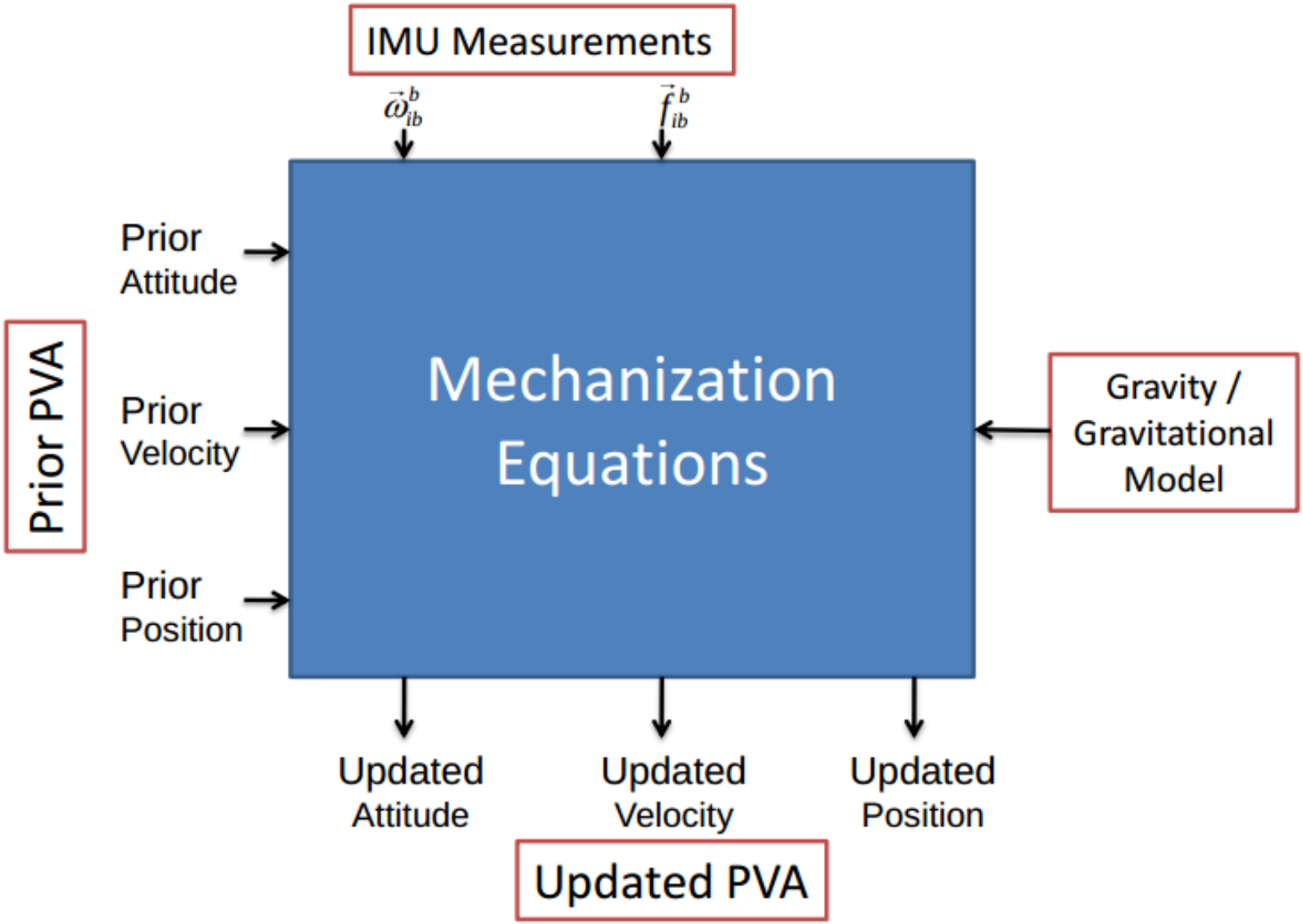
- The process of "integrating" angular velocity & acceleration to determine one's position, velocity, and attitude (PVA)
- To measure the acceleration and angular velocity vectors we need at least 3-gyros and 3-accels
  - Typically configured in an orthogonal triad
- The "mechanization" can be performed *wrt*:
  - the ECI frame,
  - the ECEF frame,
  - the Nav frame.



- An Inertial Navigation System (INS)
  - ISA — Inertial Sensor Assembly
    - Typically, 3-gyros, 3-accels, and basic electronics
  - IMU — Inertial Measurement Unit
    - ISA + compensation algorithms (i.e., basic processing)
  - INS — Inertial Navigation System
    - IMU + gravity model + "mechanization" algorithm



Mechanization Process



A Four Step Mechanization

1. Attitude Update
   - Update the prior attitude using the current angular velocity
2. Transform the specific force measurement ($\vec{f}^{\,?}_{ib} = C^{?}_{b}\vec{f}^{\,b}_{ib}$)
   - Typically, using the attitude computed in step 1
3. Update the velocity
   - Essentially integrate the result from step 2 with the use of a gravity/gravitational model ($\vec{f}_{ib} = \vec{a}_{ib} - \vec{\gamma}_{ib}$)
4. Update the position
   - integrate the result from step 3

A Four Step Mechanization