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INITIALIZATION AND ALIGNMENT OF STRAPDOWN INERTIAL NAVIGATION SYSTEM

The complementary advantages of Global Positioning System (GPS) and Inertial Navigation System (INS) sensors overcoming each other’s limitations have been the primary motivation for the integration of these systems. With development of low-cost strapdown INS the integration solutions becomes more available with respect to price, but still can provide the precise navigation solution.

Since INS is a dead reckoning system, it is necessary to perform certain initialization procedures before the navigation parameters computation: to determine the initial values for system position, velocity, and attitude in navigation coordinates. INS position initialization ordinarily relies on external sources such as GPS or manual entry; velocity initialization can be accomplished by starting when it is zero or by reference to the carrier velocity. INS attitude initialization is called alignment. INS alignment for strapdown systems is the process of computing the initial values of the coordinate transformation from sensor coordinates (body frame) to navigation coordinates (often local level frame). There are two alignment stages: accelerometer leveling (roll and pitch) and gyro compassing (azimuth).

At accelerometer leveling stage it is necessary to align Z^b and Z^l by forcing the measurements of accelerometers X^b, Y^b to zero (it means the true vertical is established). In strapdown systems the measurements f_x^b and f_y^b are tilted with respect to the vertical direction, and the accelerometer leveling is conducted mathematically. The accuracy of accelerometer leveling procedure is limited by the accelerometer biases.

Roll $\xi = \sin^{-1}(\frac{f_x^b}{g}) \cong \frac{f_x^b}{g}$, Roll error $\delta\xi = \frac{b_{fx}}{g}$,

Pitch $\eta = \sin^{-1}(\frac{f_y^b}{g}) \cong \frac{f_y^b}{g}$ Pitch error $\delta\eta = \frac{b_{fy}}{g}$

The gyro compassing stage is performed after the previous one; it uses the gyro measurements. Planimetric accelerometers can be arbitrary rotated with respect to local level frame with an azimuth angle ψ. Its error is dependant on gyro drift $b_{w_y^b}$.

Azimuth $\psi = \tan^{-1}(-\frac{w_y^b}{w_x^b})$ Azimuth error $\delta\psi = \frac{b_{w_y^b}}{w_e \cos\varphi}, (\psi \cong 0)$

For low cost inertial sensors the gyro drift exceeds the Earth rotation rate. It means that gyro compassing has to be accomplished via external aids (magnetic compass for example).

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