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Aided Inertial Navigation System (AINS™) Toolbox

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Background

Developed by The Mobile Multi-Sensor Research Group in the Department of Geomatics Engineering at the University of Calgary, the aided inertial navigation system (AINS™) Toolbox is a set of libraries written for MatLab® software which can be called separately. It also provides estimation tools to optimally combine the data files from an inertial measurement unit (IMU) together with information from other aiding sensors, such as the global positioning system (GPS), odometers, heading, and non-holonomic constraints.

Areas of Application

The AINS™ software can be easily used and/or adapted to a wide range of applications such as:

- Land vehicle navigation applications
- Direct georeferencing application for land and airborne mobile mapping applications (e.g. LiDAR, aerial photography, etc.)
- Pipeline Mapping applications (e.g. geo-pig, right-of-way mapping applications, etc.)
- Pedestrian navigation applications

Competitive Advantages

The toolbox uses state-of-the-art strapdown integration algorithms and estimation techniques. The INS mechanization applies second-order coning and sculling corrections. Many options exist for the initial alignment. For tactical or navigation grade IMUs, the analytical coarse alignment and fine alignment techniques are implemented. In-motion alignment uses GPS-derived velocities for pitch and heading initialization. Leveling with user-given heading information can be used for the alignment of low-cost IMUs. The following estimation techniques are implemented in the toolbox:

- Linearized Kalman filter with feedback (extended Kalman filter)
- The Rauch-Tung-Striebel (RTS) smoother
- A quaternion-based unscented Kalman filter
- Backward unscented Kalman filter and smoother

The toolbox supports various attitude parameterizations including the direction cosine matrix (DCM), Euler angles, rotation vector, and quaternion. Transformations between these parameterizations are also implemented. The followings briefly describe the functions of the toolbox:



- INS Alignment
 - Analytical coarse alignment
 - Fine alignment with zero velocity updates (ZUPTs) and the Earth's rotation measurements.
 - In-motion alignment using GPS-derived velocities.
- Roll and pitch from accelerometers and use given heading
- Initialization with given attitude
- INS Mechanization:
 - Second order coning and sculling correction
 - Velocity integration
 - Position integration
 - Attitude integration
- Extended Kalman Filter
 - 21 states incorporating errors in position, velocity, attitude, and sensors' bias and scale factor.
 - Coordinate update (from GPS or any other sources)
 - Navigation frame velocity update (from GPS or any other sources)
 - Vehicle frame velocity update (odometer and speedometer)
 - Zero velocity update (ZUPT)
 - Non-holonomic constraints
 - Heading update
- An RTS smoother yields best solution utilizing all the measurements of past, current, and future.
- A quaternion-based unscented Kalman filter and smoother.
- Changing Level Arm
 - In airborne survey applications, there may be changes in the lever arm from the GPS antenna to the IMU
 - This module allows the AINS™ Toolbox to account for these changes
 - Users can specify a file containing details on the lever arm changes
 - Particularly beneficial in applications where the GPS or INS platform is rotating, such as IFSAR airborne mapping systems

TECHNOLOGY



Publications

[Shin, E. H. and El-Sheimy, N. \(2004\): "An Unscented Kalman Filter for In-Motion Alignment of Low-Cost IMUs". IEEE PLANS, Monterey, CA, April 26-29 2004, pp. 273-279. \(Best paper in track award\)](#)

[Shin, E. H., Niu, X. and El-Sheimy, N. \(2005\): "Performance Comparison of the Extended and the Unscented Kalman Filter for integrated GPS and MEMS-Based Inertial Systems", Proceedings of ION National Technical Meeting, San Diego, California, January 24-26 \(CD – 8 Pages\).](#)