TECHNOLOGY


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# KINGSPAD: KINematic Geodetic System for Positions and Attitude Determination

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## Background

The University of Calgary's KINGSPAD (KINematic Geodetic System for Positions and Attitude Determination) is a software for managing and processing GPS and Strap-down INS data in an integrated fashion. Both INS and GPS are, in principle, capable of determining position and attitude of moving platforms in post-mission. In practice, due to the double integration of the INS acceleration data, the time-dependent position errors will quickly exceed the accuracy specifications for many trajectory determination applications. Frequent updating is, therefore, needed to achieve the required accuracies. GPS on the other hand, can deliver excellent position accuracy, but has the problem of cycle slips, which are in essence gross errors leading to a discontinuity in the trajectory.

The combination of the two measuring systems, therefore, offers a number of advantages. In the absence of cycle slips, the excellent positioning accuracy of differential GPS can be used to provide frequent updates for the inertial system. The inertial sensors orientation information and the precise short-term position and velocity can be used for cycle slip detection and correction. In general, the fact that nine independent measurements are available for the determination of the six required trajectory parameters greatly enhances the reliability of the system.

To optimally combine the redundant information, a Kalman filtering scheme is used whereby the inertial state vector is regularly updated by GPS measurement. Two integration strategies can be implemented at the software level using the Kalman filter approach. In the first one, a common state vector is used to model both the INS and the GPS errors. In this case, the INS measurements are used to determine the reference trajectory, and the GPS measurements to update the solution and estimate the state vector components. This is often called the centralized filter approach. In the second approach, different filters are run simultaneously and interact only occasionally. The GPS data are Kalman filtered to obtain estimates of position and velocity that are then used as quasi-observations to update the INS Kalman filter. At the same time, the GPS data are continuously checked for cycle slips. This is often called the decentralized filter approach. It has advantages in terms of data integrity and speed.

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KINGSPAD Executable runs under the WIN32 operating system with a number of userfriendly windows that provide information on the data, systems, type or processing, etc.

## Areas of Application

- Road and railway inventory systems
- Airborne mapping systems
- Georeferencing of multi sensor systems
- Engineering applications

## Competitive Advantages

- Processes the data in three different modes: pure GPS (about 7500 lines of code), pure INS (about 5000 lines of code), and hybrid INS/GPS (about 8000 lines of code)
- INS or IMU Requirements (systems that have been tested include Litton 90-100 strapdown system, Honeywell LaserRef III Strapdown System, and Litton 200)
  - Self-moding and control after application of power
  - Provide delta-V and delta-theta: change in velocity and angle output
  - Support time tagging of delta-V, and delta-theta epochs with GPS time (generally to within a small fraction of a millisecond)
- The INS module feature the following:
  - Process any INS system that can provide angular velocity and body rates. INS systems that have been used/tested by KINGSPAD include; Litton 90-100 strapdown system (64 Hz); Honeywell Laser Ref-III strapdown system (50 Hz) and the Litton 200
  - INS Calibration module (to estimate the gyro-drift and accelerometer bias)
  - Coarse/Fine Alignment modules
  - INS Mechanization module
  - INS ZUPT mode of operation
  - Accept velocity (from DGPS) and position (from GPS and/or control point)
  - update measurements
  - Georeferencing information (Position and attitude) at maximum Hz of the INS system
  - Quality control for checking the ZUPT measurements
  - Save for rewind processing
  - Save for Backward Smoothing
- The GPS module feature the following:
  - Receiver independent processing; GPS receivers that have been used includes Ashtech, Trimble, and Novatel
  - Processes static, semi-kinematic, and kinematic data
  - Fixed, Float and rapid static processing
  - Applies Kalman Filter for static and kinematic processing


  - Single and dual frequency Kinematic OTF ambiguity resolution using linear programming
  - Accurate velocity determination
  - Cycle slip detection and bad data handling
  - Interpolation of camera/laser/IFSAR event marks and importing of marked stations
  - Output: Precise Velocity, position, ambiguities, PDOP
- The Integration module feature the following:
  - De-centralized Kalman filtering
  - Provides a suite of bridging procedures in case of GPS outages;
  - Defines which GPS data will be used to update the INS, namely, position, velocity, or position/velocity
  - Selects the GPS update rate according to a specific application (e.g., airborne, land application)
  - Computes the updated INS position, velocity, and attitude at 50-64 Hz to suit different georeferencing applications;
  - Tremendous output information