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Masterstudiengang Geomatik – Vertiefung Geodäsie Fakultät für Geomatik

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Masterarbeit (Year 2012):
Implementation and Testing of a general GNSS/INS-based Multisensor-Multiplatform Navigation Algorithm under consideration of the Lever-Arm Effects based on Simulated Sensor Raw Data and Real Data from a UAV

Referent:
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Keywords:
Navigation, GNSS, INS, Sensors configuration, Lever-Arm, SIMA, Drone, Kalman Filter, Tight Coupling

Summary:

The purpose of this thesis was to help in the research and development part of project NAVKA at the Hochschule Karlsruhe.The focus of the thesis is on outdoor navigation. On the navigation platform multiple sensors are present: GNSS (which gives us position and velocity measurements) and INS sensors (accelerometers and gyros). The combination of these sensors gives a low cost navigation solution that can be offered to companiesor to the general public.

The thesis can be looked at as composed from two different parts. The first parts of the thesis, which was more of an introduction in the topic of navigation,makes use of different GNSS open source processing software: RTKLIB and GPSTK just to show the capabilities that are freely available online today. Receivers tested here also low cost: U-blox 6 T.

The second part was the creation of tight coupling system using a Kalman filter. The equations for the filter have been developed in the NAVKA project and take into account the Lever-Arm effect (a change in the position of the sensor in comparison to the center of the body). The filter uses multiple sensors as measurement sources to provide a continuous solution. The most important goals of the thesis were in the second part: the study of different sensor configurations, the impact of changing this configuration (sensor position – Lever-Arm effect, sensor frequency, sensor redundancy, and bad initialization) and the testing of real data (coming from a Microdrones drone model 4-200).

Most of the data used in the filter processing was acquired by the use of a simulator SIMA, which can provide GNSS and INS raw and processed data. Another goal of the thesis was to test and show the capabilities of this simulator and to underline the multiple benefits that this simulator brings.

The development of the Kalman filter to provide the navigation state (position, velocity, and attitude) was a multi-stage part. Each of the equations system was developed and tested separately. The equations are dependent on the input data position, velocity, accelerations and rotation rates measurements. After each input data was used to create a single filter, all of them were reunited, first to create a sensor using only GNSS data, position and velocity and then another one using the inertial data, acceleration and rotation rates. After the completion of this stage the last step was to integrate all the input data under one filter and test it with simulated and real data.

The results of the study showed that a Lever-Arm effect can help in finding an improved position or attitude (orientation) depending on the sensor configuration and the requirements of the user. The thesis proved that 3 GNSS sensor positioned in a nonlinear pattern can provide a solution for navigation. In what regards bad initialization multiple tests were carried out and the finding was that the system can cover this problem as long as the initial error is at a reasonable value when affecting all the state variables and level. If the value of the error is big on just one component (position, velocity, attitude, acceleration, orientation) than the system can only work if the other state variables are sufficiently well determined. The last part of the thesis involved the use of an actual drone to show that the filter can work with real data using the standard configuration.