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Radio-Asissted Inertial Navigation System by Tightly Coupled Sensor Data Fusion: Experimental Results

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ABSTRACT

In indoor scenarios radio-based localization systems can achieve centimeter accuracy (e.g. with UWB) with the solution being stable over time, however the number of access points (APs) that is required for a sufficient coverage is high. On the other hand, pure "inertial" navigation, based on an Inertial Measurement Unit (IMU), magnetic compass and a barometric sensor with additional step length updates (SLU) are subject to drift with time. The integration of these complementary systems can combine their advantages. Often loosely coupled integration is selected: From Time Difference of Arrival (TDoA) measurements a 3D position is estimated and used as a position update in the fusion filter. This eases data fusion a lot. However if less than 3 TDoA measurements are available, no 3D position update can be calculated.

So a *tightly integration* is preferred where ranges are processed as a TDoA measurement in the Kalman filter. IMU measurements are also fed into the Kalman filter, predicting the actual position, heading, step length and height updates by compass, SLU and barometer. Furthermore, Innovation Based Integrity Monitoring (IBIM) is used to determine faulty TDoA measurements from APs and to omit those.

In this paper, experimental results from our synchronized UWB and INS system will be presented. The inertial data is recorded with a torso-mounted Integrated Pedestrian Navigation System. The synchronous TDoA measurements are obtained with a UWB system, using one mobile receiver (integrated with the IPNS platform) and several APs.

From several indoor scenarios, positioning results are presented and analyzed regarding integrity and accuracy and showing the benefit of the tightly coupled integration with IBIM. The number of active UWB-APs is varied; even one valid TDoA (two APs) gives a significant positioning improvement compared to the loosely coupled approach.

KEYWORDS: INS, Pedestrian Navigation, UWB, Tightly Coupled, Integrity Monitoring