Abstract

Mohamed E.Tamazin

Non-Linear Modeling of Pseudorange Errors for Centralized Non-Linear Multi-Sensor System Integration

GPS signal interruption is a primary cause which affects the continuity and reliability of navigation systems that rely on standalone GPS solution. In order to obtain continuous positioning services in all environments, GPS can be integrated with inertial sensors. Micro-Electro-Mechanical-System (MEMS) based inertial sensors are preferred for vehicular navigation due to their low cost, small size, and low power consumption. However, these sensors suffer from severe stochastic error characteristics that can cause large positional error growth. To enhance the performance of vehicular navigation along with reducing the reliance on inertial sensors, three-dimensional reduced inertial sensors system (RISS) relies on measurements from one gyroscope, two accelerometers and a speed sensor (i.e. speed measurements in a vehicle are obtained from the vehicle's odometer) which are integrated with measurements from a GPS receiver. To address the non-linear error characteristics in the integrated navigation system, Mixture Particle filter (M-PF), a nonlinear filtering technique is employed to perform tightly-coupled integration of RISS with GPS. Tightly-coupled systems can provide GPS aiding during limited GPS satellite availability and thus can improve the operation and performance of the navigation system. Tightly-coupled integration utilizes pseudoranges and pseudorange rates measured by the GPS receiver. The accuracy of the positional estimates is highly dependent on the accuracy of the range measurements. This paper introduces a nonlinear system identification technique called Parallel Cascade Identification (PCI) to model pseudoranges correlated errors in the measurement model of the PF filter. When less than four satellites are visible, the identified parallel cascades for the remaining visible satellites will be used to predict the pseudo range errors for these respective satellites and correct the pseudo range value to be provided to M-PF. The proposed technique enhances the overall positioning accuracy, especially during partial GPS outages by modelling the pseudoranges correlated errors using PCI and MEMSbased RISS/GPS integration using M-PF to compute a 3D navigation solution. The effectiveness of the proposed algorithm is verified by different real-life road tests during GPS signal degradation and blockage using low cost MEMS-based RISS. Results for scenarios with intentionally ed GPS outages where the number of visible satellites varies between 3, 2, 1, and 0 are presented to demonstrate the usefulness and performance of the proposed technique. The results are examined and compared with PF tightlycoupled RISS/GPS integration without the pseudo range corrections using the PCI modules. The results are also compared with KF tightly-coupled RISS/GPS integration with and without pseudorange corrections using PCI modules. The comparison demonstrates the advantages of using PCI modules for correcting pseudo ranges for tightly-coupled integration using PF. The proposed navigation system, including the PCI modules used with PF, provides continuous determination of the navigational states with higher performance along with considerable reduction in the cost, size, and power consumption due to the use of fewer low-cost MEMS based inertial sensors, vehicle odometer, and a low-cost GPS receiver. These features make the proposed system a viable product that can provide an accurate, always available positioning solution for the common consumer.