RSS Indoor Localization and Tracking with INS Assistance

In recent years various indoor localization and tracking systems have received great attention with the increasing demand of location-aware applications in indoor environments. Wireless localization technologies such as received signal strength (RSS) based localization system is widely used due to its low implementation cost. However it suffers poor localization accuracy due to multipath and non-line-of-sight (NLOS) propagation. Unlike wireless localization system, inertial navigation system (INS) doesn't suffer from multipath and NLOS propagation issue. But INS accuracy degrades as time elapses due to accumulated noise in accelerometers and gyroscopes. Furthermore, inaccurate estimation of inertial measurement unit (IMU) orientation leads to wrong projection of gravitational acceleration into accelerometers, which will cause large localization error. Several fusion systems such as INS with RSS, INS with map etc. have been extensively explored to mitigate above mentioned issues. The existing INS based technique uses INS zero velocity update (ZUPT) with extended Kalman filter (EKF) to mitigate the orientation and localization error. ZUPT requires user to tie IMU on foot to leverage zero velocity measurement to calibrate IMU continuously. To further improve localization accuracy, particle filter (PF) is proposed to model the nonlinear system and maps are used to confine particles movement. The placement of IMU to utilize ZUPT, the computation complexity of PF and the availability of accurate maps make the fusion system challenging for implementation.

This thesis focuses on novel weighted RSS indoor localization and tracking scheme using INS projection. Our proposed scheme does not require IMU to be placed on foot and map information is not needed either. It also reduces computation time compared to PF.

This thesis derived a closed form equation to analyze the noise of acceleration along navigation frame, which leads to the error growth of stand-alone INS positioning estimation. The results will be used to calculate weight for proposed scheme in later chapters. With perfect knowledge of IMU orientation with respect to the navigation frame coordinates, this thesis proposes a novel weighted nonlinear RSS localization and tracking scheme fused with INS positioning estimation projection. Due to the accumulating impact of the noise on gyroscope, INS based localization performance deteriorates rapidly even with the known initial orientation assumption. Thus, a novel algorithm is proposed to continuously mitigate the impact of noise on gyroscopes. Simulation results obtained from three different scenarios show the proposed RSS localization scheme fused with INS projection outperforms conventional fusion scheme using EKF by up to 56%.

To develop a more practical scheme without perfect knowledge of IMU orientation with respect to the navigation frame coordinates, a novel algorithm has been proposed to estimate the initial orientation during the calibration stage. To further mitigate the noise from IMU, another algorithm is proposed to continuously mitigate the effect of noise on accelerometers. With all the proposed noise mitigation algorithms and initial calibration, simulation results obtained from three different scenarios show the proposed RSS localization scheme fused with INS projection significantly outperforms conventional fusion scheme using EKF by up to 65%.