EKF and Smoothing-based UAV Positioning Using UWB and IMU Fusion

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ABSTRACT

Unmanned aerial vehicle (UAV) positioning, which estimates a pose including 3D position and 3D orientation of a UAV with respect to a certain reference frame, is the key capability in the operation of the UAV. The global positioning system (GPS) is the most widely used for the UAV positioning, especially in outdoor space. However, in some outdoor areas where the GPS signal is blocked by tall vertical structures, and in indoor space where the whole GPS signal is unavailable, a local positioning sensor as an alternative to GPS is needed. The ultra-wideband (UWB) sensor, as a local positioning sensor, has become the most attractive solution as its ranging is highly robust to the occlusion and multipath effect. Since every UAV is equipped with an inertial measurement unit (IMU) that consists of several sensors such as an accelerometer and a rate gyroscope, more accurate positioning can be achieved generally when the UWB sensors and the IMU are fused. This paper addresses the problem of UAV positioning using UWB and IMU, where the pose of a UAV is estimated from ranging between UWB receiver at the UAV and UWB anchors at known positions and the IMU data. Existing works mostly focused on the filtering approach, e.g. Extended Kalman Filter (EKF), rather than a smoothing approach that is an another strong estimation framework based on graph optimization. Furthermore, most of the existing works was tested in limited room-sized space, thus making its operation questionable in a large space. In this paper, we implement two methods, one based on EKF and the other using smoothing. For the EKF-based method, we design EKF for estimating an UAV pose from UWB and IMU data. For the smoothing-based method, we build a factor graph from UWB and IMU data, and obtain the UAV pose using incremental inference from the graph. We tested the two methods in both simulation and a real experiment using a quadrotor in a large space, and we compared the methods in terms of accuracy and robustness.