TOA based Localization and Tracking in Indoor Multipath Environment

This thesis addresses the issue of localization and tracking using time-of-arrival (TOA) of both line-of-sight (LOS) and non-line-of-sight (NLOS) paths measured at multiple reference devices (RDs) in indoor multipath environment.

When accurate floor plan map is available, this thesis proposes a novel virtual RD (VRD) based indoor TOA localization algorithm utilized both LOS and multipath components. By introducing the concept of VRD, multipaths can be considered as virtual LOS paths originated from VRDs. Due to unknown measurement-to-path correspondence, there are a lot of possible positions satisfy the localization equation, which is known as multimodal issue. A grid based data association algorithm is proposed to estimate the correct measurement-to-path correspondence. Using the estimated data association result, the MD can be localized by two-step weighted least square method. Experimental and simulation results show that the proposed VRD based localization algorithm significantly outperforms conventional LOS based localization algorithms.

When accurate floor plan map is not available, this thesis proposes a novel simultaneous localization and mapping (SLAM) algorithm to jointly estimate the MD and map. By modeling the floor plan map as a collection of map features, the multi-RD single-cluster probability hypothesis density (MSC-PHD) filter can be utilized to jointly estimate the MD and map features. Conventional MSC-PHD filter is developed for outdoor radar-based scenarios which only considers backscatter paths. To apply it for indoor localization and tracking, LOS path and all higher-order reflections which carry information of MD and map features must be formulated. This paper proposes a new MSC-PHD filter by incorporating associations among map features due to multiple reflections, referred as multi-reflection incorporated MSC-PHD (MRMSC-PHD) filter. In addition, to mitigate high computation load of the MRMSC-PHD filter, a computational tractable implementation which combines a new greedy measurement partitioning scheme and a particle-Gaussian mixture filter is presented. Furthermore, a novel mapping error metric is proposed to evaluate accuracy of estimated map. Experimental and simulation results show that our proposed MRMSC-PHD filter outperforms existing MSC-PHD filters by a significant margin in terms of both localization and mapping accuracy.