NavInThings --- An Indoor Localization and Navigation system based on UWB

Feng Gao[1], Zhen Xu[1], Weidong Ji[1], Su Zhang[1, 2*]

(snd_gf@163.com, snd_xz@163.com, snd_jwd@163.com, su.zhang@ate-nj.com)
1. SND smart Ltd. Com., Nanjing China
2. ATE electronics Ltd. Com., Nanjing China

Abstract

We present a solution for a wireless localization network using UWB techniques. The system does not rely on a complex infrastructure for estimating the 3D position of mobile tags and tracking in the C type competing in Microsoft Indoor Localization Competition (MILC) 2018.

I. Introduction

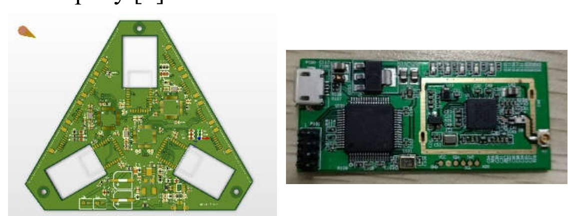
Indoor localization problems are widely happening in modern navigation and tracking applications. With the help of Ultra-wideband signals (UWB)[1], the position of a mobile device can be determined easily due to the measurement of propagation delays of an emitted signal. Based on exact positions of some fixed anchor nodes in the room, UWB promises to measure the distance accurately. However the non-line of sight operating (NLOS) conditions can't be avoided in real scenes, which decreases the localization performance seriously. To judge whether the NLOS happens, a process has been developed based on wireless signal strengths. And NavInThings, the low-cost and highly accurate indoor localization and navigation system, is developed to meet the demand of C type competing in MILC2018, which adopts several methods to improve the performance, such as NLOS judgment, multi-antenna anchors, motion sensing.

II System overview

NavInThings system is comprised of (at least) one tag, multiple anchor nodes (including one master node) and a host computer. The three dimensional positions are calculated with the help of TOF (Time of flight) and TDOA (Time Difference of Arrival) which are based on UWB signals (3.9 GHz / 6.4 GHz). A low-power MEMS IMU will be attached on each tag acting as a supplement measurement.

In the system, several anchor nodes are installed in some fixed locations in the room, one of which acts as the master. The firmware and the radio interface is equal for the normal anchors and the master. To increase the system capacity, each anchor has a 3-antenna structure, which consists of three independent UWB modules. The tag have only one UWB module on it. However, there is no difference in the firmware between the anchors and the tag, excluding the amount of UWB modules, the configuration and the MEMS attachment.

Figure 1(a) and (b) show the UWB module used in the anchor node and the tag of the system, respectively. The module in the anchor node has the same design as one in the tag. The triangle structure can make full use of every antenna of the UWB modules. The modules are based on DW1000, one product developed by Decawave Company [2].



(a) *(b)*

Fig.1 (a) The circuit diagram of UWB module in the anchor, (b) The UWB module used in a tag of NavInThings

The whole system works in the synchronous mode. The master starts a periodical measure procedure by sending a Start-Measuring instruction to all nodes. When receiving the instruction, every anchor performs a distance-measurement and reports the results to the master. The distance estimation can be based on TOF or TDOA. In the procedure, the master plays the same role as an ordinary anchor and measures the distances between the tags and it. In an area in line of sight, anchors are grouped into several cells. In every cell, the estimated distances are used to calculate the tag position.

According to the difference of the signal power transmitted in the first path and the first reflected path, whether the tag locates in the NLOS area can be judged. When NLOS areas exist, in an area out of line of sight, an ordinary anchor can act as an auxiliary master by sending the Start-Measuring instruction after receiving the main instruction sent by the master. A tag in the master-NLOS area can be located using all anchors in the section around it, including one auxiliary master and some ordinary anchors.

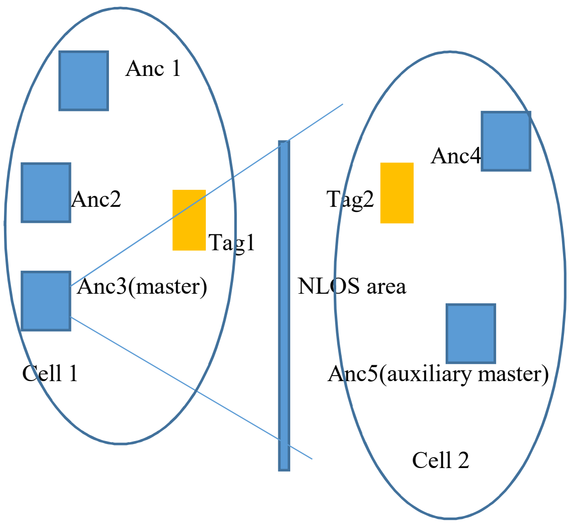


Fig. 2, Illustration of NLOS localization in the NavInThing system

In Fig.2, Tag2 locates in the NLOS area. To perform the measurement, Anc5 can act as the auxiliary master, or shadow master, and after receiving the instruction sent by the master, send auxiliary instruction to Tag2 to inform the start of measurement. The method can help to enlarge the coverage of the network geatly.

3. Distance Measurement and Tracking

The distance measurement is performed by calculating the time difference between the anchor nodes and the smart tag. While every distance between the tag and one anchor in LOS region is calculated, the position of the tag can be estimated. Although a straightforward approach would be to use all measurements and perform gauss-newton method to compute the target position, Extended Kalman Filter (EKF) is used in the system in considering the existing noise and the outlier in the distance estimation. When the tag locates in a NLOS area, high-performance IMU can be used to improve the accuracy and robustness of distance measurements.

The high precision of the system has been tested in our indoor test environment, where we have achieved an accuracy of ±10cm on a static target depending on the calibration.

After estimating the 3D position of the tag, the host computer estimates the track of every tags. The MEMS data, including samplers from a 3-Axis Gyro, a 3-Axis Magnectic and 3-Axis Accelerometer, are sent to the master to calibrate the estimation.

4. Future Development

We are currently involved with many customers from the manufacturing, intra-logistics and automotive industry. A further adaptive version of the system will be developed to suit the industrial environments.

Reference

[1]M. G. diBenedetto, T. Kaiser, A. F. Molish, I. Oppermann, C Plitano, and D. Porcino (eds). UWB Communication systems: A Comprehension Overview. EURASIP Publishing, 2005

[2]Decawave Ltd. DW1000 USER MANUAL, http//www.decawave.com/, 2015.