ATLAS: TDOA-based UWB Localization

Submission for the Microsoft Indoor Localization Competition 2018

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ABSTRACT

This extended abstract is submitted as an entry for the Microsoft Indoor Localization Competition taking place in April 2018. At the core we use ultra-wideband (UWB) technology and the time-differences of arrival (TDOA) to estimate the mobile nodes position. In order to achieve a common time-base for the distributed set of anchor nodes, a wireless clock-synchronization protocol is utilized. Our system is categorized as infrastructure-based modified commercial off-the-shelf (COTS) technology.

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1 INTRODUCTION

Recent developments in ultra-wideband (UWB) hardware enabled a new quality of wireless localization. There is a variety of work and systems already achieving highly accurate localization results. Previous indoor localization competitions demonstrate the potential of those technologies [1]. We envision to compare the accuracy and improve our system design in the course of participating in this competition.

2 SYSTEM DESCRIPTION

Our system design is based upon the previously published ATLAS localization system design [4] which we released open source and evaluated competitively [2] in 2016. The localization is utilizing the time-difference of arrival (TDOA) of the frame transmitted from the mobile unit to the statically deployed anchor nodes. In order to gain a common time-base at the anchor nodes, wireless clock synchronization [5] is employed. In known line-of-sight (LOS) environments, the system is capable of achieving control-grade localization quality that was recently used for the control of unmanned aerial vehicles (UAV), see [6].

However, in non-line-of-sight (NLOS) conditions and environments spanning over larger areas, the previously designed system faces severe difficulties. Therefore, in the course of the participation in this competition, we plan to evaluate new developments such as NLOS mitigation techniques, inertial sensor fusion and distributed wireless clock synchronization, as depicted in Fig. 1. Additional aspect beyond pure UWB-based TDOA localization are as follows:

- NLOS mitigation using basic channel response indicators
- Inertial measurement data sensor fusion
- Distributed wireless clock synchronization
- Modular design and node scheduling

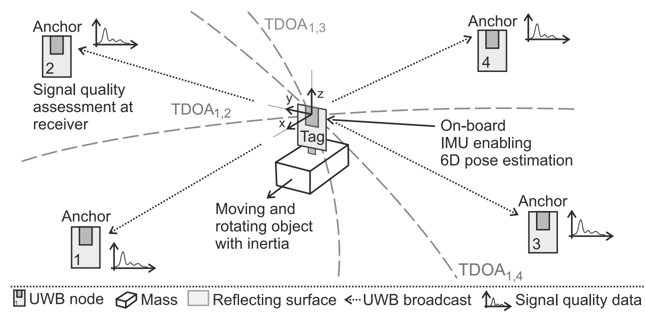

Figure 1: Illustration of the proposed concept. The localization filter is augmented with inertial measurement and signal quality data to improve the localization robustness.

In a first step, the overall system structure was redesigned to enable a distributed and scalable setup. The basis for the new system design is the robot operating system (ROS), see [3]. The system architecture is depicted in Fig. 2. The physical layer (PHY) and the precise time-of-arrival (TOA) estimation is based on the IEEE 802.15.4a-2011 UWB PHY using Decawave DWM1000 modules. A low-cost microcontroller unit (MCU) is communicating to the UWB transceiver over the serial peripheral interface (SPI). Although physically identical, the mobile unit features a low-cost inertial measurement unit (IMU) to obtain the orientation and acceleration of the tracking target. The statically deployed anchor nodes communicate over a proprietary binary protocol to the ATLAS concentrator nodes that configure the anchors and receive unsolicited TOA samples. In order to obtain localization results, the samples have to be assembled and grouped based on the extended unique identifier (EUI), the packet sequence number and the system clock. Here, the frame identifier differentiates between positioning beacons, synchronization frames and association requests. The synchronization frames are used to feed clock models of the individual anchor clocks. On the basis of those models, the anchor offsets for the distributed clock synchronization are fed into the ATLAS FaST scheduler that handles association requests and synchronization scheduling. Positioning beacon TOAs will be clock corrected and fed into the extended Kalman filter (EKF) based sensor fusion that additionally utilizes IMU and signal quality data to obtain position estimations. The positioning results will be reported and logged

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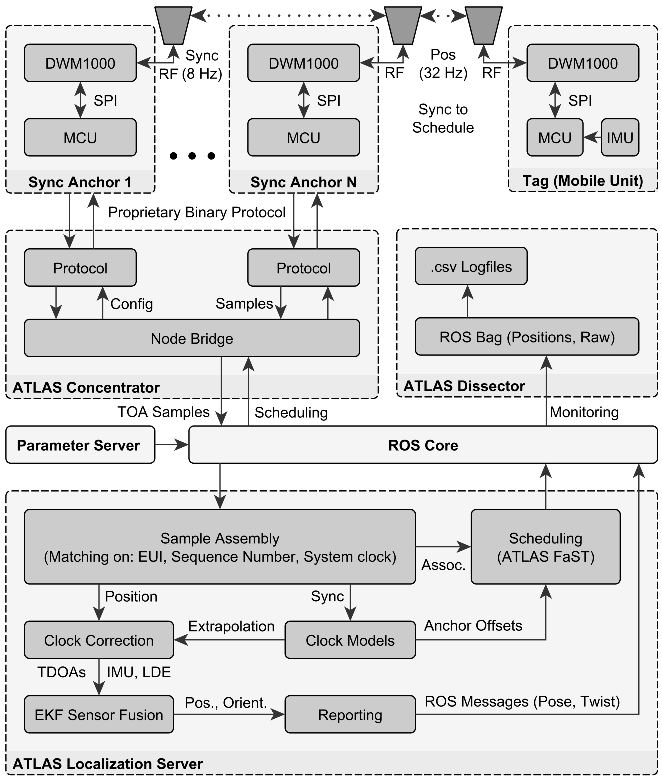

Figure 2: Schematic illustration of the system architecture.

using rosbag tools. The ATLAS dissector will enable the creation of requirement-specific comma separated values (CSV) files in post-processing for evaluation. The chosen TDOA topology used in our system design enables our mobile nodes to be very energy efficient. Only a single frame needs to be transmitted in order to obtain a full localization result. However, if a guaranteed update rate is desired, bi-directional communication, synchronization and association to the systems scheduler is required.

In the specific setup used in the competition a clock synchronization frequency of 8 Hz and a positioning rate of 32 Hz is planned. In contrast to two-way-ranging (TWR) based approaches, the TDOA approach inherently comes with one additional unknown. This reduces the accuracy of our system in areas only covered by a small number of anchors. However, in terms of the UWB channel capacity itself, we have no limitation in the amount of passive anchors listening and obtaining TOA samples. Therefore, the more static anchor nodes are used, the more accurate is the expected localization result. We look forward to compare our system design to other wireless localization approaches and gain further experience and knowledge in the course of our participation.

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