Demo: Real-Time Low-Latency Tracking for UWB tags

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ABSTRACT

Wide-scale adoption of VR/AR technologies in gaming, video conferencing and for other remote telepresence applications demands limb tracking for a more immersive experience. To that extent, camera and other visual sensors are currently employed for hand or leg tracking. But these visual sensors perform poorly when obstructed and can be bulky to wear. In an attempt to bolster limb tracking, we present UWB-Trac, a UWB + IMU based fusion tracker for VR applications. In this demo, and accompanying video[1], we showcase this UWB tracker. Furthermore, the demo will include simultaneous tracking via state-of-art HTC Vive VR trackers as a comparative baseline.

1 INTRODUCTION

A VR tracker which provides a smooth and immersive experience for a user needs to fulfill the following four requirements. (a) the system needs to furnish near real-time and low latency locations, (b) these locations need be provided at the VR headset or a central computer, (c) any solution which is deployed in the environment must have a long operation time, and (d) the locations provided needs to have cm-scale tracking accuracy in 3D environments. We observe that Ultra-wideband (UWB) based localization holds the most promise to satisfy these requirements today.

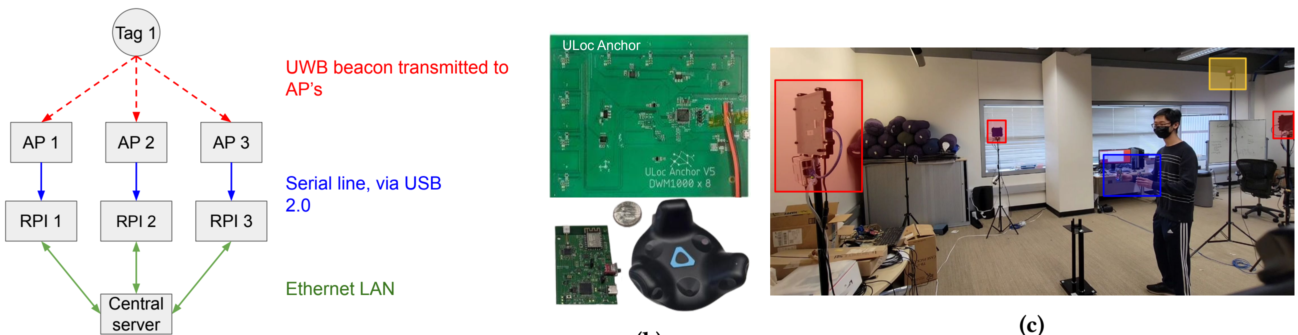
In this vein, multiple UWB-based systems have gained traction in both industry [2] and academia [4] as UWB is developed specifically as a localization-based RF protocol. Unfortunately, most systems [2] relying on two-way-ranging based localization, which require multiple time-consuming packet exchanges, fail to furnish locations at low-latency. Furthermore, many protocols [2, 4] provide locations at the tag, which adds the unnecessary step to transmit this information back to the VR headset/computer. And most critically, most protocols deployed today require one or more packets to be received at the tag which needs to be localized. Keeping in mind packet reception at the tag, which needs to perform preamble search and integrate energy below the noise floor over a wide bandwidth of the received signal [3], is known to consume over $10x$ more power, precludes a long-battery life on the tag. In order to meet the requirements needed for today's localization systems, we developed ULoc [6]. In ULoc, we design first-of-its-kind multi-antenna UWB anchors to measure the angle of arrival (AoA's) of the received UWB packet. Via triangulation using AoA's measured from at least three anchors, we can furnish cm-accurate locations for mulitple tags in the environment. Through this demonstration, we would like to showcase our technology to localize multiple tags in 3D space and in real-time. Furthermore, we will integrate HTC-Vive's VR Trackers concurrently to provide a qualitative indication of ground truth.

2 DESIGN

The design of this low-latency, accurate and low power UWB-based localization system is composed of two subsystems, the UWB-based sensing front end, which is described in full in [6], and the real-time localization and IMU fusion backend.
UWB-based Sensing Front-end: As discussed in Sec. 1, to meet the four key requirements for indoor localization on a large scale, we need to rethink the role of two-way-ranging and other ranging based localization algorithms. In ULoc, we do this by designing a UWB anchor equipped with an L-shaped antenna array using eight commercially available DWM1000 [1] chip-sets as shown in Fig. 1(b). We further design and localize a simple tag by transmitting UWB protocol-compliant 'blink' packets (red dotted arrows in Fig. 1(a)). This transmit-only architecture reduces the number of packets needed to localize the tag and reduces the power consumed at the tag. Finally, by measuring the wireless channel at the UWB anchors of these packets, we can measure the angle of arrival. Further details can be found in [6].
Real-time Location Computation: These channel measurements are transmitted over serial line (blue solid arrows in Fig. 1(a)) in compressed binary format. These binary packets are decoded on the RPI's and timestamped. The decoded CIR, FPI, UWB packet ID, tag ID and timestamps are sent to the central server over a TCP socket (green arrows in Fig. 1). Note here that the packet ID is an 1-Byte incremental counter wrapping around at 255. The packet ID is essential to sync the packets across the access points. Furthermore, if there are mulitple tags in the environment, they will encode their Tag ID in the UWB 'blink' packet as well. The tag ID's are used to segregate the multiple tags in the environment, which blink at individual time slots to prevent packet collision.

The decoded binary information from the multiple AP's arrives at the central server. To ensure realtime processing of these packets, three parallel process are set up. The first

[1] Youtube link: https://youtu.be/PJ6rDCRtPWI



(a) (b) (c)

Figure 1: (a) UWB System Design (b) ULoc Anchor (top) and Tag (bottom left) and HTC Vive tracker (bottom right) compared against a U.S. Quarter Dollar coin (c) Demo setup: The demo will be set up in a 5x5 m space, with concurrent deployment of both UWB and VR based localization for comparison. The red, blue and yellow boxes indicate the UWB anchors, tags and HTC Vive Lighthouses respectively

one is used to compute the angle of arrival. We can use a simple FFT algorithm to extract the 3D-angle of arrival, i.e., the azimuth and the elevation of the incoming signal [6]. Furthermore, a simple tracking algorithms in implemented to average out the noise in these measurements, especially during the tag's movement. The second parallel process computes the location of the multiple tags in the environment from the measured AoA. In conjunction to these UWB measurements, UWBTrac's tags also measure and publish inertial measurements via an onboard MPU-6050 IMU. These inertial measurements comprise of acceleration, angular velocity and orientation of the tag and are published via UDP packets to the central server. With these locations and inertial measurements, we use GTSAM's open sourced graph optimization framework [5] to fuse these information to provide realtime and low latency location updates for multiple tags.

Finally, the third parallel process is responsible for displaying the location of the tag via a GUI. Furthermore, we also measure and plot the location of co-located HTC Vive trackers to provide an accurate sense of ground truth and to provide a qualitative understanding of the accuracy of our system. The following section will provide more details about the specifics of the demo setup.

3 DEMONSTRATION

The demo will be setup in a 5m x 5m environment. The environment size is limited to the recommended size of the HTC-Vive VR play area. To that extent we would need a small play area, with access to a power socket and minimal obstacle clutters, to perform the demo robustly. Both the UWB and HTC-Vive tracking system will be jointly deployed as shown in Fig. 1(c). The conference attendees will be allowed to freely interact with the system, hold the UWB tags and HTC vive trackers (blue box in Fig 1(c) and Fig 1(b)) to get a feeling of the tracking performance. It is recommended to use the provided reflectors and attenuators to observe multipath and blockage effects. A sample case would be placing the tag such that the direct path is blocked, but with a reflector to allow for a clear reflection path. As explained in the previous section, each UWB Anchor (red boxes in Fig 1(c)) is connected to an RPI and all the RPI's are connected, via a network switch, to a central computer. The demo will be setup accordingly and care will be taken to avoid tripping hazards within the play area. All the UWB tags and anchors are enclosed in insulated plastic cases and will not present a hazard to the users. Finally, the tag locations will be output in a simple GUI (an example can be seen in the accompanying video). Furthermore, the Azimuth-Polar angle profiles will also be visualized to provide better intuition for the participants.

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