Sub Millimeter
3D Wireless
Positional Tracking

for

Location Based VR
(LBVR)

September 2018

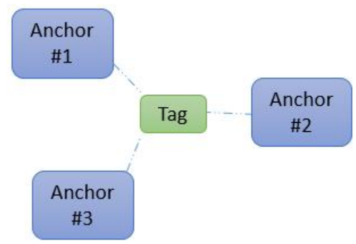
Introduction

Virtual Reality (VR) has been around for several years, but the user experience has been limited to very small spaces. Up until now, extending the space available for the user experience (enabling user mobility) was extremely expensive and difficult to setup. In this paper, an affordable, low latency, high precision 3 Dimensional (3D) wireless tracking system for Location based VR (LBVR) is introduced. This paper will walk you through the history of positional tracking technology; the problems with existing tracking for LBVR; and will introduce you to the latest and greatest tracking solution. This solution integrates three technologies: Ultra Wide Band (UWB) wireless Radio Frequency (RF), Inertial Measurement Unit (IMU), and Inside-Out camera Tracking (IOT). The total cost is under $6,000 and requires only 10 minutes to setup.

History of Positional Tracking

Wireless Positional Tracking

In order to track the 3D position of an object (tag), you need to know the distance or angle from that object to a minimum of three reference locations (anchors). Each tag or anchor has a RF transponder attached to it. The absolute 3D position can be determined using either trilateration (measuring distances) or triangulation (measuring angles). The precision of each measurement and the length of time it takes to conduct the measurement determines how good the technology is and which applications it will work for.



GPS Wireless Tracking

GPS is universally used across the globe for position tracking for outdoor applications, but is completely unusable when indoors. Typical precision obtained vary from 1 - 10 meters (m). The time between each measurement (latency) is typically 1 – 5 seconds (sec).

WiFi / BT Wireless Tracking

Wifi and BT (Bluetooth) due to their wide spread use were the first indoor wireless technologies used for positional tracking. Both of these wireless technologies use narrowband frequency signals and suffer from multipath issues; which means they have a hard time determining if the measurement is a reflection or actual distance from one RF transponder to another. Typical precision obtained from these vary between 1 - 10 (m). The measurement latency is typically 100 – 500 milliseconds (ms).

UWB Wireless Tracking

UWB is a wireless tracking technology that uses high bandwidth radio frequency pulses. This wideband technology virtually eliminates multipath issues. The precise line of sight (LOS) measurement between two transponders will be dependent on how accurately you can time the radio frequency pulses. Current technology can time these pulses down to 15 picoseconds (ps); which is about 5 millimeters (mm). Typical LOS precision obtained from this technology varies from 10 – 100 centimeters (cm). With any wireless tracking technology, the signals can pass through curtains, walls or other small objects with little to no affect to the distance measurements. The measurement latency is typically between 100 – 1,000 ms.

UWB / IMU Wireless Tracking

The IMU contains three key parts: magnetometer, accelerometer and gyroscope. Typically, the accelerometer and gyroscope data are fused together to determine orientation and linear acceleration. The magnetometer is usually not relied on due to interference with nearby metal objects. By fusing UWB wireless distance measurements with the linear acceleration from an IMU, 5 mm precision can be obtained with only 5 ms measurement latency.

Camera Positional Tracking

Inside-Out Camera Tracking (IOT)

IOT uses monoscopic or stereo video cameras mounted to the head mounted display (HMD) or tracked object to detect key features in each video frame. In the case of stereo video cameras, the depth to each key feature can also be measured. These key features are matched to the previous video frame. The relative position and rotation can be estimated provided that enough key features can be matched every frame. The relative tracking obtained from this technology works well unless the tracking is lost; which happens from time to time when lighting changes or where the texture on the walls is low in large rooms. Another issue is that the tracking is relative to when the system starts. The initial starting location is unknown or if tracking is lost, the tracking system has to be restarted. In addition, one other problem that occurs over time is the accumulation of small errors in the relative tracking which causes drift. This means physical objects in the VR scene will not appear to the user in the correct location.

Problems with Existing Tracking for LBVR

Outside-In Camera Tracking (OIT) has traditionally been used for LBVR, but is very expensive and difficult to setup. For example, an OIT to cover a 100ft x 100ft space, would consist of 192 cameras and costs $500,000. This includes camera tracking hardware, extensive infrastructure to hold cameras and extensive labor for setup and calibration[1].

The video cameras must be precisely mounted across the ceiling. These cameras locate special reflective balls mounted on the object to be tracked. Using trilateration, the 3D position of each reflective ball can be determined along with the location and rotation of the object being tracked. Across multiple video frames, the 3D motion of the object being tracked can be estimated. It requires several weeks to setup and calibrate the system. As such it must be installed in a permanent location.

The system also requires a dedicated PC with a $1,500 annually licensed software[2]. Converting an existing VR game to use the tracking system also requires extensive amount of time.

Fusion of Wireless and Camera Based Tracking

The first HMD to use IOT are just getting into the hands of developers and unfortunately, limited to tracking in small spaces[3,4]. The reason for the limitation to a small space is that over time, the IOT tracking will drift and can cause the user to run into things such as walls. Also, the tracking can completely fail due to changes in lighting, low texture on walls, or the blocking of the cameras.

An IOT tracking system can give relative sub mm tracking precision, but it does not know its location when it first starts or when the tracking is lost. The UWB / IMU wireless tracking system gives absolute positioning with 5 mm precision and hence can give the initial 3D position to the IOT during startup and whenever the IOT loses its tracking. The UWB / IMU wireless tracking system also constantly corrects the IOT drift. Therefore, the fusion of UWB/IMU + IOT is the ideal tracking technology for LBVR. To the right is an example of the fusion technology using the HTC Focus IOT + IndoTraq™ HSKT™ wireless tracking.

Comparison of Technologies

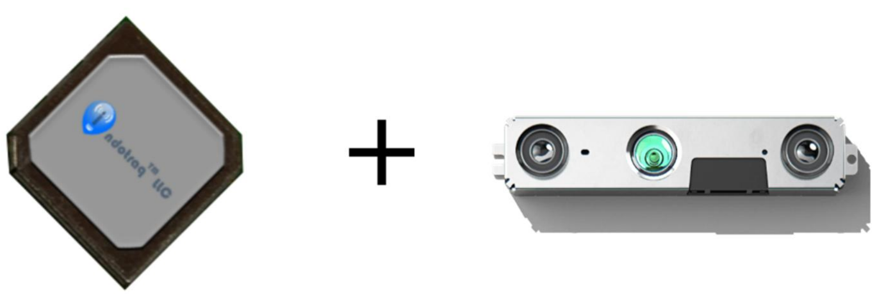
Feature	Fusion IOT + UWB/IMU	OIT
Low cost system installation	🙂	🙁
Precise sub mm 3D tracking	🙂	🙂
Super smooth with 10ms latency	🙂	🙂
Large Tracking Space 300ft x 300ft	🙂	🙁
Multiplayer	🙂	🙂
Quick and easy calibration	🙂	🙁
Integration with existing VR code	🙂	🙁
No dedicated PC required	🙂	🙁
Mobile	🙂	🙁

Conclusion

This paper has covered the history of positional tracking, problems of using outside-in camera tracking (OIT), fusion of wireless tracking with inside-out camera tracking (IOT) and a quick comparison of the two tracking technologies. Clearly, the tracking technology to use for LBVR is a fusion of wireless tracking with IOT.

IndoTraq™ is uniquely positioned to deliver the tracking solution for LBVR for under $6,000. It provides the same tracking precision and latency of an OIT system, but it adds quite a few benefits:

- Large Tracking Space – Up to 300ft x 300ft
- Quick & Easy 10-minute setup
- No Dedicated PC
- Mobile



To get the most updated information about this new tracking system, please visit: IndoTraq.com or contact sales@indotraq.com

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