A low cost 3D positioning solution of high accuracy and high refreshing rate for robot control

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Abstract

Low cost normally stands in the opposite of high accuracy and high refreshing rate for existing indoor positioning systems. LiDAR-based positioning systems provide an accuracy up to 18mm, but the extremely high cost limits their wide application. UWB-based ones achieved an accuracy of 168mm[1], however, the system of this level still costs over 10,000 US dollars, and its accuracy tends to seriously degraded due to low refreshing rate when the tracked object is in movement. Unlike human, robots require highly accurate real-time positioning system for precise operations, the cost of which we believe is the obstacle of massive production and application of such robots. A low cost (could be less than 1000 US dollars after mass production) positioning system of high accuracy (could be up to sub-mm level) and high refreshing rate (could be 60~1000Hz with the help of IMU) for robot control is developing at ElegenTech. Currently, the room scale system requires only one base station and one tracker to achieve 3 dimensional positioning and tracking, and fast initialization (less than 10mins) is expectable.

Key words

Localization, low cost high accuracy, high refreshing rate

Introduction

As AI technologies are rapidly advancing, intelligent robots that can complete more complex tasks in indoor environment such as homes and supermalls are to be expected. Knowing position is a fundamental basis for a robot to complete sophisticated tasks and the demand for accuracy is endless. However, high accuracy indoor positioning systems are extremely expensive, which makes it impossible to incorporate them into a robot of consumer level. For example, LiDAR-based SLAM technologies were mostly used by industry companies; OptiTrack real-time tracking systems were adopted by some researchers to manipulate drones or other robots. Their accuracy is promising, but the application is quite limited due to extremely high cost or/and very complex setting. UWB technology is a very good indoor positioning technology, but usually its best accuracy is over 10cm, and it also costs a lot to achieve this level, not to say complex setting process. A low cost, high accuracy real-time indoor positioning system for robot control seems to be an impossible mission in the past. Inspired by Valve's lighthouse tracking technology[2], ElegenTech is now developing a similar solution for robot control. ElegenTech believes that it will benefit everyone by introducing it into robot control.

Device and approach

The system developed consists of a lighthouse base station (at least), a tracker and the software. Currently, all components are commercial off-the-shelf products. The base station is manufactured by HTC for VR experiencing. The tracker and modules on it (Fig.1) are designed and developed by ElegenTech with a key chip designed by Valve and manufactured by Triad Semiconductor, which was used by many researchers to crack this technology[3]. The tracker itself is also the first flight controller with high accuracy indoor positioning function in the world.

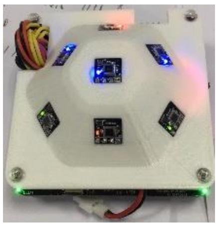

Figure.1 Tracker

Angle of arrival (AOA) approach is used in developing algorithms, and the process is not an easy one. Several algorithms have been developed, each has its own advantages and limitations, but it is safe to say that calculation on the controller is possible. Our arithmetic solution and analytical solution require only three sensors to obtain the coordinates, while Valve's needs four or five (not quite sure).

Features

Compared with other tracking technologies, this solution has many merits. It is currently the only solution that integrates high accuracy and low cost, especially suitable for control of robot at both consumer and industrial level. The expected features of products in the future are as follows.

Cost	Less than 1000 dollars
Accuracy	Up to sub-mm level
Coverage	>60m^2, scalable, enlargeable
Refreshing rate	60~1000Hz
Deployment	Very easy, less than 30min
Quantity limit	Without, as long as visible
Application	Indoor and outdoor (sunlight)

Test results

Several tests were carried out with one base station and one tracker at several different locations for about 30 seconds and the results are presented as follows. The X axis was set along the normal direction of the beaming face of the base station, the Z axis was set downward, and the base station had a small pitch angle. The coordinates are obtained through trigonometry method based on the angles received by the sensors relative to the base station. Theoretically, if all parameters are right, then the results should be absolutely right. However, many reasons may bring inaccuracy, such as fluctuations in angles received by the sensors introduced by high frequency vibration of the base station, and errors in placing sensors. Even though, the accuracy of the system beyond our capability to measure as we do not have equipment with higher accuracy for a large scale space. Thus, the results are given in fluctuations of the values of the coordinates calculated, assuming that all parameters are correct.

Results are presented by the name of point to point distance from the station to the tracker, as shown in Fig.2, Fig.3 and Table.1. It can be seen from the results that, fluctuation increases as the X value increases, and fluctuation along X axis is severer than the other two axes, which is agree with theory. The maximum deviation is ±90mm at a distance of about 9 meters, and the minimum one could be as small as ±0.06. It should be pointed out that the system could be significantly improved by introducing more base stations, calibration, better filters and better stations (such as the second generation to be released). Therefore, mm level at the whole space, sub-mm level at small space, or even higher level (like ±0.06) at a small given area is expectable.

Acknowledgement

We would like to thank Microsoft for holding the competition to promote the development of indoor positioning technologies, and expect to be listed in the Modified COTS group.

References

[1] https://www.microsoft.com/en-us/research/event/microsoft-indoor-localization-competition-ipsn-2017/

[2] https://partner.steamgames.com/vrlicensing

[3] https://www.triadsemi.com/laser-tracking-user-projects/

Table 1 Fluctuations of the values at the coordinates (unit all in mm)

Location	X	Y	Z
3.4m	±0.8(1147)	±0.06(2.18)	±1.5(1456)
4.9m	±50(4700)	±2.5(248.2)	±13(1357)
8.9m	±90(8780)	±3(207)	±15(1108)

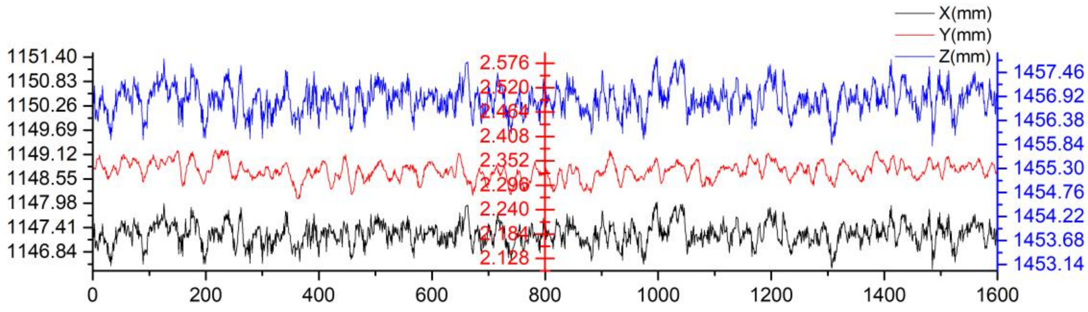

Figure.2 Fluctuations of calculated values of X, Y and Z at 3.4 meters

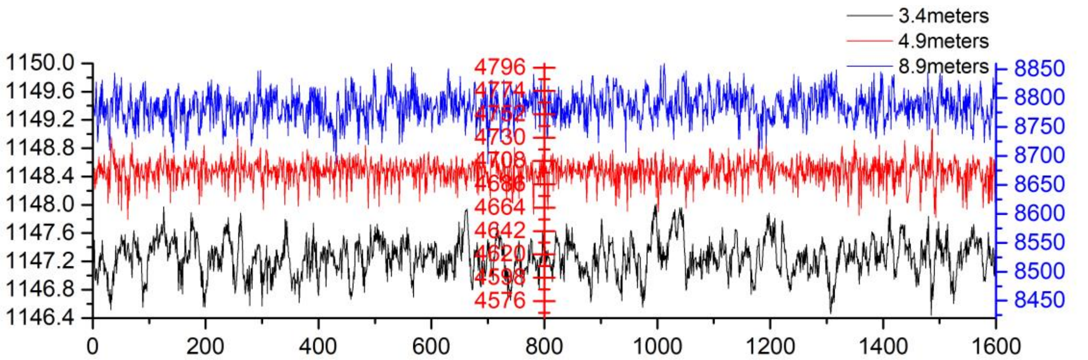

Figure.3 Fluctuations of calculated values of X at three different locations