Minimum effective range of ultra-wide band positioning

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ABSTRACT – The use of wireless technology in indoor navigation is getting traction with many reports on getting accurate positioning using Ultra-Wide Band (UWB). However, there is lack of study on the minimum effective range of UWB positioning. This paper reports the results on finding the minimum range in applying UWB positioning system using an established UWB hardware in a static condition. The results include the effect on positioning accuracy with the presence of static obstacles. From the conducted experiments, the accuracy of UWB positioning is unpredictable below than 2m. Also, obstacles in the middle of transceivers showed the lowest position error.

1. INTRODUCTION

Navigation is a tracking solution that uses position information to help users to move towards a desire destination. To navigate, position needs to be obtained first and the process is called positioning. Positioning by definition is to find the location of something or someone in relation to a specific reference area or region.

The rapid growth of wireless access and positioning technology not only offers wireless high data speeds, but also effective indoor navigation [1]. The wireless technologies include Wi-Fi, Bluetooth, Ultra-Wide Band (UWB), and ZigBee. Among the factors in choosing the wireless technology are readily available infrastructure (e.g. Wi-Fi), easy to use and energy-saving (e.g. Bluetooth), and high accuracy (e.g. UWB). However, those technologies are subject to a few drawbacks. For instance, generic Wi-Fi platforms lack high precision hardware for time-of-flight measurements, thus making positioning inaccurate [2]. Meanwhile, Bluetooth has small coverage area and require a high density of them, in which incur more cost. Likewise, UWB platforms are expensive in comparison with other technologies.

The implementation of wireless navigation needs consistent and high-quality communication performance. However, the performance of current wireless navigation can vary significantly due to radio interferences and changes in the environment [3]. According to [4], one of the factors that affect the performance of wireless navigation is the signal propagation influenced by indoor environments. The influences include building structure, building material, furniture placement, surrounding ambient and human presence.

One of the studies on the factors that influence the wireless positioning has reported that UWB positioning technology can achieved considerably good accuracy in indoor environment [5]. However, the work only investigated the range of UWB positioning between 5m to 70m. It raises question on how the UWB positioning will perform in shorter range.

This paper provides the insight of the performance of UWB positioning in shorter ranges, below 5m and recommends the minimum effective range when applying UWB positioning technology.

2. METHODOLOGY

The experiments were conducted in a closed area, approximately 3m x 5m. The UWB positioning is evaluated using four UWB devices from Decawave known as EVB1000 as shown in Figure 1. Three of the UWB devices was used as transmitters (called as anchors) and another as a receiver (called as tag). Only one transmitter was used at a time and changed to another for a repeat experiment.

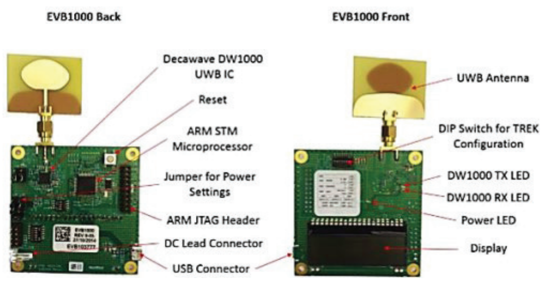

Figure 1 Front and back views of an EVB1000

In the first part of the experiments, the two devices were spaced out with clear line of sight at different ranges; 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, 3.0m, 3.5m and 4.0m. Both devices were placed 0.5m from the ground, which presumably the height of a mobile robot in the lab. The tag which connected to a laptop through USB was fixed on the wall and the anchor was secured on a tripod. The setup of the experiment is shown in Figure 2.

In the second part of the experiments, a whiteboard (90cm x 60cm) was placed between the tag and anchor, acting as an obstacle. The distance between the tag and anchor was fixed at 4m and the distance between the tag and whiteboard were varied as follows: 0.75m, 1.25m, 1.75m, 2.25m, 2.75m, 3.25m and 3.75m. Later, a 24-year-old female with a height of 172cm had replaced the whiteboard as the obstacle and the distance between the tag and human were varied as previously mentioned.

Each of position measurements was collected 10s after communication between the tag and anchor had established to allow the signal transmission stabilized. The range measurements were computed by the supplied Decawave software using Time-of-Arrival method. The average value was computed after a minute.

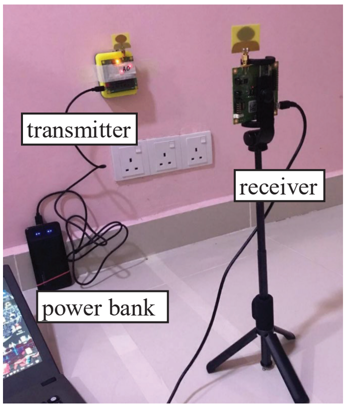

Figure 2 Experiment setup

3. RESULTS AND DISCUSSION

The averages of measured UWB position data for different transmitters and ranges were compared with the ground truths using the root mean square error (RMSE) formula:

$$RMSE = \sqrt{[((t_1\text{-}GT)^2 + (t_2\text{-}GT)^2 + (t_3\text{-}GT)^2) / 3]} \quad (1)$$

where t_1 is average range of transmitter 1, t_2 is average range of transmitter 2, t_3 is average range of transmitter 3 and GT is the ground truth.

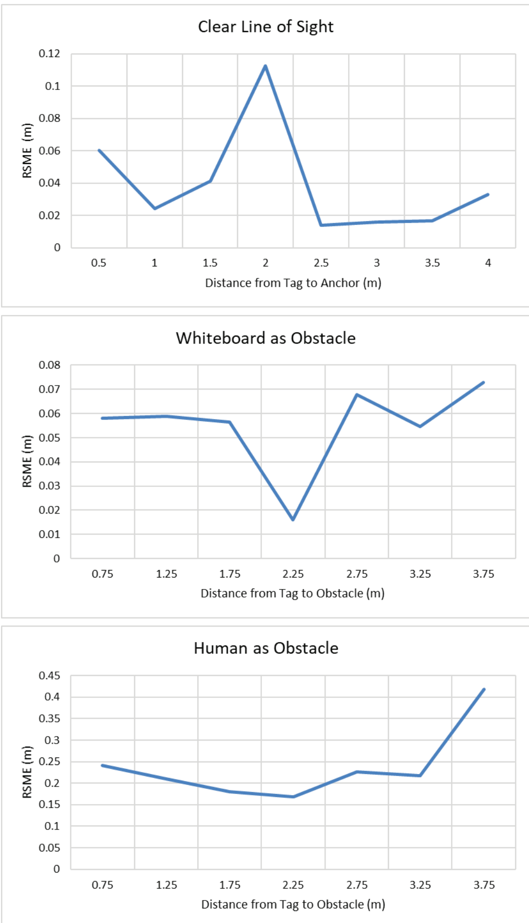

Figure 3. Root mean square errors of UWB positioning.

The RMSE for the three scenarios are plotted in the Figure 3. The line-of-sight result indicates the measurements of UWB positioning is reliable if the distance between the tag and anchor more than 2m. Below than 2m, the error is unpredictable. Noticeably, the positioning accuracy is better when the obstacles were placed at the middle of the tag and anchor. This can be observed in both obstacles where the RMSE dipped at 2.25m. The RMSE for whiteboard as obstacle is lower than human because there is an open space between the support stands of the whiteboard that allow for line-of-sight transmission.

4. CONCLUSIONS

The study has successfully determined the effective minimum range of UWB positioning. In an indoor environment, the UWB positioning is effective if the distance between the transceivers is more than 2m, as less than that, the position measured is unreliable. Secondly, the position measured is more accurate if any obstacle is in the middle of the transceivers. Further study can be done to investigate the performance if the tag placed at various heights, presence of machines and with moving obstacles.

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