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Poster

An Experimental Localization Testbed based on UWB Channel Impulse Response Measurements

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Abstract

In this paper, we demonstrate a new ultra-wideband (UWB) localization testbed, which tracks a UWB tag and estimates locations of obstacles based on channel impulse response measurements. Anchor nodes that are developed with off-the-shelf Decawave DW1000 UWB transceivers are deployed to cover the area of interest. The testbed is implemented and preliminary experiments are carried out to estimate the location of the object by analyzing channel impulse response strength of the UWB tag.

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ABSTRACT

In this paper, we demonstrate a new ultra-wideband (UWB) localization testbed, which tracks a UWB tag and estimates locations of obstacles based on channel impulse response measurements. Anchor nodes that are developed with off-the-shelf Decawave DW1000 UWB transceivers are deployed to cover the area of interest. The testbed is implemented and preliminary experiments are carried out to estimate the location of the object by analyzing channel impulse response strength of the UWB tag.

CCS CONCEPTS

• **Networks** → **Network experimentation**.

KEYWORDS

Localization, Testbed, Ultra-wideband, Channel impulse response

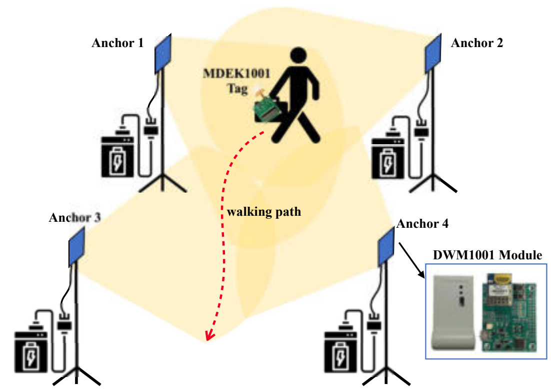


Figure 1: The anchor node and the UWB tag are developed based on Decawave DW1000 chip (left) and MDEK1001 kit (right). The localization algorithm is conducted to capture the CIR measurement.

1 INTRODUCTION

People tracking information can help the smart city service provider understand public space usage patterns so as to improve their resource allocation, which makes the city a desirable place to work and live [3, 4]. Ultra-wideband (UWB) radios are considered to enable indoor localization applications spanning the commercial and public sectors, such as asset management, pervasive medicare, and robot navigation [5], thanks to small size, low cost and low power of UWB equipments. Since the service area layout has considerable effects on signal reflection patterns and received signal strength of the UWB radio, it is difficult to estimate locations and lengths of a target objective, e.g., a wall or a car, according to channel impulse response (CIR) measurements [1].

In this paper, we demonstrate a new ultra-wideband (UWB) localization testbed, where Least Square and Kalman filter are applied to optimize the localization estimation. Specifically, 4 anchor nodes are deployed to cover the area of interest. The anchor nodes are synchronized and continuously broadcast UWB signals. A tag node that is attached to the tracking target responds the UWB signal of the anchor nodes. The anchor node and the tag are developed with the off-the-shelf Decawave DW1000 chip and MDEK1001 kit [2], as shown in Fig. 1. A localization algorithm is developed with Least Square and Kalman filter to analyze CIR measurements of a UWB tag, which is used to track the real-time location of the tag.

2 EXPERIMENTS AND PRELIMINARY RESULTS

2.1 Experiments on the testbed

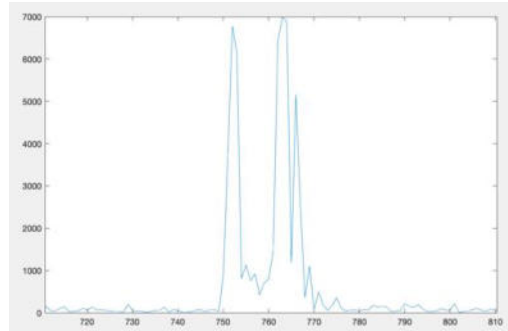
Based on the UWB testbed, we carry out experiments to measure the CIR strength at outdoor open field as well as in an anechoic chamber at CSIRO. The experiments aim to features of the CIR strength variation according to the location of the obstacle. The localization algorithm is implemented in Python, which collects the CIR measurement data samples to determine the tag's location.

Fig. 2(a-1) and Fig. 2(b-1) demonstrate the testbed setup outdoor and indoor, respectively. A metal panel is placed as the obstacle in the field, which leads to a multi-path signal reflection on the transmitted UWB signal of the anchor node. Moreover, the initial distance between the anchor node and the tag is about 7.010 meters. The distance from the metal panel to the anchor and the tag is about 4.699 and 4.547 meters, respectively. The CIR can undergo the reflection of multiple paths in the outdoor field. Thanks to the signal absorption, the CIR in the chamber can experience two paths, one is the line-of-sight (LoS) link between the anchor and the tag, and the other is the reflected signal by the panel.

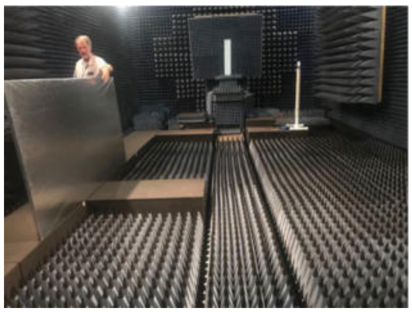
2.2 CIR strength and localization

Fig. 2(a-2) and Fig. 2(b-2) present the collected data samples regarding the CIR strength value in the outdoor field and the anechoic chamber, respectively. Given the multiple reflection paths, we can

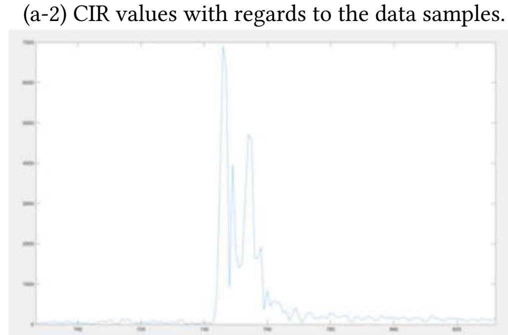
(a-1) CIR measurements at the outdoor open field.



(a-2) CIR values with regards to the data samples.



(b-1) CIR measurements in the indoor anechoic chamber.



(b-2) CIR values with regards to the data samples.

Figure 2: The CIR is measured at the outdoor open field and in the indoor anechoic chamber.

observe two main peaks of the CIR measurement in the outdoor. The peaks can be due to the LoS signal and the reflected one from the metal panel. Moreover, two peaks of the CIR also appear in the anechoic chamber. The time-of-arrival of the LoS signal is 747ns and that of the reflected one is 754ns. Hence, the experimental time difference of the LoS signal and the reflected one is about 7ns. Given the speed of signal transmission about 2.99×10^8m/s, the distance difference between the anchor and the tag, and the anchor and the metal panel can be estimated by 2.99×10^8m/s $\times$ 7ns = 2.09m. Given the measured distances 4.699m and 4.547m, the distance between the anchor node and the tag can be estimated as (4.699m + 4.547m) - 2.09m = 7.156m. Compared to the measured distance 7.010m, the estimation error is only 14.6cm.

3 CONCLUSIONS

This paper demonstrated a new UWB-based localization testbed based on the off-the-shelf Decawave DW1000 chip and MDEK1001 kit. Experiments are carried out to measure the CIR strength at outdoor open field as well as in an anechoic chamber at CSIRO. The time-of-arrival of the LoS CIR and the reflected one is captured to estimate the location the tag.

ACKNOWLEDGMENTS

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REFERENCES

[1] Changhui Jiang, Shuai Chen, Yuwei Chen, Di Liu, and Yuming Bo. 2020. An UWB channel impulse response de-noising method for NLOS/LOS classification boosting. *IEEE Communications Letters* 24, 11 (2020), 2513–2517.

[2] Antonio Ramón Jiménez and Fernando Seco. 2016. Comparing Decawave and Bespoon UWB location systems: Indoor/outdoor performance analysis. In *International Conference on Indoor Positioning and Indoor Navigation (IPIN)*. IEEE, 1–8.

[3] Kai Li, Chau Yuen, and Salil Kanhere. 2015. Senseflow: An experimental study of people tracking. In *Proceedings of the 6th ACM Workshop on Real World Wireless Sensor Networks*. 31–34.

[4] Kai Li, Chau Yuen, Salil S Kanhere, Kun Hu, Wei Zhang, Fan Jiang, and Xiang Liu. 2018. An experimental study for tracking crowd in smart cities. *IEEE Systems Journal* 13, 3 (2018), 2966–2977.

[5] Matteo Ridolfi, Abdil Kaya, Rafael Berkvens, Maarten Weyn, Wout Joseph, and Eli De Poorter. 2021. Self-calibration and Collaborative Localization for UWB Positioning Systems: A Survey and Future Research Directions. *ACM Computing Surveys (CSUR)* 54, 4 (2021), 1–27.