RA^{2}LOC: A ROBUST ACUCRATE ACOUSTIC INDOOR LOCALIZATION SYSTEM

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ABSTRACT

In this demo, we present RA^{2}Loc, a modified acoustic indoor localization system based on acoustic ranging with modified mobile devices, designed for industrial-markets. An RA^{2}Loc demo system is comprised of one tag node, one sink node with computer, and at least three beacon nodes. As the sink node sends a localization signal, tag node sends the sound signal afterwards beacon nodes receive the sound signal, then we have the time of arrival (TOA). Computer calculates the coordinate of tag node with TOA localization approach. Based on our experiment in office scenario, the localization error is observed to be about 10 cm.

Index Terms—Localization, Acoustic, RA^{2}Loc.

I. INTRODUCTION

Along with development of Internet of thing (IoT) technology, indoor localization is attracting increasing attention from academia and industry in recent years. There is a wide requirement on indoor localization technology, such as security monitoring, automatic guided vehicle (AGV) guiding and indoor navigation[1], [2], [3].

In indoor localization field, or in Microsoft Indoor localization competition, Ultra Wide Band (UWB) technology is widely used, and it can obtain quite high accuracy. However, the high price of UWB node limits its implement. So, we present an inexpensive solution, RA^{2}Loc system. The frequency of the sound signal designed is 18kHz 22kHz, therefore we can use general speaker and microphone. Each node, which is shown in Fig.1, is composed of STM32F4 Soc, WM8978 codec, microphone(beacon), speaker(tag), Zigbee communication, etc. The whole system is economic for each node costs about 10 dollars.

II. SYSTEM OVERVIEW

The RA^{2}Loc demo system consists of one tag node, four beacon nodes and one sink node which is connected to computer. The tag node and beacon nodes are
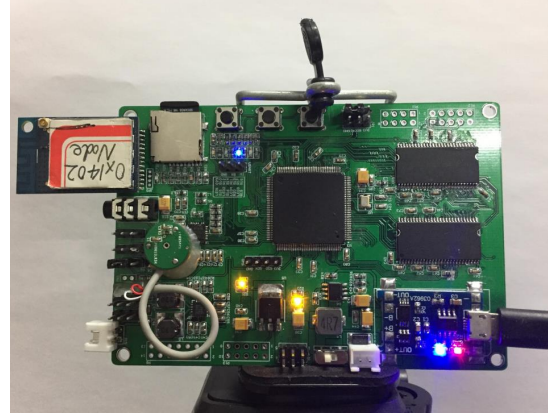

Fig. 1. The photo of the beacon.

connected to sink node through the Zigbee network. And the sink node is connected to the computer via serial port. The sink node is to control the system and to transfer the information from beacon nodes to computer. The conceptual architecture of the demo system is shown in Fig.2.
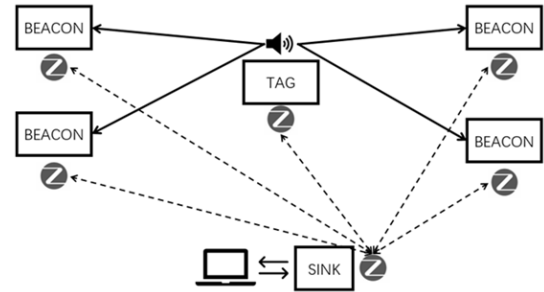

Fig. 2. Conceptual architecture of RA^{2}Loc demo system.

The main process of localization in RA^{2}Loc system can be split into 3 steps: calibration, ranging and location estimation.

- Calibration: The premise of TOA approach is the accurate coordinate of every beacon nodes. As a result, we should calibrate 4 beacon nodes before ranging and location estimation. In general, we manually obtain the accurate coordinate by LiDAR.
- Ranging: First, the sink node sends a localization signal through Zigbee to ensure the tag node and beacon nodes receive the signal at the same time. In other words, the whole system is synchronized. Second, the moment the tag node receives the signal, it sends a Linear Frequency Modulation sound signal, meanwhile beacon nodes start the timer. Then the beacon nodes receive the sound signal and calculate the time of arrival. Therefore, we can obtain the distance of the tag node and beacon nodes.
- Location estimation: The sink node receives the TOA information of beacon nodes and transfers it to computer by serial port. Then computer can estimate the coordinate of the tag node by method of maximum likelihood and display the result.

III. DEPLOYMENT

Basically, the demo system contains four beacon nodes to be deployed. They should be placed in different heights to avoid being set in the same altitude plane, which would otherwise cause bad height accuracy. To keep the line of sight (LOS) between the tag node and the beacon node, beacon nodes should deploy high up.
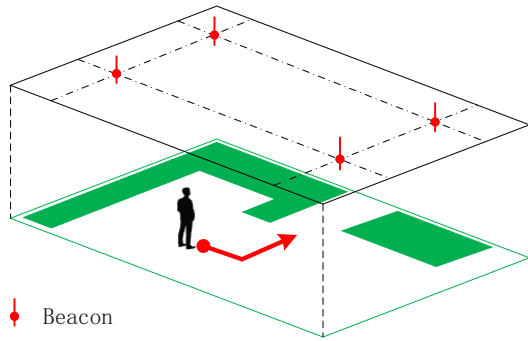

Fig. 3. The deployment of RA^{2}Loc demo system.

IV. EVALUATION

Theoretically, three beacon nodes are enough to estimate 3D coordinate. However, more beacon nodes can yield more accurate result. Furthermore, the more beacon nodes we have, the higher possibility of success in picking out the non line of sight (NLOS) beacon nodes and eliminating the effect of shelter. On the basis of the experiment in office room with four beacon nodes, the accuracy of location can reach about 10cm. In addition, general shelters such as people, plank and bags barely affect the accuracy.

V. REFERENCES

[1] X. Wang, C. Zhang, F. Liu, Y. Dong, X. Xu. "Exponentially Weighted Particle Filter for Simultaneous Localization and Mapping Based on Magnetic Field Measurements," *IEEE Trans. Instrum. Meas.*, vol. 66, pp. 1658–1667, 2017.

[2] H. Liu, H. Darabi, P. Banerjee, J. Liu. "Survey of Wireless Indoor Positioning Techniques and Systems," *IEEE Trans. Syst. Man Cybern. Part C Appl. Rev.*, vol. 37, pp. 1067–1080, 2007.

[3] L. Zhang, D. Huang, X. Wang, C. Schindelhauer, Z. Wang. "Acoustic NLOS Identification Using Acoustic Channel Characteristics for Smartphone Indoor Localization," *Sensors.*, vol. 17, pp. 1–22, 2017.