AALOC: AN ACCURATE ACOUSTIC INDOOR LOCALIZATION SYSTEM

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ABSTRACT

We present AAloc, an acoustic indoor localization system based on acoustic ranging which is very convenient for smartphone positioning. An AAloc demo system consists of about 10 acoustic beacons and a smartphone. Beacons are deployed in different hight to establish a beacon space. This gives a 3D relative coordinate for 3D target localization. A combined localization approach of TDOA and TOA is used. According to our experiment in office scenario, the localization error is observed to be less than 20cm.

Index Terms— Smartphone, Localization, Acoustic Signal, AAloc

I. INTRODUCTION

Recently, as the mobile device has been already available for the people, the demand of user localization for navigation in large structures where GPS services are severely limited, such as big mall, subway station, airport is obvious [1]. Various indoor localization systems have been developed for commercial applications such as precision marketing, indoor navigation and industrial robots navigation. Many systems in Microsoft Indoor Localization Competition last year have achieved excellent positioning accuracy. Recent research on leveraging ubiquitous microphone sensor in a smartphone introduces a convenient approach of ranging by using the audible band acoustic signals[2][3].

We proposed an acoustic indoor localization system, AAloc, which is fully compatible with a conventional smartphone and doesn't need to interface any hardware. A demo system of AAloc include about ten beacons and a smartphone. We use beacons to establish a 3D relative coordinate system. A combined localization approach of TDOA and TOA is used to obtain accurate position estimation through exchanging a modulated LFM audio signal between the smartphone and specifically designed central beacon. Each beacons costs no more than 20$.

II. SYSTEM OVERVIEW

A whole demo system of AAloc include only ten beacons(one central beacon included) and a smartphone. All of them are connected with WiFi network. The conceptual architecture of AAloc demo system is shown in Fig.1. Target(smartphone) positioning can split in three main stages: 3D coordinate calibration, measurement and position estimation. Before ranging and position estimation, 3D relative coordinate established by beacons should be calibrated by manpower to obtain accurate coordinate figure, even though AAloc could calibrated by itself. Range between target and beacons is obtained by exchanging a modulated LFM audio signal between smartphone and central beacon. Then, each nodes sends its range information to a computer through WiFi network. The position is calculated on computer and the result is displayed on smartphone.Block diagram of beacon is shown in Fig.2. Microphone, speaker, signal processing, WiFi communication, battery are 5 main components of our beacons.

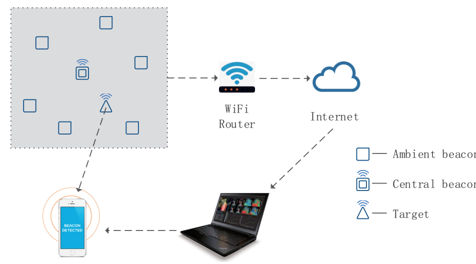

Fig. 1. Conceptual architecture of AAloc demo system

In AAloc, a combined localization approach of T-DOA and TOA is used to obtain accurate position estimation. Smartphone speaker transmit a modulated LFM audio signal for the localization. After received this signal, central beacon immediately response and transmit this signal by it's own speaker. This audio signal exchanging process is recorded by smartphone and beacons. Each of them calculates TDOA value of two signals through recorded audio data and transmit results to computer. TOA estimation based on TPSN protocol provides ranging information from smartphone to central beacons, and its accuracy directly affects the overall position resolution. For the beacon coordinate has been calibrated, we can easily obtain all distances

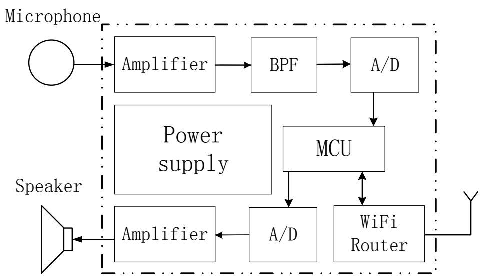

Fig. 2. Block diagram of beacons

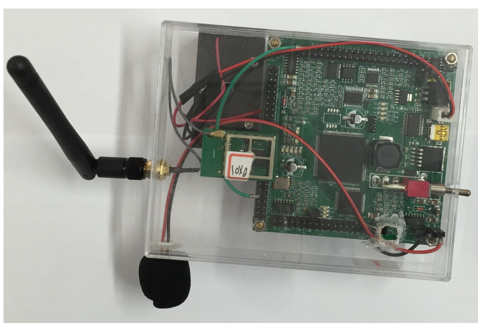

Fig. 3. Photo of beacon

form smartphone to ambient beacons.

With the measured distances form beacons available, weighted multilateration can be performed to localize the smartphone. According to our experiment in office scenario, the localization error is observed to be less than 20cm. A main source of error affect the final position estimation is the error of TDOA and TOA estimation which mainly related to sound speed uncertainty and multipath propagation.

III. DEPLOYMENT

The conceptual deployment of beacons in AAloc demo system is shown in Fig.4. For the aim of accuracy 3D localization, beacons should be deployed in different hight to establish a beacon space instead of a plane. This can provide a 3D coordinate system for 3D smartphone localization. According to real world, we can put beacons on ceiling, on wall or hang them in the air, and adjust beacon position to ensure each of them are in line of sight.

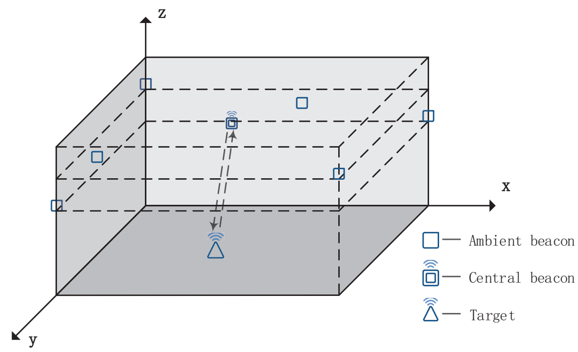

Fig. 4. Conceptual deployment of beacons

IV. REFERENCES

[1] Hui Liu, Houshang Darabi, Pat Banerjee, and Jing Liu. *Survey of Wireless Indoor Positioning Techniques and Systems*. IEEE Transactions on Systems, Man, and Cybernetics. 2007, 37(6): 1067-1080.

[2] Kaikai Liu,Xinxin Liu,and Xiaolin Li. *Guoguo: Enabling Fine-grained Smartphone Localization via Acoustic Anchors*. IEEE Transactions on Mobile Computing. 2015,1(61).

[3] Alexander Ens, Fabian Hoflinger, Johannes Wendeberg, Joachim Hoppe, Rui Zhang, Amir Bannoura, Leonhard M.Reindl, and Christian Schindelhauer. *Acoustic Self-Calibrating System for Indoor Smart-Phone Tracking*. International Journal of Navigation and Observation. 2015,Vol.2015.