Telocate ASSIST

Acoustic Self-calibrating System for Indoor Smartphone Tracking

Joachim Hoppe, Sebastian Sester, Joan Bordoy, Fabian Höflinger, Johannes Wendeberg
Telocate GmbH
Freiburg im Breisgau, Germany
http://www.telocate.de
info@telocate.de

***Abstract*—In this contest abstract we describe our system for precise indoor smartphone tracking called ASSIST. A smartphone app shows the user a virtual map of the indoor environment with the current position. For localization, the built-in loudspeaker of the smartphone emits sound impulses, containing frequencies at the upper limit of human hearing. These sound impulses are detected by stationary acoustic receivers that are mounted to the ceiling. The receivers are synchronized and connected to a server unit via network communication. With a TDOA-algorithm (Time Differences of Arrival) the position of the smartphone is calculated at the server unit and then sent to the smartphone wirelessly. The achieved accuracy is in the range of 10 cm.**

Keywords—indoor localization; acoustics; smartphone; TDOA

I. INTRODUCTION

Pedestrian navigation in buildings using the smartphone is one of today's great challenges – the awareness of location has become a key factor to the development of Smart Mobility and new applications [1] in public buildings. However, the achievable accuracy of today's systems for smartphone localization lack the precision and reliability required for many applications [2]. [3]

II. SYSTEM OVERVIEW

Our localization system consists of an application for smartphones and stationary acoustic receivers to be installed in the rooms of an ASSIST service provider. One receiver can cover an area of approximately 100 m². For localization multiple receivers are needed, at least three. In complex indoor areas the number of necessary receivers may increase. When a person enters an indoor environment, which is equipped with ASSIST, a smartphone app can be downloaded to the person's own device and will then connect the phone to the server unit. After assigning a unique ID to the device, the smartphone emits a specific inaudible acoustic signal (chirp) using its built-in speakers in the frequency range of 18-22 kHz, which is detected by the receiver devices. From measuring the reception times the server can calculate the location of the phone with a TDOA-algorithm. Together with location-dependent contextual information the locality information is forwarded over the normal mobile connection to the phone. In this way, the user is enabled to track his current location in a building up to a precision of centimeters.

The server unit obtains the recorded timestamps from the receivers via network (wireless or non-wireless). Knowing the propagation speed of sound and the arrival times at the receivers, the position of the smartphone and receivers can be calculated. [3]

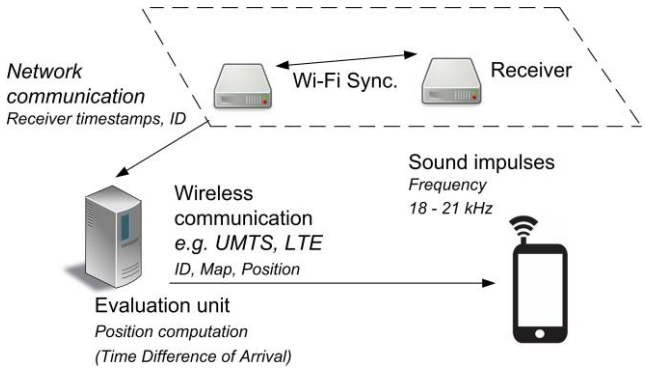

Fig. 1. ASSIST overview containing smartphone, multiple acoustic receivers and server unit.

Our approach to localization allows simultaneous localization of multiple smartphones, though in the contest we will use only one smart phone. The installation effort can be reduced dramatically if the system is implemented in a self-calibrating manner, like explained in [4]. This aspect of the system is currently under development and not used for the contest.

III. ACOUSTIC RECEIVERS

Our custom made acoustic receivers contain a MEMS microphone with subsequent amplification stages and an ADC to convert the acoustic signal into the digital domain. The receivers are able to reliably detect a chirp signal from a smartphone over a distance of 15 m. Chirp correlation is also done in the receivers and the timestamps are exchanged via network (wireless or wired LAN).

Fig. 2. Telocate custom made acoustic receiver

IV. Deployment requirements

The acoustic receivers have to be attached to the ceiling. Each receiver requires a power supply unit. For the contest the receivers will be synchronized with Ethernet cables. Wireless connection is also possible and can serve as a backup. The size of one receiver is approximately 120 mm x 65 mm x 40 mm, with a weight of approximately 200 g. Other equipment needed is a server unit, which also needs a power supply unit and is preferably connected to the receivers by a wired connection.

Summary

We propose our ASSIST indoor localization system to take part in this year's Microsoft Indoor Localization Competition because it offers high accuracy in tracking the position of a smartphone. After installation of a smartphone app the end-user can use his own device for indoor navigation. Inaudible acoustic signals, emitted by the smartphone, are used for localization. The infrastructure that needs to be provided consists of multiple custom made acoustic receivers and a server unit. The receivers need to be placed at the ceiling of the indoor environment and detect the sound signals from the smartphone. For the calculation of the smartphone position a TDOA-algorithm is used. The localization data is send wirelessly to the smartphone where it is visualized on a virtual map, showing the current position of the user.

References

[1] N. Simon and J. Bordoy et al., Indoor Localization System for Emergency Responders with Ultra Low-power Radio Landmarks, International Instrumentation and Measurement Technology Conference (I2MTC`2015), Pisa, Italy.

[2] F. Hoeflinger, Lokalisierungssysteme für die Positionsbestimmung von Personen und Objekten im Innenraum, Der Andere Verlag / ISBN 3862474453, 9783862474455 17, 2014.

[3] J. Bordoy, F. Höflinger, J. Wendeberg, N. Simon, L. Reindl. Smart Phone Localization System with High Accuracy for Blind Persons. In Proc. of International Conference on Indoor Positioning and Indoor Navigation (IPIN'2015), Banff, Canada.

[4] F. Höflinger, J. Wendeberg, R. Zhang, J. Bührer, M. Hoppe, A. Bannoura, L. Reindl, and C. Schindelhauer. Acoustic Self-calibrating System for Indoor Smartphone Tracking (ASSIST). In IPIN'12: Proc. 3rd. International Conference on Indoor Positioning and Indoor Navigation, 2012.