Acoustic Receivers for Indoor Smartphone Localization

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ABSTRACT

Precision, cost, installation effort and the robustness in dynamic environments are important characteristics of indoor localization systems. Many of these requirements can be fulfilled by systems using sounds to locate a moving signal beacon. If smartphone owners use their own devices for indoor navigation assistance, there is no need to equip them with additional hardware.
As the built-in loudspeakers of most smartphones are able to emit sound outside the range of human hearing, they can be used as mobile tags for indoor localization systems without drawing adverse attention. For localization approaches that evaluate the time of arrival, incoming signals need to be detected with precise and deterministic timing, and the system should not be affected by background noise. Additionally, it should be possible to distinguish multiple emitters.
In this contribution, we propose three solutions for creating receiver devices for sound signals emitted by commercial smartphones: The first approach includes an analog filter and amplifier stage with subsequent envelope detection. The second approach uses a single tone detection IC, used for example in DTMF (dual-tone multi-frequency) circuits, improving suppression of background noise. The third approach is implemented on a micro-computer. A signal with a sharp autocorrelation function is received from a sender and correlated with a template. These approaches may be used for indoor localization systems, as for example the ASSIST (Acoustic Self-calibrating System for Indoor Smartphone Tracking), which is envisaged for personal navigation in crowded indoor locations. Furthermore, we have analyzed the frequency response of several smartphone loudspeakers to select appropriate microphones and the frequency range to work in. With receivers using our approaches, detection of sound signals emitted by smartphones is possible up to a range of more than 10 meters. The signal times can be detected up to a precision of 0.1 ms. The time differences of arrival (TDOA) of multiple receivers can be used to calculate the position of a smartphone with an accuracy of a few centimeters, which is sufficient for most applications in indoor environments.

KEYWORDS: smartphone localization, ultrasound