Dataset: Single-Anchor Indoor Localization with Decawave DW1000 and Directional Antennas

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ABSTRACT

Highly-accurate localization of wireless devices is a critical feature of future Internet-of-Things applications. Due to its superior time-domain resolution, ultra-wideband (UWB) technology allows centimeter-level positioning accuracy. Still, setting up an anchor-based UWB localization system requires extensive labour and costs. Recent works have shown that, instead of multiple physical anchors, the exploitation of multipath reflections from walls minimizes the required infrastructure to a single anchor. This dataset contains an extensive measurement campaign in two complex indoor environments with one anchor. It contains line-of-sight as well as non-line-of-sight situations. Furthermore, we have acquired datasets using directional antennas at the anchor to allow observing the impact of the angular domain on the localization performance.

CCS CONCEPTS

• **Computer systems organization** → *Embedded and cyber-physical systems*; • **Networks** → Location based services;

KEYWORDS

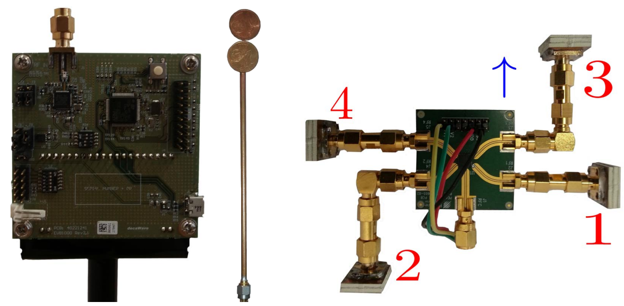
Indoor localization, ultra-wideband, multipath, single-anchor.

1 INTRODUCTION

Its centimeter-level accuracy makes ultra-wideband (UWB) technology well-suited as a future localization technology in scenarios with limited global navigation satellite system reception such as indoor environments. The commercialization of the IEEE 802.15.4-compliant Decawave DW1000 UWB transceiver [1] enables also low-cost and mobile applications, hence, it positioned UWB as a valid contender for future location-aware IoT applications.

State-of-the art localization systems require at least three anchors. In fact, existing UWB-based indoor localization systems typically use even more to enhance the reliability. This increases the cost, complexity, and set up time of the system.

The high bandwidth and consequently high resolvability of multipath components (MPCs), in contrast, enables the use of multipath information in a single anchor indoor localization scheme such as *SALMA* [3]. Hence, instead of multiple physical anchors, the system exploits multipath reflections from walls to tear down the position estimate to a unique solution even in the case of a single anchor. By knowing the locations of reflecting objects (e.g., floor plan), the theoretical multipath propagation of candidate points are determined. The latter are located at a circle around the physical anchor. Its radius is defined by the distance between the tag (located at an unknown position $\mathbf{p} \in \mathbb{R}^2$) and anchor (located at a known position $\mathbf{a} \in \mathbb{R}^2$), which is determined in a double-sided two-way ranging scheme (DS-TWR). The theoretical multipath propagation is compared with the derived channel impulse response (CIR) provided by the DW1000 using a likelihood function. The candidate who fits best with the measured CIR is selected as the estimated tag position. This dataset consists of 14000 measurements to intensively evaluate *SALMA*. Providing these data, we encourage other research groups to come up with new innovative single anchor localization systems.



(a) (b)

Figure 1: Decawave EVB1000 node with omni-directional antenna (a) and switchable directional antenna system (b) [3].

2 EXPERIMENTAL SETUP

The datasets are acquired with Decawave EVB1000 platforms (see Fig. 1a) employing the low-cost IEEE 802.15.4 compatible UWB transceiver DW1000. The following settings are used by the DW1000: maximum data rate (6.8 Mbps), pulse repetition frequency of 64 MHz, preamble symbol repetition of 1024, and channel 7. To capture different scenarios and environments, we performed measurements in two different rooms, containing obstacles and scattering objects. The first room is an office environment with several computers, desks, shelves, and chairs (Room A, see Fig. 2a and Fig. 2c), the second room simulates a stockroom, with desks and storage racks filled with beer crates and folders (Room B, see Fig. 2b and Fig. 2d). The tag is placed in each room at $N_p = 35$ evenly distributed evaluation points (marked with red crosses in Figure 2). The anchor, instead, is located at a fixed position (marked with blue circle) and is connected to a notebook for acquiring the datasets. The antenna at the tag is a self-made omni-directional dipole antenna (see Fig. 1a).

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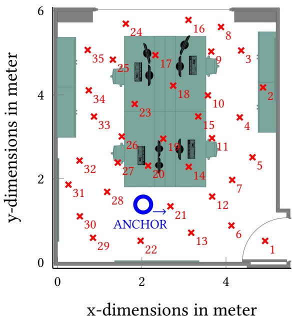
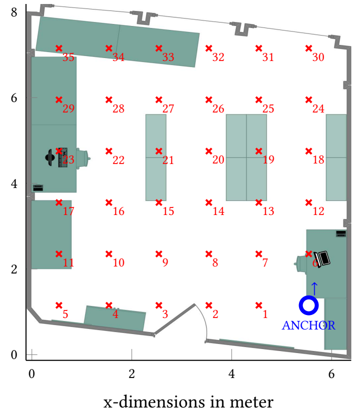


(a) Room A: Plan



(b) Room B: Plan

(c) Room A: Picture

(d) Room B: Picture

Figure 2: Experimental setup: we consider 35 evaluation points (red crosses) in two different environments [3].

At the anchor, instead, we employ either the same omni-directional antenna or a switchable directional antenna system [2] (see Fig. 1b).

3 THE DATA

The provided datasets contain the measurement campaigns conducted for the *SALMA* evaluation [3]. Each dataset consists of the variables discussed in Table 1. N_S is the number of samples contained in each CIR. We use $N_S = 99$ for all datasets. The sampling period is set to $T_s = 1/f_s = 1/(2 \cdot 499.2MHz) = 1.0016ns$. The number of antennas is denoted as N_A, which is either $N_A = 1$ (omnidirectional) or $N_A = 4$ (directional). N_E is the number of evaluations: for each scenario and evaluation point, we have performed 100 measurements ($N_E = 100$). Thus, $N_P = 35$ evaluation points results in $N_E \cdot N_P = 3500$ evaluations per scenario. In total four different scenarios are covered:

- **Scenario A:** In Room A we have mounted both anchor and tag on a tripod at a height of 1.50m, i.e., well above the obstacles, so to have clear LOS conditions. At the anchor side we have mounted the omnidirectional antenna (see Fig. 1a).
- **Scenario B:** Same as Scenario A, except that we have mounted the directional antenna system on the anchor. Thus, for each evaluation, $N_A = 4$ measurements were acquired. The orientation and antenna indices are marked in Fig. 1b and Fig. 2a.
- **Scenario C:** In Room A we have mounted anchor and tag at a height of 1.20m corresponding to the height of monitors and shelves (dashed line in Fig. 2c). Depending on the position of the evaluation points, this results in obstructed LOS and/or blocked specular multipath components for 32 points.
- **Scenario D:** In Room B anchor and tag are mounted at a height of 1.20m, thus, at the height of obstacles such as the beer crates in the six shelves in the middle of the room (see Fig. 2d). In total, at 31 points, either LOS or MPCs are blocked.

Variable	Format	Notes
Dynamic data		
cir	$[N_S \times N_A \times N_E \times N_P]$	Contains the complex channel impulse responses.
$distance$	$[N_A \times N_E \times N_P]$	Contains the DS-TWR distance between the anchor and tag.
$firstPath$	$[N_A \times N_E \times N_P]$	Contains the index of the sample determined by the DW1000 to be the first path (leading edge).
$preamCnt$	$[N_A \times N_E \times N_P]$	Preamble Accumulation Count. This is the number of accumulated preambles [1, p.97 ff.]. It is required to normalize the amplitude of the channel impulse responses.
Static data		
$posBS$	$[2 \times 1]$	Contains x and y coordinate of the anchor position **a**.
$posEP$	$[N_P \times 2]$	Contains x and y coordinate of the N_P evaluation points.
$floorplan$	$[N_W \times 4]$	Contains the coordinates (Format:$[x_1, y_1, x_2, y_2]$) of N_W wall segments.

Table 1: Variables stored for each dataset.

ACKNOWLEDGMENTS

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