

Datasets of Indoor UWB Measurements for Ranging and Positioning in Good and Challenging Scenarios – v2.0

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1. Purpose

This dataset consists of range and positioning measurements collected from an Ultra-Wide Band (UWB) development board. The Real Time Location System (RTLS) based on UWB is set in the CTTC's Indoor Navigation Lab. The dataset is intended primarily for researchers without access to a laboratory for indoor positioning purposes with UWB-based equipment. Moreover, this dataset should be helpful for investigating ranging and positioning algorithms in unchallenging as well as in challenging scenarios (i.e., scenarios with Non-Line of Sight (NLOS) propagation conditions and challenging geometries).

2. Overview

The datasets contain range and positioning measurements collected from an UWB development board DWM1001 from Decawave, in the static indoor laboratory environment. Data were captured in this lab with different conditions that affect the positioning performance. Thus, scenarios with different propagation conditions between the nodes and different geometries were set up.

- DWM1001 UWB nodes form a Real Time Location System that includes anchor nodes that know their own position coordinates and one tag node whose position coordinates are estimated as part of the measurement procedure. More information about this RTLS, the positioning algorithm of the tag and the DWM1001 UWB nodes can be found in the web page of the manufacturer.
- The RTLS is set up in the CTTC's Indoor Navigation Lab. Anchor nodes are placed on the walls and the tag node on a tripod. Anchor and tag nodes are placed in reference positions whose coordinates were estimated with a total station.
- This RTLS is based on anchor-based positioning. Firstly, the tag node estimates the range between tag and the corresponding anchor nodes. Secondly, the tag node estimates its position and quality factor of the position. The tag node reports position and quality factor, if applicable. This type of positioning is affected by several parameters, including propagation conditions, but also by the geometry that anchor nodes form.

- The static indoor lab environment allows to set up scenarios with different conditions that affect the positioning performance. In order to estimate the error and the quality of positioning, we resort to some parameters such as statistics parameters, Geometric Dilution of Precision (GDOP) metric and the Positioning Quality Factor given by the tag node. The scenario types were designed considering the values of these metrics in the lab: Scenario B is the best-case scenario; scenarios D and C are intermediate scenarios and scenarios A are challenging scenarios. The quality of positioning is degraded from scenario B to A.
- The scenario setups include Line of Sight (LOS) and Non-LOS propagation conditions as well as easy/medium/challenging geometries.
- We consider LOS conditions when there are no obstacles between the corresponding anchor and tag nodes. SoftNLOS and hardNLOS conditions are configured with obstacles between the corresponding anchor node and the tag node in a controlled way. We consider that in softNLOS condition the standard deviation of range error increases and in hardNLOS condition the error of range includes a bias.
- Different geometries are set up in the lab with the anchor nodes placement: easy, medium, and challenging geometries for positioning purposes. We consider that easy geometry refers to not anchor nodes positions aligned on a straight line (1 anchor node per wall). Medium geometry: 2 anchor nodes positions aligned on a straight line (2 anchor nodes placed on a wall) and 2 not. Challenging geometry: 3 or 4 anchor nodes positions aligned on a straight line (3 or 4 anchor nodes placed on a wall).
- The maximum number of anchor nodes with which the tag node estimates its position is 4. Tag node selects 4 anchor nodes from those in range. When decreasing the number of anchor nodes to 3, the quality of positioning also decreases. For challenging scenarios such as A4, positioning is not always provided by the tag node. More information about this RTLS can be found in the web page of the manufacturer.

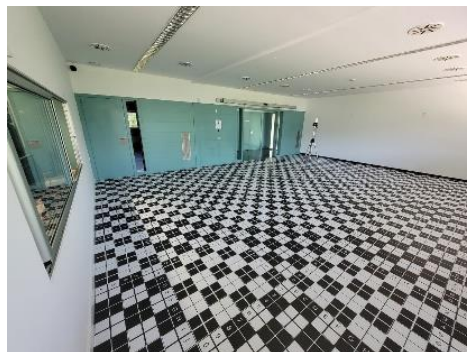


Figure 1. The Indoor Navigation Lab with the Real Time Location System (RTLS) set.

3. Hardware configuration and measurements

Data are collected from UWB nodes DWM1001 of Decawave (MDEK1001 system). Nodes contain DW1000 chip (DW) that is IEEE 802.15.4 (UWB physical layer) standard compliant (configuration: channel 5 - 6.5 GHz, 6.8 Mbps and 500 MHz bandwidth). The collected and needed data are summarized in the following paragraphs:

- **Distances to anchor nodes (and ID of anchor nodes):** they are collected from the USB of tag node. Distances are estimated by tag node. The update rate is set to 10Hz.
- **Position of the tag node:** it is collected from the USB of tag node. The location update rate is set to 10Hz. Position is estimated by the tag node when 3 conditions are met: i) tag node has 3 or more tag-anchor distances estimated; ii) Internal Location Engine (LE) of the tag node is

enabled. LE reports position and Quality Factor; and iii) Positions of anchor nodes have to be stored in memory of anchor node.

- **Position Quality Factor:** it is collected from the USB of tag node. It is a parameter whose value ranges from 0 to 100, being a value close to 100 indicative of good position quality. More information can be found in the web page of the manufacturer. The location update rate is set to 10Hz. Position Quality Factor is estimated by tag node when 3 conditions are met: i) tag node needs 3 or more tag-anchor distances estimated; ii) Internal Location Engine (LE) of the tag node is enabled. LE reports position and Quality Factor; and iii) Positions of anchor nodes have to be stored in memory of anchor node.
- **Reference positions of the tag and the anchor nodes:** coordinates of the anchor nodes have to be estimated with accuracy close to mm. Reference positions are estimated with a total station.

4. Scenarios setup and implementation

Four kinds of scenarios were set up. They are presented in the following Table and Figures: challenging scenarios (A), good scenarios (B) and intermediate scenarios (C and D). Moreover, the Figures show the map of the laboratory and the nodes placement for the scenarios. Red triangles are the anchor nodes, and the black circle is the tag node. Anchor nodes are placed on the walls of the lab (WALL1a, ..., WALL7) and tag node is mounted on a tripod (FLOOR7).

Scenario	Anchor node number	Propagation Conditions	Geometry
A1 (Challenging)	3	HardNLOS	Easy geometry
A2 (Challenging)	4	2 nodes in LOS and 2 nodes in hardNLOS	Challenging geometry
A3 (Challenging)	3	HardNLOS	Challenging geometry
A4 (Challenging)	4	1 node in LOS and 3 nodes in hardNLOS	Challenging geometry
B (Good)	4	LOS	Easy geometry
C1 (Intermediate)	4	softNLOS	Challenging geometry
C2 (Intermediate)	4	softNLOS	Challenging geometry
D (Intermediate)	4	LOS	Medium geometry

Table 1. Scenarios.

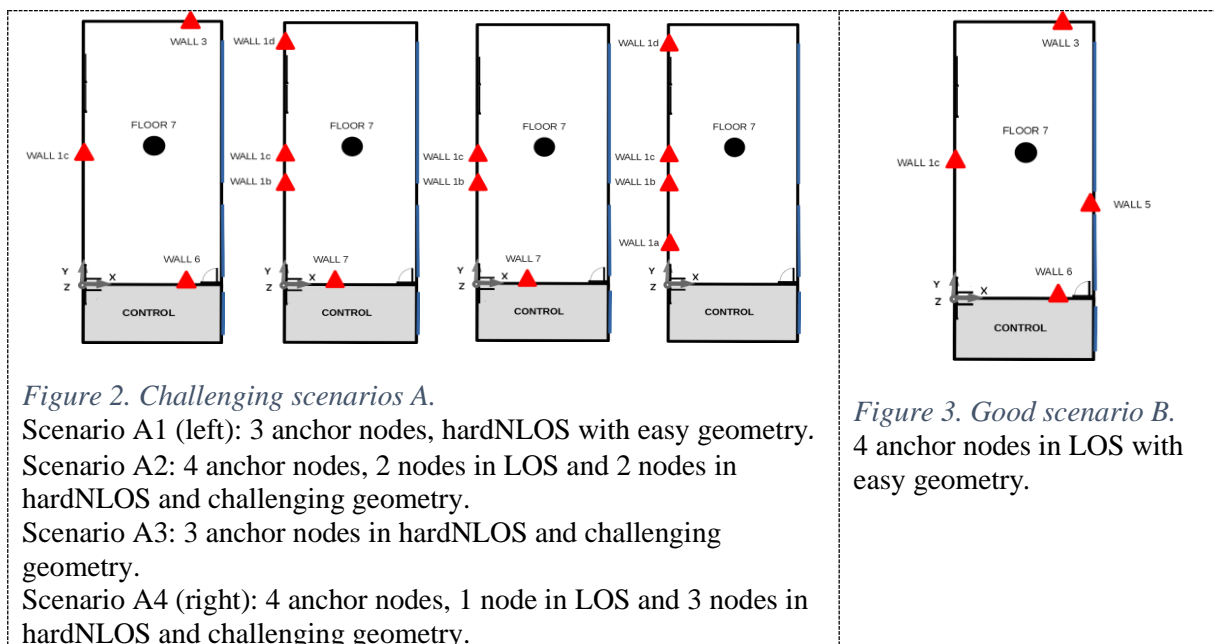


Figure 2. Challenging scenarios A.

Scenario A1 (left): 3 anchor nodes, hardNLOS with easy geometry.

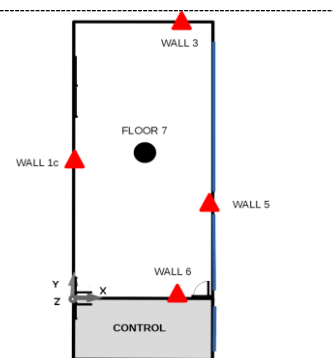
Scenario A2: 4 anchor nodes, 2 nodes in LOS and 2 nodes in hardNLOS and challenging geometry.

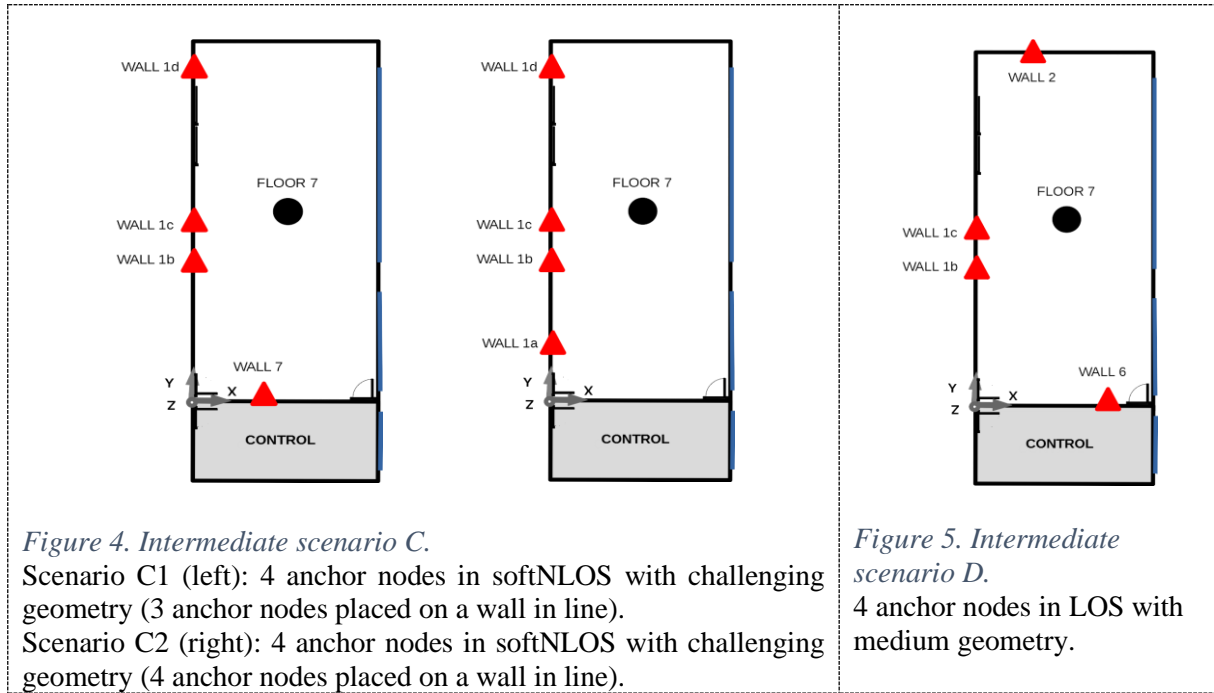
Scenario A3: 3 anchor nodes in hardNLOS and challenging geometry.

Scenario A4 (right): 4 anchor nodes, 1 node in LOS and 3 nodes in hardNLOS and challenging geometry.

Figure 3. Good scenario B.

4 anchor nodes in LOS with easy geometry.





In the data capture there may be systematic errors due to the setup of the scenarios or the hardware used or other causes. Because of this, data is collected at different dates and times and with different setup of the same scenarios. However, typical location accuracy is around $X-Y < 10$ cm in LOS, following the specifications of the manufacturer.

The steps to set up of the scenarios were the following:

- i) Setting up scenario B and checking the positioning metrics such that location accuracy Root Mean Square Error (RMSE) $X-Y < 15$ cm.
- ii) Setting up the new corresponding scenario without displacing the tag and moving the anchor nodes to new positions to reproduce the geometries and propagation conditions reference in Table 1.
- iii) Checking the new positioning metrics and collecting data with the new corresponding scenario.

The tag node is mounted on a tripod (Figure 6). Data is collected by a laptop from the USB interface of the tag node. A Matlab script collects data and stores them in files.

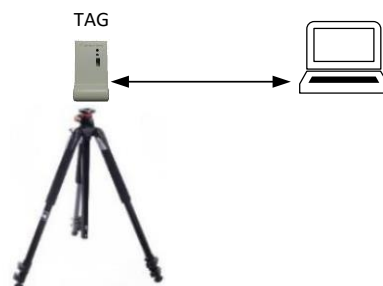


Figure 6. The tag node is mounted on a tripod.

5. File structure

The datasets are organized in a collection of files, each compressed in rar format, and have self explanatory names. The collected data is stored in files with around 1500-2000 positioning measurements following the format:

Date, Time, Total number of Anchor Nodes in range, Enable of Positioning, Neighbour number, ID of Anchor Node, Range (cm), Position (x,y,z) (m) provided by tag node, Quality Factor

Each row shows information of ranging between tag and the corresponding anchor. These information includes the following parameters:

- Date.
- Time.
- Total number of Anchor Nodes in range: it is the total number of anchor nodes to perform ranging and positioning. They are in range of the tag node.
- Enable of Positioning: it is related to the target node position. Is the position provided by tag node? (0-No, 1-Yes).
- Neighbour number: it is the anchor node number to perform ranging.
- ID of anchor node to perform ranging.
- Range (cm) between the tag and the corresponding anchor node.
- Position (x,y,z) (m) provided by tag node. This parameter has correct value when enable is 1.
- Quality Factor provided by tag node. This parameter has correct value when enable is 1.

In order to generate the current version v2.0 of this data set from the previous one v1.0, new data has been added and some data that had already been presented has been corrected.

6. How to cite and acknowledge

Please cite this dataset as indicated on the Zenodo website. If you use this dataset, we appreciate if you drop us an e-mail at ana.morarega@cttc.es. We thank you for any comments and feedback.