Datasets of Indoor UWB Measurements for Ranging and Positioning in Good and Challenging Scenarios – v1.0

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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 not challenging but also 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 to 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 hardware 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 in the walls and the tag node on a tripod. Anchor and tag nodes are placed in reference positions whose coordinates are 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. 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 to 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 good and 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: good, intermediate and challenging geometries for positioning purposes. We consider that not good geometry refers to not anchor nodes positions aligned on a straight line. Intermediate geometry: 2 anchor nodes positions aligned on a straight line and 2 not. Poor geometry: 4 anchor nodes positions aligned on a straight line.

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

3. Hardware configuration and Measurements

Data is 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 Mps and 500 MHz BW). The collected data are summarized in the following Table:

Data	**Hardware Requirements**	**Hardware Configuration and Comments**
Distances to anchor nodes (and ID of anchor nodes)		-Data rate configuration is 10 Hz. -Distances are estimated by tag node.
Position of tag node	-3 or more tag-anchor distances have to be estimated by the tag node.	-Data rate configuration is 10 Hz.

	-Internal Location Engine (LE) of the tag node is enabled. LE reports position and Quality Factor. -Position of anchor nodes are stored in memory of anchor node.	-Position is estimated by tag node.
Position Quality Factor	-3 or more distances tag-anchor are estimated by the tag node. -LE is enabled. -Position of anchor nodes are stored in memory of anchor node.	-Data rate configuration is 10 Hz. -Estimated by tag node.
Reference positions of Tag and Anchor nodes	-The coordinates of the anchor nodes have to be estimated with accuracy close to mm.	-Reference positions are estimated with a Total Station.

Table 1. Summary of Data.

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.

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

Table 2. Scenarios.

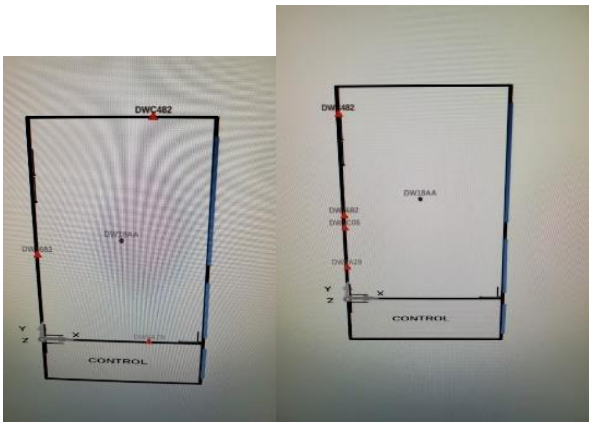

Figure 2. Challenging scenario A:
- A1: 3 anchor nodes, hardNLOS with good geometry (left).
- A2: 4 anchor nodes, 2 nodes in LOS and 2 nodes in hardNLOS and poor geometry (right).

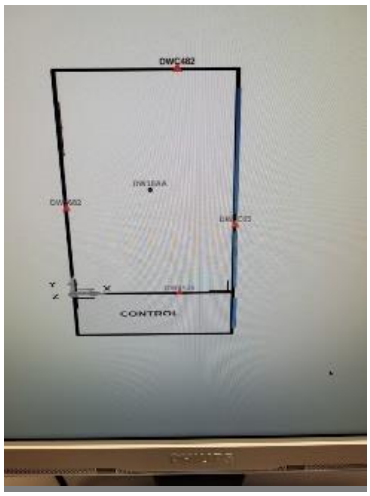

Figure 3. Good scenario B:
- 4 anchor nodes in LOS with good geometry.

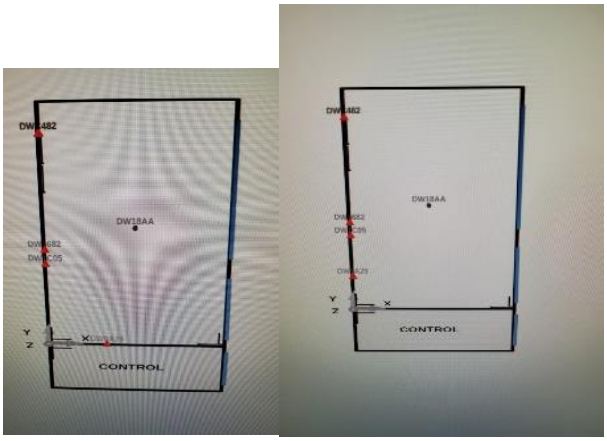

Figure 4. Intermediate scenario C:

- C1: 4 anchor nodes in softNLOS with poor geometry (left).
- C2: 4 anchor nodes in softNLOS with poor geometry (right).

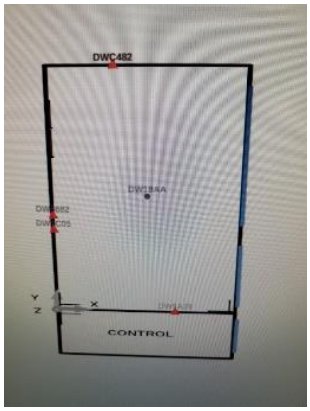

Figure 5. Intermediate scenario D:
- 4 anchor nodes in LOS with intermediate geometry.

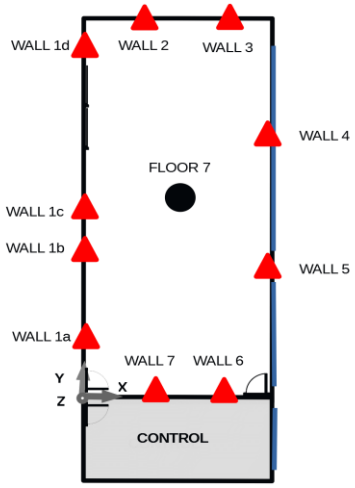

Figure 6. Anchor nodes are placed on walls of the lab (WALL1a, ..., WALL7) and tag node is mounted on a tripod (FLOOR7).

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 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 X-Y≤10cm.
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 2.
iii) Checking the new positioning metrics and collecting data with the new corresponding scenario.

The tag node is mounted on a tripod (Figure 7). Data is collected by a laptop from the USB interface of the tag node. A Matlab script collects data and stores them in files.

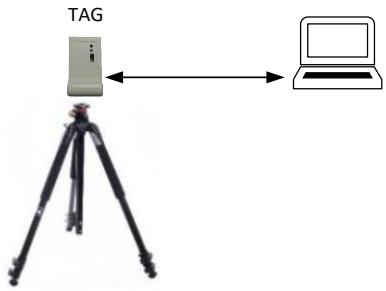

Figure 7. The tag node is mounted on a tripod.

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 measurements following the format:

Date	Time	Number of Anchor Nodes in range		Target node position is provided by Tag Node? 0-No, 1-Yes		
Neighbour number	ID of Anchor Node	Range (cm)	(Constant value for testing purposes)	(Constant value for testing purposes)	Position (x,y,z) (m) provided by tag node	Quality Factor

Table 3. Sets of collected data are stored in files.

```
2021/06/08 11:40:03.113 4 1
1 5682 331.000 200.0000 0.0000 3.290   4.320   1.780 77
2 1C05 355.000 200.0000 0.0000 3.290   4.320   1.780 77
3 C482 433.000 200.0000 0.0000 3.290   4.320   1.780 77
4 9A29 440.000 200.0000 0.0000 3.290   4.320   1.780 77
2021/06/08 11:40:03.155 4 1
1 5682 333.000 200.0000 0.0000 3.300   4.320   1.720 77
2 1C05 352.000 200.0000 0.0000 3.300   4.320   1.720 77
3 C482 434.000 200.0000 0.0000 3.300   4.320   1.720 77
4 9A29 437.000 200.0000 0.0000 3.300   4.320   1.720 77
```

Figure 8. Example of the data format: two data sets of Scenario B.

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.moraregа@cttc.es. We thank you for any comments and feedback.