Readme

Dataset of Moving Vulnerable Road Users and Vehicle Using a Fully Polarimetric mm-Wave MIMO Radar

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Referencing the Dataset

W. Bouwmeester, F. Fioranelli, and A. Yarovoy, "Dataset of Moving Vulnerable Road Users and Vehicle Using a Fully Polarimetric mm-Wave MIMO Radar." doi: 10.4121/7e080aea-2a1b-4262-834c-9a8d926f2474

```
@misc{bouwmeester-2024-data,
  title = {Dataset of {{Moving Vulnerable Road Users}} and {{Vehicle Using}} a {{Fully Polarimetric}} {{mm}}-{{Wave MIMO Radar}}},
  author = {Bouwmeester, Wietse and Fioranelli, Francesco and Yarovoy, Alexander},
  doi = {10.4121/7e080aea-2a1b-4262-834c-9a8d926f2474}
}
```

Reference for reading material of the used dataset

[1] W. Bouwmeester, F. Fioranelli, and A. Yarovoy, "Classification of Dynamic Vulnerable Road Users Using a Polarimetric mm-Wave MIMO Radar," *Under review for IEEE Transactions on Radar Systems*, 2024.

Dataset Collection

Polarimetric MIMO Radar System

This dataset is collected using an, in collaboration with Huber+Suhner AG, custom developed fully polarimetric MIMO mm-Wave Automotive radar system. The radar system is based on Texas Instruments' AWR2243BOOST radar evaluation module and the corresponding AWR2243 automotive FMCW radar chip with 3 transmit channels and 4 receive channels.

Instead of the standard series-fed patch arrays used in the regular AWR2243BOOST evaluation module, a custom 3D-printed polarimetric antenna was used to enable fully polarimetric capabilities (Fig 1). This 3D-printed antenna features sub-arrays consisting of 8 open-ended waveguide radiating elements each. The radiating elements are placed diagonally to create an orthogonal polarisation basis. More specifically, TX1, TX2, RX3, and RX4 are indicated as positive diagonal polarisation (PD), while TX3, RX1, and RX2 are indicated as negative diagonal polarisation (ND).

Furthermore, the AWR2243BOOST module is placed on a DCA1000 processing board to enable efficient transfer of the raw ADC output data to a computer using Texas Instrument's mmWave Studio version 3.0.0.14.

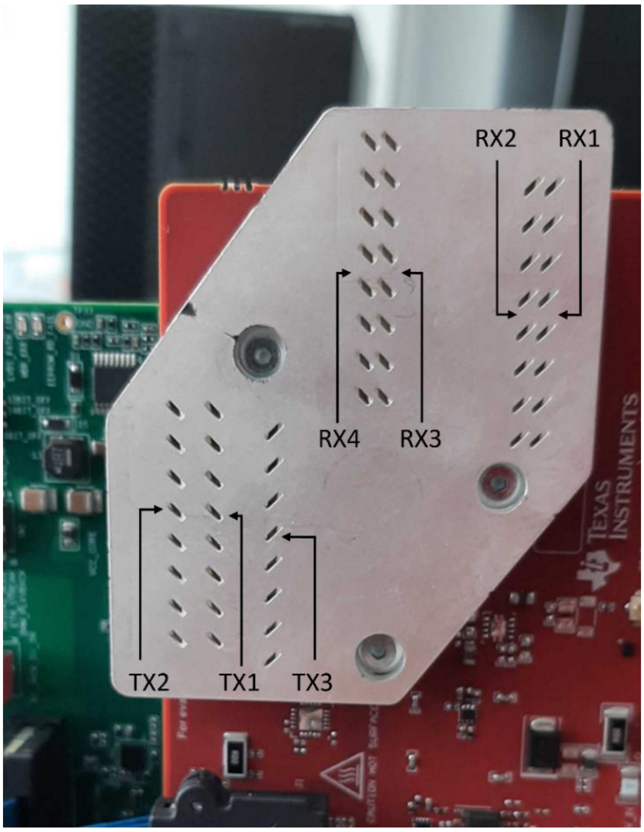

Fig. 1. Photograph of the 3D-printed antenna including channel names corresponding to the subarrays.

The physical locations in metres of the sub-arrays are given in the matlab-code below, where the columns indicate the transmitter/receiver index and the rows represent the x-, y-, and z-coordinates respectively:

```
tx_loc = 1e-3*[16.16 20.08 9.97;
               0 0 0;
               -4.38 -4.38 -6.34];
rx_loc = 1e-3*[-16.66 -14.7 -0.935 1.02;
               0 0 0 0;
               17.18 17.18 21.1 21.1];
```

Data Collection Procedure

The radar is configured with the waveform parameters listed in Table I. The sensing scheme is configured so that the transmitters transmit chirps in interleaved successive order, i.e., TX1 – TX2 – TX3, which is repeated 64 times per frame.

Two types of measurements were performed, namely calibration measurements and measurements of moving targets. The calibration measurements were performed using a Rohde&Schwarz AREG800A radar target simulator with an AREG8-81S horn antenna front-end. The radar target simulator was set to simulate two targets at a distance of 24 and 28 m with velocities of 3 and -3 m/s. The first set of calibration measurements was captured on August 30th, 2023 and the second set on June 6th, 2024. The first set of calibration measurements was performed with 20 frames while the second series was performed with 3 sets of 1000 frames each to achieve higher accuracy. For more information on how to use this calibration data, see [1].

Table I. Radar waveform parameters used for the measurements.

Parameter	*Value*
Start Frequency	77 GHz
Frequency Slope	101.388 MHz/μs
ADC Sample Start Time	5.12 μs
ADC Idle Time	7 μs
ADC Sample Rate	22000 ksps
ADC Samples	750
Chirps per Frame	64
Frame Repetition Time	10 ms

The measurements of moving targets were split up in two measurement campaigns. The first campaign was conducted on January 17th, 2024 and the second on May 7th, 2024. During the first campaign 5 bicyclists and 5 pedestrians were measured, while the second campaign includes measurements of 3 pedestrians, 3 bicyclists, a motorcyclist and a car. It is suggested to use calibration coefficients computed from the first calibration measurements for the first measurement campaign and calibration coefficients from the second set of calibration measurements for the second measurement campaign.

In both measurement campaigns, all targets were measured moving along four different directions, these were: towards the radar, away from the radar, diagonally towards the radar and diagonally away from the radar. Each measurement was repeated three times to obtain more statistical information. A schematic drawing of the measurement setup is shown in Fig. 2.

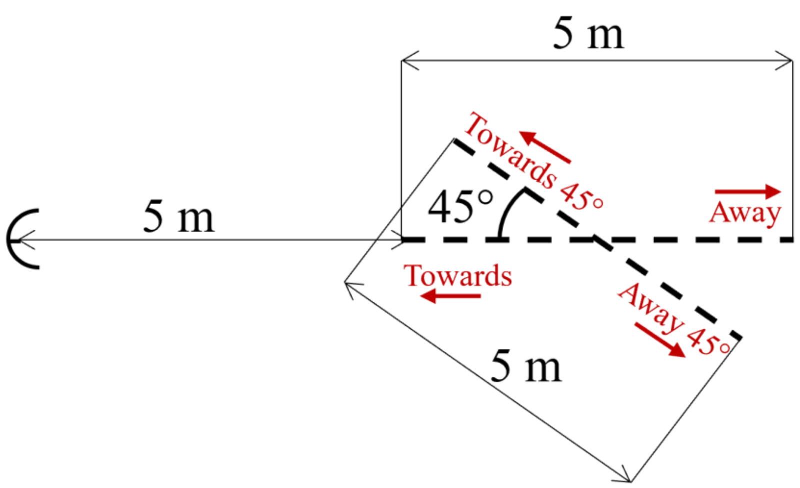

Fig. 2. Measurement geometry as used during both measurement campaigns for the measurements of moving vulnerable road users.

Dataset organisation and file description

The dataset comprises 4 folders, each folder corresponding to a series of measurements, two with calibration data named “[date] Calibration Measurements” and two with moving target measurement data from each measurement campaign named “[date] VRU Measurements”.

The folder corresponding to the first calibration measurements directly contains raw measurement data in the “.bin” file. The folder with the second set of calibration measurements is further divided into three sets of measurements, in which the corresponding raw data can be found.

The folders with the measurements of moving targets are subdivided into folders corresponding to the test subject, movement direction, and class, following the naming convention of “[person]-[class]-[heading]”. Inside these folders, the raw data from the measurements can be found, which is named as follows: “[Class] [Heading] [Measurement Number]_Raw_[part].bin”. The software used to collect the data from the radar splits the raw data files in multiple parts when they become larger than 1 GB, which needs to be accounted for when loading the data.

Furthermore, the raw data is accompanied by log files, which contain the output from Texas Instruments’ mmWave studio, which shows the commands executed to configure the radar and perform the data collection.

Processing

To process the data from the raw data files, the script named “DCA1000 With xWR12xx and xWR14xx MATLAB Example” provided by Texas Instruments in section 9.1 of their “Mmwave Radar Device ADC Raw Data Capture (Rev. B)” application note can be used. Once the raw data is loaded, it can be further processed as described in [1].

Acknowledgements

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