IEEE CTW 2020 Data Competition

Self-Supervised Learning for User Localization

Background

User localization is an increasingly important feature of wireless communication systems enabling a wide range of applications, such as navigation, smart factories and cities, surveillance, security, and IoT. Moreover, accurate position information can be used for improved radio resource management, beamforming as well as channel estimation. Although machine learning-based methods can achieve state-of-the art localization accuracy, their biggest drawback is the need for large quantities of labeled data, i.e., channel state information (CSI) and the corresponding coordinates. Moreover, whenever significant changes in the radio environment occur, new data must be acquired which renders supervised learning approaches impractical for most scenarios.

Self-supervised learning methods have led to a tremendous reduction of the quantity of labeled data needed in computer vision and natural language processing. The goal of this competition is to evaluate the potential of self-supervised learning for user localization based on CSI.

Competition and Evaluation Criteria

The object of the competition is to design and train an algorithm that can determine the position of a user, based on estimated channel frequency responses between the user and an antenna array. Possible solutions may build on classic algorithms (fingerprinting, interpolation) or machine-learning approaches. Channel vectors from an outdoor measurement campaign created with the channel sounder in described [1] will be used. The dataset comprises channel responses and associated position ground truth information for a small fraction of the examples. The dataset may be partitioned into training and validation sets as found appropriate for the algorithm development and training.

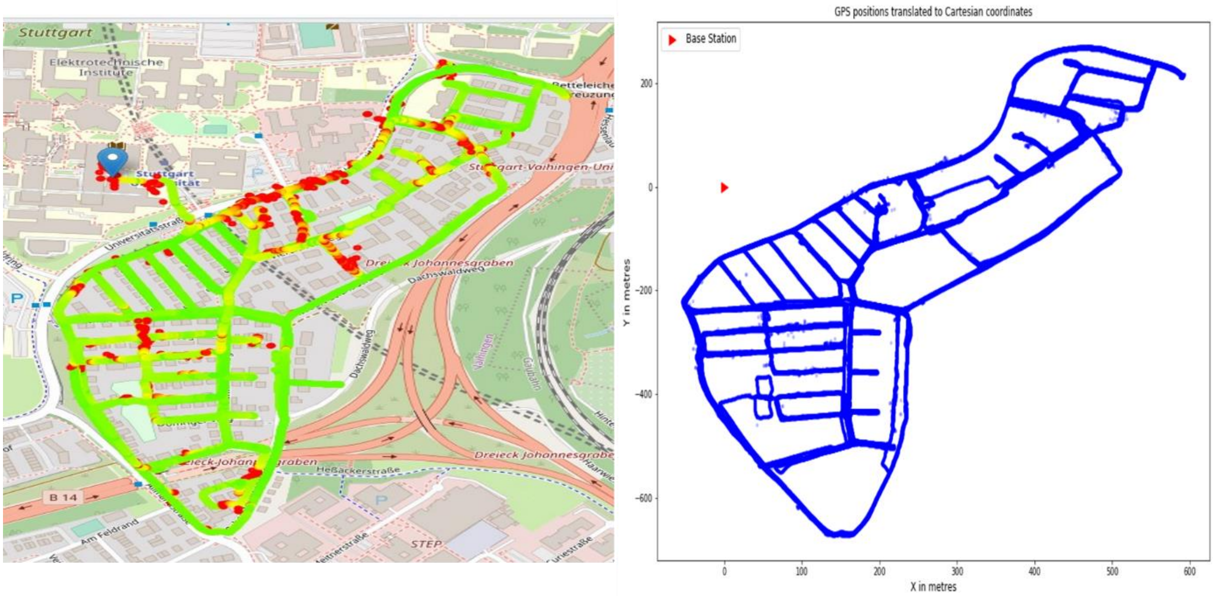
To compete, teams should download the dataset and develop algorithms. One week prior to the conference, on the morning of May 10, 2020 (11:59 PM Pacific Time), a set of test data comprising of only channel responses (but no ground truth) will be distributed. The participating teams should run their algorithms on this test dataset and submit their estimated position coordinates to ctw2020.datacomp@gmail.com no later than May 11, 2020 (11:59 PM Pacific Time). The results must be submitted as a CSV file where the first column is the x coordinate, the second is the y coordinate, and the third is the z coordinate. The rows must have the same order as that of the released test dataset. All competitors must submit a 2-page abstract, describing their algorithms and experiments by May 15, 2020 (11:59 PM Pacific Time) and present a poster at the conference. The instructions for preparing the poster will be posted on the conference website. Note that to be considered a valid participant in the competition, the competitors are expected to submit the 2-page abstract and attend the conference to present a poster, otherwise, they will be withdrawn from the competition. The winners will be determined by the organizers, by evaluating and comparing the root-mean-square position error, averaged over all positions in the test dataset for the submitted solutions on the test data.

Awards

The competitors who are placed first, second, and third will receive certificates. In addition, the first-place winner will receive a $200 prize and the second-place winner will receive a $100 prize.

About the Dataset

The dataset was acquired by the massive MIMO channel sounder described in [1]. Specifically, channel responses were measured outdoors between a moving transmitter and an 8x8 antenna array (horizontally polarized patch antennas). As transmitter, an SDR-equipped cart, was used which was moved around in a residential area of several hundred square meters. The SDR transmitted uplink OFDM pilots with a bandwidth of 20 MHz and 1024 subcarriers at a carrier frequency of 1.27 GHz. Ten percent of the subcarriers were used as guard bands, leaving 924 usable subcarriers. 8 of the 64 antennas were perpetually malfunctioning, and hence, only 56 antennas provided useful measurements. Ground truth was acquired with the help of a differential GPS. For every location, 5 channel measurements were recorded. The GPS data was transformed to a local Cartesian coordinate system with the receiver placed at the origin on the XY–plane. The third coordinate represents the height.



The left figure shows the path traversed (latitude/longitude) during the recording of the measurements using a differential GPS. The right figure shows the transmitter positions (on the X Y-plane) transformed to a local coordinate system to have dimensions in meters, with the base station at (0,0). Map generated through https://www.openstreetmap.org.

The data is provided in the HDF5 format and is available through the following link:
https://www.dropbox.com/sh/nvgox5e6udpkqni/AACpTPwdQI_8jkRZjHlOGfqPa?dl=0

The link contains the training data and has two zipped files.

1) **“CTW2020_labelled_data.zip”** - contains the Folder **“CTW2020_labelled_data”**. Each file in the folder contains the following:
   a) **H_Re**: Real part of the estimated channel matrices, and is of shape (number of samples, number of working antennas, number of used subcarriers, number of measurements per location). In this case, it is of shape [number of samples, 56, 924, 5].
   b) **H_Im**: Imaginary part of the estimated channel matrices, and of the same shape as H_Re.
   c) **SNR**: Signal-to-noise ratio measured at each antenna during channel estimation. This is of shape [number of samples, 56, 5].
   d) **Pos**: Ground truth positions of the transmitter, represented in the Cartesian coordinate system. The shape is [number of samples, 3], with the second dimension representing [x,y,z] in that order.

There is a total of 4979 labelled samples.

2) **“CTW2020_labelled_data.zip”** - contains the Folder **“CTW2020_unlabelled_data”**. Each file in the folder contains the above variables apart from “Pos”. There is a total of 36192 unlabelled samples

Note: *On purpose, the data associated with a part of the map (two streets, to be precise) has been omitted from the labelled dataset but will be a part of the test dataset*. *During the channel estimation, some of the estimates could not be obtained due to a very low SNR at the receiver, and hence they have been stored as zeros.*

The test data set (to be released on the morning of May 10, 2020) contains 4616 data samples. Specifically, the data set contains

- H_Re of shape [4616,56,924,5]
- H_Im of shape [4616,56,924,5]
- SNR of shape [4616,56,5].

For each sample in the test dataset, the participating teams are expected to provide a 3-dimensional estimate (representing [x,y,z] in that order) of the position. The final estimates should be of shape [4616,3].

A Jupyter Notebook file is provided together with the dataset to illustrate how the data can be loaded.

Contact

Questions about the dataset:

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Questions about the CTW competition:

- Nariman Farsad, nfarsad@stanford.edu
- Andrew W. Eckford, aeckford@yorku.ca

References

[1] Maximilian Arnold, Jakob Hoydis, and Stephan ten Brink, “Novel Massive MIMO Channel Sounding Data applied to Deep Learning-based Indoor Positioning”, Proc. SCC, 2019.