MS Thesis Topic: AI-based 3D Mapping with 6G signals

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I. Background

One of the technological enablers of 6G will be the use of very high carrier frequencies (24 GHz - 1 THz). At these frequencies, it is necessary to use very fine beams for providing sufficient SNR. Since the channel attenuation increase with frequency, much finer beams are needed to maintain the required SNR as we scale in frequency. This provides both challenges and opportunities. A main challenge due to high frequency operation is that the links are sensitive to blockages (as signals will not be able to penetrate obstacles) and misalignment. This in turn will require significant overhead in terms of beam alignment, refinement, and beam searching. In other words, the radio signals behave more like lasers, providing very high rates but with very small footprint. A second main challenge is that conventional signal processing techniques, modulation formats, and coding will need to be revisited, as communication will not be limited by bandwidth or interference, but also by hardware limitations.

A major opportunity is this same property [1], [2]: by virtue of the small beamwidth and the fact that most obstacles are opaque to high frequency signals (24 GHz - 1 THz) can be exploited to provide new sensing functionalities, ranging from pollution sensing to LIDAR-like functionality.

Radio sensing can be accomplished by monostatic, bistatic, and multistatic setups. In monostatic sensing, transmitter (TX) and receiver (RX) are co-located, so a single device is involved in the sensing operation. In bi-static sensing, TX and RX are separated, and generally unsynchronized. Finally, in the multistatic regime, there is 1 TX and multiple RX. In all cases, the goal is to determine a description of the environment (e.g., locations of objects based on range and angle measurements).

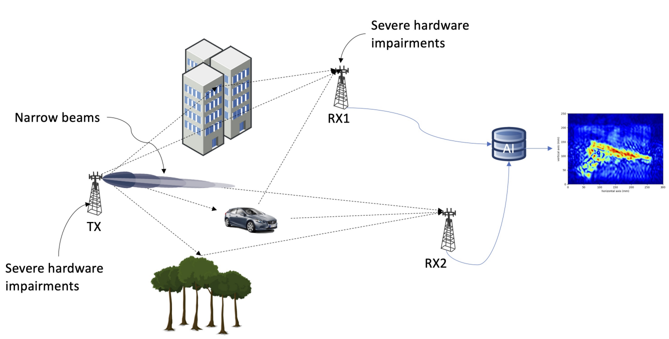

Fig. 1. Considered multi-static setup where the signals at the different receivers are processed to create a 3D image of the environment. The goal of this project is to develop the AI unit, based on models of the propagation, signals, and hardware limitations.

II. Goal

The main goal of this thesis is to investigate supervised learning methods that can map an environment based on THz signals in a hardware limited setting. The map will comprise several extended objects, of which we would like to determine the size, shape, and electromagnetic properties. The study will comprise the following parts:

- Literature study of related methods and models (e.g., in tomography [3], [4]).
- Description and simulation of channel [5] and hardware models
- Data synthesis in a practical 6G deployment scenario with various objects, with support from Ericsson.
- Development of deep learning methods that take as input the received waveforms from different RXs and should provide as output a 3D map of the environment. Waveforms may be pre-processed.
- Sensitivity analysis to strength of hardware impairments.
- Extension to sensing using several bands (FR1, FR2, THz).
- Write a conference paper to report the main finding.

III. Prerequisites

A solid math background. Strong programming skills. Independent, problem-solving.

IV. Thesis details

This thesis can be a 60 credit thesis (1 student) or a 30 credit thesis (2 students). For more information, contact the examiner at henkw@chalmers.se.

References

[1] H. Sarieddeen, N. Saeed, T. Y. Al-Naffouri, and M.-S. Alouini, “Next generation terahertz communications: A rendezvous of sensing, imaging, and localization,” *IEEE Communications Magazine*, vol. 58, no. 5, pp. 69–75, 2020.

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[3] M. Ljubenovic, S. Bazrafkan, J. De Beenhouwer, and J. Sijbers, “Cnn-based deblurring of terahertz images.” in *VISIGRAPP (4: VISAPP)*, 2020, pp. 323–330.

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