Tremplin Recherche ESIEE - UniPi, Italy

Title: AI-enabled THz communications

Research lab: LIGM, MMSID team

Supervisor:

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Co-advisors:

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- Dr. Florence Nadal, ESIEE Paris

International collaboration:

• Dr. Giacomo Bacci, University of Pisa, Italy

Context: The use of terahertz (THz) communications [1] offers a promising way to significantly contribute to improving sustainable mobility in future wireless networks. However, moving the carrier frequency to the (sub-)THz spectrum (from 0.1 to 10 THz) leads to a limited propagation range and a sparse sub-THz channel, challenges that need to be addressed. Hence, highly-directional beams (even narrower than the ones needed for mmWave communications) must be employed by both the transmitter and the receiver to concentrate the signal energy. Such beams can be formed using high-gain antenna arrays, which contain a large number of elements and yet occupy little space thanks to the small wavelengths [2,3]. For this purpose, modern AI techniques (based on neural networks) have recently shown tremendous potential [4].

Objectives: In this *tremplin recherche*, the main goal is to investigate the beam-alignment problem for THz communications with a focus on AI-techniques. Specifically, the objectives are:

OBJ-1. Perform a comparative state of the art on AI-based beam-alignment techniques for THz and mmWave wireless communications.

OBJ-2. Investigate the potential of available simulations environments, such as Sionna [4], and datasets, such as DeepMIMO [5], in the THz spectrum domain.

OBJ-3. Propose a relevant dataset for the beam-alignment relying on AI techniques for THz communications.

Requirements: the candidate should have a working knowledge on AI and deep learning methods, and solid computer literacy skills (especially Python, MatLab, ...). Notions of wireless communications are a definite plus.

Student level: Master 2 or E5

Potential ESIEE tracks: *Informatique, Datascience et intelligence artificielle, Systèmes embarqués, Systèmes électroniques intelligents, Génie industriel, Énergie, Artificial Intelligence and Cybersecurity*

Possibility to continue with a 6-month PFE (Master 2 - level internship) depending on available funding and scholarships. A 2025 PHC Campus France ``Galileo'' project has been submitted for funding international mobilities between the French and Italian team.

References

[1] T. Kürner et al., Introduction to THz Communications, Springer, 2021.

[2] H. Do et al., "Terahertz line-of-sight MIMO communication: Theory and practical challenges," *IEEE Commun. Mag.*, 2021.

[3] [9] **G. Bacci**, L. Sanguinetti, and E. Björnson, "Spherical wavefronts improve MU-MIMO spectral efficiency when using electrically large arrays," *IEEE WCL*, 2023.

[4] I. Chafaa, **R. Negrel, E.V. Belmega**, and M. Debbah, "Self-supervised deep learning for mmWave beam steering exploiting sub-6 GHz channels," *IEEE TWC*, May 2022.

[5] J. Hoydis et al., "Sionna: An open-source library for next-generation physical layer research," 2022 (https://github.com/NVlabs/sionna)

[6] A. Alkhateeb, "DeepMIMO: A generic deep learning dataset for millimeter wave and massive MIMO applications," 2019 (https://deepmimo.net).