Master Internship/Stage de Fin d'Études 2023/2024
"Towards Fundamental Limits of Distributed Acoustic Sensing"

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Location: The student will be working at the COMELEC Department of Telecom Paris.

Related Fields: Sensing, Estimation, Optics, Information theory.

Project Description: Great technological efforts are currently also being made to integrate sensing besides communication on the over 4 billion kilometers of optical fiber covering our planet for the purpose of monitoring changes in the surrounding environment, buildings, and infrastructures (e.g., oil pipes). A particularly appealing technology is distributed acoustic sensing (DAS) [1, 2] where the transmitting terminal sends light pulses into a fiber and based on the backscattered signals estimates vibrations (pressure), temperature or other environmental or structural phenomena. A major advantage of DAS is that it allows to simultaneously estimate phenomena located at different locations next to the fiber because imperfections all along the fiber reflect a small portion of the incoming light pulses.

The first task of this project will be to study existing models for DAS systems through an indepth analysis of the physical properties of the optical fiber. The goal will be to establish a rather accurate but still sufficiently simple stochastic model for the DAS pulse train sensing proposed in [3, 4, 5], which has achieved impressive practical performances. This will facilitate the second task of the project, which is to establish analytic and numerical information-theoretic bounds on the optimal performances of the proposed model and to propose improved sensing methods.

Expected Skills: This is an interdisciplinary project between physics, communications, and information theory. The candidate is expected to have good analytic and engineering skills and a solid background in physics, communications, and information theory. The project will consist of 60 % theory and 40 % programming.

References

[1] A. H. Hartog, *Introduction to Distributed Optical Fiber Sensors*. CRC Press, 2017.

[2] A. Masoudi and T. P. Newson, "Analysis of distributed optical fibre acoustic sensors through numerical modelling," *Opt. Express*, vol. 25, no. 25, pp. 32 021–32 040, Dec 2017.

[3] S. Guerrier, C. Dorize, E. Awwad, and J. Renaudier, "Introducing coherent MIMO sensing, a fading-resilient, polarization-independent approach to φ-OTDR," *Optical Express*, vol. 28, no. 14, pp. 21 081–21 094, Jul 2020.

[4] C. Dorize, S. Guerrier, E. Awwad, and J. Renaudier, "Revisiting distributed acoustic sensing: A telecom approach inspired from optical transmission," in *27th International Conference on Optical Fiber Sensors*. Optica Publishing Group, 2022, p. Th4.7.

[5] C. Dorize, S. Guerrier, E. Awwad, K. Benyahya, H. Mardoyan, and J. Renaudier, "Advanced fiber sensing leveraging coherent systems technology for smart network monitoring," in *Optical Fiber Communication Conference (OFC) 2022*. Optica Publishing Group, 2022, p. M2F.6.