PhD thesis proposal: "Robust machine learning based communication systems"

1 Context

Machine Learning (ML) based solutions, and more specifically neural networks, are being increasingly applied to digital communication systems as shown in [1]. The ever growing number of applications range from error correction, to synchronization, channel equalization, as well as pulse shaping, and other solutions for the physical layer.

ML based solutions are particularly appealing for digital communication systems due to three main reasons. First, they achieve close to optimal performances whilst being considerably lass complex as compared to classical algorithms. This allows them to be good candidates for lightweight communication systems such as IoT systems for instance. Second, these solutions do not require compulsorily a known statistical model of the communication environment, but merely a set of realizations of its processes. As such, they can better adapt to communication environments which are not fully parameterized and for which, classical algorithms would require a closed form description of their statistics. And last, but not least, through more evolved tools such as auto-encoders, neural based communication systems can be optimized in an end to end manner, allowing thus to explore more intricate joint design of the communication blocks such as non linear error correction coding, coded modulations, joint equalization and decoding, ...

However, ML-based communication systems present many limitations, which hinder their deployment on a large scale. First, the design of such solution (in terms of network structures, optimizers, training conditions,...) is, to date, mainly heuristic, and though some works [2] tried to give a formalism to their constructions, much remains to be understood. Second, due to the large packet sizes which are encountered in current high throughput communication systems, neural based solutions cannot match up to the classical algorithms since their design is often not scalable in terms of packet lengths. And finally, but most importantly, ML-based solutions can be very sensitive to a change of domain between the training and validation datasets [3]. Such robustness issues preclude the usage of generic neural based solutions in a variety of scenarios.

In this thesis, we will investigate the design of robust ML-based solutions for digital communication systems, i.e., ML-based solutions with good generalization properties, relying on tools from information theory and statistical learning theory.

2 Research team

ISAE-Supaéro is a leading institute in applied research for aeronautical and aerospace engineering. The Department of Electronics, Optronics and Signal processing (DEOS) is leading research in various electrical engineering topics amongst which are "secure and high spectral efficiency satellites and aeronautical communications".

The main advisor of the thesis will be Meryem Benammar, associate profession in DEOS, whose research activities lie mostly in information theory, with applications to communication engineering and statistical learning theory.

The thesis will be held under the direction of Jérôme Lacan, professor in ISAE-Supaéro, who is an expert in various error correction coding related topics, including erasure codes, and in security and cryptography.

3 Candidate profile and application

Applicants should be graduated master (or/and engineer) students. A strong background in applied mathematics is required since the research assignment requires tools from information theory and statistical learning. Good communication skills in English are necessary (written and spoken), as well as good development skills (Python, Matlab, ...). Applications from candidates familiar with digital communications, information theory or machine learning are particularly encouraged.

- Applications (CV, cover letter, academic records) are to be addressed to {meryem.benammar,jerome.lacan}@isae-supaero.fr
- Dates and duration: Late 2020 till late 2023 (36 months)
- European citizenship: constraint for the funding
- **Application deadline: open until July 20th, 2020**.

References

[1] T. J. O'Shea and J. Hoydis, "An introduction to machine learning communications systems," *arXiv preprint arXiv:1702.00832*, 2017.

[2] M. Benammar and P. Piantanida, "Optimal training channel statistics for neural-based decoders," in *2018 52nd Asilomar Conference on Signals, Systems, and Computers*, Oct 2018, pp. 2157–2161.

[3] ——, "On robust neural-based decoders," in *2019 53rd Asilomar Conference on Signals, Systems, and Computers*, Nov 2019.