Ph.D. Position:
Efficient Massive MIMO Processing Using Deep Learning

Summary

Research areas:	Machine learning, wireless communication.
Supervisors:	Dr. Vincent Gripon (IMT Atlantique; vincent.gripon@imt-atlantique.fr)
	Dr. François Leduc-Primeau (ETS; francois.leduc-primeau@lacime.etsmtl.ca)
Director:	Prof. François Gagnon (ETS)
Start date:	September 2018 or later.
Institution:	Dual-diploma Ph.D. at École de Technologie Supérieure (Montréal, Canada) and IMT Atlantique (Brest, France).

Context of the Research

Massive MIMO (mMIMO) is a technique that enables large capacity increases for wireless systems combined with even larger energy efficiency improvements [1] by using a large number of antennas (e.g. 256) to transmit and receive data. It is thus one of the most promising approaches for increasing the throughput and the number of concurrent users in cellular systems. However, in its standard form, mMIMO requires as many RF transceivers as there are antennas, which makes them costly. Additionally, they require demanding signal processing, which threatens to offset some of the energy efficiency improvements in transmit power. Therefore, it is highly desirable to identify methods that will allow reducing both the complexity of the RF frontend, as well as the complexity of the processing required. This is especially true since the objective of future wireless systems is to achieve the increases in throughput and number of users while also decreasing the overall energy consumption [2], which implies a significant decrease of the energy consumption per transmitted bit.

Objectives

The objective of this thesis will be to propose methods to efficiently perform the real-time optimization required for mMIMO communication. Given the tremendous success of deep neural networks (DNN) in solving demanding optimization problems such as image recognition and speech processing, they are now attracting a lot of interest (see for example [3] and references therein) for solving the most difficult optimization problems in communications. Even though in the case of communication and specifically in MIMO precoding and detection, optimal or near-optimal algorithms are known, methods based on neural networks are expected to allow a reduction in computational complexity and be better suited for achieving fast hardware implementations. For instance, the DNN-based MIMO detector proposed in [4] achieves a performance similar to standard near-optimal algorithms while reducing computing time by 30 times in a specific example.

The Ph.D. student will be supervised by a team of researchers covering several research specialties in order to come up with truly innovative solutions for mMIMO processing. He will develop extensive knowledge of state-of-the-art deep learning models and training methods, and also a good understanding of the mMIMO optimization problem. He will then propose new deep learning architectures and training methods that are adapted to the problem, while taking into account the computational and hardware complexity of his solutions.

Supervision and Funding

The research training of the Ph.D. student will be split between *IMT Atlantique* in France and *École de Technologie Supérieure* (ETS) in Canada, and will lead to a double diploma awarded jointly by both institutions. The amount of time spent at each institution can be adjusted based on the preference of the candidate.

At IMT Atlantique, the student will be supervised by Dr. Vincent Gripon. Dr. Gripon's research focuses on machine learning theory and applications. He received his M. Sc. from ENS-Cachan in 2008 and Ph.D. from Télécom Bretagne in 2011. Since then, he coauthored about 70 papers in the fields of artificial neural networks and signal processing.

At ETS, the student will be supervised by Dr. François Leduc-Primeau. Dr. Leduc-Primeau's research focuses on the efficient hardware implementation of communication and signal processing algorithms. Dr. Leduc-Primeau received his Ph.D. from McGill University in 2016. He was awarded several scholarships, including the Postdoctoral Fellowship from Canada's Natural Science and Engineering Research Council (NSERC).

General supervision will be provided by Prof. François Gagnon. Prof. Gagnon has been a professor in the Department of Electrical Engineering at ETS since 1991, and served as the department's director from 1999 to 2001. He is the holder of two research chairs: the Richard J. Marceau Industrial Research Chair for Wireless Internet in developing countries and the NSERC-Ultra Electronics Chair in Wireless Emergency and Tactical Communication. Professor Gagnon serves on the boards of funding agencies and companies. He holds 7 patents and has coauthored more than 250 papers in the fields of wireless communications, signal processing, and microelectronics.

The position is fully funded and travel fees between France and Canada are also covered.

Candidate Profile

- Master's degree in Computer/Electrical Engineering, Computer Science, or related discipline.
- Basic knowledge of communications and signal processing.
- At least one of: 1) prior research experience in information theory, wireless communications, or signal processing; or 2) prior research experience in machine learning.
- Demonstrated programming experience.
- Other desirable skills: Optimization, hardware design.

How to Apply

Send an e-mail to vincent.gripon@imt-atlantique.fr and francois.leduc-primeau@lacime.etsmtl.ca with the subject line "ML-mMIMO PhD position", including a full CV, university transcripts, recommendation letters or contacts from former teachers/advisors, and a statement (max. 1 page) describing how your experience prepares you for this project.

Deadline for applying is April 15th at midnight, time of Montréal.

References

[1] E. G. Larsson, O. Edfors, F. Tufvesson, and T. L. Marzetta, "Massive MIMO for next generation wireless systems," *IEEE Commun. Magazine*, vol. 52, no. 2, pp. 186–195, Feb. 2014.

[2] L. J. Young, "Telecom experts plot a path to 5G," *IEEE Spectrum Magazine*, Oct. 2015.

[3] T. J. O'Shea and J. Hoydis, "An introduction to deep learning for the physical layer," *CoRR*, vol. abs/1702.00832, 2017. [Online]. Available: http://arxiv.org/abs/1702.00832

[4] N. Samuel, T. Diskin, and A. Wiesel, "Deep MIMO Detection," *ArXiv e-prints*, Jun. 2017.