PhD Proposal at CEDRIC laboratory of CNAM School

Machine Learning for Efficient Massive MIMO processing in Beyond 5G and 6G

Summary

Research areas: wireless communications, machine leaning

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Context of the research

Massive multi-user MIMO (MU-MIMO) [MAR10] has been recognized as one of the most promising approaches for future generations (beyond 5G and 6G) of wireless systems, representing the most ultimate enablers of enhanced energy-efficiency (EE) and spectral-efficiency (SE) [LAR14]. However, massive MIMO deploys as many RF transceivers as there are antennas, which are expected to be inexpensive to enable cost- and energy-efficient massive MU-MIMO BS deployments. Furthermore, the associated hardware impairments require advanced signal processing, threatening the massive MIMO's good qualities related to SE and EE. Some techniques have been proposed in order to allow the use of energy-efficient RF frontend [KON18][ZAY19][ZAY19b], but their complexity are still an open challenging issue, especially with fast time-varying channel and large number of users. Therefore, it is highly desirable to identify new approaches to reduce the complexity of the processing required, making massive MU-MIMO more attractive for B5G and 6G.

On the other hand, **deep learning (DL)** based machine learning (ML) has been shown to be an advanced tool capable of building universal classifiers and/or approximate general functions. Previous works using artificial neural networks (ANN) have been able to efficiently perform the real-time optimization required for massive MU-MIMO (see for example [WAN19] [WEN18] [HUA18] [DEM20]). However, these classical DL methods adopt a data-driven approach to identify the most adequate architecture of an ANN that fits well input-output data pairs where a huge amount of live data is required, which is not practical in real-time systems due to fast-varying, complexity, energy consumption in data acquisition process.

In order to overcome this problem, in the deep learning community new advanced approaches are currently being investigated in order to complement purely data-driven Machine Learning (ML), such as **knowledge-driven** ML [ZAP19] (i.e., using prior information based on theoretical models) and **meta-learning** [CHE20] (learning to learn) approaches.

Objectives

This PhD thesis will study technologies and opportunities available to embrace DL to tackle the aforementioned massive MIMO's issues. Specifically, it will investigate the combination of the two approaches of knowledge-driven ML and meta-learning to (i) allow the use of low-cost and low-power hardware components, such as power amplifiers (PAs) and ADC/DAC (PAPR reduction and nonlinear distortion problems will be addressed); (ii) channel estimation under hardware imperfection (the main challenge will be the reduction of the training overhead); (iii) radio resource management for real-time energy-efficiency maximization (PA imperfection and channel estimation error will be considered). Our goal will be to replace or improve existing optimization algorithms by approximating them with efficient fast deep networks. Reducing the computational cost of neural networks at inference time through quantization or compression can also be investigated [CHE19].

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