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Internship proposal (6 months)

Federated learning-based channel state information compressing for massive MIMO communication system

(reference QLI052022)

Internship supervisor

Mitsubishi Electric R&D Centre Europe**:**

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Overall context

Mitsubishi Electric R&D Centre Europe is a research laboratory thinking up new generations of communication systems and future technologies in the field of energy and the environment. In the French branch located in Rennes, the research center particularly focusses on scalable communication technologies and reliable software methodologies in order to meet the demands of future ICT-based consumer services and professional applications in factory automation, automotive, railway, satellite, and access networks.

In recent years, artificial intelligence (AI) and machine learning (ML)-based methods have attracted great research interest in physical layer design problems of the wireless communication domain. Thanks to AI/ML algorithms, a communication system that is modeled as a chain of multiple independent blocks with different functionalities can be replaced by a more compact non-modular system model with better end-to-end performance. Channel estimation and compression, among many other problems in physical layer design, have been intensively studied using AI/ML.

Conventionally, model training is mostly done via centralized learning where the whole training dataset from all the users is collected at the base station (BS). It introduces huge communication overhead for data collection. Distributed machine learning methods are poised to drastically improve performance by leveraging the richness of the data collected at the user equipment (UE).

Internship subject

In a multi-user communication system with many antennas (often called multi-user massive multiple input multiple output (MIMO) system), the design of the transmission precoder is based on the channel state information (CSI) obtained at the transmitter side. The CSI acquisition is performed through pilot-based channel estimation. For a wideband MIMO system with many transmission antennas and users, the CSI feedback complexity will soon become prohibitive. To reduce the CSI feedback complexity, CSI compressing should be applied. Such CSI compressing design can be based on either conventional quantization/lossy source coding techniques or be based on a data-driven AI/ML-based algorithm.

Considering the frequency domain correlation for wideband channels and the spatial correlation for users located close to each other, an AI/ML algorithm can implicitly exploit such information to compress the CSI and reduce the CSI feedback overhead.

In this internship, we consider the following scenario: A set of remote UEs observe a set of pilot signals transmitted by a MIMO base station (BS). The number of pilots seen by each UE is limited. The goal of the system is to learn a compressor for CSI. The training of this CSI compressor should occur in a distributed/federated manner, with the BS orchestrating the training and maintaining a centralized model. Training must occur within a set communication budget and model size.

To summarize, the objective is to develop and evaluate a federated learning-based algorithm for distributed training and compressing of MIMO CSI with realistic constraints such as communication budget, model size, and communication latency/algorithm convergency being taken into account.

Detailed objectives

- Bibliographic study of the state-of-the-art algorithms related to AI/ML-based CSI compressing and such kind of data-driven CSI compressing under a federated learning context.
- Development of a federated learning-based CSI compressing algorithm which takes into account realistic communication constraints.
- Algorithm implementation and simulation validation with the provided multi-user massive MIMO channel measurement data set.
- Writing the internship report.

Prerequisites

- Interest in applying machine learning/ artificial intelligence methods to solve wireless communication problems
- Capacity to develop in Python and Matlab
- Autonomy
- Good skills in English (read and written)
- Good literature search skills

Duration: 6 months

Period: from Feb/March 2023 (possibility of flexibility, depending on schools' internships periods)

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Thank you to provide us an application letter and your CV mentioning the reference of the internship.

The signature of an Internship Agreement with your school is mandatory.