Machine Learning for beam-alignment in large mmWave MIMO

PhD Position at Telecom ParisTech

Context and research subject

Multi-user Massive MIMO has been proposed to answer the increase of spectral efficient demand to met the 5G requirements. Massive MIMO employing suitable precoding techniques can yield large gains in spectral efficiency and energy efficiency as compared to conventional MIMO systems, as the effects of noise and interference are negligible when the number of antennas approaches infinity. But, some limitations due to the realistic urban environment induce a decrease on the obtained gains. In particular, beamforming and combining are vital to establish any communication in a millimeter-wave (mmWave) MIMO link. Due to the high bandwidth and operating frequency, beamforming/combining need to be done in the analog domain, since fully digital beamforming/combining is infeasible in such architectures. Specifically, the beam-alignment problem consists of finding a pair of transmit and receiver beams, that maximize the SNR of the link. In a mmWave MIMO setting, the transmitter and receiver select their beams from an analog set of possible beam patterns. In many standards (including WiGig) beam-alignment is done by naive beam sounding, i.e., exhaustively testing each pair in transmitter and receiver beam patterns, and finding pair that maximizes the SNR. Evidently, the signaling overhead scales with the product of the codebook sizes. This is particularly problematic for mmWave systems due to the inherently low-coherence time, and the need for large codebooks at the transmitter and receiver.

We aim in this work to propose a new approach for beam-alignment that greatly reduces this overhead by leveraging the recent advances in machine learning. The proposed approach will be based on the sounding of only some beam-pairs, and using the SNR of these sounded beam-pairs, to train a (non-linear) classifier and predict the SNR of the remaining beam-pairs. The PhD student will investigate several non-linear Machine Learning methods as shallow neural network, matrix factorization and some of its variants. Another goal of the thesis will be to determine the sample complexity for these methods, i.e., the minimum number of training samples for this learning task : this will in turn determine the sounding overhead of the proposed beam-alignment method, which is critical in determining the feasibility of the approach in a realistic setting.

Requirements

To be eligible for the PhD position, the candidate must possess a master degree in electrical engineering, or a related field. The applicant must have excellent analytical background (probability theory, optimization theory, and machine learning) and a drive to pursue fundamental research. A solid background in wireless communication, signal processing, and millimeter-wave communications is a major advantage. Skills with experience using C and /or Python programming for implementing machine learning methods may be very advantageous.

Salary

The research grant is awarded for 3 years and its monthly net salary is about 1400€.
Expected starting is : **September 2019**.

Application

Applications must be send by email, with the following attachments (in English or French) as separate **pdf** files :

1. Complete CV containing contact information of at least two referees
2. Motivation letter (prior knowledge, research interests and career plans)
3. Diplomas : Scanned copies of diplomas and transcripts of the records of relevant previous degrees

Contact

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