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التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم

Ain Shams University Information Network

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قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
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Ain Shams University
Faculty of Engineering
Electronics and Communications Engineering Department

Decontaminating Pilots in Massive MIMO -5G Systems

A Thesis
Submitted in partial fulfillment for the requirements for the degree of Doctor of Philosophy in Communications Engineering
(Electronics and Communications Engineering)

By

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Statement

This dissertation is submitted as a partial fulfillment of the degree of Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering), Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Waleed Abd-Elshafi Ali Elshazly

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Thesis Summary

Time division duplexing (TDD) Massive multiple-input, multiple-output (MIMO) operation is limited by user terminals (UTs) mobility which leads to a short coherence block and a limited number of orthogonal pilots. In the multi-cell system, the pilots of the home cell are reused in the adjacent cells to some degree called pilot reuse factor *r*, so channel estimates in the home cell are contaminated with that of other cells using the same pilots. This is known as pilot contamination, which leads to degradation of channel estimation and occurrence of interference from the same pilot UTs which can't be removed by increasing base station (BS) antennas number.

Pilot contamination has two main effects on uplink (UL) and downlink (DL) data transmission in TDD Massive MIMO. First, it increases the mean square error (MSE) of channel estimation, which affects the quality of combining and precoding vectors that provide high array gains and mitigate the interference from different pilots UTs. Second, it increases the interference from the same pilots UTs that is enlarged by the array gain, similar to the desired signal.

The main objective of this thesis is to mitigate pilot contamination in Massive MIMO system and to enhance the system spectral efficiency (SE) by developing a mitigation technique to combat the pilot contamination problem and its effects. The proposed technique is Laplacian centralized scattering-spatially correlated Rayleigh fading channel model. This model gives a more accurate description, especially for cell-edge users. It results in an accurate spatial channel correlation matrix calculation that enhances the channel

estimation quality under pilot contamination and enhances the quality of combining and precoding vectors. Also, multi-cell minimum mean square error (M-MMSE) combining and precoding vectors are applied to mitigate pilot contamination and enhance cell throughput.

Spatial channel correlation increases the degree of favorable propagation when the UTs have different spatial characteristics. Spatial channel correlation is useful in practice to enhance the channel estimation quality under pilot contamination. In this thesis, the proposed centralized Laplacian scattering-spatially correlated Rayleigh fading model performance is compared with both one- ring scattering-correlated Rayleigh fading and uncorrelated Rayleigh fading channel models performances for different pilot reuse factors (r=1, 2, and 4) and for different combining and precoding schemes such as single-cell minimum mean square error (S-MMSE), Regularized Zero-Forcing (RZF), Zero-Forcing (ZF), and maximum ratio (MR) in mitigating pilot contamination and realizing larger SE.

The highest SE of the proposed Laplacian centralized scattering-spatially correlated Rayleigh fading model is achieved when using M-MMSE combining and precoding scheme and the pilot reuse factor equals 4 but at the expense of increased computational complexity. Increasing the pilot reuse factor improves system SE and reduces the effect of interfering signals but leads to an increase of pilot samples and reduction of the number of UL and DL data samples in the coherence block. The TDD Massive MIMO system achieves higher cell throughput than the long term evolution (LTE) system for the same channel bandwidth.

Multi-cell scenario is used, which is more practical and complex than single-cell massive MIMO scenario. The reason for better performance of M-MMSE combining and precoding scheme is the M-MMSE obtains useful estimation of channels to UTs in other cells and use them to mitigate interference from the same pilot users and interference from different pilot users.

The optimum precoding and combining vectors are calculated and the corresponding maximum signal-to-interference plus noise ratios (SINRs) of UL and DL are calculated. The UL and DL SE per cell (bit/s/Hz/cell) of Massive MIMO system is calculated. The complexity of the proposed scheme is calculated and compared with other combining and precoding schemes. The theoretical results are validated by using Matlab Simulation.

Key words:

- Massive MIMO.
- Pilot contamination.
- Channel estimation.
- Spectral efficiency.
- Multicell MMSE.
- Large random matrix theory.
- Combining and precoding.
- Laplacian scattering-spatially correlated Rayleigh fading model.
- One- ring scattering-spatially correlated Rayleigh fading model.
- Uncorrelated Rayleigh fading.

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