AF MIMO RELAYING WITH ESTIMATED CSI

by

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Certificate

This is to certify that the thesis entitled **"AF MIMO RELAYING WITH ESTIMATED CSI"** being submitted by Ms. Arti M.K. to the Department of Electrical Engineering, Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy is the record of the bona-fide research work carried out by her under my supervision. In my opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted either in part or in full to any other university or institute for the award of any degree or diploma.

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Abstract

A significant interest is received by multiple-input multiple-output (MIMO) relaying techniques because of their advantages like increased capacity, data rate, diversity gain, and array gain. Several relaying strategies are proposed in the literature like amplify-and-forward (AF), decode-and-forward, selection relaying, and incremental relaying. AF is the most attractive technique among all cooperative protocols because of its simple processing at the relay terminals. In literature, a key assumption in most of the works over AF MIMO relaying is that the instantaneous channel state information (CSI) is perfectly known at different nodes involved in cooperation. However, in practice, exact CSI is not available and MIMO channel matrices have to be estimated at different nodes by using training data.

In this thesis, we discuss methods of channel estimation and decoding in AF based MIMO relay networks. We derive three different decoders, namely decoder-I, decoder-II, and decoder-III, for orthogonal space-time block codes (OSTBCs) using pilot symbol-aided channel estimation over Rayleigh fading MIMO channels, in an AF based cooperative communication system. Decoder-I is a decoupled de-

coder which uses estimated channel gains in decoding. The other two decoders jointly process the received pilot signals and data samples through vector derivative (decoder-II) and probability density function marginalization (decoder-III). Simulation results show that decoder-II and decoder-III have almost the same performance. However, decoder-II is computationally less complex as compared to decoder-III. We also derive an expression for the moment generating function (m.g.f.) of the received signal-to-noise ratio (SNR) at the destination for decoder-I and by using this m.g.f. the analytical symbol error rate (SER) for an M-ary phase-shift keying (M-PSK) is obtained.

Next, we investigate the problem of channel estimation and decoding of OSTBCs in a two-way AF MIMO relay network. We obtain a joint decoder for a pilot symbol-aided two-way AF based MIMO cooperative system. The decoder jointly processes the received OSTBC data and pilot matrix by using the vector derivative over the two-way MIMO relay channel. We derive a closed-form expression in Rayleigh fading for the m.g.f. of the received SNR at both cooperating users for the decoder; and then investigate the system performance based on analytical expressions for the SER, diversity order, and array gain.

Furthermore, we study an AF based one-way MIMO cooperative relay network in which beamforming is done by using estimated channels in a Rayleigh fading environment. A protocol for training of the source, relay, and destination is described and methods of channel estimation are presented. Simulation results show that the trained MIMO relay system based on beamforming outperforms the trained MIMO relay system without beamforming. It is also shown that the performance of the beamforming based MIMO relay system improves with increase in the number of receive antennas at the destination. We analyze the SER versus SNR performance of beamforming based AF relaying with perfect channel knowledge at the source, relay, and destination. An expression of the m.g.f. of the received instantaneous SNR at the destination is derived. By using this m.g.f., an exact expression for the SER of M-PSK is obtained.

Moreover, we also consider a beamforming and combining scheme for a two-way AF MIMO relay network. An approximate expression for the SER of the scheme in Rayleigh fading for M-PSK is obtained based on the m.g.f. of the instantaneous received SNR. The diversity order is also analytically derived. It is shown by simulations that the considered scheme outperforms existing schemes for beamforming and combining in a two-way AF MIMO relay systems. We also discuss beamforming and combining in a two-way AF MIMO relay system with estimated channel gains.

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