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An effective approach for low-complexity maximum likelihood based automatic modulation classification of STBC-MIMO systems

Key words: Multiple-input multiple-output; Space-time block code; Maximum likelihood; Automatic modulation classification; Zero-forcing

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Motivation

- Automatic modulation classification (AMC) is an essential part of electronic warfare operations and commercial applications like software-defined radio (SDR), cognitive radio, and spectrum sensing.
- Multiple-input multiple-output (MIMO) systems tackle the modern requirements of high data rates and reliability in multipath fading environments. The problem of AMC poses new challenges in the context of MIMO communication.
- Space-time block code (STBC) is a transmit diversity methodology of MIMO systems, sending multiple copies of the desired signal for high reliability transmission.
- The maximum-likelihood classifiers provide the optimal solution in the Bayesian sense; however, it is always desired to reduce the complexity of maximum likelihood (ML) classifiers.

Main idea

- In this study, we propose a simple yet effective approach for ML-based modulation classification of STBC-MIMO systems.
- Modulated signals received at different antennas are equalized using zero-force equalization.
- The average likelihood ratio test (ALRT) function is modified to use the equalized symbols without having to use the symbols at individual antennas.
- Blind scenarios are emulated by inducing the estimation error variance for imperfect channel state information (CSI).
- Three different antenna configurations (i.e., 2×1, 2×2, and 4×4) are used to verify the proposed approach.

Method

- A typical ALRT function is modified to use the equalized symbols received.
- For each modulation hypothesis (i.e., BPSK, QPSK, 8PSK, and 16QAM), 500 Monte-Carlo simulations are performed for a signal-to-noise ratio (SNR) range of –15 to 15 dB to estimate the probability of correct classification.
- To emulate the blind scenarios, classification curves are obtained for different values of CSI estimation error variance (σ_e^2).

Major results

- Classification curves for the **BPSK** modulation hypothesis for two different antenna configurations

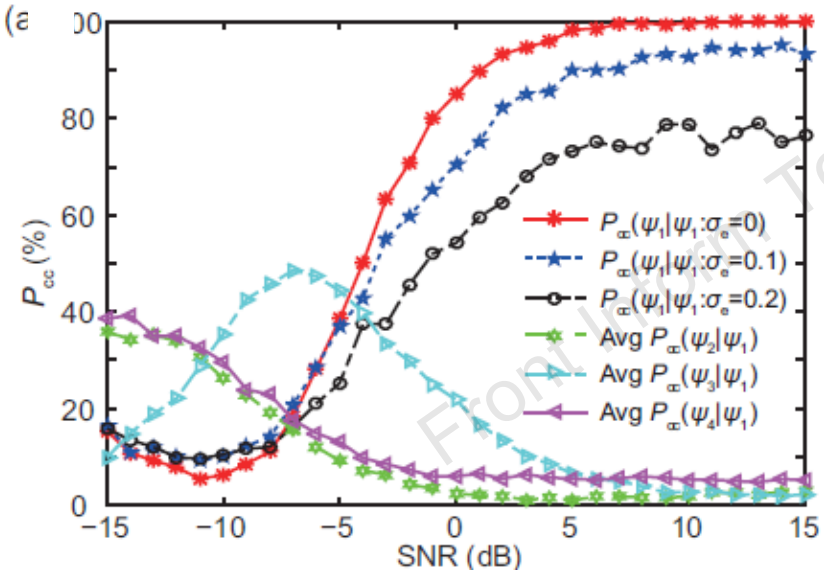

Fig. 1 P_{cc} for the **BPSK** hypothesis for a **2**×**1** antenna configuration

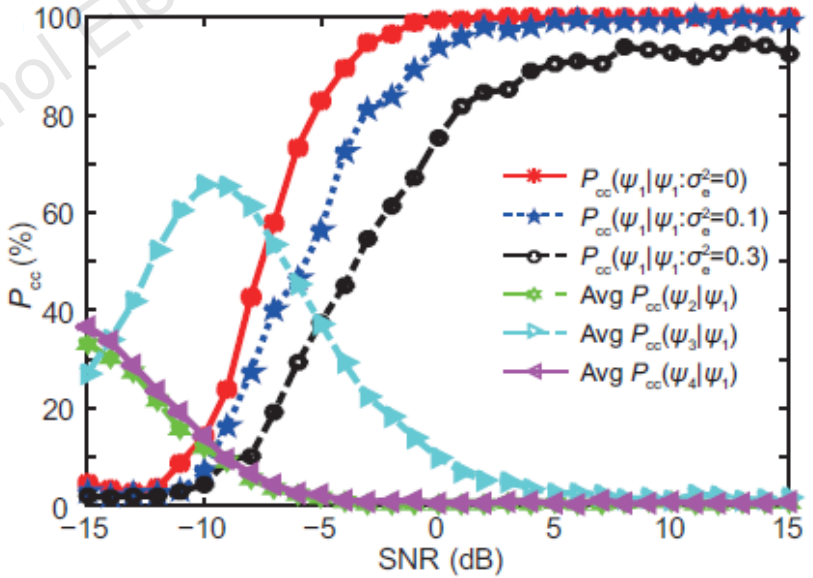

Fig. 2 P_{cc} for the **BPSK** hypothesis for a **2**×**2** antenna configuration

Major results (Cont'd)

- Classification curves for **BPSK** and **8PSK** modulation hypotheses for a 4×4 antenna configuration

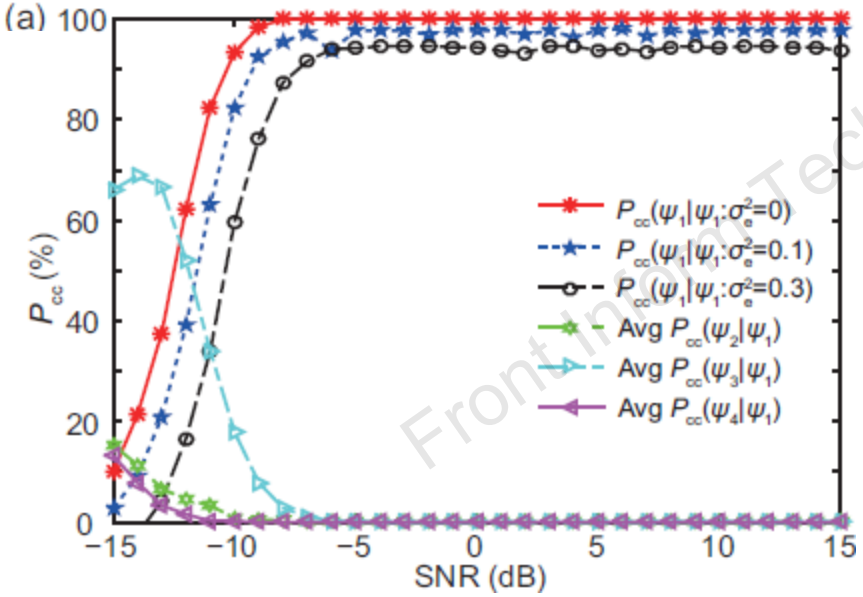

Fig. 3 P_{cc} for the **BPSK** hypothesis for a **4×4** antenna configuration

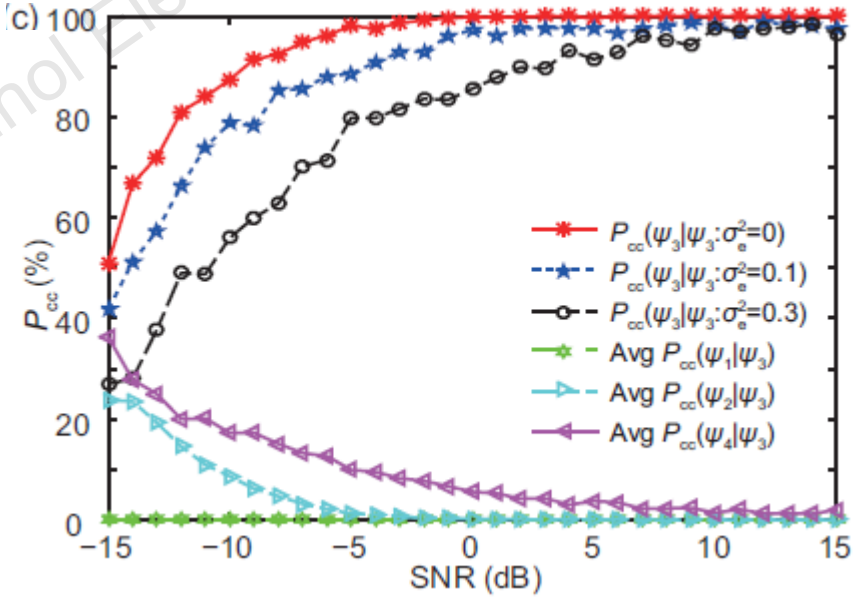

Fig. 4 P_{cc} for the **8PSK** hypothesis for a **4×4** antenna configuration

Conclusions

- A simple methodology is proposed to tackle the problems of AMC in STBC-MIMO systems, using the zero-forcing equalization technique to modify the typical ALRT function.
- It provides a less complex max-likelihood solution for AMC in STBC-MIMO systems.
- Simulation results reveal that better classification accuracy can be achieved even for higher channel estimation errors using zero-force equalization.
- Using deep learning to tackle the similar problem could be an interesting avenue for future research.