

Orthogonal Space-Time Block Coding for V2V LOS Links with Ground Reflections

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Abstract—This work presents a capacity analysis of space-time block codes (STBC) for vehicle-to-vehicle (V2V) communication in modified line-of-sight (LOS) scenarios. The aim is to assess how performance of the V2V LOS channel is influenced by ground reflections. STBCs of various coding rates are evaluated using antenna elements distributed over the surface of two contiguous vehicles. A multi-ray tracing tool is used to model the multiple constructive/destructive interference patterns of the transmitted/received signals by all pairs of Tx/Rx antenna links. The results show that STBCs are capable of counteracting the fades produced by the destructive self-interference components across a range of inter-vehicle distances. Notably, the effectiveness of STBCs in deep fades is shown to outperform schemes with exclusive receive diversity. Higher-order STBCs with rate losses are also evaluated, showing interesting gains even for low coding rate performance, particularly, when accompanied by a multiple antenna receiver. Overall, these results can shed light on how to exploit transmit diversity in slow fading vehicular channels.

Index Terms—LOS, MIMO, STBC, Two-ray model, V2V.

I. INTRODUCTION

Vehicle-to-vehicle (V2V) communication is a promising yet challenging aspect of vehicular networks and Intelligent Transportation Systems (ITS) [1]. V2V communication performance is crucial for several safety-critical vehicular applications, e.g., platooning [2], which rely on vehicles networking capabilities to improve transportation efficiency and road safety.

Multiple-input and multiple-output (MIMO) antenna systems are one of the prospective upgrades to be implemented

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in future connected vehicles [3] (including platoons), aiming at improving channel capacity and reliability with minimum spectrum efficiency losses. MIMO theory and its applications is a well-known subject in wireless communication [4], offering vast practical and theoretical knowledge with proven success in the vehicular realm.

Space-time block codes (STBC) are a classical approach to achieve transmit diversity in MIMO systems. STBCs started with the pioneering work of Alamouti in [5] who proposed an effective and low-complex pre-coding/decoding scheme over space-time dimensions. The work paved the way for several other coding techniques achieving diversity at the transmitter side. Notably, achieving results equivalent to a maximum-ratio combining (MRC) receiver [6]. While the advantages of STBCs in conventional stochastic fading channels remains well understood, its potential to counteract deterministic fading due to ground reflections has not been fully exploited for vehicular applications with time-invariant channels.

In this work, we investigate the performance of STBCs in V2V MIMO LOS links scenarios with steady traffic (see e.g. [7], [8] for further motivations), or scenarios with reduced stochastic scattering, i.e., characterized by a time-invariant LOS channel, but also highly influenced by (deterministic) ground signal reflections. This is unlike the more typical approach to counteract stochastic fading in scenarios with scattering prevalence (see e.g. [9]). The deterministic analysis is built upon our prior work in [10] where we established the V2V channel model to account for self-interference patterns that appear when using multiple antennas with ground reflections. Specifically, STBCs of various coding rates are evaluated across a range of inter-vehicle distances. Interestingly, the capacity results reveal gains that outperform schemes of exclusive receive diversity. These results suggest STBCs can be used as a valid option to mitigate deterministic fades in V2V MIMO LOS channels showing slow or time-invariant statistics.

II. RELATED WORK & MOTIVATION

MIMO technology lies at the core of improved connectivity towards the next generation of wireless communication systems [11]. STBCs are a simple but rather powerful MIMO solutions with a still unexplored performance in vehicular

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