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Optimal precoding for full-duplex base stations under strongly correlated self-interference channels

Key words: Linear precoding; Full-duplex; Achievable rate region; Strongly correlated self-interference channel

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Motivation

- Full-duplex (FD) radios, which simultaneously transmit and receive on the same frequency, can potentially double the spectral efficiency compared with the conventional half-duplex (HD) ones.
- However, severe self-interference (SI) between the transmit (Tx) and receive (Rx) antennas at the FD radio is difficult to be completely removed by the existing SI cancellation methods.
- In the presence of residual SI, linear precoding was studied for the FD cellular systems, to balance the SI suppression and the data transmissions for both the uplink (UL) and downlink (DL) channels.

Motivation

- The existing research on precoding design for the FD cellular system focuses mainly on the general SI channel case, which leads to non-convex optimization problems, and the obtained precoding schemes achieve only sub-optimal performance.
- Given a specific antenna placement, the correlations between the MIMO SI channels can be deduced at the beginning, and used as prior knowledge to design a more efficient precoding scheme.

Main idea

- As a commonly existed scenario in short-range communications, we consider the case that the SI channel is strongly correlated, i.e., the SI channel matrix is of rank one.
- By exploiting the rank-one property of the SI channel matrix, the non-convex optimization problem under the general SI channel case is transformed into convex optimization problem to obtain the optimal precoding scheme.

Method

1. First, the DL rate maximization problem subject to a targeted UL rate is formulated as a non-convex optimization problem to characterize the achievable rate region for the considered system.
2. In the considered scenario of the rank-one SI channel matrix, the above optimization problem is transformed into a convex problem, which can be solved by standard convex optimization tools.
3. Moreover, the proposed scheme is applied to the general SI channel case with proper approximation to the SI channel.

Major results

- Sum rates evaluated by the scheme in Nguyen et al. (2013) are equal to the global maximums evaluated by the proposed scheme under two different random strongly correlated SI channel realizations.

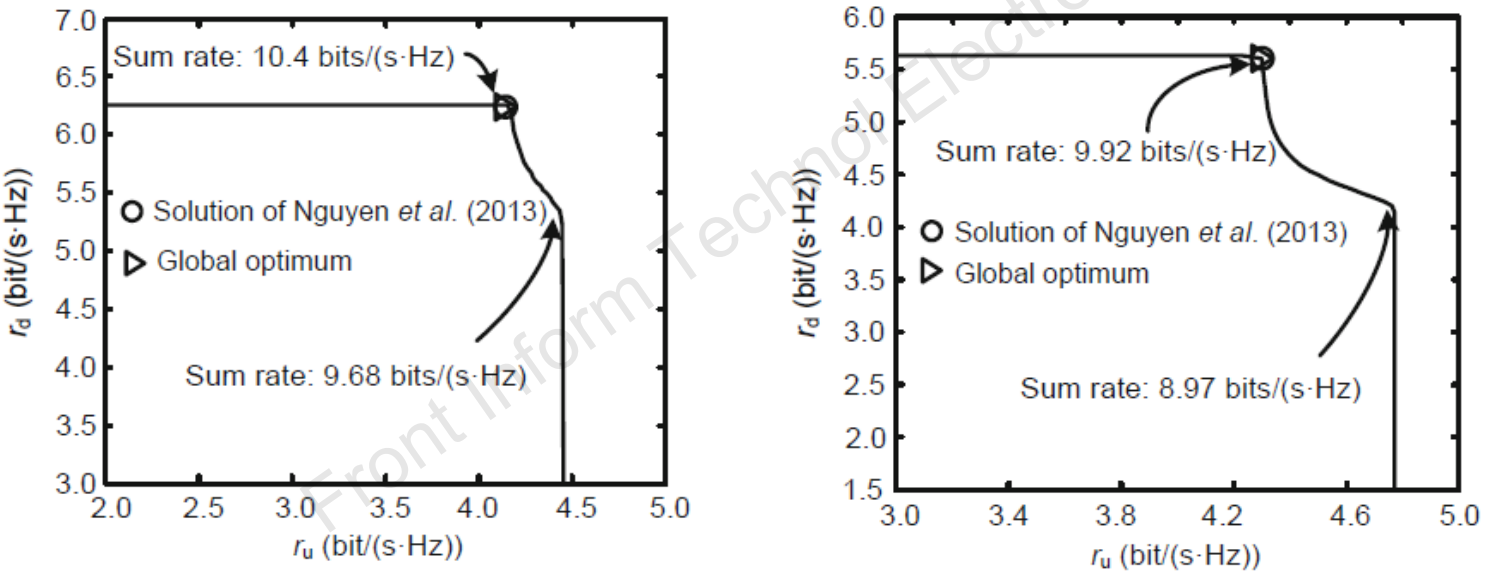

Fig. 3 Achievable rate regions calculated by using the proposed scheme, compared with the rate pairs evaluated by the scheme in Nguyen et al. (2013) under two different random strongly correlated SI channel realizations, where the sum rates evaluated by the scheme in Nguyen et al. (2013) are the optima

Major results

- Sum rates evaluated by the scheme in Nguyen et al. (2013) are just local maximums respectively, with 1.35 bits/(s·Hz) and 0.36 bits/(s·Hz) lower than the global maximums under another two different random strongly correlated SI channel realizations.

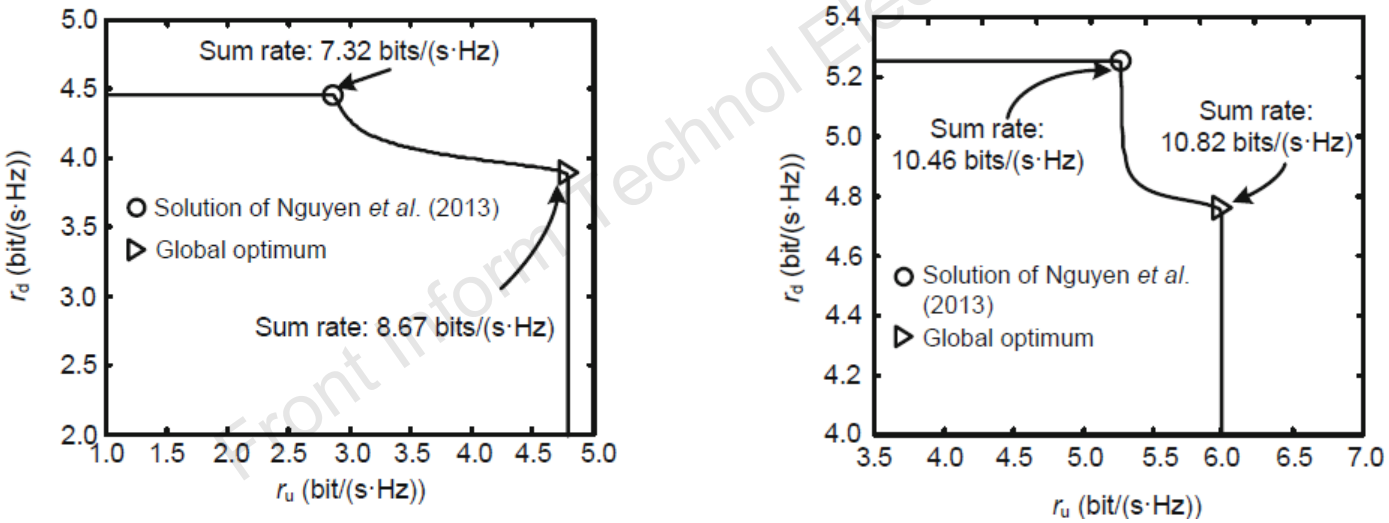

Fig. 4 Achievable rate regions calculated by using the proposed scheme, compared with the rate pairs evaluated by the scheme in Nguyen et al. (2013) under two different random strongly correlated SI channel realizations, where the sum rates evaluated by the scheme in Nguyen et al. (2013) are not the optima

Conclusions

- The downlink transmission rate maximization problem subject to a targeted uplink rate is formulated as a non-convex optimization problem to characterize the achievable rate region for the FD system.
- Considering the case that the SI channel is strongly correlated, the above problem is transformed into a convex problem by exploiting the rank-one property of the SI channel, which can be solved efficiently.
- Numerical results demonstrated that, compared to the precoding design in Nguyen et al. (2013), which offered a sub-optimal solution, the proposed scheme achieved the optimal performance.