University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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"Channel Estimation and Channel Prediction for Wireless Communication Systems"

Department of Electrical and Computer Engineering

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Engineering and Computer Science Building
Room 468

Supervisory Committee:
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Abstract

In this dissertation, channel estimation and channel prediction are studied for wireless communication systems. Wireless communication for time-variant channels becomes more important by the fast development of intelligent transportation systems which motivates us to propose a reduced rank channel estimator for time-variant frequency-selective high speed railway (HSR) systems and a reduced rank channel predictor for fast time-variant at fading channels. Moreover, the potential availability of large bandwidth channels at mm-wave frequencies and the small wavelength of the mm-waves, offer the mm-wave massive multiple-input multiple-output (MIMO) communication as a promising technology for 5G cellular networks. The high fabrication cost and power consumption of the radio frequency (RF) units at mm-wave frequencies motivates us to propose a low-power hybrid channel estimator for mmwave MIMO orthogonal frequency-division multiplexing (OFDM) systems.

The work on HSR channel estimation takes advantage of the channel's restriction to low dimensional subspaces due to the time, frequency and spatial correlation of the channel and presents a low complexity linear minimum mean square error (LMMSE) estimator for MIMO-OFDM HSR channels. The channel estimator utilizes a four dimensional (4D) basis expansion channel model obtained from band-limited generalized discrete prolate spheroidal (GDPS) sequences. The proposed channel estimator outperforms the conventional interpolation based least square (LS) and MMSE estimators since it properly exploits the channel's band-limitation property. Simulation results demonstrate the robust performance of the proposed estimator for different delay, Doppler and angular spreads.

Channel state information (CSI) is required at the transmitter for improving the performance gain of the spatial multiplexing MIMO systems through linear precoding. In order to avoid the high data rate feedback lines, which are required in fast time-variant channels for updating the transmitter with the rapidly changing CSI, a subframe-wise channel tracking scheme is presented. The proposed channel predictor is based on an assumed DPS basis expansion model (DPS-BEM) for exploiting the variation of the channel coefficients inside each sub-frame and an auto regressive (AR) model of the basis coefficients over each transmitted frame. The proposed predictor properly exploits the channel's restriction to low dimensional subspaces for reducing the prediction error and the computational complexity. Simulation results demonstrate that the proposed channel predictor out-preforms the DPS based minimum energy (ME) predictor for different ranges of normalized Doppler frequencies and

has better performance than the conventional Wiener predictor for slower time-variant channels and almost the similar performance to it for very fast time-variant channels with reduced amount of computational complexity.

The work on the hybrid mm-wave channel estimator considers the sparse nature of the mm-wave channel in angular domain and leverages the compressed sensing (CS) tools for recovering the angular support of the MIMO-OFDM mm-wave channel. The angular channel is treated in a continuous framework which resolves the limited angular resolution of the discrete sparse channel models used in the previous CS based channel estimators. The power leakage problem is also addressed by modelling the continuous angular channel as a multi-band signal with the bandwidth of each subband being proportional to the amount of power leakage. The RF combiner is designed to be implemented using a network of low-power switches for antenna subset selection based on a multi-coset sampling pattern. Simulation results validate the effectiveness of the proposed hybrid channel estimator both in terms of the estimation accuracy and the RF power consumption.