Electrical Engineering Seminar Series &
Dallas Chapter of IEEE Signal Processing Society Present

Indefinite Quadratic Forms in Gaussian Random Variables: Distribution, Scaling, and Application to the Broadcast Channel

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Many applications in statistics, signal processing, and communications deal with quadratic forms in Gaussian random variables. In this talk, we study the distribution and scaling of quadratic forms in Gaussian random variables and apply that to study the scaling of broadcast channels. In the first part of the talk, we show how to use complex integration to derive the distribution of an arbitrary indefinite quadratic form of Gaussian variables. For zero mean circularly symmetric Gaussian variables, the distribution is obtained in closed form. When the variables are real and/or nonzero mean, the distribution can be expressed as a 1-dimensional integral. Our approach can be naturally extended to obtain the joint distribution of two or more indefinite quadratic forms. In the second part of the talk, we use some of the results of the first part to study the effect of spatial correlation between transmit antennas on the sum-rate capacity of the MIMO broadcast channel (i.e., downlink of a cellular system). Specifically, for a system with a large number of users n, we analyze the scaling laws of the sum-rate for the dirty paper coding (DPC) and for different types of beamforming transmission schemes. When the channel is i.i.d., it has been shown that for large number of users n, the sum rate is equal to M*loglog(n) + M*log SNR where M is the number of transmit antennas. When the channel exhibits some spatial correlation with a covariance matrix R, we show that this results in an SNR hit that depends on 1) the multiuser broadcast technique and 2) on the eigenvalues of the correlation matrix R. We quantify this hit for DPC and various beamforming techniques. We briefly discuss precoding techniques for reducing the hit on RBF in the presence of correlation. Part of this work was done jointly with Prof. Masoud Sharif (Boston University) and Prof. Babak Hassibi (California Institute of Technology).

Dr. Tareq Al-Naffouri obtained his PhD in Electrical Engineering in 2004 from Stanford University. In 2005, he was a visiting researcher in the Electrical Engineering Department at California Institute of Technology. In September 2005, he joined the Electrical Engineering Department at King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, as an assistant professor. Since Feb. of this year, he has been with the Electrical Engineering Department at the University of Southern California (USC) as a Fulbright Scholar. Dr. Al-Naffouri's research interests are in adaptive and statistical signal processing and their application to wireless communications and in multiuser wireless networks. His research on adaptive signal processing won the best student paper award. He has held internship and research positions in NEC, Tokyo, National Semiconductors, Santa Clara, CA, Beceem Communications, Santa Clara, CA, the University of California at Los Angeles, and California Institute of Technology. More information about the speaker available at http://faculty.kfupm.edu.sa/EE/naffouri/.

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