Random Matrix Theory for Wireless Communications

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Description

The asymptotic behaviour of the eigenvalues of large random matrices has been extensively studied since the fifties. One of the first related result was the work of Eug`ene Wigner in 1955 who remarked that the eigenvalue distribution of a standard Gaussian hermitian matrix converges to a deterministic probability distribution called the semi-circular law when the dimensions of the matrix converge to +1. Since that time, the study of the eigenvalue distribution of random matrices has triggered numerous works, in the theoretical physics as well as probability theory communities. However, as far as communications systems are concerned, until the mid 90's, intensive simulations were thought to be the only technique to get some insight on how communications behave with many parameters. All this changed in 1997 when large system analysis based on random matrix theory was discovered as an appropriate tool to gain intuitive insight into communication systems. In particular, the self-averaging effect of random matrices was shown to be able to capture the parameters of interest of communication schemes. The results led to very active research in many fields such as, just to name a few:

1- MIMO Broadcast systems with a large large number of users
2- MIMO (and Network MIMO) systems with a large number of users
3- Design of multi-stage detectors
4- Cognitive Radio
5- Dense networks (Massive MIMO and Small Cells)

Objective

The course is intended to give a comprehensive overview of random matrices and their application to the analysis and design of communication systems (LTE, Cognitive networks). As communication systems become more and more complex, the course should provide the students/researchers with appropriate mathematical tools to cope with the analysis and design of suited schemes

Programme

Day 1:
Overview and Historical development.
Basic Results on Random Matrix Theory.
Some Results on deterministic matrices.
Stieltjes Transform Method.

Day 2:
The moments approach Method.
The role of the Cauchy-Stieltjes transform in communications.
Applications to MIMO LTE systems

Day 3:
Applications to cognitive radio systems
Applications to advanced receiver design

Instructor

Prof. Mérouane Debbah entered the Ecole Normale Sup´erieure de Cachan (France) in 1996 where he received his M.Sc and Ph.D. degrees respectively. He worked for Motorola Labs (Saclay, France) from 1999-2002 and the Vienna Research Center for Telecommunications (Vienna, Austria) until 2003. He then joined the Mobile Communications department of the Institut Eurecom (Sophia Antipolis, France) as an Assistant Professor until 2007. He is now a Full Professor at Supelec (Gif-sur-Yvette, France), holder of the Alcatel-Lucent Chair on Flexible Radio and a recipient of the ERC starting grant MORE (Advanced Mathematical Tools for Complex Network Engineering). His research interests are in information theory, signal processing and wireless communications.
He is a senior area editor for IEEE Transactions on Signal Processing. M´erouane Debbah is the recipient of the ”Mario Boella” award in 2005, the 2007 General Symposium IEEE GLOBECOM best paper award, the Wi-Opt 2009 best paper award, the 2010 Newcom++ best paper award as well as the Valuetools 2007, Valuetools 2008, Valuetools 2012 and CrownCom2009 best student paper awards. He is a WWRF fellow. In 2011, he received the IEEE Glavieux Prize Award.

Literature

The course will be based on the following book:
R. Couillet, M. Debbah, ”Random Matrix Theory Methods for Wireless Communications”, Cambridge University Press, to appear, 2010