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Stochastic Geometry and Random Graphs in Wireless Networks

25 February - 1 March, 2013

Dates and Venues

25-26 February IT 134
27-28 February IT 105
1 March IT 106

Brief outline of the course

Section		Topic	Presentation Time (h)
Mathematical Background	Stochastic Geometry [1-3]	Intro. to Measure Theory	2
		Point Process	6
		Voronoi Tessellation	1
	Random Graphs [4]	Non-Geometric Random Graphs	3
		Geometric Random Graphs	5
Applications	Classical Results	Interference in Wireless Networks	2
		Capacity of Wireless Networks	3
		Random Walk in Random Graphs (Rumor Spreading)	1
		Percolation Theory-Connectivity	1
		Cellular Communication	1
		Routing in Ad-hoc Networks	1
	Our Works	One-Hop Flooding	2

Abstract

Stochastic Geometry and Random Graphs

Goal: The goal of this course is to provide an introduction to the framework of stochastic geometry which is an essential tool in analyzing random processes that are based on discrete events in time or space. Handling such random phenomena, especially in spatial domain, is not trivial, and therefore, most work that deals with such models is generally based on simulation studies. In this course, we will introduce the proper framework and mathematical tools through which such random distributions can be analyzed and results can be derived for many practical scenarios of interest in analytic terms. Stochastic geometry has found wide range of applications in areas such as astrology, forestry, and material science. However, our key focus in this course is application of such framework to wireless networks. As nodes are generally distributed randomly in space, spatial random models play a key role in viewing wireless networks from an analytic perspective. Another area of research that we will cover in this course, and is closely related to stochastic geometry, is the area of geometric random graphs. In this course, we will view random graphs from a more general perspective and introduce the key concepts of non-geometric random graphs as well. Such networks have recently become of key interest in analysis of more general networks, such as social and biological networks. Examples from such networks are also provided in this course.

Course Organization: This course is organized in two parts. In the first part, we will cover the required mathematical concepts. We will start from concepts such as measure theory and point processes that provide the theoretical basis for stochastic geometry. We will then introduce geometric and non-geometric random graphs and the key concepts of degree distribution, branching process, **Erdős–Rényi** graphs, and Boolean and Nearest Neighbor graphs. In the second part of the course, we will provide key applications of the developed theory in wireless networks. Topics such as interference, network capacity, connectivity, percolation, cellular modeling, and routing in ad-hoc networks are covered. We will also give examples from our own research work in analysis of one-hop networks and flooding in wireless networks. Open research topics and future directions in this field are discussed at the end.

References

[1] M. Adams, V. Guillemin, “Measure Theory and Probability”, The Wadsworth & Brooks/Cole Mathematics Series, 1986.

[2] A. Baddeley, “Spatial point processes and their applications” Lecture Notes in Mathematics 1892, Page(s): 1-75 Springer, 2006.

[3] Francois Baccelli, Bartlomiej Blaszczyszyn, Stochastic Geometry and Wireless Networks, Part I: Theory Foundations and Trends in Networking, Now Publishers Inc., 2009.

[4] Massimo Franceschetti, Ronald Meester, Random Networks for Communication, Cambridge Series in Statistical and Probabilistic Mathematics, 2007.

Biography

Babak Hossein Khalaj received his MSc. and Ph.D. degrees in Electrical Engineering from Stanford University, Stanford, CA, in 1992 and 1995, respectively. In 1995, he joined KLA-Tencor, San Jose, CA, as a Senior Algorithm Designer, working on advanced processing techniques for signal estimation. From 1996 to 1999, he was a Senior Design Engineer with Advanced Fiber Communications and Ikanos Communications, Mountain View, CA, working on latest generation VDSL systems. From 1998 to 1999, he was the Coeditor of the Special Compatibility Standard Draft for the ANSI-T1E1 Group. From 2006 to 2007, he was a Visiting Professor with the Centro de Estudios e Investigaciones Técnicas de Gipuzkoa (CEIT), San Sebastian, Spain. He is the author of many papers in signal processing and wireless communications and has been a member of technical programm committee of many IEEE conferences. He is the holder of two U.S. patents and was the recipient of the Alexander von Humboldt Fellowship during 2007–2008. His current areas of research are cooperative and cognitive networks, mathematical analysis of wireless networks, and applications of game theory and incentive mechanisms in communication networks.