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Autoregressive Moving Average Graph Filters

Geert Leus
Delft University of Technology

Abstract:
One of the cornerstones of the field of graph signal processing are graph filters, direct analogues of time-domain filters, but intended for signals defined on graphs. In this talk, we will give an overview of the graph filtering problem. More specifically, we look at the family of autoregressive moving average (ARMA) graph filters, for which finite impulse response (FIR) graph filters yield a special case. ARMA graph filters (i) can approximate any desired graph frequency response with low filter orders, (ii) give exact solutions for tasks such as graph signal denoising and interpolation, and (iii) are suitable for time-varying settings, which occur when the graph signal and/or the graph topology are changing in time. Related to the latter aspect, we will also study the stochastic setting in this talk, where the graph signal and/or the graph topology are randomly time-varying and filtering in the mean is considered. Numerical results will accompany the theoretical results, showing that ARMA graph filters are practically appealing for static, time-varying, and stochastic settings.

Bio:
Geert Leus received the MSc and PhD degree in Electrical Engineering from the KU Leuven, Belgium, in June 1996 and May 2000, respectively. Currently, Geert Leus is an "Antoni van Leeuwenhoek" Full Professor at the Faculty of Electrical Engineering, Mathematics and Computer Science of the Delft University of Technology, The Netherlands. His research interests are in the area of signal processing for communications, array processing and networking. Geert Leus received a 2002 IEEE Signal Processing Society Young Author Best Paper Award and a 2005 IEEE Signal Processing Society Best Paper Award. He is a Fellow of the IEEE and a Fellow of EURASIP. Geert Leus was the Chair of the IEEE Signal Processing for Communications and Networking Technical Committee, a Member-at-Large to the Board of Governors of the IEEE Signal Processing Society, and an Associate Editor for the IEEE Transactions on Signal Processing, the IEEE Transactions on Wireless Communications, the IEEE Signal Processing Letters, and the EURASIP Journal on Advances in Signal Processing. Currently, he is a member of the IEEE Sensor Array and Multichannel Technical Committee and serves as the Editor in Chief of the EURASIP Journal on Advances in Signal Processing.
Learning graphs from data: A graph signal processing perspective

Xiaowen Dong
Massachusetts Institute of Technology

Abstract:
The construction of a meaningful graph topology plays a crucial role in the success of many graph-based representations and algorithms for handling structured data. When a good choice of the graph is not readily available, however, it is often desirable to infer the graph topology from the observed data. In this tutorial, I will first survey classical solutions to the problem of graph learning from a machine learning viewpoint. I will then discuss a series of recent works from the fast-growing field of graph signal processing (GSP) and show how signal processing tools and concepts can be utilized to provide novel solutions to this important problem. Finally, I will end with some of the open questions and challenges that are central to the design of future GSP algorithms for graph learning.

Bio:
Xiaowen Dong is a Postdoctoral Associate in the Human Dynamics Group of the MIT Media Lab. His research focuses on emerging signal processing and machine learning techniques on graphs, and their applications in understanding human behavior, decision making and societal changes. Prior to joining MIT, he received the Ph.D. degree in Signal Processing from the Swiss Federal Institute of Technology (EPFL), and the M.Sc. degree (with Distinction) in Signal Processing and Communications from The University of Edinburgh.
Abstract:
With the advent of 3D sensing technologies, we can now represent objects and surrounding environments by 3D point clouds---collections of large numbers of 3D points on an object's surface measured by a sensing device. 3D point cloud is becoming an important type of geometric data structure and is widely used in a number of applications, including virtual reality, high-precision mapping, scanning of historical artifacts, 3D printing and digital elevation modeling, among others. In this talk, I will present a brief overview of some common tasks and techniques to process 3D point clouds, including denoising, inpainting, registration, compression, editing, segmentation and recognition. I will also talk about recent progress from a perspective of graph signal processing, including recovery of 3D point clouds, compression of dynamic 3D point clouds and resampling of large-scale 3D point clouds. Finally, I will point out some future directions.

Bio:
Siheng Chen is a postdoctoral research associate in the Department of Electrical and Computer Engineering at Carnegie Mellon University. He received his B. Eng degree in Optoelectronics Engineering in 2011 from Beijing Institute of Technology, the M.S degrees in Electrical and Computer Engineering and Machine learning in 2012 and 2016, respectively, and the Ph.D degree in Electrical and Computer Engineering in 2016 from Carnegie Mellon University. His research interests include signal processing, machine learning and data mining.
Stationary graph signals

Santiago Segarra
Massachusetts Institute of Technology

Abstract:
Stationarity is a cornerstone property that facilitates the analysis and processing of random signals in the time domain. Although time-varying signals are abundant in nature, in many practical scenarios the information of interest resides in more irregular graph domains. In this talk, we overview recent advances in extending the notion of stationarity to graph processes. This is a challenging task due to the irregularity of the underlying graph domain. Firstly, coexisting stationarity definitions are presented along with explanations of their genesis, advantages, and disadvantages. Secondly, we introduce the concept of power spectral density for graph processes and propose a number of methods to estimate it. These methods include nonparametric approaches such as correlograms and window-based average periodograms, as well as parametric approaches. Finally, we illustrate our covariance and power spectral density estimation schemes in synthetic and real-world graphs.

Bio:
Santiago Segarra received the B.Sc. degree in industrial engineering with highest honors (Valedictorian) from the Instituto Tecnológico de Buenos Aires (ITBA), Argentina, in 2011, the M.Sc. in electrical engineering from the University of Pennsylvania (Penn), Philadelphia, in 2014 and the Ph.D. degree in electrical and systems engineering from Penn in 2016. Since September 2016, he has been working as a postdoctoral research associate with the Institute for Data, Systems, and Society at the Massachusetts Institute of Technology. His research interests include network theory, data analysis, machine learning, and graph signal processing. Dr. Segarra received the ITBA's 2011 Best Undergraduate Thesis Award in industrial engineering, the 2011 Outstanding Graduate Award granted by the National Academy of Engineering of Argentina, the Best Student Paper Awards at the 2015 Asilomar Conference and the 2016 IEEE Statistical Signal Processing Workshop, and the Best Paper Award at the 2016 IEEE Sensor Array and Multichannel Signal Processing Workshop.
Graph wavelets and filter banks: Designs in graph spectral domain

Yuichi Tanaka
Tokyo University of Agriculture and Technology

Abstract:
Graph signal processing (GSP) integrates (spectral) graph theory with signal processing, and it can be viewed as a generalization of the existing signal processing framework for irregularly-structured high-dimensional data. As in classical signal processing, graph wavelets and filter banks are a fundamental building block of GSP and they have been studied extensively to realize multiscale (multiresolution / multirate) GSP algorithms. In this talk, I will introduce recent approaches for designs of graph wavelets and filter banks, especially in the graph spectral domain. I will also discuss recent open questions and challenges related to the topic.

Bio:
Yuichi Tanaka received the B.E., M.E. and Ph.D. degrees in electrical engineering from Keio University, Yokohama, Japan, in 2003, 2005 and 2007, respectively. He was a Postdoctoral Scholar at Keio University, Yokohama, Japan, from 2007 to 2008, and supported by the Japan Society for the Promotion of Science (JSPS). From 2006 to 2008, he was also a visiting scholar at the University of California, San Diego. From 2008 to 2012, he was an Assistant Professor in the Department of Information Science, Utsunomiya University, Tochigi, Japan. Since 2012, he has been an Associate Professor in Graduate School of BASE, Tokyo University of Agriculture and Technology, Tokyo, Japan. Currently he has a cross appointment as a PRESTO Researcher, Japan Science and Technology Agency. His current research interests are in the field of multidimensional signal processing which includes: graph signal processing, image and video processing with computer vision techniques, distributed video coding, objective quality metric, and effective spatial-frequency transform design.

Dr. Tanaka has been an Associate Editor of IEEE Transactions on Signal Processing since 2016 and also IEICE Transactions on Fundamentals since 2013. Currently he is an elected member of the APSIPA Image, Video and Multimedia Technical Committee. He was a recipient of the Yasujiro Niwa Outstanding Paper Award in 2010, the TELECOM System Technology Award in 2011, and Ando Incentive Prize for the Study of Electronics in 2015. He also received IEEE Signal Processing Society Japan Best Paper Award in 2016 and Best Paper Awards in APSIPA ASC 2014 and 2015.
**Geometric Deep Learning for data-driven Graph Representations**

Joan Bruna  
Courant Institute, NYU

**Abstract:**  
Deep Learning, thanks mostly to Convolutional architectures, have recently transformed computer vision and speech recognition. Their ability to encode geometric stability priors, while offering enough expressive power, is at the core of their success. In such settings, geometric stability is expressed in terms of local deformations, and it is enforced thanks to localized convolutional operators that break the estimation across scales. However, many problems across applied sciences, from particle physics to recommender systems, are formulated in terms of signals defined over non-Euclidean geometries, and also come with strong geometric stability priors. In this talk, we will present an overview of techniques that exploit geometric stability in general geometries with appropriate neural network architectures. We will show that these techniques can all be framed in terms of local graph generators such as the graph Laplacian. We will present some stability certificates, as well as applications to computer graphics, particle physics and graph community detection.

**Bio:**  
Joan Bruna graduated from Universitat Politecnica de Catalunya (Barcelona, Spain) in both Mathematics and Electrical Engineering. He obtained an M.Sc. in applied mathematics from ENS Cachan (France). He then became a research engineer in an image processing startup, developing realtime video processing algorithms. He obtained his PhD in Applied Mathematics at Ecole Polytechnique (France). He was a postdoctoral researcher at the Courant Institute, NYU, New York, and a postdoctoral fellow at Facebook AI Research. In 2015, he became Assistant Professor at UC Berkeley, Statistics Department, and starting Fall 2016 he joined the Courant Institute (NYU, New York) as Assistant Professor in Computer Science, Data Science and Mathematics (affiliated). His research interests include invariant Signal representations, high-dimensional statistics and Stochastic processes, Deep Learning, and its applications to signal processing.
Stochastic Graph Processes

June Zhang
University of Hawai‘i at Mānoa

Abstract:
Graph signal processing has focused primarily on static signals on graph structures. There have been some works recently on deterministic (linear) models of signal propagation on graphs. Noise models used in graph signal processing have largely been independent Gaussian. In this talk, we present a stochastic (non-Gaussian) graph process on arbitrary, finite-sized graph intended as a model for the spread of contagion in a networked population. The scaled SIS process deviates from classical epidemics model by assuming exponential, rather than linear, dependence on the state of neighboring nodes. This modification, however, allows us to compute the equilibrium distribution of the process in closed-form, showing a relationship between the well-known Ising distribution from statistical mechanics and reversible Markov process. Analysis (when possible) of the distribution shows the effect of dynamics parameter and the graph structure on the equilibrium behavior. Transient behavior analysis of the scaled SIS process remains an open question.

Bio:
June Zhang is an assistant professor at the University of Hawai‘i at Mānoa in the Department of Electrical Engineering. She received her B.S. with Highest Honor in Electrical and Computer Engineering from the Georgia Institute of Technology and M.S. in Electrical and Computer Engineering from Stanford University. She received a Ph.D. in Electrical and Computer Engineering from Carnegie Mellon University in December 2015. She was a recipient of the Georgia Hope Scholarship, the National Science Foundation Graduate Research Fellowship, and the Microsoft Azure Research Award from 2015-2016, and was an ORISE Fellow in the Viral Hepatitis Lab at the Centers for Disease Control and Prevention (CDC) from 2016-2017. Her interests are network science, graph signal processing, stochastic processes, data science, bioinformatics, and human-computer interaction.