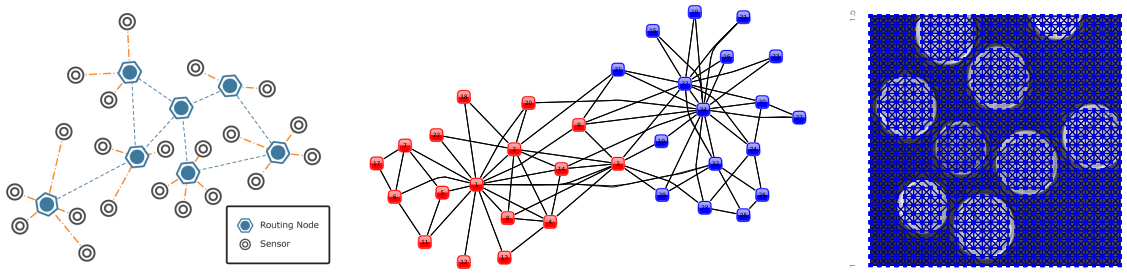
EE599 Graph Signal Processing (3 units)

Course Syllabus

Term: Fall 2015.

Course Title: EE599 Graph Signal Processing

Background: Graphs have long been used in a wide variety of problems, such analysis of social networks, machine learning, network protocol optimization, decoding of LDPCs or image processing. Techniques based on spectral graph theory provide a "frequency" interpretation of graph data and have proven to be quite popular in many of these applications. In the last few years, a growing amount of work has started extending and complementing spectral graph techniques, leading to the emergence of "Graph Signal Processing" as a broad research field. A common characteristic of this recent work is that it considers the data attached to the vertices as a "graph-signal" and seeks to create new techniques (filtering, sampling, interpolation), similar to those commonly used in conventional signal processing (for audio, images or video), so that they can be applied to these graph signals.



Goals: In this class we provide an overview of this emerging area. The course is aimed at graduate students who have already completed basic coursework in the general areas of signal processing, communications and controls. We start with a review of core concepts, including a review of relevant linear algebra and signal processing concepts. This will be followed by a discussion of advanced topics, focusing on how well established concepts in signal processing are being extended to graph signals (most of this work has taken place in the last 10 years). Finally, we will study specific applications of graph signal processing methods.

Instructor:

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Lecture: Tuesday and Thursday, 11:00-12:20pm

Office Hours: TBD.

Grading: Participation in class discussions (10%), Homework (10%), Midterm (40%), Project (40%).

Pre-requisites: **EE 483, EE 441**

Textbook: No required textbook. The reference material will include textbooks as well as a number of recent articles (see below for a partial list). Class notes will be distributed.

Tentative Schedule:

Week 1	Introduction – Why Graph Signal Processing: concepts, applications and challenges
Week 2	Introduction to graph concepts – Linear algebra review
Week 3	Spectral graph theory – Orthogonal transforms review
Week 4	Frequency interpretation – Nodal Theorems
Week 5	Graph filtering – Vertex and Spectral interpretations
Week 6	Advanced Topic 1: Shift invariance, localization and uncertainty principles
Week 7	Advanced Topic 2: Downsampling
Week 8	Advanced Topic 3: Wavelets
Week 9	Advanced Topic 4: Multiresolution and graph approximation
Week 10	Advanced Topic 5: Directed Graphs — **Midterm**
Week 11	Application 1: Image Processing
Week 12	Application 2: Sensor Networks
Week 13	Application 3: Machine Learning
Week 14	Application 4: Finite State Machines
Week 15	**Project Discussions and Presentations**

References

[1] Fan RK Chung. *Spectral graph theory*, volume 92. AMS Bookstore, 1997.

[2] Dragoš M Cvetković, Peter Rowlinson, and Slobodan Simić. *An introduction to the theory of graph spectra*. Cambridge University Press Cambridge, 2010.

[3] David K Hammond, Pierre Vandergheynst, and Rémi Gribonval. Wavelets on graphs via spectral graph theory. *Applied and Computational Harmonic Analysis*, 30(2):129–150, 2011.

[4] Peyman Milanfar. A tour of modern image filtering: new insights and methods, both practical and theoretical. *Signal Processing Magazine, IEEE*, 30(1):106–128, 2013.

[5] Sunil K Narang and Antonio Ortega. Perfect reconstruction two-channel wavelet filter banks for graph structured data. *Signal Processing, IEEE Transactions on*, 60(6):2786–2799, 2012.

[6] Aliaksei Sandryhaila and Jose MF Moura. Discrete signal processing on graphs. *IEEE transactions on signal processing*, 61(5-8):1644–1656, 2013.

[7] David I Shuman, Sunil K Narang, Pascal Frossard, Antonio Ortega, and Pierre Vandergheynst. The emerging field of signal processing on graphs: Extending high-dimensional data analysis to networks and other irregular domains. *Signal Processing Magazine, IEEE*, 30(3):83–98, 2013.

[8] Daniel Spielman. Spectral graph theory. *Lecture Notes, Yale University*, 2009.

Statement for Students with Disabilities:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible.

DSP is located in STU 301 and is open 8:30 A.M.-5:00 P.M., Monday through Friday. Website and contact information for DSP:
`http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html`,
(213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX), ability@usc.edu (email).

Statement on Academic Integrity: USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect ones own academic work from misuse by others as well as to avoid using anothers work as ones own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, (scampus.usc.edu) contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A.

Emergency Preparedness/Course Continuity in a Crisis : In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.