# Tutorial

**Session:**     Tutorial 6
**Time:**        Wednesday December 16, 14:00-17:20
**Place:**       Room Y302

# Graph Signal Processing for Image Compression & Restoration

**Speakers:**     Prof. Gene Cheung, National Institute of Informatics, Tokyo, Japan
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## Abstract

Graph signal processing (GSP) is the study of discrete signals that live on structured data kernels described by graphs. By allowing a more flexible graphical description of the underlying data kernel, GSP can be viewed as a generalization of traditional signal processing techniques that target signals in regular kernels-e.g., an audio clip sampled periodically in time-while still providing a frequency domain interpretation of the observed signals. Though an image is a regularly sampled signal on a 2D grid, one can nonetheless consider an image patch as a graph-signal on a sparsely connected graph defined signal-dependently. Recent GSP works have shown that such approach can lead to a compact signal representation in the graph Fourier domain, resulting in noticeable gain in image compression and restoration. Specifically, in this tutorial we will overview recent advances in GSP as applied to image processing. We will first describe how a Graph Fourier Transform (GFT)-a generalization of known transforms like Discrete Fourier Transform (DFT) and Discrete Cosine Transform (DCT)-can be defined in a signal-dependent manner and leads to compression gain over traditional DCT for piecewise smooth images, outperforming H.264 intra by up to 6.8dB. We will then describe how suitable graph-signal smoothness priors can be constructed for a graph-based image denoising algorithm, outperforming state-of-the-art BM3D by up to 2dB for piecewise smooth images. Similar graph-signal smoothness priors can also be used for other image restoration problems, such as bit-depth enhancement of low-bit-depth images for HDR displays and de-quantization of compressed JPEG images. Finally, we will discuss how the graph Laplacian can be used as a contrast-enhancement booster for images captured in poorly lit environments that are also corrupted with noise.

## Biographies

**Gene Cheung** received the B.S. degree in electrical engineering from Cornell University in 1995, and the M.S. and Ph.D. degrees in electrical engineering and computer science from the University of California, Berkeley, in 1998 and 2000, respectively. He was a senior researcher in Hewlett-Packard Laboratories Japan, Tokyo, from 2000 till 2009. He is now an associate professor in National Institute of Informatics in Tokyo, Japan. He is an adjunct associate professor in the Hong Kong University of Science & Technology (HKUST) (2015-present). His research interests

include image & video representation, immersive visualcommunication and graph signal processing. He has published over 150 international conference and journal publications. He has served as associate editor for IEEE Transactions on Multimedia (2007--2011) and DSP Applications Column in IEEE Signal Processing Magazine (2010--2014). He currently serves as associate editor for APSIPA Journal on Signal & Information Processing (2011--present) and SPIE Journal of Electronic Imaging (2014--present), and as area editor for EURASIP Signal Processing: Image Communication (2011--present). He served as the lead guest editor of the special issue on "Interactive Media Processing for Immersive Communication" in IEEE Journal on Special Topics on Signal Processing, published in March 2015. He served as a member of the Multimedia Signal Processing Technical Committee (MMSP-TC) in IEEE Signal Processing Society (2012-2014), and a member of the Image, Video, and Multidimensional Signal Processing Technical Committee (IVMSP-TC) (2015-2017). He has also served as technical program co-chair of International Packet Video Workshop (PV) 2010 and IEEE International Workshop on Multimedia Signal Processing (MMSP) 2015, area chair in IEEE International Conference on Image Processing (ICIP) 2010, 2012-2013, 2015, track co-chair for Multimedia Signal Processing track in IEEE International Conference on Multimedia and Expo (ICME) 2011, symposium co-chair for CSSMA Symposium in IEEE GLOBECOM 2012, and area chair for ICME 2013-2015. He was invited as plenary speaker for IEEE MMSP 2013 on the topic "3D visual communication: media representation, transport and rendering". He is a co-author of best student paper award in IEEE Workshop on Streaming and Media Communications 2011 (in conjunction with ICME 2011), best paper finalists in ICME 2011, ICIP 2011 and ICME 2015, best paper runner-up award in ICME 2012 and best student paper award in ICIP 2013.

**Xianming Liu** is an Associate Professor with the Department of Computer Science, Harbin Institute of Technology (HIT), Harbin, China. He also works as a project researcher at National Institute of Informatics (NII), Tokyo, Japan. He received the B.S., M.S., and Ph.D degrees in computer science from HIT, in 2006, 2008 and 2012, respectively. In 2007, he joined the Joint Research and Development Lab (JDL), Chinese Academy of Sciences, Beijing, as a research assistant. From 2009 to 2012, he was with National Engineering Lab for Video Technology, Peking University, Beijing, as a research assistant. In 2011, he spent half a year at the Department of Electrical and Computer Engineering, McMaster University, Canada, as a visiting student, where he then worked as a post-doctoral fellow from December 2012 to December 2013. He has published over 30 international conference and journal publications, including top IEEE journals, such as TIP, TCSVT, TIFS; and top conferences, such as CVPR, IJCAI and DCC.