Date: Tuesday, June 30, 2015
Time: 13:30 – 14:30
Venue: Seminar Room C700, Level C, Lab 3
Speaker: **Professor Justin Dauwels**
Affiliation: **Nanyang Technological University, Singapore**

Title: Ultrafast noise-resilient phase reconstruction from intensity images

Abstract:

Quantitative phase imaging has applications in biology and surface metrology, since objects of interest often do not absorb light but cause measurable phase delays. Phase cannot be directly measured by a camera, and so phase objects are invisible in an in focus imaging system because they are transparent. Phase can be recovered from a series of images taken with various complex transfer functions. Methods that use intensity images measured through focus are especially interesting because they have the advantage of a simple experimental setup and wide applicability. The stack of defocused intensity images can be obtained in an imaging system with an axial motion stage, which represents a typical microscope.

We propose a novel low-complexity recursive filter to efficiently recover quantitative phase from a series of noisy intensity images taken through focus. We first transform the wave propagation equation and nonlinear observation model (intensity measurement) into a complex augmented state space model. From the state space model, we derive a sparse augmented complex extended Kalman filter (ACEKF) to infer the complex optical field (amplitude and phase), and find that it converges under mild conditions. The proposed method is efficient, robust and recursive, and may be feasible for real-time phase recovery applications with high resolution images.

We have also extended this method to phase retrieval from a stack of through-focus intensity images taken with a microscope employing partially coherent illumination of any arbitrary source shape (coherence) in Köhler geometry. We recover not only the quantitative phase and amplitude distributions of the sample under partially coherent illumination, but also an estimate of the unknown source shape itself. Our algorithm uses a Kalman filtering approach which is fast, accurate and robust to noise. We validate the method experimentally with a commercial microscope having varying condenser aperture shapes. The method is experimentally simple and the algorithm is general for all wave-field imaging, so should find use in optical, X-ray and other phase imaging systems. This is joint work with Jingshan Zhong, Dr. Lei Tian, and Dr. Laura Waller from UC Berkeley.

Bio:

Justin DAUWELS is an Assistant Professor with School of Electrical & Electronic Engineering at Nanyang Technological University (NTU). He is also the Deputy Director of ST Engineering-NTU Corporate Lab and the Director of Neuroengineering Program at the School of EEE. His research interests are in Bayesian statistics, iterative signal processing, machine learning and computational neuroscience. Prior to joining NTU, Justin was a research scientist during 2008-2010 in the Stochastic Systems Group (SSG) at the Massachusetts Institute of Technology, led by Prof. Alan Willsky. He received postdoctoral training during 2006-2007 under the guidance of Prof. Shun-ichi Amari and Prof. Andrzej Cichocki at the RIKEN Brain Science Institute in Wako-shi, Japan. He obtained his PhD degree in electrical engineering from the Swiss Polytechnical Institute of Technology (ETH) in Zurich in December 2005. The research of his lab has been featured by BBC Click/World News, Singapore Straits Times, national TV, and various other media. Outcomes include real-time algorithms for large-scale urban traffic prediction; real-time algorithms for analysing human social behaviour; real-time noise-resilient algorithms for phase imaging; novel data analytics for biomedical signals; tools for large-scale modelling of extreme events.