Inverse Problems in Imaging

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Timetable: 16 hrs. Class meets every Tuesday and Thursday from 14:30 to 16:30. First lecture on Tuesday, January 12, 2016. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: Basic notions of probability theory, linear algebra, calculus and differential equations, knowledge of computing programming using Matlab.

Examination and grading: A short programming assignment (30% of the final grade) and a final exam (70% of the final grade).

Aim: The course provides an introduction to inverse problems in image processing, such as denoising, deblurring, and blind deconvolution. The main focus is to present analytical and numerical tools for solving inverse problems and to illustrate connections to several other bilinear problems in imaging, such as independent component analysis, dictionary learning/sparse coding, and matrix factorization.

Course contents:

- *The fundamentals of inverse problems:* image formation models, illposedness and ill-conditioning, denoising and deblurring problems, apriori information, regularization techniques, a primer on numerical solvers.
- *The Bayesian formulation and methodologies:* generative models, image priors, inference methods (e.g., Conditional Mean, Maximum a Posteriori)
- *Numerical methods:* a primer on convex optimization, descent algorithms, the Primal-Dual method, Expectation-Maximization, Variational Bayes, Majorization Minimization.
- *Advanced problems and techniques in imaging:* sparsity-based reconstructions, total variation denoising and deblurring, blind deconvolution, relations to other bilinear problems in imaging.

References:

[1] M. Bertero and P. Boccacci, *Introduction to Inverse Problems in Imaging*, Inst. of Physics Publications 1998.
[2] S. Boyd and L. Vandenberghe, *Convex Optimization*, Cambridge University Press 2004.
[3] R. T. Rockafellar, *Convex analysis*, Princeton University Press 1996.
[4] C. M. Bishop, *Pattern Recognition and Machine Learning*, Springer 2012.
[5] A. Chambolle and T. Pock, *A first-order primal-dual algorithm for convex problems with applications to imaging*, J. of Mathematical Imaging and Vision, 40(1), 120-145, 2011.
[6] D. Wipf and H. Zhang, *Revisiting Bayesian Blind Deconvolution*, Energy Minimization Methods in Computer Vision and Pattern Recognition, 40-53, 2013.
[7] T. Chan and C. K. Wong, *Total variation blind deconvolution*, IEEE Transactions on Image Processing, 7(3), 370-375, 1998.
[8] D. Perrone and P. Favaro, *Total variation blind deconvolution: The devil is in the details*, Computer Vision and Pattern Recognition, 2909?2916, 2014.

Presentation material will be provided at the course and will be available on the course website together with additional research articles and books.