Inverse Problems in Imaging (COMP0114)

Description

Aims:
To introduce the concepts of inverse problems, optimisation, and appropriate mathematical and numerical tools applications in image processing and image reconstruction;

Learning outcomes:
On successful completion of the module, a student will be able to:
1. To understand the principles of forward and inverse problems, illposedness, and regularisation.
2. Acquire skills in mathematical methods and programming techniques for solving inverse problems using optimisation and other methods.
3. Gain experience in practical problems in Imaging Science, including image enhancement, reconstruction and tomography.

Content:
Introduction:
- Example problems;
- Data Fitting Concepts;
- Existence;
- Uniqueness;
- Stability;
- Bayesian interpretation;

Mathematical Tools:
- Linear Algebra:
- Solving Systems of Linear Equations;
- Over and Under Determined Problems;
- Eigen-Analysis and SVD;

Variational Methods:

Key information

Year: 2019/20
Credit value: 15 (150 study hours)
Delivery: PGT L7, Campus-based
Reading List: View on UCL website
Tutor: Prof Simon Arridge
Term: Term 2
Timetable: View on UCL website

Assessment

- Report: 20%
- Report: 20%
- Coursework: 10%
- Report: 50%

Find out more

For more information about the department, programmes, relevant open days and to browse other modules, visit ucl.ac.uk

Disclaimer: All information correct as of August 2019. Please note that aspects of the module may be subject to change. UCL will make best efforts to inform applicants of major changes.
Calculus of Variation;
Multivariate Derivatives;
Frechet and Gateaux Derivatives;

Reguarisation:
- Tikhonov and Generalised Tikhonov;
- Non-Quadratic Regularisation;
- Non_Coex Regularisation;
- Methods for selection of regularisation parameters;

Numerical Tools:
- Descent Methods:
- Steepest Descent;
- Conjugate Gradients;
- Line Search;

Newton Methods:
- Gauss Newton and Full Newton;
- Trust-Region and Globalisation;
- Quasi_Newton;
- Inexact Newton;

Optimisation Methods:
- Least-Squares Problems;
- Linear Least Squares;
- Non_linear Least Squares;
- Non-Quadratic Problems;
- Poisson Likelihood;
- Kullback_Leibler Divergence;
- Lagrangian penalties and constrained optimisation;
- Proximal methods:

Concepts of sparsity:
- L1 and total variation;
- wavelet compression;
- dictionary methods;
- Bayesian Approach:
- Maximum Likelihood and Maximum A Posteriori estimates:
- Expectation_Minimisation:
- Posterior Sampling:
- Confidence-Limits;
- Monte Carlo Markov Chain;

Applications:
- Image Denoising;
- Image Deblurring;
- Inpainting;
- Linear Image Reconstruction:
- Tomographic Reconstruction;
- Reconstruction from Incomplete Data;
- Non-Linear Parameter Estimation;
- General Concepts;
- Direct and Adjoint Differentiation;

Other Approaches:
- Learning Based Methods;

Requisites:
In order to be eligible to select this module, a student must be registered on a programme for which it is a formally-approved option or elective choice AND must have (i) taken COMP0137 in Term 1 (if not, contact the Module Leader); and (ii) a strong competency in mathematical and programming skills, including Fourier Theory (discrete and continuous, sampling, convolution), Linear Algebra (Eigenvalues and Eigenvectors, Matrix Algebra), Calculus (functions of multiple variables, calculus of variation), Probability (Gaussian and Poisson probabilities, Bayes Theorem), and Matlab programming (multidimensional arrays, image visualisation, anonymous functions).
Self-Assessment Test:
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