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Numerical Optimisation, COMPGV19

Numerical Optimisation, COMPGV19

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Topic outline

- General

General

COMPGV19: Numerical Optimisation

Lecturer: Marta Betcke (m.betcke@ucl.ac.uk)

Office hours: Term time: Tuesday 1pm-2pm, EFB 3.08 (call 34355 from the phone at the 3rd floor entrance from Roberts Building). Out of term per appointment.

Time/Room:

Monday: 11am-1pm Main Quad Pop Up G02 **(lecture)**,

Tuesday: 9am-11am Torrington (1-19) G12 **(lecture)**,

Wednesday: 10am-11am The Royal National Hotel, Galleon Suite B **(tutorial)**

[38-51 Bedford Way, Bloomsbury, London WC1H 0DG]

Form: 30h of lectures organised in 15 x 2h sessions (some lecture slots will be canceled at lecturers discretion)

10 x 1h tutorials weekly

This module teaches a comprehensive range of state of the art numerical optimization techniques.

It covers a number of approaches to unconstrained and constrained problems, methods for smooth and non-smooth convex problems as well as basics of non-convex optimisation.

Syllabus:

- Mathematical formulation and types of optimisation problems
- Unconstrained optimization theory e.g.: local minima, first and second order conditions
- Unconstrained optimization methods e.g.: line-search, trust region, conjugate gradient, Newton, Quasi-Newton, inexact Newton
- Smooth convex optimization: first order methods e.g. gradient descent, Nesterov, second order methods e.g. Newton
- Least Squares problems
- Constrained optimization theory e.g.: local and global solutions, first order optimality, second order optimality, constraints qualification, equality and inequality constraints, duality, KKT conditions
- Constrained optimization methods e.g.: penalty, barrier and augmented Lagrangian methods, least squares with smooth and non-smooth regularisation
- Non-smooth optimization e.g: subgradient calculus, subgradient methods, proximal operator, operator splitting, ADMM, non-smooth penalties e.g. L1 or TV.

Resources:

Numerical Optimization, Jorge Nocedal and Stephen J. Wright, Springer

Convex Optimization, Stephen Boyd and Lieven Vandenberghe, Cambridge University Press, see webpages of both authors for extensive collection of lecture notes.

In particular see Stephen Boyd's Convex Optimisation I and Convex Optimisation II slides. There is many other resources on the respective lecture pages including special tutorials, publications, codes and video cast of the lectures.

Nick Gould's lectures on nonlinear optimisation can be found here. On the page you can find lecture slides as well as the accompanying paper. In particular recommended for its detailed treatment of the KKT system.

Assessment: 5% x 8 coursework

60% project (20% proposal + 40% execution)

- Q & As Forum
- Announcements Forum

- Assessment

Assessment

- Assignment 1-4 Assignment (Turnitin)

The assignments 1-8 will be a series of short problems set weekly for submission through TurnItIn and Cody Courseworks@Mathworks before the next tutorial session (ie. by 10am on Wed) when the solutions will be discussed and made available online. Therefore, **no late submission will be possible**.

You are required to submit a short PDF report generated by the MATLAB's "publish" function from your solution script and upload your implementation of algorithms to Cody Courseworks@Mathworks as specified in each assignment. In your report please comment on each step of your solution (numerical and analytical) and whenever needed use latex code to include equations. You can answer the theoretical questions outside of MATLAB script in an extra document. Please merge the resulting PDFs, with the theoretical part first, followed by the MATLAB published PDF.

Cody coursework Numerical Optimisation is hosted at

https://coursework.mathworks.com/v2/courses/4113-numerical-optimisation

Please make sure that .../v2/... appears in the path, as there seem to be two versions of the platform which is not transparent and the course is only visible under v2.

The mark and short feedback (complementary to the solutions made available online) will be returned via Moodle within a week.

EDIT: Mathwoks has merged the websites with v2 and without it. Please submit your assignments to

https://coursework.mathworks.com/courses/4113-numerical-optimisation

- Assignment 5-8 Assignment (Turnitin)

- Project proposal Assignment (Turnitin)

The attached project description is an example of a problem you could approach. However, you are free to consider any problem provided it is **sufficiently challenging and it can be solved by optimisation**. You can take **an equivalent level of difficulty problem from your specific field**.

The goal of the proposal is to provide background research on the particular problem, formulate it in optimisation framework, and propose case studies. Note, you are not required to propose methods for its solution, this will be the subject of the project itself. Just identify the type / characteristics of the problem (linear, convex, constraint/unconstraint etc). Take the described subsampled MRI example as a gauge of the level of research and analysis required for the standard component and what would be considered as a challenge.

You are required to submit a PDF report of length up to approximately 2000 words (excluding captions and references).

The feedback will be returned via Moodle within 4 weeks.

- Project proposal: Example problem File 107KB PDF document
- Project Assignment (Turnitin)

The project will involve solving the real world optimisation problem identified and derived in the proposal.

The attached proposal and project description should be taken as an example of a problem you could approach. However, you are free to consider any problem provided it is **sufficiently challenging and it can be solved by optimisation**. You can take **an equivalent level of difficulty problem from your specific field**.

The aim of the project is then to investigate *different* ways of solving this optimisation problem under *different* regimes. Again, let the described subsampled MRI image reconstruction problem guide you about the level of problem study that should be undertaken to achieve the standard component and how to include a challenge component into your problem.

You are required to submit a PDF report of length approximately 2000 words (excluding captions and references) *complementary* to the proposal submitted earlier. The report should identify the challenges of the proposed optimisation problem, motivate your choices of optimisation methods for its solution, design relevant case studies and evaluate the obtained results.

The accompanying Matlab codes should be submitted as a zip archive folder named after you e.g. "JohnSnow" containing "solution.m" script and all necessary support functions. You can use any codes which were given out as a solution to the assignments in the course of the lecture or reuse your own implementations. It is your responsibility that the "solution.m" script is running upon unpacking (not running codes will get 0 marks). The "solution.m" file must be compliant with MATLAB's publish function so that html can be created which corresponds to the results in the report. The html will be the marked output. Alternatively, you can use iPython notebooks but the codes given out in the lecture will be in Matlab.

The report contributes 80% and the generated html 20% to the mark for this component.

The feedback will be returned via Moodle within 4 weeks.

- Project description: Example problem File 113.3KB PDF document
- Assignments

Assignments

-

Assignment 0: Example

assignment0.pdf

solution0_exercise1.pd
f

-

Assignment 1

assignment1.pd
f

solution1.pdf

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Assignment 2

assignment2.pd
f

lineSearch.m

solution2.pdf

zoomInt.m

-

Assignment 3

[assignment3.pdf]

[solution3_2dSubspace.pdf]

[solution3.pdf]

Assignment 4

[assignment4.pdf]

[solution4_exercise1.pdf]

[solution4_exercise2c1.pdf]

[solution4_exercise2c2.pdf]

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  assignment5.pd
  f

  solution5.pdf

-

  Assignment 6

  assignment6_exercise3.
  m

  assignment6.pd
  f

  mcg.m

  solution6.m

  solverCM2dSubspaceExtLS.
  m

surfaceFunc_matrix.m

surfaceFunc_vector.m

surfaceGrad.m

surfaceHess.m

trustRegionLS.m

visualizeSurface.m

- Download folder
-

Assignment 7

assignment7.pdf

solution7.pdf

solverCMlevenberg.

m

-

Assignment 8

assignment8.pdf

backtracking.m

descentLineSearch.m

interiorPoint_Barrier.m

interiorPoint_PrimalDual.m

lineSearch.m

realLog.m

solution8_exercise2.m

solution8_surface.
m

solution8.pdf

surfaceGrad.m

surfaceGradIneq.
m

surfaceGradPhi.
m

surfaceHess.m

surfaceHessPhi.
m

surfaceIneq.m

surfacePhi.m

visualizeConvergence.
m

visualizeSurface.
m

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- Background

Background

  - Background: Lecture slides File 730.5KB PDF document
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- Line search

Line search

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Trust region

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- Conjugate gradient

Conjugate gradient

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- Quasi-Newton

Quasi-Newton

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Large-scale

  - Large scale: Lecture slides File 434.3KB PDF document
- Least squares

Least squares

  - Least squares: Lecture slides File 322.9KB PDF document
- Constraint optimisation

Constraint optimisation

  - Constraint optimisation: Lecture slides File 320.9KB PDF document

- Solution of problems with equality constraints

Solution of problems with equality constraints

  - Solution of problems with equality constraints: Lecture slides File 165.3KB PDF document
- Constraint optimisation: penalty and augmented Lagrangian methods

Constraint optimisation: penalty and augmented Lagrangian methods

  - Penalty and augmented Lagrangian methods: Lecture slides File 2.8MB PDF document
- Constraint optimisation: interior point methods

Constraint optimisation: interior point methods

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- Nonsmooth optimisation

Nonsmooth optimisation

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  - Solutions tutorial Nonsmooth Optimisation Folder

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Latest announcements

- 25 May, 21:02
  Marta M Betcke
  Revised marks / check your feedback!
- 24 May, 17:40
  Marta M Betcke
  Project marks
- 9 May, 22:05
  Marta M Betcke
  Delay in returning project marks
- 28 Mar, 10:25
  Marta M Betcke
  Project codes clarification
- 14 Mar, 16:38
  Charlie Tickle
  Change of Teaching Venue - Wednesday 21st March 2018

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Upcoming events

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Activity since Saturday, 4 August 2018, 2:23 PM
Full report of recent activity...

No recent activity

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