MA2000: OTML

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Evaluation (Tentative)

Quiz 1: 20

Quiz 2: 20

Project: $20 = 10$ (*presentation*) $+ 10$ (*report*)

End Assessment: 40

Textbooks and References

Textbooks:

1. Sra, Suvrit, Sebastian Nowozin, and Stephen J. Wright, eds. Optimization for machine learning. MIT Press, 2012. (ISBN: 9780262016469):
2. Roberto Battiti, Mauro Brunato. The LION Way: Machine Learning plus Intelligent Optimization. Lionsolver, Inc. 2013.(ISBN: 9781496034021)

References:

1. Bubeck, Sebastien. "Theory of Convex Optimization for Machine Learning." arXiv preprint arXiv:1405.4980, 2014.
2. Algorithms for Optimization, Mykel J. Kochenderfer (Author), Tim A. Wheeler (Author), 2019, ISBN-13: 978-0262039420; ISBN-10: 0262039427 (ebook)

Syllabus

UnConstrained Optimization: Fibonacci and Golden-Section Search

Constrained Optimization: Lagrange Multiplier, Karush Kuhn Tucker(KKT) Conditions, First order and Second-order necessary conditions for minima and maxima; convex sets and functions, convex optimization; Duality, IRLS

Derivative or Gradient Based Optimization: Gradient descent; batch gradient descent; stochastic gradient descent; Adam.

Second-Order Methods: Conjugate gradient method- Quasi Newton method- Newton method

Stochastic Methods: Particle Swarm Optimisation (PSO), Simulated Annealing (SA), Monte-carlo methods for stochastic optimization.

Combinatorial Optimization: Mincut-Maxflow-normalized cut

If I feel unhappy, I do mathematics to become happy. If I am happy, I do mathematics to keep happy.. - Rényi, Alfréd

The Definition

The Definition

Optimization means to find the best possible solutions out of the available alternatives under the given circumstances.

Applications

- Mechanics
- Economic and Finance
- Biology
- Electrical Engineering
- Civil Engineering Operation Research
- Economics
- Control Engineering
- Geophysics
- Molecular Modeling
- Computer Science
- Data Science

Classifications: Based on type of constraints

1. Constrained optimization problem.

    1.1 Multivariable optimization with equality constraints

    1.2 Multivariable optimization with inequality constraints optimization

2. Unconstrained optimization problem

    2.1 Single variable unconstraint optimization

    2.2 Multivariable unconstrained optimization: Hessian Matrix

Classifications: Based on the nature of the equations involved

1. Linear programming problems.

   1.1 Simplex Method

   1.2 Big M mathod

2. Nonlinear programming problems

   2.1 Unrestricted search method with fixed and accelerated step size

   2.2 Fibonacci search method

   2.3 Golden section methods.

   2.4 Conjugate gradient method

Classifications: Based on random search

1. Deterministic Optimization.

   1.1 Gradient Decent

   1.2 Conjugate Gradient Method

2. Stochastic Optimization (Gradient or Derivative free)

   2.1 Particle swarm method

   2.2 Simulated Annealing.

   2.3 Genetic Algorithm

Classifications: Others

1. Local Optimization
2. Global Optimization

OR

1. Convex Optimization
2. Non-convex Optimization

OR

1. Continuous Optimization(Objective function are required to be continuous variables)
   1.1 Method uses all calculus techniques
2. Discrete Optimization
   2.1 Combinatorial Optimization
   2.2 Integer Programming

Classifications: There are discrete deterministic

Optimization Problem

- Convex
  - Linear
    - LP
  - Nonlinear
    - Convex NLP
- Nonconvex
  - Discrete
    - Linear
      - MILP
    - (Nonlinear)
      - Convex Relaxation
        - Convex MINLP
      - Nonconvex Relaxation
        - Nonconvex MINLP
  - Continuous
    - Nonconvex NLP