Optimization for Data Science

MAL7070

Syllabus

- **Unconstrained Optimization :** Convex sets and functions, Optimality conditions: First order, second order, line search methods, least squares, steepest descent, newton method, Quasi-Newton Method, conjugate gradient methods.
- **Constrained Optimization :** barrier method, penalty method, interior point methods, KKT method and Lagrangian Duality, simplex, Frank and Wolfe method, applications to dynamic programming and optimal control.

Time Table

- Optimization for data science is a 2 credits course.
- Time Table slot : YQ

1. Saturday – 11:30 AM - 1:00 PM
2. Sunday – 11:30 PM – 1:00 PM

Evaluation Scheme

- Major Examination – 50%
- Quizzes – 15 % (Fractal 1)
- Assignment – 10% (Fractal 1)
- Quiz and Assignments – 25% (Fractal 2)

Books

- Amir Beck, Introduction to Nonlinear Programming (2014), Theory, Algorithms and Applications with Matlab, MOS-SIAM Series on Optimization.
- M.S.Bazaraa, H.D. Sherali, and C.M.Shetty (2006), Nonlinear Programming: Theory and Algorithms, Third Edition, Wiley.
- Kambo, N. S., Mathematical Programming Techniques, Second Edition, Affiliated East West Press, 2005

Introduction to optimization

- Optimization is the act of obtaining the best result under the given circumstances.
- Minimize the effort (cost) or Maximize the output (Profit).
- Cost or Profit is always a function of certain variables. Our aim is to maximize or minimize this function.
- There is no single method available for solving all optimization problems efficiently. Hence, a number of optimization methods have been developed for solving different types of optimization problems.

Example

A company makes two types of circuits. They need Capacitors, Resistors and transistors for making these circuits. The more information is given in the following table:

	Circuit 1	Circuit 2	Stock
C	4	0	16
R	2	2	12
T	2	4	20
profit	2	3	

How this company can maximize their profit?

- Consider the following problem

  Minimize $f(z)$ **Objective function**

  Subject to

  $g_i(z) \leq 0$, $i = 1, 2, \ldots, m$ **Inequality Constraints**

  $l_j(z) = 0, j = 1, 2, \ldots r$ **equality Constraints**

  $z \in X$.

- X is subset of R^n.
- The above problem must be solved for values of z, such that it satisfies the constraints and minimizes objective function.

- Constrained optimization
- Unconstrained optimization

- Linear Programming Problem.
- Non linear Programming Problem.
- A vector satisfying all the constraints of a given problem is called feasible solution of the problem.
- The collection of all feasible solutions is called feasible region.
- The minimization problem is to find feasible solution k such that $f(k) \le f(z)$ for all feasible solutions z. Such a solution is called optimal solution.
- $\text{Min } f(z) = \text{Max } (-f(z))$
- $\text{Max } f(z) = \text{Min } (-f(z))$