國立臺北大學自然資源與環境管理研究所
107 學年度第二學期『環境系統分析專題』

課程講義(15)：非線性規劃與演算法
Nonlinear Programming and Algorithms

- NONLINEAR PROGRAMMING -- INTRODUCTION
  - □ Formulations of the Models and Complexity
  - □ Local Optima vs. Global Optima
  - □ Convexity and Convex Programming
    - ⇨ Convexity of a Function: Convex, Concave and Un-determinant
    - ⇨ Convex Region vs. Non-convex Region
  - □ Analytical Solutions vs. Numerical Solutions
    - ⇨ Linearization of Nonlinear Objective Function => May not be necessary nowadays!
    - ⇨ Software Packages => Lingo, What'sBest, Euler etc.
  - □ Nonlinear Programming (Chapter 13) in Applied Mathematical Programming (http://web.mit.edu/15.053/www/AMP-Chapter-13.pdf)

- UNCONSTRAINED OPTIMIZATION
  - □ Minima, Maxima and Saddle Points
    - ⇨ Necessary Conditions and Sufficient Conditions
  - □ Gradient of a Function (First Derivatives)
  - □ Hessian Matrix (Second Derivatives)
    - ⇨ Positively Definite: All the Eigenvalues are Positive

- LAGRANGE MULTIPLIERS AND OTHER METHODS
  - □ Lagrange Multiplier Method
    - ⇨ Constraints with All Equalities
    - ⇨ Properties of the Lagrange Multipliers
  - □ Kuhn-Tucker Conditions: Constraints with Inequalities
  - □ Gradient Search Procedure (Greedy) => Danger of Being Trapped at Local Optima
  - □ Applying Maximum Entropy Principle to Solving the Unfair Dice Problem

- ALGORITHMS FOR NONLINEAR PROGRAMS
  - □ Numerical Methods (Chang, 2002, Chap.5)
    - ⇨ Newton Method, Conjunctive Direction and Conjunctive Gradient Methods
  - □ Top-Ten Algorithms
  - □ Heuristic Algorithms => Soft Computation => Emulation of Natural Phenomena
    - ⇨ Artificial Neural Network; Genetic Algorithms
    - ⇨ Simulated Annealing; Tabu Search
    - ⇨ Ant Search, Ant Colony Algorithm, Swarm Intelligence, etc.

- OPTIMIZATION ALGORITHMS (Wikipedia)
  - Monte Carlo Simulation (Metropolis Algorithm)
  - Simplex Algorithm of George Dantzig, designed for linear programming
  - Interactive Methods: Newton's method, Sequential quadratic programming…
  - Global Convergence
  - Heuristic (Metaheuristic) Algorithms

    In computer science and mathematical optimization, a metaheuristic is a higher-level procedure or heuristic designed to find, generate, or select a heuristic (partial search algorithm) that may provide a sufficiently good solution to an optimization problem, especially with incomplete or imperfect information or limited computation capacity.

    ⇨ Local search vs. global search; Single-solution vs. population-based

    ⇨ Hybridization and memetic algorithms; Nature-inspired metaheuristics