More Views on Optimization

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Biologically-Inspired Intelligent Systems

CSCI-633

1/29/2026

(Last Time) An Algorithmic View

- **Optimization viewed as iterative movement of a dynamical system**
  - **Metaheuristic algorithm = a single or multi-agent moving along a trajectory (e.g., a gradient flow)**

An Ideal Algorithm?

- Better algorithm (algo) – use less computation & fewer iterations
  - Extreme case: algo should take t = 1 iteration

$f(x) = ax^2$ where $a > 0$, the well-known Newton-Raphson method

$$x_{t+1} = x_t - \frac{f'(x_t)}{f''(x_t)} \tag{2.6}$$

is the ideal algorithm. If we start the iteration from any random guess $x_0 = b$, we have

$$x_1 = x_0 - \frac{f'(x_0)}{f''(x_0)} = b - \frac{2ab}{2a} = 0, \tag{2.7}$$

which gives the global optimal solution $f_*(0) = 0$ at $x_* = 0$.

  - Same ideal algo does not work as well non-convex/non-quadratic functions

Algorithmic View: A Self-Organizing System

- ***[White board notes]***

Table 2.1 Similarity between self-organization and an optimization algorithm.

Self-Organization	Features	Algorithm	Characteristics
Noise, perturbations	Diversity	Randomization	Escape local optima
Selection mechanism	Structure	Selection	Convergence
Reorganization	State changes	Evolution	Solutions

Algorithmic View: Exploration vs. Exploitation

- ***Exploitation*** – uses info obtained from problem of interest to generate new soln's (better than existing ones)
  - Local (information/process), like gradient in gradient ascent
  - Leads to high convergence rates but gets stuck in local optima (starting point matters!)
- ***Exploration*** – helps search through space efficiently, generate soln's w/ diversity/far from current soln's
  - Global scale search
  - Less likely to get stuck in local optima/mode (potential for global optimality) but slow convergence & potential waste of resources (too far!)
- Key: Balance! (finding perfect balance is a hyper-optimization problem)

Questions?