Topic 14 – Particle Swarm Optimization
Wednesday, April 20

<u>Announcements</u>
→ Tomorrow's office hours moved to 2:30pm - 3:30pm (still Teams, same link)

In all of our previous metaheuristics, we have tracked a <u>single</u> solution moving through the search space.

Particle Swarm Optimization (PSO) – 1995
This is our first "population metaheuristic"
– we will track many candidates at a time and they will interact with each other

<u>Set up</u>: You have N particles, each representing a solution in the search space. Each particle starts at a random position.

Each particle will have a velocity, that depends on three things:

1) its current velocity
2) the best solution that particle has ever seen
3) the best solution any particle has ever seen

(vectors)

Let $x_i(t)$ and $v_i(t)$ denote the position and velocity of particle i at time t.

$$x_i(t+1) = x_i(t) + v_i(t+1)$$

(the velocity determines how the particle moves from one time to the next)

the vector from pos. to best sol.

$$v_i(t+1) = \alpha \cdot v_i(t) + \beta \cdot r_1 \cdot (b_i(t) - x_i(t)) + \gamma \cdot r_2 \cdot (B(t) - x_i(t))$$

$b_i(t)$ = best solution particle i has seen by time t

$B(t)$ = best solution any particle has seen by time t

α, β, γ: weighting factors (fixed real #s) that you decide on ahead of time

Standard first try: $\alpha = 0.9$, $\beta = 1$, $\gamma = 1$

r_1 and r_2: random <u>vectors</u> in $[0,1]$.

<u>Note</u>: $b_i - x_i$ and $B - x_i$ are differences of solutions in the search space, so we need to have a definition of that.

Easy for continuous spaces ($\mathbb{R}^n$)

Demos:

→ Talk α, β, γ

Problem: What if your particles run away?

* You need to keep your particles in regions that satisfy the constraints.
  - → Could be nice bounds like
    $$-2\pi \le x, y \le 2\pi$$
  - → Could be worse, like that spring problem
  - → Could be even worse: could be

forbidden areas mixed with allowed areas

* What do you do if your particle moves to an invalid spot?

Option 1) If a new position violates a constraint, just don't move. If you wait long enough, inertia decays ($\alpha < 1$), so eventually, you might move somewhere good.

Option 2) Destroy the particle and create a new one at a random position.