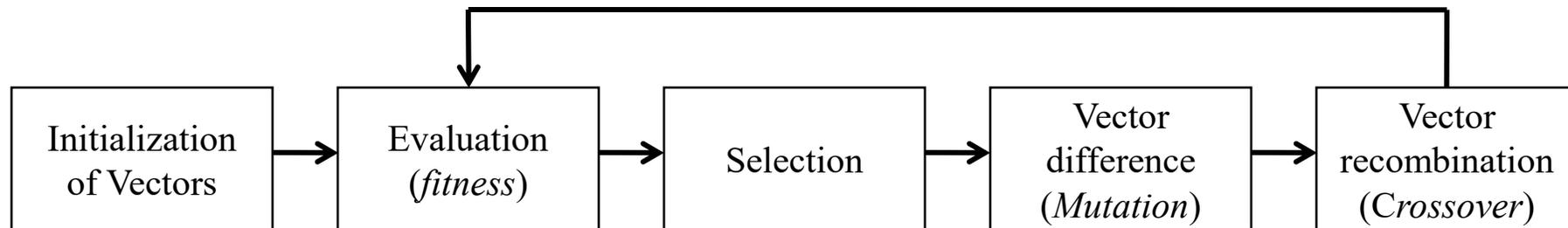# On Swarms of Particles: Wisdom of the Flock

Alexander G. Ororbia II

Biologically-Inspired Intelligent Systems

CSCI-633

2/17/2026

# *Last Time:*
Metaheuristic: Differential Evolution (DE)

- Devised for continuous search spaces, derivative-free vector-based evolutionary algorithm (differential evolution)

  - *DE/{rand, best}/K/{bin, exp} (a suite of mini-algorithms for DE)*

  - Relies on mutation/crossover operators (in tandem w/ selection)

Initialization of Vectors	→	Evaluation (*fitness*)	→	Selection	→	Vector difference (*Mutation*)	→	Vector recombination (*Crossover*)

Swarm Intelligence

- Uses *real number randomness* and *global communication* (instead of mutation/crossover as in evolution)

- Easier to implement – (also) no encoding/decoding needed

- Particle swarm (optimization) pioneered basic ideas of swarm intelligence

- **Operation** – adjust piecewise paths of individual agents (quasi-stochastic manipulation of positional vectors)
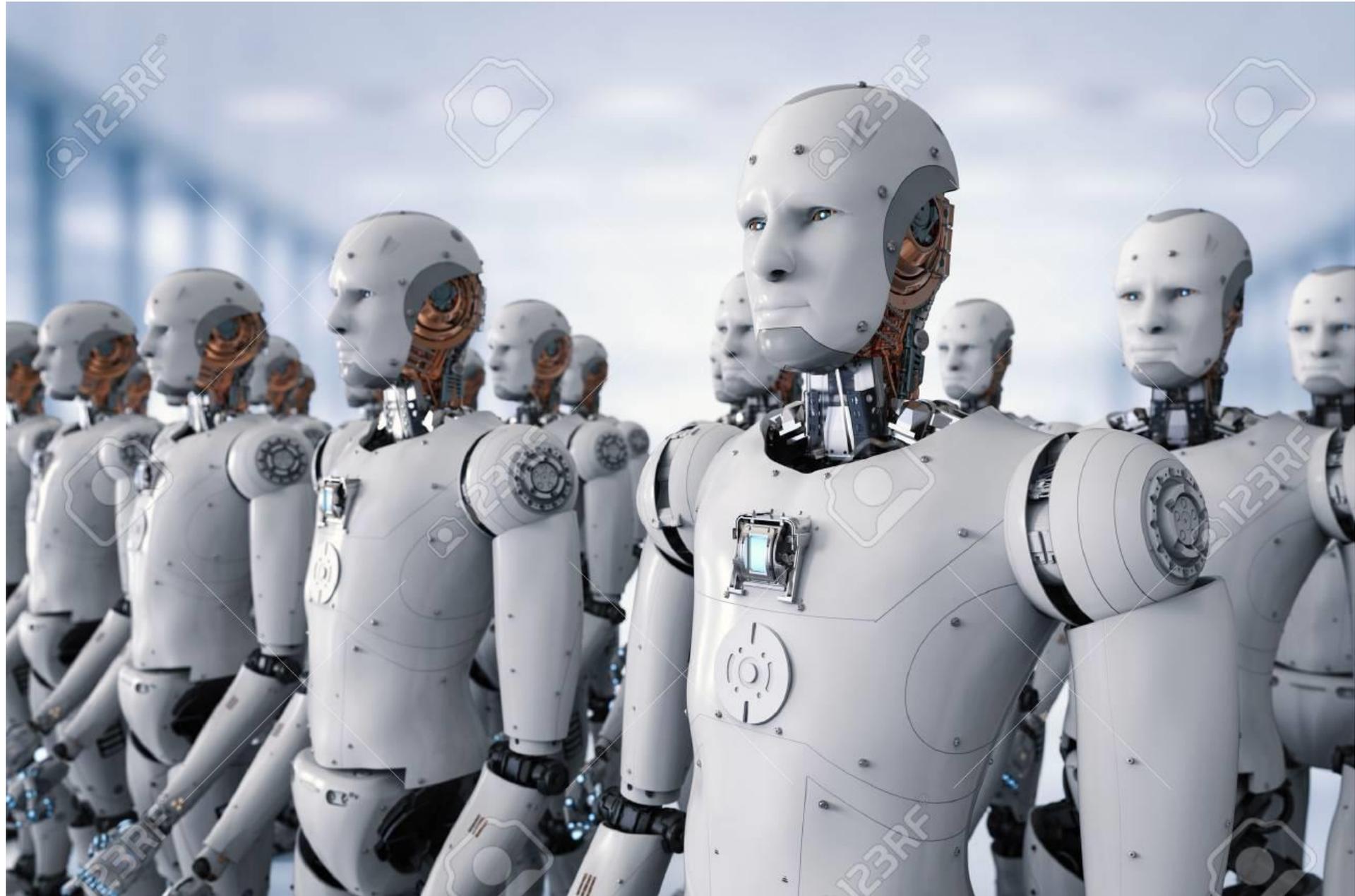
Roger, roger!

Particle Swarm Optimization (PSO)

- Agent *i* = "particle", guided by stochastic & deterministic component (Kennedy & Eberhart, 1995)
  - Inspired by swarm/schooling behavior of fish and birds
- Attracted to:
  - Current global best location, $\boldsymbol{g}^*$ (social intelligence)
  - Current local best location, $\boldsymbol{x}_i^{*(t)}$ (cognitive intelligence)
- Has tendency to move randomly (injected noise)

- Using local (individual) best might be increasing diversity in solution quality

PSO Mechanics

- When particle finds better position (than in history), updates location for agent i

- At any t, a global best for n agents is tracked
  - Aim: find global best among current best solutions until objective no longer improves (or after iteration cutoff)

PSO Mechanics

WHITE BOARD TIME!
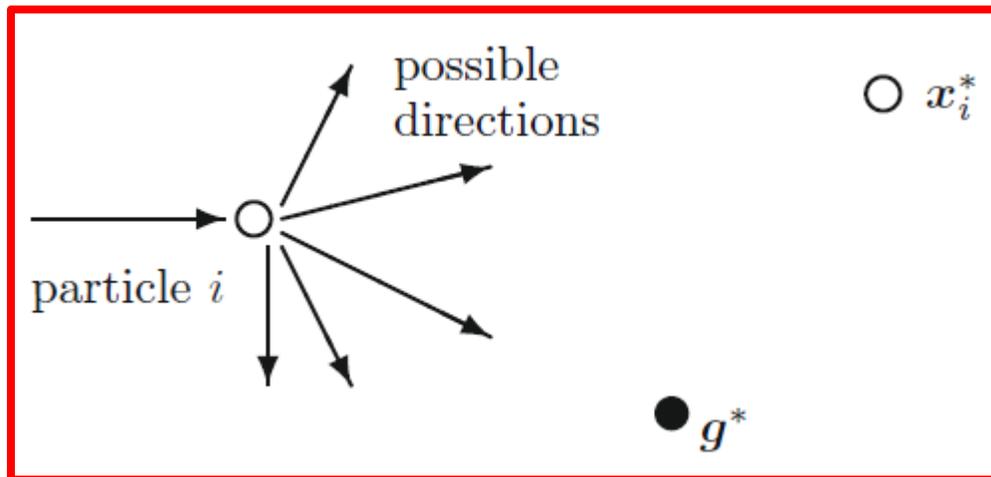
Particle Swarm Optimization

Objective function $f(\boldsymbol{x})$, $\boldsymbol{x} = (x_1, ..., x_d)^T$

Initialize locations $\boldsymbol{x}_i$ and velocity $\boldsymbol{v}_i$ of n particles.

Find $\boldsymbol{g}^*$ from $\min\{f(\boldsymbol{x}_1), ..., f(\boldsymbol{x}_n)\}$ (at $t = 0$)

while (criterion)

    for loop over all n particles and all d dimensions

    Generate new velocity $\boldsymbol{v}_i^{t+1}$ using equation (7.1)

    Calculate new locations $\boldsymbol{x}_i^{t+1} = \boldsymbol{x}_i^t + \boldsymbol{v}_i^{t+1}$

    Evaluate objective functions at new locations $\boldsymbol{x}_i^{t+1}$

    Find the current best for each particle $\boldsymbol{x}_i^*$

    end for

    Find the current global best $\boldsymbol{g}^*$

    Update $t = t + 1$ (pseudo time or iteration counter)

end while

Output the final results $\boldsymbol{x}_i^*$ and $\boldsymbol{g}^*$

Accelerated PSO (APSO)

WHITE BOARD TIME!

Questions?