Practical Optimization Algorithm Design

Lesson 13: Swarm Intelligence

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Contents

Introduction

- Swarms of tiny, simple creatures able to colossal achievements
- Emergence
- Self-Organization
- Swarm Intelligence

Particle Swarm Optimization

- Copy the behavior with which swarms / schoals / flocks in nature find food
- Search space is subset of real vectors numbers: $\mathbb{G} \subseteq \mathbb{R}^n$
- Population = swarm of particles which move in $\mathbb{G}$
- Genotype = position of particle p
- Endogenous information = velocity vectors of particles $p.\mathbf{v}$
  best found position so far $best(p).\mathbf{g}$
- $N(p)$: neighbors of particle p

Particle Swarm Optimization

- In each iteration for each particle p:

1) Velocity Update:

$$p.\mathbf{v} = randomUni[0, \mathbf{c}_i) * (best(p).\mathbf{g}_i - p.\mathbf{g}_i) + randomUni[0, \mathbf{d}_i) * (best(N(p)).\mathbf{g}_i - p.\mathbf{g}_i)$$

Social Component

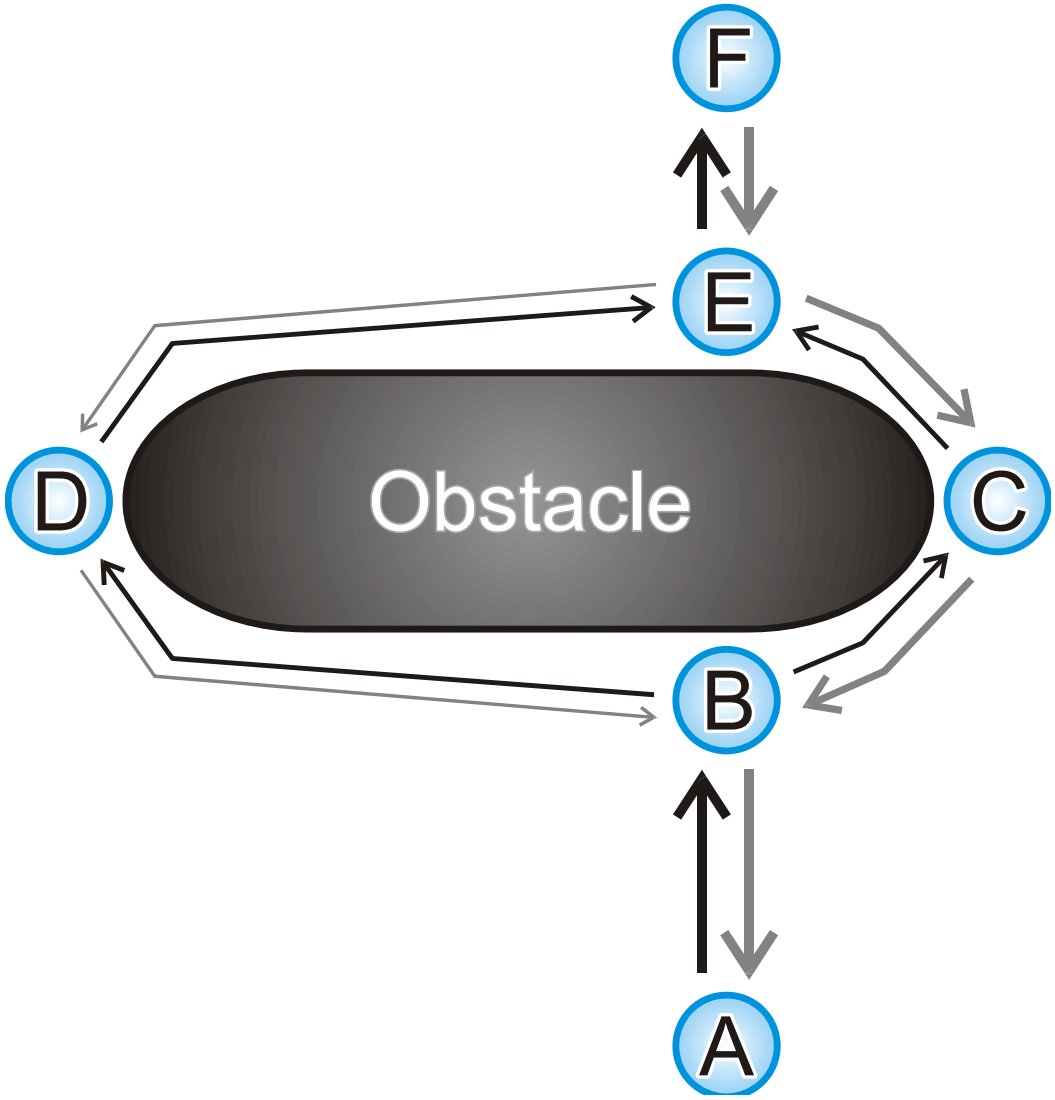
2) Afterwards – Position Update:

$$p.\mathbf{g} = p.\mathbf{g} + p.\mathbf{v}$$

Ant Colony Optimization

- Simulation of the way ants form a path in order to solve optimization problems which can be represented as graphs
- Ants move from one location to another
- And lay down pheromone: stigmergy = communication by modifying the environment
- Paths with more pheromone on them are more likely to be followed
- These are often the shortest paths
- Many combinatorial problems can be considered as finding the shortest path on a graph. Example: TSP

Ant Colony Optimization



Ant Colony Optimization

- An ant located in node i in ACO chooses the next node j where it will go according to
  1) the distance between i and
  2) the amount of pheromone on the edge connecting i and j

- $$p_{i,j} = \frac{(\tau_{i,j})^{\alpha}(\eta_{i,j})^{\beta}}{\sum_{\forall k}(\tau_{i,k})^{\alpha}(\eta_{i,k})^{\beta}}$$

$p_{i,j}$ probability of an ant to go to j (if at location i)

α, β weights

$\tau_{i,j}$ pheromone on the edge connecting i and j

$\eta_{i,j}$ visibility of node j from node i: inversely proportional to the distance between i and j

Ant Colony Optimization

- At the end of each algorithm round, “pheromone” is dispersed and the trails are updated ($\eta_{i,j}$ stays constant)
- $$\tau_{i,j} = (1-\rho)\tau_{i,j} + \Delta\tau_{i,j}$$
- ρ is the evaporation coefficient
- $\Delta\tau_{i,j}$ is the new pheromone dispersed
- the amount usually depends on the quality of the paths the edge (i,j) was part of
- In TSP: inversely proportional to length of tour

Summary

- Collectives of simple creatures able to colossal achievements
- Swarm Intelligence
- PSO: Copy flocking behavior
- ACO: copy ground-based movements / stigmergy

谢谢你们！

再见！