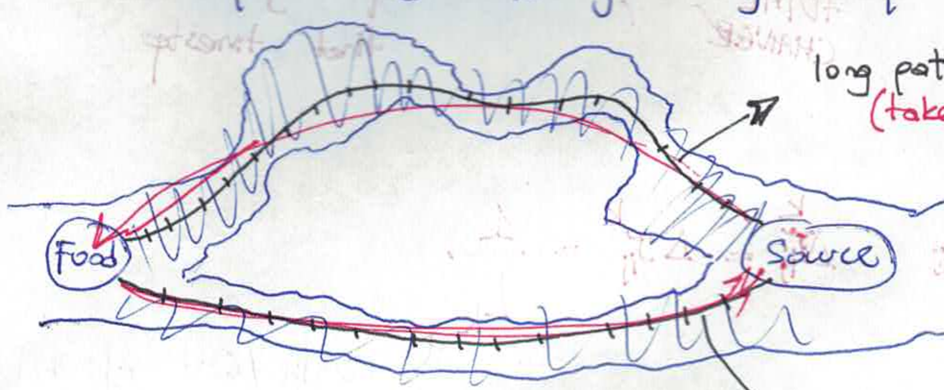
Ant Colony Optimisation

18.02.2020 @ CMPE 373

- Theoretical Biology (1987) (Jean-Louis Deneubourg) → Optimisation / Engineering (1992) (Marco Dorigo)

- path finding behaviour of ants searching for food
  - -> subset of swarm intelligence
    - >> decentralized, collective behavior,
  - -> Application: Traveling Salesman, Scheduling, Routing
    - >>> Advantage: Ability to adopt dynamic enviroments'

- Ants follow very basic rules
  - >> pheromone trails used for communication
  - >> ants take a path depending on the strength of the pheromone
  - >> pheromone trails gradually evaporate



- 1 ant taking long path deposit 1 unit pheromone in 2 minutes
- At the same time, an ant may be able to lay 2 units of pheromone (each taking 1 min)

⇒ Longer path will be used less in time, and all pheromone will evaporate on longer path

Constructing PATH [DECISION]

ant k

$$i \xrightarrow{p_{ij}^{k}} j$$

$$p_{ij}^{k} = \frac{\tau_{ij}^{\alpha} / d_{ij}^{\beta}}{\sum_{o} \left(\tau_{io}^{\alpha} / d_{io}^{\beta} \right)}$$

pheromone level

distance (laziness)

importance / control parameters

proba of ant (k) selecting (j) from (i)

other nodes

Pheromone Update

$$\tau_{ij} = (1-\rho)\, \tau_{ij} + \underbrace{\Delta \tau_{ij}}$$

[PREVIOUS]

[NEW] amount of pheromone on edge i-j

rate of pheromone evaporation

(negative feedback)

TOTAL amount of new pheromone deposited during one unit of time

(positive feedback)

$$\Delta \tau_{ij} = \sum_{k} \Delta \tau_{ij}^{k}$$

TOTAL CHANGE

Sum of every ants pheromone deposit passing through edge i-j during that timestep

$$\Delta \tau_{ij}^{k} = \Delta \tau_{ij}^{k} = \frac{1}{L_k}$$

Length / Cost of ant k's tour

Short for pheromone update

$$\tau_{ij} = \underbrace{(1-\rho)\, \tau_{ij}}_{\text{evaporation of pheromone}} + \underbrace{\sum_{k} 1/L_k}_{\text{new pheromone deposits of passing-by ants}}$$

evaporation of pheromone

(−) feedback

new pheromone deposits of passing-by ants

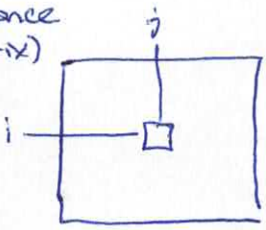
(+) feedback

Traveling Salesman

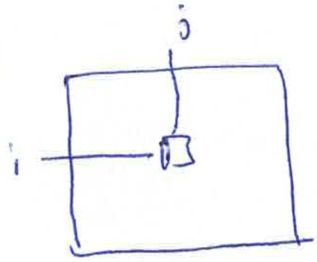
- Ants travel from stating location to the final, visiting all cities.

- They deposit more pheromone on shorter distances (in the same amount of time) then long ones.

distance (matrix)



pheromone (matrix)

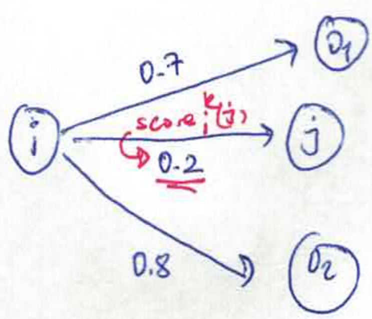


$$\text{pherome} = \frac{1}{\text{n of cities}}$$

Initial → random ~~noise~~ uniformly

DECISION

$$proba_i^k(j) = \frac{pheromone[i,j]^\alpha / distance[i,j]^\beta}{\sum_o pheromone[i,o]^\alpha / distance[i,o]^\beta} = \frac{score_i^k(j)}{\sum_o score_i^k(o)}$$



$$P_{ij}^k = \frac{0.2}{0.2 + 0.7 + 0.8} = 0.142$$

PHEROMONE UPDATE

$$\Delta_{ij}^k = \frac{1}{d_{ij}^k} \text{ or } \frac{1}{L_k}$$