Ant Colony Optimization: An Overview

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OVERVIEW

- What is ACO?
- Terminology
- The Algorithms
- ACO in motion
- Applications of ACO

WHAT IS ANT COLONY OPTIMIZATION?

- Used to find optimal paths inside of a graph and give approximate solutions to optimization problems
- Based on ants method of finding food

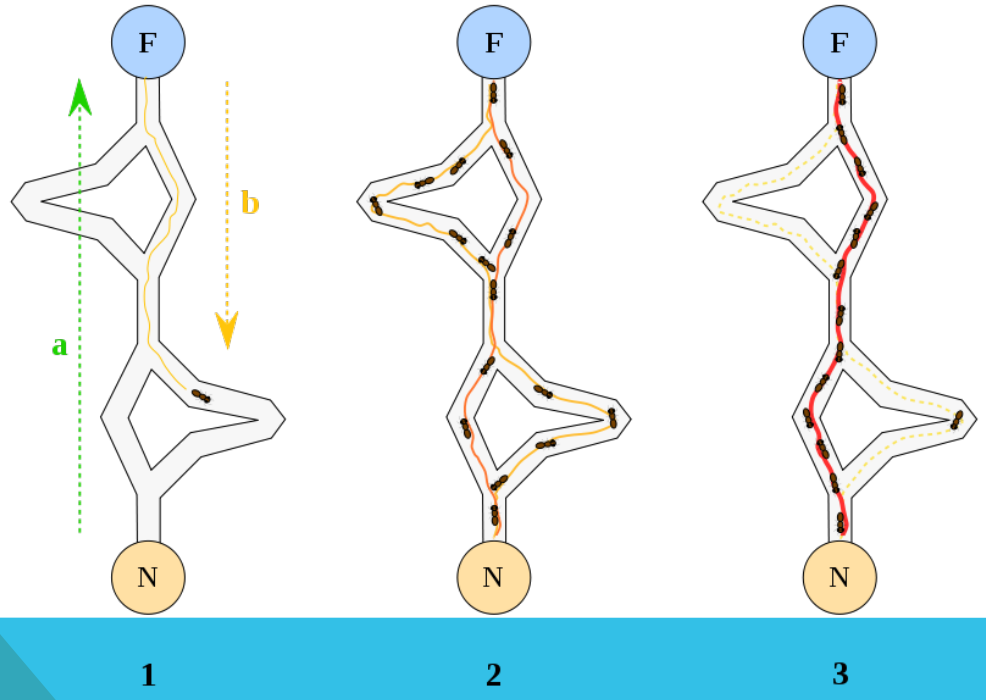


Image Source: Wikipedia

TERMINOLOGY

- Pheromone
- Tabu list
- Pheromone evaporation
- Visibility

THE ALGORITHMS – CHOOSING A CITY

- Each ant has a tabu list
- Next city decided by probability (going from city i to city j)
- J(i, k) are the cities the ant still has to travel to from city i
- n = 1/d(i, j) which is the visibility between the cities i and j
- T(i, j) (t) is the amount of pheromone between cities I and j at time t

$$p_{i,j}^{k}(t) = \frac{\left[\tau_{i,j}(t)\right]^{\alpha} \cdot \left[\eta_{i,j}\right]^{\beta}}{\sum_{l \in J_i^k} \left[\tau_{i,l}(t)\right]^{\alpha} \cdot \left[\eta_{i,j}\right]^{\beta}}$$

THE ALGORITHMS – DEPOSITING PHEROMONE

- Represents each edge (i, j) that the ant visited in iteration t
- Otherwise, it is zero.
- Q is a constant, and L is the cost of the ant's tour, usually the length, with t representing iteration and k representing the ant

$$\Delta\tau_{i,j}^{k}(t) = \begin{cases} Q / L^{k}(t) \\ 0 \end{cases}$$

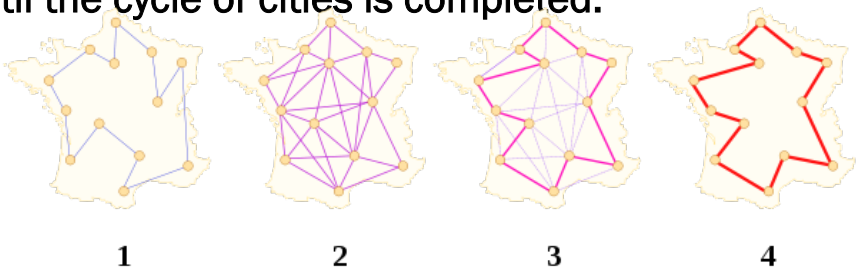
THE ALGORITHMS – PHEROMONE DECAY

- Each edge will have a coefficient p applied to it to represent decay
- M represents the amount of ants in the system

$$\tau_{i,j}(t+1) = (1-\rho)\cdot\tau_{i,j}(t) + \sum_{k=1}^{m}\left[\Delta\tau_{i,j}^{k}(t)\right]$$

ANT COLONY OPTIMIZATION IN ACTION

- Set number of iterations the optimization will run
- Each edge gets updated with an extremely tiny, uniform level of pheromone
- Each ant is set to a random city
- Tours for each ant are built with the probability algorithm for choosing the next city
- Check to see if the best tour built is better than the current solution if one exists. If so, we make the best tour become the current solution.
- Pheromone decay algorithm is applied, keeping in mind that no ant will lay pheromone until the cycle of cities is completed.



APPLICATIONS OF ANT COLONY OPTIMIZATION

- Traveling salesman problem
- Vehicle routing (school buses, deliveries, waste collection)
- Network routing (solves congestion, routing problems)
- Circuit design (modified usages of ACO to determine value of capacitors, inductors, etc)

SUMMARY

- Ant Colony Optimization is an efficient method to finding optimal solutions to a graph
- Using three algorithms based on choosing a city, updating pheromone trails and pheromone trail decay, we can determine an optimal solution to a graph
- Ant Colony Optimization has been used to figure out solutions to real world problems, such as truck routing

WORKS CITED

Back, Thomas. "Ant Colony Optimization." *Natural Computing Group*. Web. 13 Oct. 2010. <http://natcomp.liacs.nl/NC/slides/aco.pdf>.

Meyer, Bernd. "Ant Colony Optimization." *Monash University*. Web. 11 Oct. 2010. <http://www.csse.monash.edu.au/~berndm/CSE460/Lectures/cse460-9.pdf>.

Algorithm images from Meyer, Bernd.