Swarm Intelligence

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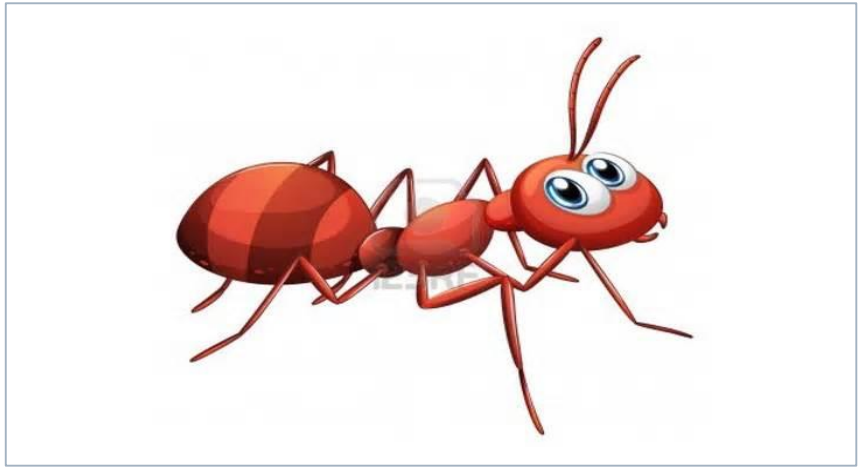
Contents

Ant Colony Optimization (ACO) 蚁群优化

- It is a probabilistic technique for solving computational problems which can be used to finding optimal paths in a graph.
  它是一种解决计算问题的概率技术，可以用于发现一个图上的最佳路径。
- Initially was proposed by Marco Dorigo in 1992 in his PhD thesis.
  最初是由Marco Dorigo于1992年在他的博士论文中提出的。
- The algorithm was inspired by the behavior of ants seeking a path between their nest and a source of food.
  该算法是受蚂蚁在蚁巢和食物源之间寻找路径行为的启发而形成的。



Concept of Ant Colony Optimization 蚁群优化的概念

- Ants navigate from nest to food source blindly:

  蚂蚁从蚁巢到食物源之间盲目地游荡：

  - Shortest path is discovered via pheromone trails

    最短路径是通过费洛蒙嗅迹发现的

  - Each ant moves at random

    每个蚂蚁随机地移动

  - Pheromone is deposited on path

    费洛蒙就遗留在路径上

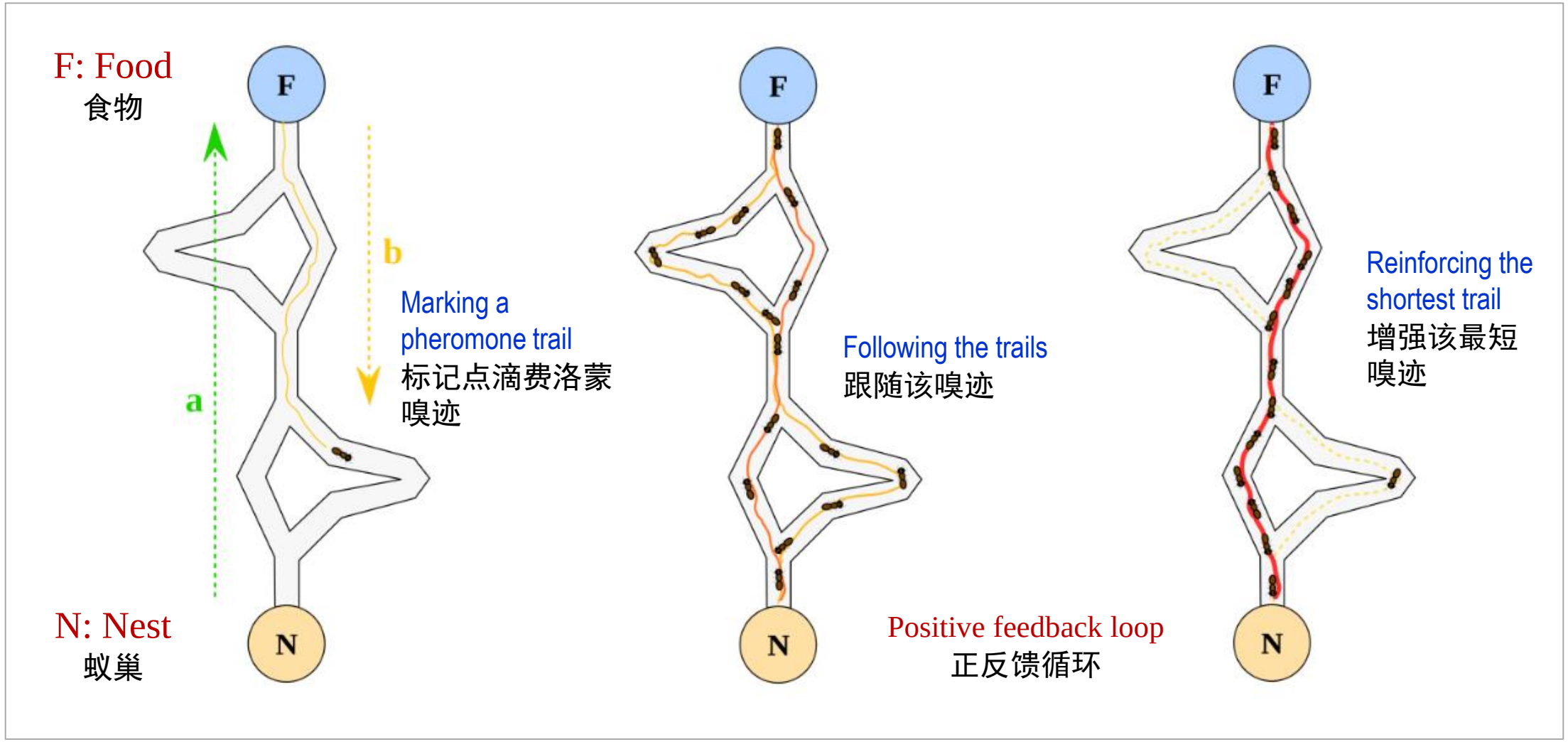
  - Ants detect lead ant's path, inclined to follow

    蚂蚁察觉到前面蚂蚁的路径，跟随而去

  - More pheromone on path increases probability of path being followed

    路径上更多的费洛蒙增加了跟随该路径的概率

Concept of Ant Colony Optimization 蚁群优化的概念

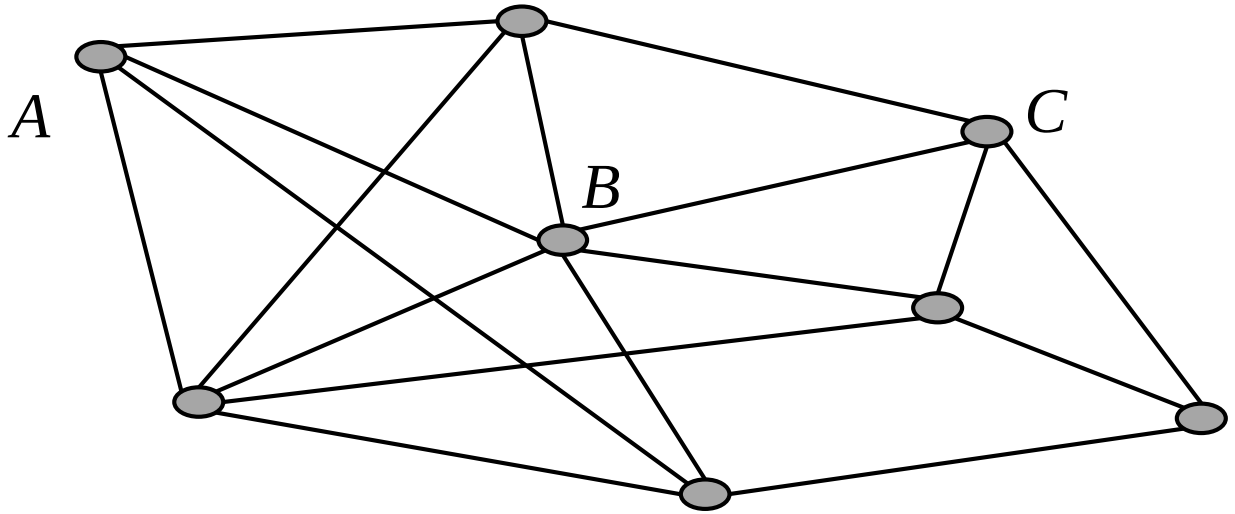


Algorithm of Ant Colony Optimization 蚁群优化算法

- Virtual “trail” accumulated on path segments
  在路径段上积累“虚拟”嗅迹
- Starting a node selected at random
  开始时随机选择某个节点
- The path selected at random: based on amount of “trail” present on possible paths from starting node; higher probability for paths with more “trail”
  随机选择一条路径：基于从初始节点至合适路径上出现嗅迹的量；具有较多嗅迹的路径则具有较高的概率
- Ant reaches next node, selects next path
  蚂蚁到达下一个节点后，再选择下一个路径
- Repeated until most ants select the same path on every cycle
  重复直到更多的蚂蚁在每个循环中都选择同一个路径

Example: Travelling Salesperson Problem (TSP) 旅行推销员问题

- A salesman spends his time visiting n cities.
  一个推销员花时间访问n个城市。



	A	B	C	…
A	0	12	34	…
B	12	0	76	…
C	34	76	0	…
…	…	…	…	…

- He visits each city just once and finishes up where he started.
  他每次仅访问一个城市，最后回到他出发的地方。
- In what order should he visit them to minimize the distance?
  他应该按什么顺序访问这些城市才能使距离最短？

Example: Travelling Salesperson Problem (TSP) 旅行推销员问题

- Key points for TSP are as following:

  TSP的要点如下：

  - not a state-space problem

    不是一个状态空间问题

  - "states" = possible tours = $(n\text{-}1)!/2$

    "状态" = 可能的旅行路线 = $(n-1)!/2$

- TSP is an NP-hard problem in combinatorial optimization, important in operations research and theoretical computer science.

  TSP是组合优化中的一个NP难问题，在运筹学和理论计算机科学中非常重要。

- TSP is a special case of the travelling purchaser problem (TPP).

  TSP是旅行采购员问题（TPP）的一个特例。

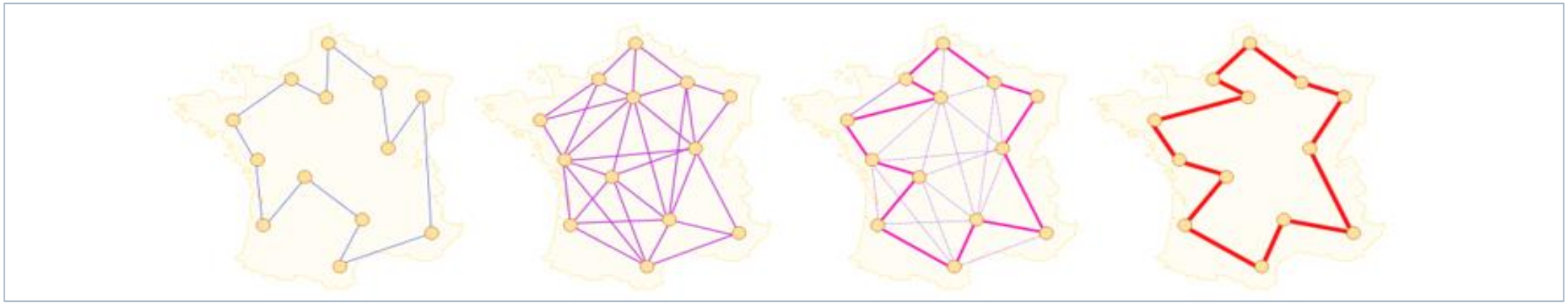
Example: Travelling Salesperson Problem (TSP) 旅行推销员问题

- The first Ant Colony Optimization algorithm was aimed to solve the *Travelling Salesperson Problem*, in which the goal is to find the shortest round-trip to link a series of cities.

  最早的蚁群优化算法旨在解决旅行推销员问题，其目标是找到连接所有城市的最短往返旅程。

- The general algorithm is relatively simple and based on a set of ants, each making one of the possible round-trips along the cities.

  一般的算法相对简单，基于一群蚂蚁，每个都能够沿着这些城市形成一个可能的往返旅程。



Applications of Ant Colony Optimization 蚁群优化的应用

- Have been applied to many combinatorial optimization problems:
  已经被用于许多组合优化问题：

Scheduling problem	进度安排问题
Vehicle routing problem	车辆路径问题
Assignment problem	分派问题
Device Sizing Problem in Physical Design	物理设计中的设备量尺问题
Edge Detection in Image Processing	
Classification	图像处理中的边缘检测
Data mining	
	分类
	数据挖掘

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Contents

Particle Swarm Optimization (PSO) 粒子群优化

- Proposed by James Kennedy & Russell Eberhart in 1995. Inspired by social behavior of birds and fishes.

  由詹姆斯·肯尼迪和拉塞尔·埃伯哈特于1995年提出。受鸟类和鱼类的社会行为的启发。

- Uses a number of particles that constitute a swarm moving around in the search space looking for the best solution.

  采用若干粒子构成一个围绕搜索空间移动的群体来寻找最优解。

- Each particle in search space adjusts its “flying” according to its own flying experience as well as the flying experience of other particles.

  搜索空间的每个粒子根据它自己的飞行经验和其它粒子的飞行经验调整它的“飞行”。

Bird Flocking 鸟群

- A group of birds are randomly searching food in an area.
  一群鸟在一个区域随机地寻找食物。
- There is only one piece of food in the area being searched.
  在该被搜索区域仅有一块食物。
- All the birds do not know where the food is.
  所有的鸟都不知道食物在哪儿。
- But they know how far the food is in each iteration.
  但它们在经过每次环飞后知道食物有多远。
- So what's the best strategy to find the food?
  因此发现食物的最好策略是什么？
- The effective one is to follow the bird which is nearest to the food.
  最有效的方法是跟随离食物最近的鸟。

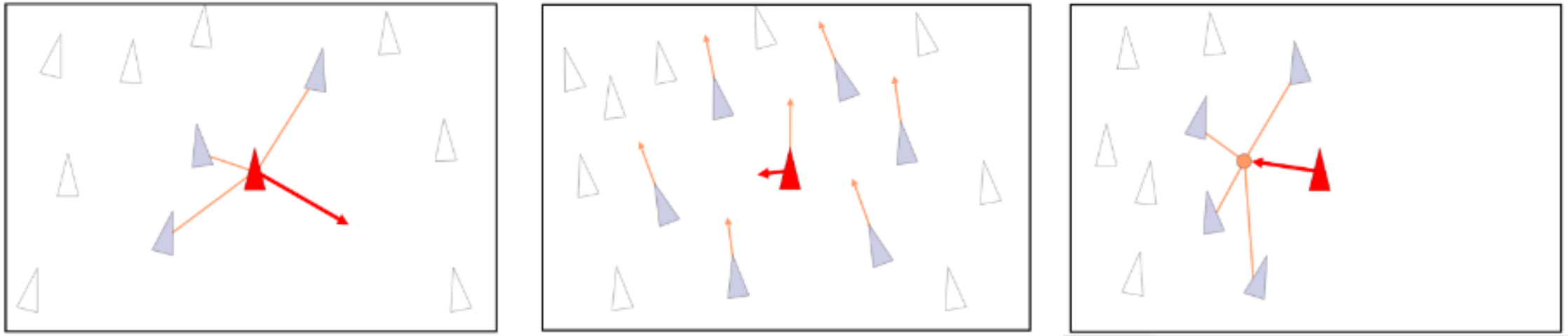
Bird Flocking 鸟群

- Only three simple rules

  仅需三个简单的规则

  - (a) Avoid collision with neighboring birds; (b) Match the velocity of neighboring birds; (c) Stay near neighboring birds.

    （a）避免与相邻的鸟碰撞；（b）保持与相邻的鸟相同的速度；（c）靠近相邻的鸟。



(a) (b) (c)

Algorithm of Particle Swarm Optimization (PSO) 粒子群优化算法

For each *particle*
    Initialize *particle*
Do
    For each *particle*
        Calculate fitness value
        If fitness value > best fitness value (*pBest*) in history
            set fitness value as new *pBest*
    Choose *particle* with best fitness value of all particles as *gBest*
    For each *particle*
        Calculate *particle* velocity
        Update *particle* position
While maximum iterations or minimum error criteria is not attained

Artificial Neural Network (ANN) and PSO

- An ANN is a computing paradigm that is a simple model of the brain, and the back-propagation algorithm is the one of the most popular method to train the ANN.

  ANN是一种大脑简单模型的计算范型，而反向传播算法是训练ANN的最受欢迎的方法之一。

- There have been significant research efforts to apply evolutionary computation (EC) techniques for the purposes of evolving one or more aspects of ANNs.

  已经有重要的的研究工作，为了改进ANNs的一个或多个方面，应用了进化计算计算（EC）。

Artificial Neural Network (ANN) and PSO

- Several papers reported using PSO to replace the back-propagation learning algorithm in ANN.

  若干篇论文报告了采用粒子群优化来替代ANN中的反向传播学习算法。

- It showed PSO is a promising method to train ANN. It is faster and gets better results in most cases.

  论文表明，PSO是一种训练ANN的有前途的方法，它快速并且在多数情况下取得了更好的结果。

Thank you for your attention!