Applications of Ant Colony Optimization

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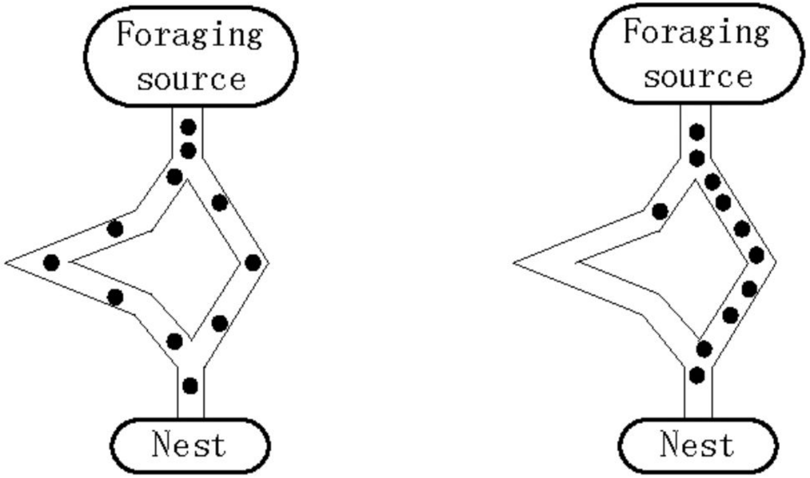
Situation: You have to approximate an optimal solution to an NP-Hard problem.

What would ants do?

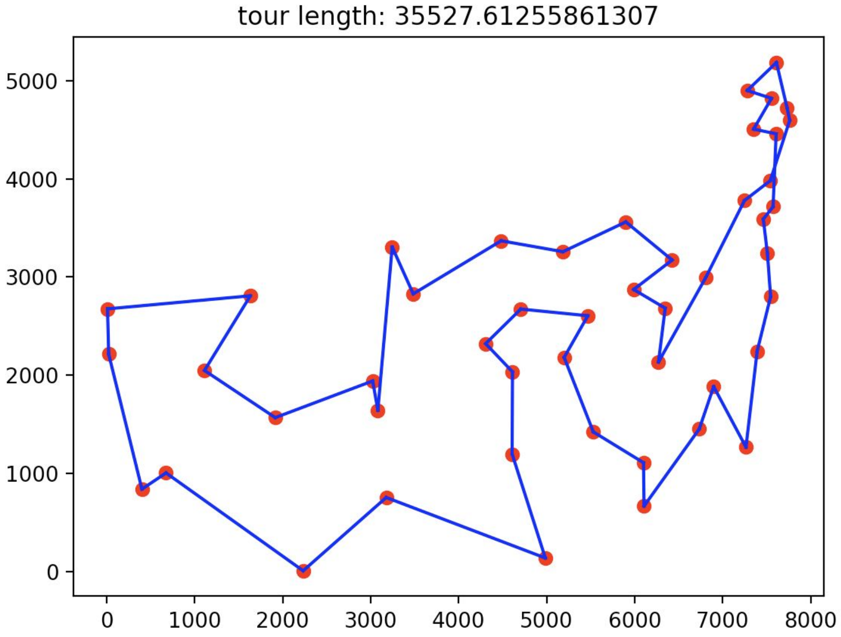
- When searching for a food source, ants deposit **pheromones** on the ground
- Ants are more likely to navigate in a direction that has a higher pheromone concentration
- Leads to the ants finding the most efficient path!

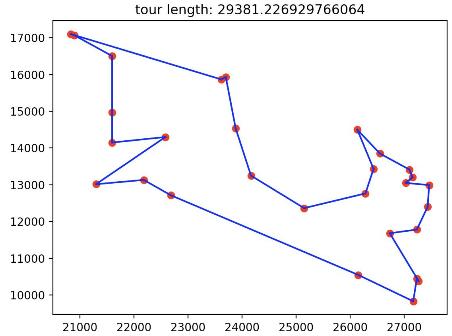


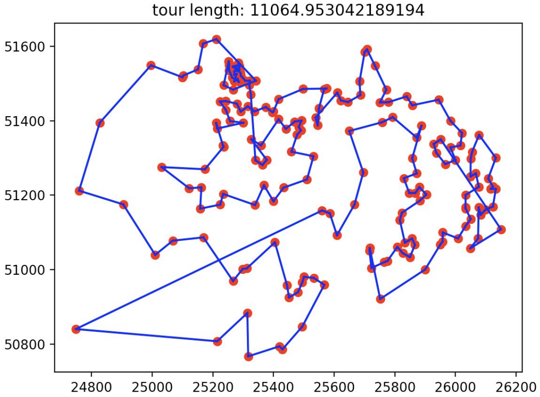
The ACO Algorithm

```
procedure ACO is
    initialize pheromone matrix
    loop
        loop
            each ant applies a state transition rule to incrementally build a solution
            apply local pheromone updating rule
        until all ants have built a complete solution
        apply global pheromone updating rule
    until end_condition
end procedure
```

Application I: Travelling Salesman Problem (Live Demo!)

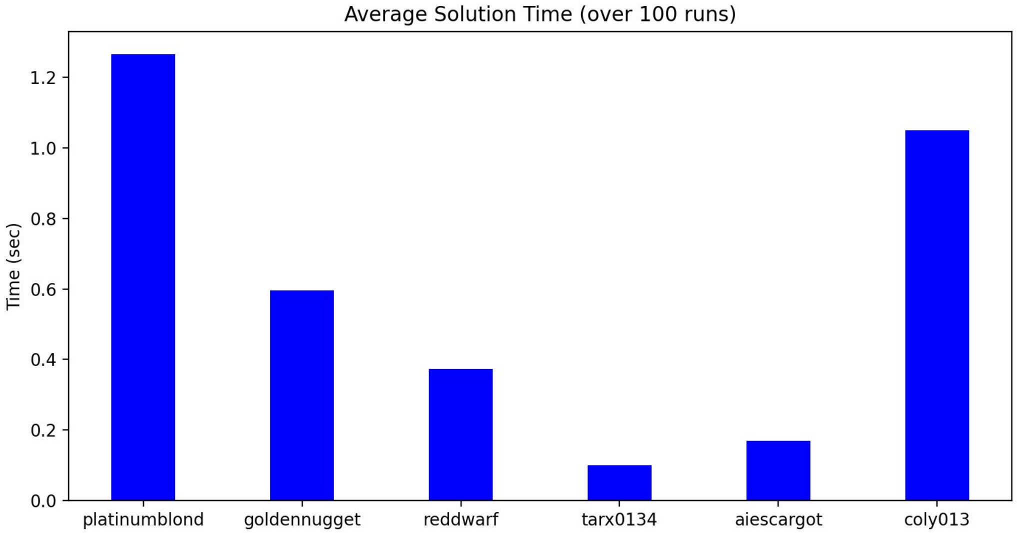


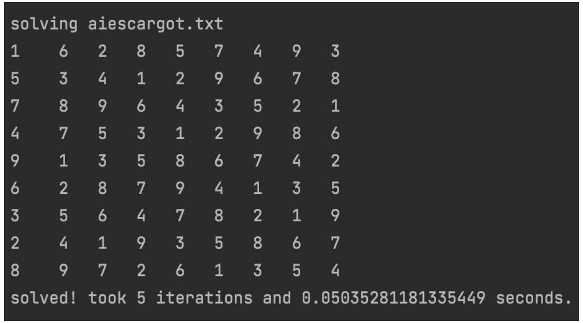




Entries in the pheromone matrix for every edge.

Application II: Sudoku Solver





```
solving aiescargot.txt
1    6    2    8    5    7    4    9    3
5    3    4    1    2    9    6    7    8
7    8    9    6    4    3    5    2    1
4    7    5    3    1    2    9    8    6
9    1    3    5    8    6    7    4    2
6    2    8    7    9    4    1    3    5
3    5    6    4    7    8    2    1    9
2    4    1    9    3    5    8    6    7
8    9    7    2    6    1    3    5    4
solved! took 5 iterations and 0.05035281181335449 seconds.
```

Entries in the pheromone matrix for every possible value of every cell.

Conclusions

- Benefits of ACO
  - An idea that generalizes to a vast amount of problems
  - Quickly generates near-optimal solutions to NP-Hard problems
- Drawbacks of ACO
  - Often gets stuck in local minima
  - No guarantees about the optimality of the solution (or how close to optimal the solution will be)
  - Very sensitive to changes in hyperparameters
- Ways to mitigate these drawbacks
  - Local Search
  - Constraint propagation
  - Pheromone evaporation

Thank you all for a great semester!

Code at https://github.com/jacobe90/aco-applications