Swarm Intelligence

Other ACO Algorithms and ACOTSP

Leonardo Bezerra and Leslie Perez Caceres

IRIDIA – Université Libre de Bruxelles (ULB)
Bruxelles, Belgium
lperez@iridia.ulb.ac.be
leonardo@iridia.ulb.ac.be

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Review

- We have studied:
  - Ant System
  - MAX-MIN Ant System
  - Ant Colony System
- What do they have in common?
  - Each ant builds a solution in each iteration
  - Ants are guided by:
    - Heuristic Information
    - Pheromone Information
  - Pheromone evaporates during the search
  - Pheromone is updated by ants according to the solution found

Review
Ant System

```
1 For #iterations
2   For each ant Do
3     Choose a random starting city
4     While tour is not complete
5       Select next city [random proportional transition rule]
6     EndWhile
7   EndFor
8   Update pheromone [all ants,
                      Proportional to tour length]
9 EndFor
```

Review
MAX-MIN Ant System

```
1 For #iterations
2   For each ant Do
3     Choose a random starting city
4     While tour is not complete
5       Select next city [random proportional transition rule]
6     EndWhile
7   EndFor
8   Update pheromone [(best) ant,
                      tour length proportional,
                      respect max and min pheromone values]
9   If convergence Then
10    Reinitialize pheromone
11  EndIf
12 EndFor
```

Review
Ant Colony System

```
 1 For #iterations
 2   For each ant Do
 3     Choose a random starting city
 4     While tour is not complete
 5       Select next city [pseudo-random proportional
                           transition rule]
 6       Local Update of pheromone
 7     EndWhile
 8   EndFor
 9   Global Update of pheromone [global best ant,
                                 tour length proportional]
10 EndFor
```

ACOTSP

- ACOTSP developed by Thomas Stützle, provides the implementation of a set of ACO algorithms to solve the TSP.
- Which algorithms are implemented?
  - **Ant System**
  - Elitist Ant System
  - **MAX-MIN Ant System**
  - Rank based Ant System
  - Best-worst Ant System
  - **Ant Colony System**

ACOTSP
Elitist Ant System

- Elitism refers to favour best individuals to guide the search. → intensification
- After each iteration the **global best ant** deposit pheromone along with the others.
- Introduce a new parameter ***e*** that controls the contribution of the global best ant to the pheromone update – **number of elitist ants**.

$$\tau_{ij}(t) = (1-\rho)\cdot\tau_{ij}(t-1) + \sum_{k=1}^{m}\Delta\tau_{ij}^{k} + e\,\Delta\tau_{ij}^{bs}$$

ACOTSP
Rank-based Ant System

- After each iteration the ants:
  - are **ranked** regarding their tour quality.
  - deposit pheromone according to their rank – the best ones contribute more.

The global best ant deposit pheromone with the others.

$$\tau_{ij}(t) = (1-\rho)\cdot\tau_{ij}(t-1) + \sum_{r=1}^{\omega-1}(\omega-r)\Delta\tau_{ij}^{r} + \omega\Delta\tau_{ij}^{bs}$$

ACOTSP
Best-worst Ant System

Transition rule and pheromone evaporation as in Ant System

- Pheromone update after each iteration:
  - The global best ant contributes positively to the pheromone update
  - The worst iteration ant contribute negatively to the pheromone update (additional evaporation)
    - This is only applied in the edges present in the worst ant and absent in the global best ant.
- Pheromone trails mutation → diversification
  - Mutation deposit (+/-) is calculated according to runtime/#iterations elapsed and average quality of the best tour
- Restart of the search when stagnation
  - The distance between the best and the worst solution is less than 5%

ACOTSP
Options: Algorithms

- How to specify the algorithm?
  - ***--as*** *: Ant System*
  - ***--eas*** *: Elitist Ant System*
  - ***--ras*** *: Rank-based Ant System*
  - ***--mmas*** *: MAX-MIN Ant System*
  - ***--bwas*** *: Best-worst Ant System*
  - ***--acs*** *: Ant Colony System*
- Look for other parameters using ***./acotsp –help***
- Related parameters:

  --q0: q_0: prob. of best choice in tour construction (ACS)

  --elitistants: number of elitist ants (EAS)

  --rasranks: number of ranks in rank-based Ant System (RAS)

ACOTSP
Options: Other

- Other general parameters

--tries: number of independent trials (runs)

--tours: number of steps in each trial (max tours evaluated per trial)

--time: maximum time for each trial (seconds)

--seed: seed for the random number generator

--optimum: to stop if tour better or equal optimum is found

--ants: number of ants

--nnants: nearest neighbours in tour construction

- To use of candidate list to construct solutions

--alpha: alpha (influence of pheromone trails)

--beta: beta (influence of heuristic information)

--rho: rho (pheromone trail evaporation)

--localsearch: 0: no local search 1: 2-opt 2: 2.5-opt 3: 3-opt

ACOTSP

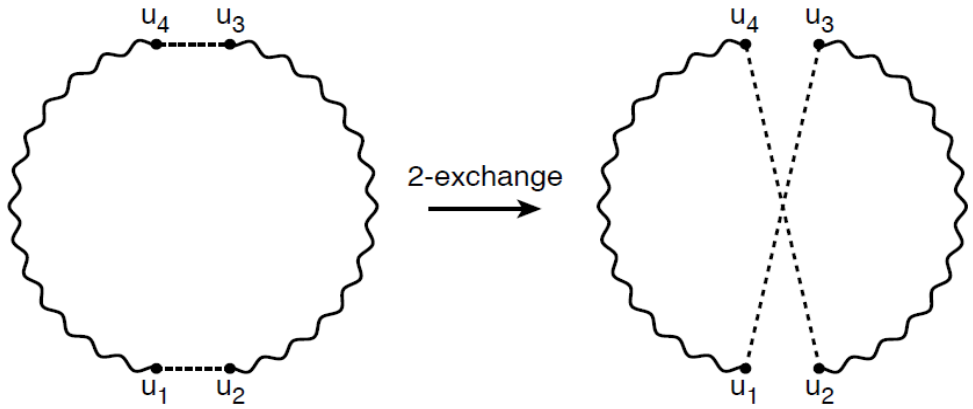
Options: Local search

- Local search starts from solution already constructed and moves through the search space from one neighbour to other.
- ACOTSP offers the possibility of applying a local search procedure to improve the tour founded by the ant.
- The options are:
  - 2-opt
  - 2.5-opt
  - 3-opt

ACOTSP

Options: Local search

- 2-opt
  - Heuristic: Select two edges and exchange them (2-exchange)
  - Repeat this process for all the edges combinations looking for improvement



- 3-opt follows the same idea using 3 edges (superset of 2-opt)
- 2.5-opt: Evaluates the insertion of a node coming from edge (A-B) between the nodes of other edge (C-D). Ex. A-C-B

ACOTSP

Options: Local search

- The exercises are focused in analysing and comparing the different algorithms that are implemented in ACOTSP.
- Check the output of the algorithm and the information that it gives to you.
- On the website there is a pair of instances that will be used in this exercise. Also you can find other instances a bit more difficult, for advanced analysis.