Improvement of the efficiency and quality of the MAX-MIN Ant System
Outline

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**Introduction**

- NP problems
  - TSP
  - Scheduling
  - Set covering
- Conventional algorithms
  - Take too much time
  - Large instances intractable
- Stochastic algorithms
Background Information - ACO

- Ant colony optimization
- Based on real ant behaviour
- Targets problems reducable to shortest path in a graph
- Stochastic
Background Information - ACO

- Ants find a path
- Pheromones deposited on path
- Solution eventually converges to a single path
- Pheromone evaporates over time
- Example of Stigmergy
Background Information - ACO

Variations
- Elitist Ant System
- Rank based Ant System
- MAX-MIN Ant System

MAX-MIN Ant System
- Lower & Upper limits on pheromone trails
- Only one ant allowed to deposit

Local search
Thesis Statement

To improve on the solution quality and speed of the MAX-MIN Ant System against various problems by applying modifications to the main metaheuristic and incorporating new local search techniques.
Attempted Approaches

- Merging MMAS with Lin-Kernighan Heuristic
- Utilizing multiple ant groups with local pheremone matrices
- Incorporating Stubborn Ants mechanism (to be done)
Background Information - LKH

- Lin-Kernighan Heuristic
- Targets TSP
- Adaptive-opt vs. 2/3-opt
Background Information – Stubborn Ants

- In normal case, ants use pheromone and heuristic
- Stubborn ants remember their solution
- Previous ant solution becomes a factor

\[
p_{ij}^k(t) = \frac{[\tau_{ij}(t)]^\alpha \cdot [\eta_{ij}]^\beta}{\sum_{l \in \mathcal{N}_i^k} [\tau_{il}(t)]^\alpha \cdot [\eta_{il}]^\beta}
\]

\[
p_{ij}^k(t) = \frac{[\tau_{ij}(t)]^\alpha \cdot [\eta_{ij}]^\beta \cdot \delta_{i,j}^k(t - 1)}{\sum_{l \in \mathcal{N}_i^k} [\tau_{il}(t)]^\alpha \cdot [\eta_{il}]^\beta \cdot \delta_{i,l}^k(t - 1)}
\]

\[
\delta_{a,b}^k(t) = \begin{cases} 
\gamma & \text{if } (a,b) \in \mathcal{E}_{t-1}^k \text{ or } (b,a) \in \mathcal{E}_{t-1}^k \\
1 & \text{otherwise}
\end{cases}
\]
Results Summary

- MMAS – LKH hybrid almost always better and faster than:
  - MMAS solo
  - LKH solo
- Splitting ants into groups resulted in results comparable to MMAS
  - Allowed the removal of global pheromone array
Current Goals

- Attempt to improve MMAS using ant groups
- Test stubborn ants effectiveness against different problems
  - Sequential ordering
  - Probabilistic TSP
Related Work

Thank You
References


References


[6] LKH (Keld Helsgaun), http://www.akira.ruc.dk/~keld/research/LKH


