Ant Colony Optimization Applied to Map Generalization

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Background

- PhD Project
- Simulated Annealing Work
- Ant Colony
  - Quality?
  - Speed?
  - Usability
  - Parallelization
What is Ant Colony Optimization?
Travelling Salesman Problem
Tour length = 38
TCP – ACO Approach

while stop conditions not met /*start next iteration*/

for each ant
    start at random city
    while more cities to visit
        travel to "best" available city
    end while
    maintain record of this iterations shortest tour
end for

decay pheromone for all edges
increase pheromone for edges belonging to this iterations shortest tour
maintain record of overall shortest tour

end while

“best” is decided through a stochastic mechanism where the probability of selecting a particular city is governed by heuristic information (immediate benefit) and pheromone value (historical benefit).
3 Ants, iteration 1

Tour length = 52

Tour length = 40

Tour length = 50
3 Ants, iteration 2

Tour length = 42

Tour length = 39

Tour length = 38
ACO and Map Generalization

- Schematic Maps
- River Symbolization
Schematic Maps

• Silvania Avelar - Algorithm based on iterative improvement optimization / gradient descent

• Characteristics of schematic map

  – An abstract diagrammatic representation of a network

  – Topologically correct

  – Simplified lines

  – Lines re-oriented so that they lie horizontal, vertical or diagonal

  – Scale in congested areas expanded at the expense of scale in areas of lesser node density
Example - Network
Example - Simplify
Example – Re-orientate
Example – Re-scale congested areas
ACO Algorithm – General Idea

• Iterative Improvement
  – Initial state
  – Evaluate state
  – Modify state
  – Decision making process
  – Repeat until
Initial State

• Initial data sets
  – Linear network
  – OS road centrelines (OSCAR)
  – Pre-generalized using ArcInfo Generalize
Modify State

• “Greedy” displacement
  – Pick a single vertex
  – Generate a displacement
Evaluate State - Constraints

(a) Topological
(b) Orientation
(c) Length
(d) Angle
(e) Rotation
(f) Clearance
(g) Displacement
Evaluate State - Cost

Cost =

Topological x W1 + Orientation x W2 +
Length x W3 + Angle x W4 +
Rotation x W5 + Clearance x W6 +
Displacement x W7
Map Schematization – ACO Approach

while stop conditions not met /*start next iteration */
    for each ant
        randomize vertex order
        for each vertex
            perform "best" displacement
        end for
        maintain record of this iterations lowest cost schematic
    end for
    decay pheromone for all pheromone grid cells
    increase pheromone for grid cells corresponding to this iterations lowest cost schematic
    maintain record of overall lowest cost schematic
    reset network configuration
end while

perform local search?

"best" is decided through a stochastic mechanism where the probability of moving to a particular location is governed by heuristic information (immediate benefit) and pheromone value (historical benefit).
Vertex maximum displacement
Pheremone Grid
(1 per vertex)
After iteration 1
After iteration n
Initial cost = 650
Best cost = 70 (80 seconds)
Best cost = 138
(> 600 second)
River Symbolization

(a)

(b)

(c)

(d)
while stop conditions not met /*start next iteration*/
    for each ant
        randomize segment order
        for each segment
            perform “best” split(s)
        end for
        maintain record of this iterations lowest cost segmentation
    end for
    decay pheromone for all pheromone grid cells
    increase pheromone for grid cells corresponding to this iterations lowest cost schematic
    maintain record of overall lowest cost segmentation
    reset network configuration
end while

perform local search?
Conclusion

• Ant Colony Optimization – works
• Ant Colony Optimization – improves on SA?
  – Quality, speed, ease of use
• Future
  – More testing (including more realistic data)
  – Other map generalization problems
  – Parallelization