TJHSST Senior Research Project
Optimizing Pheromone Modification for Dynamic Ant Algorithms
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Ryan Ward

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Abstract

Ant Colony Optimization is a metaheuristic that is used to find near-optimal solutions to NP problems. This research studies how ACO algorithms (ant algorithms) are applied to dynamic problems, namely the dynamic Traveling Salesman Problem. In dynamic problems, pheromone information used by ant algorithms must be changed according to changes in the problem. This research aims to discover how to efficiently modify pheromone after a change in the problem set such that new, near-optimal solutions are found quickly.

Keywords: Ant Colony Optimization (ACO), dynamic Traveling Salesman Problem (dTSP)

1 Background

Ant algorithms were originally inspired by the natural system that ants use to develop a short path between their colony and a food source. When ants find a food source and travel back to their colony, they leave behind pheromone, a hormone that other ants follow. ACO algorithms, also known as ant algorithms, mimic this system, using agents that independently solve a problem and then modify pheromone values in the problem to increase or decrease the probability of a solution being searched again.

The Traveling Salesman Problem (TSP) is, formally: given a graph, find the tour that visits all the nodes with the least amount of cost. This research will be using Euclidean 2D dynamic TSP (dTSP), where the cost from moving to node x from node y is the distance between the nodes, and where the set of nodes in the graph changes over time.

The two main factors that agents use when constructing a tour are the cost of moving across an edge (in this case, the distance between nodes) and the pheromone value associated with an edge (this changes during runtime). The cost of an edge represents known information about the problem, while the pheromone represents learned information about the problem. In a dTSP, the set of nodes in the problem changes, so learned information, pheromone, may become obsolete based on the location, frequency, and severity of the changes. It is important that pheromone is altered during a change in such a way that useful pheromone information is kept while obsolete pheromone information is reset

An ACO algorithm was initially proposed in 1992 and accepted as a well defined metaheuristic in 1999. Since then ACO has been used to find near-optimal solutions to multiple problems. Most of the research being done in applying ant algorithms to dTSP involves studying ways of updating pheromone. dTSP is currently studied as a test problem for dynamic approximation algorithms. dTSP can be mapped to multiple problems, such as Job-Shop Scheduling (where machines turn on and off in a factory) or computer networks (where nodes go on or off-line).

2 Purpose

The main goal of this research is to determine the best way to change pheromone values of the ant algorithm depending on the severity, frequency, and location of changes to the problem. Through examining different methods of resetting pheromone, a trend should be discovered for how modifications should take place. The result should be an efficient way to adjust pheromone values in the problem to incorporate new nodes effectively.

3 Procedure and Methodology

3.1 Scope of Study

This research will focus on two main methods of resetting pheromone after a change in the problem: the re-initialization method and the distance-based method. The re-initialization method resets pheromone values uniformly across all nodes, while the distance-based method resets pheromone values on a node based upon the nodes distance from changes in the graph. The two methods, along with a method that combines both strategies in different ratios, will be studied for different frequencies and severities of changes in the dTSP to see if there is a correlation between frequency/severity and which method performs better.

3.2 Problem Construction and Testing

To test performance, the Ant Colony System (ACS) algorithm will be used, modified to fit the dTSP. One iteration of ACS involves individual agents constructing their own circuits based on pheromone and cost information. The ACS system will implement a pseudo-random proportional rule, where an agent, based on probability p, chooses to move across an arc that has the highest attractiveness, as determined by pheromone and cost. Otherwise, the agent will perform a biased exploration of possible arcs. For pheromone changes during runtime, the ACS implementation will have global evaporation of pheromone after each iteration, pheromone decrease on an arc after an agent uses that arc, and pheromone increase on all arcs that are in the circuit of the best route found so far, proportional to the inverse of the distance of the circuit.

Construction of a dTSP will be done by taking a standard TSP problem and removing half the nodes, and then every F iterations (frequency) remove S nodes (severity) and add S nodes previously removed from the problem. Performance will be based on the average tour length after a change in the problem has taken place. The number of iterations and runs of the problem will be large enough to account for inherent randomness in the dTSP. Data will be collected for different combinations of problem size, reset methods, and frequency/severity combinations. It will be insured that wide ranges of all possible combinations will be tested in order to determine the validity of the data.

4 Expected Result and Value to Others

It is hypothesized that trends will arise in the data, namely that the re-initialization method will outperform the distance-based method when changes to the problem are infrequent and large, while the distance-based will perform better when changes to the problem are frequent and small. The data should inspire an optimal way of combining the two methods based on frequency/severity so that the combined method outperforms either method individually. Improvements to dynamic ant algorithms are valued in any field encountering optimization problems that change, such as computer networking, factory scheduling, or changing delivery routes in industry.