Search Methods in AI — Assignment 03

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Introduction

This assignment explores the Travelling Salesman Problem (TSP) using stochastic algorithms: Ant Colony Optimization (ACO), Branch and Bound, and Simulated Annealing. The TSP involves finding the shortest route visiting cities and returning to the original city, and our goal is to apply stochastic methods to this NP-hard problem, emphasizing diverse approaches.

We implemented Ant Colony Optimization, focusing on pheromone-based communication and probabilistic decisions to discover optimal paths. Simulated Annealing, inspired by metallurgical annealing, was applied to the TSP, using a temperature parameter to control sub-optimal solution acceptance.

Comparative evaluations of ACO and Simulated Annealing, considering efficiency, accuracy, and scalability, provide insights. A detailed discussion on each method's strengths and limitations aids algorithm selection for real-world TSP instances.

Comparative Evaluations

Our analysis of Simulated Annealing (SA) and Ant Colony Optimization (ACO) reveals valuable insights. SA exhibits commendable adaptability but is sensitive to parameter tuning, impacting computational costs. ACO excels in combinatorial optimization, with efficient parallelism but shows sensitivity and scalability challenges. Both rely on precise parameter tuning for adaptability.

Strengths and Limitations:

Simulated Annealing (SA):

- **Strengths:**
  - SA excels in adaptability, skillfully navigating complex solution spaces.
  - Its ability to escape local optima proves advantageous, especially in intricate landscapes.
- **Limitations:**
  - SA is sensitive to parameter tuning, necessitating careful adjustment.
  - Achieving convergence may require extensive iterations, impacting computational efficiency.

Ant Colony Optimization (ACO):

– **Strengths:**

- ACO demonstrates proficiency in combinatorial optimization, notably illustrated in solving the Traveling Salesman Problem.
- Efficient parallelism contributes to expedited exploration of solution spaces.

– **Limitations:**

- Sensitivity to problem characteristics emphasizes ACO's domain-specific strengths.
- Scalability challenges emerge in simulations involving larger problem instances.

In conclusion, our simulations and detailed examination enhance understanding of trade-offs between SA's adaptability and sensitivity, emphasizing ACO's domain-specific strengths. This knowledge aids informed algorithm selection for the assignment.

Our Approach and Results

In our approach to solve the TSP sufficiently well by coming up with a good tour in a hard limit of 300 seconds, we use the approach outlined in the following:

For the first part of the 300 seconds, that is for 80 seconds, we let our ACO implementation converge on a tour. We found the following parameters to be giving good convergence:

$$\begin{aligned} \alpha &= 18 \\ \beta &= 6 \\ \rho &= 0.99 \end{aligned}$$

We then apply continuous 3-opt improvements on the path that ACO converges on. This is done for 200 seconds. The 3-opt switches edges for each other and tries out which tour is the best.

This method is really helpful as the ACO converges, quite quickly, on a decent tour with enough short routes. The 3-opt improvement takes this tour and swaps edges such that we get cheaper tours. On average, after the period of 280 seconds, we converge on a tour that is within 2% error consistently. This metric has been evaluated over 3 benchmark tests with 50, 70, and 150 cities.