DOKUZ EYLÜL ÜNİVERSİTESİ

MÜHENDİSLİK FAKÜLTESİ

ENDÜSTRİ MÜHENDİSLİĞİ BÖLÜMÜ

**IND 3982 INTRODUCTION TO COMPUTATIONAL INTELLIGENCE PROJECT REPORT**

2021503117- Batuhan BİLGİN

**Abstract**

In this project, the vehicle routing problem is solved using the Artificial Bee Colony (ABC) algorithm (Karaboga & Akay, 2005). The vehicle routing problem is a critical issue in logistics and distribution systems, aiming to minimize costs. The ABC algorithm is an optimization technique inspired by the foraging behavior of natural bees. However, due to the tight constraints in the problem, generating feasible solutions became increasingly difficult as the problem size grew. The solution process required more time and computational power as larger datasets were encountered.

**CHAPTER 1**

**INTRODUCTION**

Optimization problems are critical in various fields such as logistics, manufacturing, and transportation. These problems involve finding the best possible solution from a set of feasible options while adhering to specific constraints. Efficiently solving optimization problems is essential, especially in real-world scenarios where resources are limited, and operational efficiency is crucial.

One effective approach to tackling complex optimization problems is through **metaheuristic algorithms**. These algorithms are designed to provide near-optimal solutions without the need for exhaustive searches, making them suitable for large and complex problems. Metaheuristics such as Genetic Algorithms (GA), Simulated Annealing (SA), Particle Swarm Optimization (PSO), and **Artificial Bee Colony (ABC)** algorithms are widely used due to their flexibility and effectiveness. The ABC algorithm, inspired by the foraging behavior of bees, is particularly notable for its simplicity and efficiency in solving various optimization problems.

The **vehicle routing problem (VRP)** is a well-known optimization problem in logistics. It involves determining the most efficient routes for a fleet of vehicles to deliver goods to customers while minimizing total travel distance, time, or cost. This problem is challenging because it is NP-hard, meaning that the complexity increases significantly as the number of vehicles and customers grows. Metaheuristic algorithms like ABC are well-suited for solving the VRP as they can efficiently navigate large solution spaces and handle complex constraints.

In this project, the ABC algorithm was employed to address the vehicle routing problem. Due to the stringent constraints of the problem, it became increasingly difficult to find feasible solutions as the problem size expanded. Despite these challenges, the ABC algorithm demonstrated its capability in providing good solutions within a reasonable timeframe, highlighting its potential for practical applications in logistics and transportation optimization.

**CHAPTER 2: ARTIFICIAL BEE COLONY (ABC) ALGORITHM**

The Artificial Bee Colony (ABC) algorithm is a nature-inspired optimization technique introduced by Karaboga and Akay (2005). It mimics the foraging behavior of honeybees to search for optimal solutions to complex optimization problems. The ABC algorithm is classified as a metaheuristic, which means it seeks near-optimal solutions without the need for exhaustive searching, making it particularly suitable for large-scale, computationally expensive problems.

**2.1 Overview of the ABC Algorithm**

The ABC algorithm is based on the collective behavior of honeybee colonies, where individual bees (referred to as "artificial bees") explore a solution space in search of the best nectar sources (solutions). The algorithm operates in three main phases: employed bee phase, onlooker bee phase, and scout bee phase.

* **Employed Bee Phase:** Employed bees exploit the currently known nectar sources (solutions). Each bee evaluates a solution and attempts to find a better one by exploring neighboring solutions. If a better solution is found, it is updated.
* **Onlooker Bee Phase:** Onlooker bees observe the employed bees and choose the best solutions based on the probability of their quality (fitness). The onlooker bees then move toward the best solutions in the search space to improve the overall solution pool.
* **Scout Bee Phase:** If an employed bee cannot find a better solution within a certain number of iterations, it becomes a scout bee and randomly explores the solution space. This phase helps maintain diversity and avoid local minima.

This cyclical process continues until a stopping criterion (such as the maximum number of iterations or convergence threshold) is met.

**2.2 Applications of the ABC Algorithm**

The ABC algorithm has been successfully applied to a variety of optimization problems, including but not limited to:

* **Function Optimization:** Finding the minimum or maximum of a mathematical function.
* **Vehicle Routing Problem (VRP):** Optimizing delivery routes for vehicles to minimize travel distance or time while meeting specific constraints, as applied in this project.
* **Job Shop Scheduling:** Scheduling tasks in manufacturing processes to minimize makespan or tardiness.
* **Clustering and Data Mining:** Optimizing the grouping of data points to discover meaningful patterns.

**2.3 Advantages and Challenges of the ABC Algorithm**

The ABC algorithm offers several advantages:

* **Simplicity:** The algorithm is easy to implement and requires few parameters.
* **Robustness:** It is effective in handling both continuous and discrete optimization problems.
* **Parallelism:** The ABC algorithm can be adapted to parallel computing environments, improving its efficiency for large-scale problems.

However, there are challenges, especially when dealing with larger problem sizes:

* **Convergence Speed:** The algorithm may require more iterations to converge for complex problems.
* **Solution Quality:** While the ABC algorithm often finds good solutions, it may struggle with achieving the global optimum in highly constrained environments.

**2.4 Variants and Improvements**

To address the challenges and improve performance, several variants of the ABC algorithm have been proposed:

* **ABC with Local Search:** Incorporating local search techniques to enhance the exploration and exploitation balance.
* **Hybrid ABC Algorithms:** Combining ABC with other metaheuristic algorithms like Genetic Algorithms (GA) or Particle Swarm Optimization (PSO) to leverage their complementary strengths.
* **Adaptive ABC:** Adjusting algorithm parameters dynamically during the search process to improve convergence.

These advancements aim to overcome the limitations of the basic ABC algorithm and improve its efficiency and effectiveness in solving real-world problems.

**CHAPTER 3: PROBLEM DEFINITION**

In this project, the objective is to solve a variant of the vehicle routing problem (VRP) with specific constraints and an optimization function. The problem consists of a set of nodes labeled from 0 to n, with the journey starting at node 0 and ending at node n+1. Each node must be visited exactly once, and the route must adhere to the following rules:

* **Transition Restrictions:**
  + For nodes where i<n/2i < n/2i<n/2, transitions from an odd-numbered node to an even-numbered node are prohibited.
  + For nodes where i≥n/2i \geq n/2i≥n/2, transitions from an even-numbered node to an odd-numbered node are prohibited.
* **Objective Function:** The objective is to minimize the following cost function:

L×Δ+DL \times \Delta + DL×Δ+D

Where:

* + DDD is the total distance of the route.
  + Δ\DeltaΔ is the difference between the longest and shortest distances between any two connected nodes.
  + LLL is the maximum distance between any two connected nodes multiplied by the number of nodes involved in that particular connection.

The challenge lies in finding a feasible route that satisfies the transition restrictions and minimizes the cost function. As the problem size grows, the computational difficulty increases, making it an ideal candidate for optimization techniques like the Artificial Bee Colony (ABC) algorithm.

**CHAPTER 5: CONCLUSION**

In this project, the Vehicle Routing Problem (VRP) was tackled using the Artificial Bee Colony (ABC) algorithm. The problem involved specific node transition constraints and an objective function to minimize. While the constraints made it challenging to find feasible solutions, the ABC algorithm was able to provide good results within a reasonable time frame.

However, as the problem size increased, the difficulty of finding feasible solutions grew, requiring more computational power and time. Despite these challenges, the ABC algorithm proved to be an effective method for solving complex optimization problems.

In conclusion, the ABC algorithm is a useful tool for optimization problems in fields like logistics and transportation. Future work could focus on exploring the algorithm's performance with larger datasets and more complex constraints.

**REFERANCES**

Karaboga, D. (2005). An idea based on honey bee swarm for numerical optimization, Technical report tr06, Erciyes University, Engineering faculty, computer. Erişim adresi: https://abc.erciyes.edu.tr/pub/tr06\_2005.pdf