CHAPTER 1

INTRODUCTION

1.1 Rationale

Travelling is a necessity for individuals, especially for those who are tired of working or want to refresh their minds. Every region must have a variety of exciting tourist attractions. However, challenges arise when tourists do not know the tourist destinations available in the area or have never visited the area before. Therefore, a system is needed to recommend tourist attractions to be visited by considering the closest route and constraints such as service time intervals (operating hours) so that tourists can maximize their vacation time optimally.

Many previous studies have developed optimization techniques and efficiency of tourist routes by analogizing the solution of the Travelling Salesman Problem (TSP). TSP is a problem in finding the shortest route that visits a number of points exactly once. In tourist routes, these points can be interpreted as tourist destinations visited by tourists. Basically, the algorithm for solving TSP (even if used for the case of multiple days of tourist visits) only produces one optimal route. If the daily timeframe is met, the tourist route will be truncated and continued the next day with the same route. Therefore, in this study, we analogize the problem as Vehicle Routing Problem (VRP) to generate optimal routes.

Vehicle Routing Problem (VRP) is an optimization problem that is often applied in delivery or distribution routes. In addition to determining distribution routes, VRP can also be utilized to solve other problems, such as flow shop scheduling. In VRP, a number of vehicles depart from a depot and visit different locations for each vehicle exactly once, then return to the depot. In this context, the vehicles can be considered as days of travelling, for example, vehicle one to determine the first day's tourist route, vehicle two to determine the second day's tourist route, and so on.

Many previous studies have solved multi-day tourist route problems analogous to solving TSP using various methods such as Tabu Search [17], Simulated Annealing (SA) [3], and Artificial Bee Colony (ABC) [8]. These studies produce routes for itineraries for several days. However, the disadvantage is that the route generated is only one for several days, so it needs to be cut based on time constraints. This results in non-optimal daily routes. Thus, in this study, we propose a new approach to solve the multi-day travel problem by analogizing this problem as a VRP solution to generate more optimal routes for multi-day trips.

In this study, we use a Genetic Algorithm (GA) hybridized with Simulated Annealing (SA), known as Hybrid Genetic and Simulated Annealing (HGSA). We use the Genetic Algorithm (GA) due to its ability to find optimal solutions in local and global solution spaces and is an effective probability-based optimization algorithm for complex planning [20]. However, GA has the disadvantage of fixed crossover and mutation probabilities so that it can get stuck at the local optimum. This is because GA tends to explore solutions around the area that have already been found. To overcome this, GA need to be combined with other metaheuristics, such as SA. SA are known for their ability to explore the solution space extensively to find new solutions that may be better than the ones already found [2, 22]. In other words, SA can help GA avoid getting stuck in local optima.

The proposed method also considers user preferences (multi-criteria), such as the rating of tourist attractions, total cost, and time. The concept of Multi-Attribute Utility Theory (MAUT) is used to handle the problem. In addition, the system must also consider another factor, i.e., time windows (for tourist attractions and tourists). Time windows of tourist attractions refer to the operating hours (opening and closing hours of tourist attractions). In contrast, time windows of tourists refer to the schedule they desire during the tour.

1.2 Theoretical Framework

1. Vehicle Routing Problem (VRP)

   VRP is a generalization of TSP where there are a number of vehicles that must visit a number of locations with efficient routes. VRP is relevant for multi-day tour route planning because each vehicle can be likened to one day of tour. VRP allows to optimize routes based on various constraints such as time constraints, capacity, and service intervals.

2. Hybrid Genetic and Simulated Annealing (HGSA)

   Genetic Algorithm (GA) is a population-based optimization algorithm that mimics the process of natural evolution. GA works by generating, selecting, combining, and mutating candidate solutions to find the optimal solution. GA is effective in exploring the solution space but can get stuck in local optima. Simulated Annealing (SA) is an optimization algorithm that mimics the cooling process of materials in metallurgy. SA is able to escape from local optima by exploring the solution space more widely. Combining GA with SA (HGSA) provides a combination of GA's strengths in exploration and exploitation with SA's ability to avoid local optima.

3. Multi-Attribute Utility Theory (MAUT)

   MAUT is a decision-making theory that helps in evaluating and selecting alternatives based on several criteria. In the context of tourist route planning, MAUT can be used to assess and combine tourist preferences such as tourist attraction popularity, total cost, and time. By using MAUT, the recommendation system can accommodate various user preferences to generate routes that are more in line with their wishes.

4. Time Windows

   Time windows refer to specific time limits during which a tourist attraction opens and closes and the traveler's time preferences during the trip. In planning a tour route, it is important to consider time windows so that each visit to a tourist attraction can be done during its operating hours and according to the schedule desired by the tourist.

By integrating these theories and concepts, this research aims to develop a comprehensive model for multi-day tourist route planning that overcomes the limitations of existing methods. This study uses VRP for multi-day tour route optimization. HGSA is applied to find the optimal route by utilizing the strengths of GA and SA. MAUT is used to accommodate user preferences, and time windows are calculated to ensure visits are in accordance with tourist operating hours and schedules. The combination of these theories and concepts supports the development of an optimal multi-day tour route recommendation system that is in accordance with user preferences.

1.3 Conceptual Framework/Paradigm

1.3.1 Conceptual Framework

The study focuses on optimizing multi-day tourist routes using a Hybrid Genetic and Simulated Annealing (HGSA) algorithm to address the Vehicle Routing Problem (VRP). The framework incorporates several key variables that influence the performance and outcome of the proposed model:

1. Tourist Preferences and Constraints

   - Rating: The rating or popularity of tourist attractions.
   - Cost: Financial considerations for visiting attractions.
   - Travel Time : The total travel time of the trip in several days of the visit.
   - Time Windows: Operational hours of attractions and tourists' preferred visiting times.

2. Performance Metrics

   - Fitness Value: Combines DOI, cost, and time to evaluate the quality of routes.
   - Travel Time: Total time spent travelling between attractions and hotels.
   - Total Cost: Combined expenses of visiting attractions.
   - The Number of Attractions Included : Quantity of tourist attractions included in the itinerary.
   - Average Rating: Aggregated preference ranking of the selected attractions.

3. Comparison with Other Algorithms

    - Genetic Algorithm (GA)
    - Firefly Algorithm (FA)
    - Grey Wolf Optimizer (GWO)
    - Particle Swarm Optimization (PSO)

1.3.2 Relationships

- Tourist Preferences & Constraints directly impact the Optimization Algorithms by defining the parameters and boundaries within which the algorithms operate.
- The Optimization Algorithms (HGSA) process the input preferences and constraints to generate routes, which are then assessed using the Performance Metrics.
- The results of the Performance Metrics offer quantitative evidence of the HGSA algorithm's effectiveness, which can be compared against the performance of other optimization algorithms like FA, GWO, and PSO.

1.4 Statement of the Problem

VRP is often applied to solve various problems such as flowshop scheduling problems [7], goods delivery [1, 21], and military logistics distribution [9]. In this study, we apply the Vehicle Routing Problem (VRP) to solve multi-day tourist route problems. In VRP there are a number of vehicles, these vehicles represent days of travel. Each vehicle will find the best route for each day, so that the resulting route is more optimal. Unlike the Traveling Salesman Problem (TSP), where the resulting route is only one (single route) so that it is necessary to cut it based on time constraints. This causes the route to be suboptimal. Therefore, VRP is more suitable for solving multi-day tour route problems.

On the other hand, previous studies have widely used the Genetic Algorithm (GA) to solve TSP and VRP. However, no one has applied GA to solve multi-day tour route problems, either analogous to TSP or VRP. In this study, we use GA hybridized with Simulated Annealing (SA), known as Hybrid Genetic and Simulated Annealing (HGSA). We use GA because of its ability to find optimal solutions in both local and global solution spaces and is an effective probability-based optimization algorithm for complex planning. However, GA has the disadvantage of fixed crossover and mutation probabilities so that it can get stuck at a local optimum. This is because GA tends to explore solutions around the area that has been found. To overcome this, GA needs to be combined with methods such as Simulated Annealing (SA) which excels in exploration, because it is able to explore the solution space widely to find new solutions that may be better than the solutions that have been found.

In addition, tourists usually use the services of tour guides to get structured tour routes. However, often the tour routes recommended by tour guides do not match user preferences, so that the travel experience becomes less memorable. For this reason, the model we built in this study considers several attributes (time, cost, and rating) to match user preferences. The MAUT concept is used to evaluate the fitness value of the resulting route, to ensure that the recommended route matches user preferences. There are several main questions in this study.

1. How does the performance compare between the VRP and TSP approaches in generating multi-day itineraries?
2. How does the performance of the hybrid algorithm (HGSA) compare with the standalone algorithm (GA) in generating multi-day itineraries?
3. How does the performance of HGSA compare with three other common algorithms in solving TSP and VRP (Firefly Algorithm (FA), Grey Wolf Optimizer (GWO), and Particle Swarm Optimization (PSO)) in generating multi-day itineraries?

1.5 Objective and Hypotheses

1. Objective
   (a) Generating optimal multi-day tourist routes analogous to VRP, proving that the VRP solution is superior to the TSP solution for solving the multi-day tourist route problem in terms of fitness values and other metrics.
   (b) Applying the Hybrid Genetic and Simulated Annealing (HGSA) to produce optimal tourist routes according to user preferences for multi-day visits.
   (c) Proving that HGSA is superior in generating multi-day tourist routes than GA and three other common algorithms for solving VRP in terms of fitness values and other metrics.
2. Hypotheses
   (a) The multi-day tourist route problem analogous to VRP will produce a more optimal route than if analogous to TSP.
   (b) GA hybridized with SA will produce a more optimal routes for multi-day visits because of SA's advantage in exploration, enabling SA to explore the solution space widely to find new solutions that may be better than the solutions that have been found.

1.6 Assumption

In this study, several assumptions have been made to simplify the problem and focus on the main objectives of the study. These assumptions are as follows:

1. Availability of Tourist Location Data

   It is assumed that data regarding the location, operating hours, and related information of each tourist attraction is available and accurate. This data includes geographic coordinates, opening and closing hours, and a brief description of the tourist attraction.

2. User preferences

   It is assumed that user preferences regarding attractions, including popularity, cost, and visiting time, can be collected and expressed quantitatively. These preferences are used to determine the utility of each route generated by the system.

3. Visit Time and Duration

   It is assumed that the duration of visits to each tourist attraction can be estimated accurately and remains constant throughout the study. There is no significant variation in the time of visits that affects the travel plan.

4. Number of Tour Days

   It is assumed that the number of days available for touring is predetermined. Each day is considered as one 'vehicle' in the VRP model, with a route to be optimized for each day. For example, if a user wants to travel for 3 days, then there will be 3 vehicles that will search for routes for each day.

5. Use of Algorithms

   It is assumed that the Hybrid Genetic and Simulated Annealing (HGSA) algorithm used in this study is capable of finding near-optimal solutions to multi-day tour route optimization problems. This algorithm is implemented with the assumption that parameters such as mutation and crossover probabilities are set correctly based on parameter tuning testing.

6. Time Windows Handling

   It is assumed that the time windows for each tourist attraction (operating hours) and tourists' time preferences can be handled effectively by the proposed model, so that each generated route meets the specified time constraints.

The above assumptions are set to provide a clear framework for this research and allow focus on the development and testing of a multi-day tour route optimization model.

1.7 Scope and Delimitation

This research focuses on the development and implementation of a multi-day tour route optimization model using the Vehicle Routing Problem (VRP) analogy with the Hybrid Genetic and Simulated Annealing (HGSA) Algorithm. The scope of this research covers the following aspects:

1. Attractions to visit, hotels for accommodation (in this case the hotel is considered as the starting point and end point of the route), and DOI values as their preferences (multi criteria: rating, cost, time) are selected and inputted by the user.
2. The independent variables in this research are the POI selected by the user and the DOI for each preference entered by the user. We consider DOI for the number of POIs included in the itinerary as a control variable. Meanwhile, travel plans and fitness valuesare produced as dependent variables.
3. The dataset we use in this research is Yogyakarta.
4. We do not consider time-dependent tourism types, such as culinary tourism or nightlife attractions.
5. Each tourist attraction is visited only once and by a single vehicle.
6. Our research considers multi-plan trips, so we will recommend several routes with the highest fitness values (top-n routes)
7. The tour operates daily from 8 am to 8 pm.

1.8 Significance of the Study

In this study, we propose a new model to solve multi-day tourism problems by analogizing this problem as solving VRP to generate more optimal routes in multi-day trips using the Hybrid Genetic and Simulated Annealing (HGSA) method and applying the Multi-Attribute Utility Theory (MAUT) concept to consider user preferences.