CHAPTER 1

INTRODUCTION

1.1 Rationale

The hustle of city life makes people, especially urbanites, need tourism to fulfil their psychological needs. Typically, tourists prefer destinations that align with their interest for a satisfying vacation experience [13]. However, the profusion of available points of interest (POIs) and the constraints confronted by tourists, such as limited budgets and time restrictions, give rise to new challenges [24]. Tourists need to create an itinerary that satisfies their interest, influenced by attributes like POIs ratings, the number of POIs included in the itinerary, cost, and travel duration [22]. In addition, they often require more than one day to visit the desired POIs [32]. Creating an itinerary can be done with the help of a travel agent but at a high cost. Therefore, it is necessary to have a system that can help tourists by generating a travel itinerary for several days automatically [2, 16, 29].

Generating a travel itinerary is a part of the Tourist Trip Design Problem (TTDP) known as an NP-Hard. Thus, an approximation method, such as the metaheuristic method, is needed in its generation process [11, 15]. Liao and Zheng [14] and Yochum et al. [34] have developed travel itinerary generation methods, but they focused only on single-day itinerary. Studies on the multi-day travel itinerary problem have been carried out by assuming the problem as the Traveling Salesman Problem (TSP) [2, 16, 29]. However, TSP is considered unsuitable for multi-day travel itinerary generation as it is designed to generate a travel route in a single trip [33]. The implementation of TSP for multi-day travel itinerary generation problem (TSP approach) is done by creating an itinerary that visits all POIs in a single trip and then dividing the itinerary according to the number of travel days and the daily travel duration limit. This implementation causes the itinerary to be not optimal.

The multi-day travel itinerary generation problem can be assumed as the vehicle routing problem (VRP), an advancement from the TSP [4]. The VRP addresses challenges in delivering goods with multiple vehicles, ensuring each customer is visited only once and by a single vehicle [6]. VRP has several variations such as the Capacitated VRP (CVRP) and the VRP with Time Windows (VRPTW). In the CVRP, each vehicle has a load limit of the same amount. The load can be the total weight of goods delivered or the number of customers served by each vehicle (capacity constraint) [17]. On the other hand, VRPTW is a VRP with the condition that each vehicle must deliver goods to customers within a specific time frame, which can be different for each customer (time window constraint) [9]. The multi-day travel itinerary generation problem has several constraints such as the travel duration limit per day and the opening and closing hours for each POI. It can be assumed to be the Capacitated VRP with Time Windows (CVRPTW). The number of travel days is considered to be the number of vehicles in the VRP, the travel duration limit per day is assumed to be the capacity constraint, and the POI's opening and closing hours are considered to be the time window constraint.

This study is focusing on generating a multi-day travel itinerary by assuming it to be the CVRPTW (VRP approach). The system created in this study can generate a travel itinerary for several days that satisfies user interest. Attributes considered in this study include the rating and cost of POIs, the number of POIs included in the itinerary, and the travel duration. In addition, this study introduces two penalty attributes, addressing cases where desired POIs are not included in the itinerary and instances where daily travel duration surpasses the specified daily travel duration limit. The generated travel itinerary is evaluated using the Multi-Attribute Utility Theory (MAUT) as the fitness function to estimate user interest based on the attributes. This study uses the hybrid Ant Colony System (ACS) and Brainstorm Optimization (BSO) with local search techniques such as 2-opt and 2-interchange (the hybrid ACS-BSO algorithm) that has been proven to work well in VRPTW [17]. This study uses a dataset containing POIs and hotels in Yogyakarta, a city with many popular POIs in Indonesia [16].

Several contributions have been made to this study. Firstly, generating a more optimal multi-day travel itinerary with the VRP approach using the hybrid ACS-BSO algorithm. This algorithm has the advantage to avoid local optima and improves both the exploitation and exploration of the solution space [25]. Secondly, to ensure that the generated multi-day travel itinerary satisfies user interest, this study introduces new considered attributes, i.e., the number of POIs included in the itinerary and the penalty attributes.

1.2 Theoretical Framework

The main objective of this study is to generate a multi-day travel itinerary using the VRP approach, addressing the limitations of the TSP approach. The TSP approach assumes the multi-day travel itinerary generation problem as a TSP, where optimization is performed for all POIs in a single trip, then divided into several days based on the number of travel days and daily travel duration limit [2, 16, 29]. This results in the generated multi-day travel itinerary being less optimal because TSP is designed for single-trip optimization, thus involving only the travel duration attribute in the optimization process [33]. On the other hand, the multi-day travel itinerary generation problem can be assumed to be CVRPTW. VRP essentially optimizes routes for logistic distribution using multiple vehicles, where each customer is visited only once by a single vehicle [6]. CVRPTW is VRP with two main constraints, i.e., capacity and time window constraints [17]. The capacity constraint limits the number of customers visited or the amount of logistics carried by each vehicle. The time window constraint imposes restrictions where each customer has specific time windows to be visited [9]. In this study, the number of travel days is assumed to be the number of vehicles in the VRP, the daily travel duration limit is the capacity constraint, and the POI's opening and closing hours are assumed to be the time window constraint.

Generating a travel itinerary is a part of the Tourist Trip Design Problem (TTDP), known as an NP-Hard. Thus, an approximation method, such as the metaheuristic method, is needed in its generation process [11, 15]. This study utilizes the hybrid ACS-BSO [25] to optimize the multi-day travel itinerary. The hybrid ACS-BSO operates by incorporating BSO within the ACS framework. Additionally, this research also employs 2-opt and 2-interchange as operators within BSO. The integration of ACS and BSO strengthens exploitation and exploration within ACS. BSO enhances exploitation with 2-opt and exploration with 2-interchange.

The generated multi-day travel itinerary should satisfy user interest. Several attributes considered in this study influenced user interest, such as POIs ratings, the number of POIs included in the itinerary, cost, and travel duration [2, 16, 29]. This study utilizes MAUT as a fitness function to evaluate the generated solution. MAUT operates by giving weight to each attribute. Subsequently, MAUT calculates the sum of weight times attribute value divided by the sum of weights. The result of this calculation can be interpreted as how much the generated solution satisfies user interest. The more MAUT value the better the solution [23].

1.3 Statement of the Problem

Previous studies assume the multi-day travel itinerary generation problem as the Traveling Salesman problem (TSP) [2, 16, 29]. However, TSP is considered unsuitable for multi-day travel itinerary generation as it is designed to generate a travel route in a single trip [33]. The implementation of TSP for the multi-day travel itinerary generation problem (TSP approach) is done by creating an itinerary that visits all POIs in a single trip and then dividing the itinerary according to the number of travel days and the daily travel duration limit.

To overcome the limitation of the TSP approach, this study proposes a new approach by assuming the multi-day travel itinerary generation problem as CVRPTW (VRP approach). Furthermore, this study proposes the hybrid ACS-BSO as the optimization algorithm. The main questions in this study are as follows:

1. What are the performance differences between the hybrid ACS-BSO and other conventional algorithms in generating a multi-day travel itinerary?
2. What are the performance differences between the hybrid ACS-BSO and standalone algorithms in generating a multi-day travel itinerary?

3. What are the performance differences between the VRP approach and the TSP approach in generating a multi-day travel itinerary?

1.4 Objective and Hypotheses

This study hypothesizes that a more optimal generated solution can be achieved by assuming the multi-day travel itinerary generation problem as a CVRPTW (VRP approach) and utilizing the hybrid ACS-BSO as the optimization algorithm. This hypothesis is supported by the following information:

1. CVRPTW is the improvement of TSP used to optimize multi-routes with capacity and time window constraints [9, 17, 25].

2. Hybrid optimization can enhance the quality of the generated solution by leveraging the strengths and mitigating the weaknesses of each optimization algorithm [25].

3. Hybrid ACS-BSO can strengthen the exploration and exploitation process, which has been proven in the VRPTW case [25].

This study has several objectives to prove the hypothesis. The objectives of this study are as follows:

1. To generate an optimal multi-day travel itinerary by assuming the problem as CVRPTW using hybrid ACS-BSO algorithm.

2. To prove that the hybrid ACS-BSO is better than the other conventional algorithms (GA, TS, and SA) in generating an optimal multi-day travel itinerary.

3. To prove that the hybrid ACS-BSO is better than the standalone algorithms (ACS and BSO) in generating an optimal multi-day travel itinerary.

4. To prove that VRP approach is better than the TSP approach in generating an optimal multi-day travel itinerary

1.5 Assumption

Several assumptions are made in this study. First, the multi-day travel itinerary generated in this research is used to assist users in planning their entire journey. Therefore, this study assumes that users utilize the recommender system in this research before embarking on their travel. Additionally, the study assumes that users already know their desired Points of Interest (POIs) and hotel, the Degree of Interest (DOI) of each attribute that influences their interest, and the duration of their travel. Second, the travel durations used in this study, both between POIs and between POIs and hotels, utilize typical travel durations obtained from the Google Maps API. Third, this research assumes that the mode of transportation used by users is solely a car. Fourth, this study only considers the opening and closing hours of each POI on Sunday and the entrance fee of each POI as the cost of each POI. Finally, this study assumes that the travel activities commence at 08:00 AM and conclude at 08:00 PM each day .

1.6 Scope and Delimitation

This study assumes that users have prior knowledge of their desired POIs and hotels, the degree of interest (DOI) of each attribute influencing their interest, and the duration of their travel. Thus, the desired POIs and the DOI of travel duration, rating, and cost attributes are considered independent variables. In contrast, the DOI of the number of POIs included in the itinerary and the penalty attributes are treated as control variables. The generated itinerary and fitness values are regarded as the dependent variables.

The dataset used in this study is the POIs and hotels in Yogyakarta. This study only considers each POI's opening and closing hours on Sunday, and each POI's entrance fee as cost. In addition, this study does not consider time-dependent tourism, such as culinary tourism or nightlife attractions. The time visit of each desired POI is solely based on the optimization process and the time window constraint .

1.7 Significance of the Study

Several contributions have been made to this study. Firstly, generating a more optimal multi-day travel itinerary with the VRP approach using the hybrid ACS-BSO algorithm. This algorithm has the advantages of avoiding local optima and improves both the exploitation and exploration of the solution [25]. Secondly, to improve the evaluation of the generated multi-day travel itinerary, this study introduces new considered attributes, i.e., the number of POIs included in the itinerary and the penalty attributes.