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A case study of heterogeneous fleet vehicle routing problem: Touristic distribution application in Alanya

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Abstract. In this study, Fleet Size and Mix Vehicle Routing Problem is considered in order to optimize the distribution of the tourists who have traveled between the airport and the hotels in the shortest distance by using the minimum cost. The initial solution space for the related methods are formed as a combination of Savings algorithm, Sweep algorithm and random permutation alignment. Then, two well-known solution methods named as Standard Genetic Algorithms and random search algorithms are used for changing the initial solutions. Computational power of the machine and heuristic algorithms are used instead of human experience and human intuition in order to solve the distribution problem of tourists coming to hotels in Alanya region from Antalya airport. For this case study, daily data of tourist distributions performed by an agency operating in Alanya region are considered. These distributions are then modeled as Vehicle Routing Problem to calculate the solutions for various applications. From the comparisons with the decision of a human expert, it is seen that the proposed methods produce better solutions with respect to human experience and insight. Random search method produces a solution more favorable in terms of time. As a conclusion, it is seen that, owing to the distribution plans offered by the obtained solutions, the agencies may reduce the costs by achieving savings up to 35%.

Keywords Tourism; tourist distribution; vehicle routing problem; fleet size and mix vehicle routing problem; heuristic algorithms.

AMS Classification: 90-08, 90B06, 90C27, 68W25.

1. Introduction

Transportation and logistics are in the center of interest of modern economies [1]. It is seen that the range between 11% and 13% of total production cost is constituted by transportation costs [1]. For instance, it is estimated that 15% of the total expenditures are constituted by transportation expenditures in Canada and England [1]. The results of a research conducted in Europe show that among the cost items of the enterprises in terms of international trade, the amount of transfer, warehousing, stocking and administrative costs are 40%, 26%, 18% and 16%, respectively. The same study displays that more income in the amount of 30 billion dollars can be obtained by reducing the costs 10% by efficiently using logistics and Supply Chain

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Management (SCM) in the food sector [2]. Another study shows that the typical working acquisition of integrated supply chain brings the 16%-18% increase in the distribution performance, 25%-60% decrease in stocking amounts, 30%-50% improvement in the cycle time, 25%-80% certainty in predictions and 10%-16% productivity raise in the facilities of enterprises [21].

Tourism is the most important service industry in which human transportation is a very sensitive subject in terms of countries' economies. Important tourism centers such as Antalya and Alanya which desire to be a powerful brand as a tourism destination should give special importance to transportation facilities. Comfortable choices regarding air, sea, land and railway transportations should be presented to the tourists' choices with the most reasonable prices [3]. Transportation has been rather important in tourism sector when its contributions to countries' economies are considered. Savings in the transportation area can be obtained by qualitative and quantitative decision approaches. With these savings, service quality, efficiency, productivity and profitability can be increased and thus costs can be decreased. In addition to all these, improvements regarding environmental, ecological and historical assets will increase customer satisfaction and make a contribution to sustainable tourism.

In this study, Fleet Size and Mix Vehicle Routing Problem is considered in order to optimize the distribution of the tourists who have traveled between the airport and the hotels in the shortest distance by using the minimum cost. For this aim, two well-known solution methods named as Standard Genetic Algorithms and Random Search Algorithms are used. The initial solution space for the related methods are formed as a combination of Savings algorithm, Sweep algorithm and random permutation alignment. For the seeding, Savings and Sweep Algorithms are used to provide a single solution alternative for each vehicle type if the capacity of any vehicle is not exceeded for the demands of the customers. And for the routing, vehicle type with minimum cost of empty space is chosen. In the last section, real life applications of heterogeneous fleet VRP for Alanya destination are demonstrated.

2. Background

One of the most important variations of Vehicle Routing Problem (VRP) is the problem of determining fleet of vehicles characterized by various capacities and costs which can be used in various delivery activities. This special problem is known as Mixed VRP or Heterogeneous Fleet VRP [4]. The problem of Fleet Size and Mix VRP (FSMVRP) is a kind of VRP and may be defined as routing of a fleet of heterogeneous vehicles in order to make a service to a group of customers whose distribution requirements are known and as establishing a fleet composed of these vehicles [5]. VRP with heterogeneous fleet is a variation of classical VRP [6]. The fleet of heterogeneous vehicles has vehicles with different capacities, fixed costs for the vehicles and variable costs and that fleet serves to the customers with the given features [7] [8] [9]. Since, VRP with heterogeneous fleet is a generalized version of classical VRP, it is also known to be an NP-hard problem. The aim is to form a cluster of routes by minimizing the total value of the costs [10].

VRP is classified into two groups when the features such as the capacities of vehicles and their fixed and variable costs are considered. If all the vehicles have the same capacity, and the same fixed and variable cost values, this problem is called as Homogeneous VRP. Otherwise, if one or more features are different for the vehicles, this kind of problem is known as Heterogeneous VRP. Three models of Heterogeneous VRP are studied in the literature. The first one is based on the idea that variable cost is equal for all the vehicles and there is infinite number of ready to use vehicles of each type. This model is called Vehicle Fleet Mix (VFM), Fleet Size and Mix VRP or Fleet Size and Composition VRP. The second model takes into consideration the variable cost which differs depending on the vehicle type that is ignored within the first model. The third model is called VRP with a Heterogeneous Fleet of Vehicles or Heterogeneous Fixed Fleet VRP (HFFVRP). For instance, a visual interactive decision support system for the HFFVRP with and without backhauls is presented in the literature [11]. HFFVRP eliminates the assumption of unlimited number of vehicles regarding the second model and solves the same problem with a limited number of vehicles [8] [9] [4] [12].

However, heuristic methods are generally used as the solution of the problem regarding the heterogeneous fleet vehicles is not possible with exact methods. There are many studies in which heuristic methods are applied intensely in the literature [13] [8].

3. Application

3.1. Model formulation

Suppose that $G=(V, A)$ directed graph is provided, here $V=\{0,1,2,...,n\}$ are $n+1$ vertices, A is a cluster of arcs, n=0 shows the depot and the other n vertices out of the depot equals the cluster $V'=V-\{0\}$ representing the customers. Each customer requires q_i unit assets from $i \in V'$ depot (it is assumed that the requirement of the depot is $q_0=0$). The heterogeneous fleet of the vehicles is positioned in the depot and cares the claims of the customers. The vehicle fleet includes k types of vehicles and the set of vehicles is shown as $\psi=\{1,2,...,k\}$. Each vehicle type of $k \in \psi$, m_k vehicles are ready to use in the depot and each has the equal capacity of Q_k. Each type of vehicle is associated to a fixed cost of f_k and this is defined with the cost of amortization or rent for this model. In addition, each model has the arc of $arc(i, j) \in A$ and each vehicle type has the cost of c_{ij}^k routing which is not negative $k \in \psi$.

A route is defined as the couple (R,k) and here while R is defined as $R=\left(i_1, i_2, ..., i_{|R|}\right)$, $i_1=i_{|R|}=0$ and $\left\{i_2, i_3, ..., i_{|R|-1}\right\} \subseteq V'$, a simple G cycle includes the depot and k is the type of the vehicle which is assigned to the route. R represents the visit path in a route and the set of the customers (including the depot). If the total demands of the visited customers on the route does not exceed the Q_k capacity of vehicles (namely, if the constraint $\sum_{h=2}^{|R|-1} q_{i_h} \le Q_k$ is provided), (R,k) route is a feasible solution. The cost of the route is calculated adding the fixed cost of the assigned vehicle to the route to total cost of arc shaping the route and determined with the formula of:

$$TCL_p = \sum_{h=1}^{|R|-1} c_{i_h i_{h+1}}^k + f_k \tag{1}$$

where TCL_p is the total cost for p^{th} route found by adding the fixed cost of the assigned vehicle to the total cost of arcs shaping the route. And the total cost function is expressed as the total cost of the route as follows:

$$TotCost = \sum TCL_p \tag{2}$$

The above equation is used to minimize both the distance of each route and total cost. The most common model of Heterogeneous VRP includes designing the suitable routes' arc with the minimum total cost, namely:

- Each customer is certainly visited by a single vehicle;
- The number of the routes formed by the vehicle type which is signified by $k \in \psi$ cannot be more than m_k.

Two models of the problem have an increasing importance naturally: The first one is symmetrical and the costs for each couple of i, j customers are symmetrical as $c_{ij}=c_{ji}$ and for each vehicle type $k \in \psi$ is provided. The other model is the asymmetrical one. In addition, there are many variations of these general problems in literature in terms of interested cost type and applicable fleets. Especially, as a result of changing the features of the problem stated below, new VRP variations are formed. These features are the vehicle fleets including each vehicle type is infinite, that is to say $m_k=+\infty$, $\forall k \in \psi$; the fixed costs of the vehicles are not taken into consideration, namely $f_k=0$, $\forall k \in \psi$; the routing costs are vehicle independent, namely $c_{ij}^{k1}=c_{ij}^{k2}=c_{ij}$, $\forall k_1, k_2 \in \psi$, $k_1 \neq k_2$, and $\forall (i, j) \in A$.

Constructing the routes is another problem regarding the problems of Fleet Size and Mixed VRP (FSMFV). The routing structure is explained by a suggestion of Ochi et al. [14] about the route construction [14].

The following strategy has been suggested for the heterogeneous Fleet VRP. $\psi=\{1,2,...,k\}$ is the set of vehicle types. Under the circumstances of $Q_1 \le Q_2 \le ... \le Q_k$ and $f_1 \le f_2 \le ... \le f_k$, the capacity of t_i type vehicle is Q_i and f_i is the fixed cost of the related vehicle. Each petal is structured as follows. Algorithm analyses the possibilities of the vehicles formed by k type of the vehicles and chooses t_i vehicle type which shows the minimum value for $(Q_i - D_i) f_i$ and here D_i defines the total demand of petal which is formed by using vehicle t_i. Obviously, the size of each petal will change depending on the assigned vehicle type. In the studies still being conducted by Ochi et al. [14], the logic of choosing routes $\left(Q_i - D_i\right) f_i$ has been employed for heterogeneous fleet types [15] [16].

Moreover, while Ochi et al. [14] use Petal Algorithm in order to form the solution space, Liu et al use Sweep Algorithm in order to form some parts of the solution space. In addition, they form the other part by using Savings Algorithm and the third part is formed in a random permutation way. Savings and Sweep Algorithms can provide solutions for a single vehicle type; thus, possible solution sets are formed by employing Sweep and Savings algorithms for each vehicle type of heterogeneous vehicle sets. Savings and Sweep Algorithms provide a single solution alternative for each vehicle type if the capacity of any vehicle is not exceeded for the demands of the customers. For this reason, if the number of the vehicle type is k, both Savings and Sweep Algorithms provide set of solutions between 1 and k. After the initial search space is formed as Liu et al. [16], different solutions are obtained by using standard GA approach and random search.

3.2. The definition of the problem

Figure 1. A geographical distribution of some Alanya hotels, Source: [17]

The 30% of tourists visiting Turkey prefer Antalya region. Around 24% of these tourists who prefer Antalya visit Alanya. The map above shows an example of geographical distribution for some of the hotels in Alanya. According to the statistics of 2011, the number of the foreign tourists who visited Alanya region is 2 million 500 thousand [18]. The tourists planning to visit this region are determined one year before their arrivals by the sales of the major tour operators in Europe that work with local agencies. These agencies give various logistic services to some of these tour operators such as seasonal renting of hotel rooms, transportation between airports and hotels and also the other required services. When the agencies in Alanya are analyzed, it has been determined that they have been using various computer programs having similar features in order to carry out these services. These programs have been effectively used by the agencies while meeting the needs of the enterprises, producing and controlling services. Moreover, these programs can carry out the services such as receiving and sending some data from the databases of the tour operators in Europe. However, when these task periods are analyzed, it has been seen that these programs cannot plan which type and what capacity of vehicles will be used and when the tourists will be collected or distributed while the tourists are being transported from the airport to the hotels or vice versa. This shortage in distribution plan is made up by the professional workers who know the situation of the region and hotels well. For the collection or distribution planning, generally human experiences and intuitions are used combined with some spread sheets and rule of thumb. It would be optimistic to expect obtaining an optimal or nearly optimal solution from a human expert each time.

While some of the agencies have their own vehicle fleets, the others rent the vehicles from a firm. The collection or distribution operations are conducted by their vehicles and/or rented vehicles. The agency that the application data has been received does not have its own fleet; thus, they rent the vehicles to give a service. In accordance with the seasonal agreement between the agency and the vehicle supplier, the responsibility of the contractor firm is as follows: the vehicles having the required type and capacity by the agency will be provided by the vehicle supplier firm at the required time and quantity. In such a situation, unlimited number of required type of vehicles and their quantity are available for the agency. Being in conformity with the market, 4 types of vehicles are used intensively in Alanya. The renting costs and capacities of these vehicles are different and are given in Table 1. Thus, the encountered structure of the problem is determined as The Fleet Size with Fixed cost and Mixed VRP.

Table 1. The seasonal renting costs according to capacity and vehicle type

SN	NV	VT	Q	VR	UC
1	BUS	t_1	46	320	6.95
2	TURKUAZ	t_2	25	245	9.80
3	MIDI	t_3	22	180	8.18
4	MINI	t_4	14	130	9.28

SN: Sequence Number; NV: Name of the vehicle; VT: Vehicle Type; Q: Vehicle Capacity (person); VR: Vehicle Rent (TL); UC: Unit Cost (TL/person)

Source: Renting costs of 2011 from the data regarding the relevant agency.

3.3. The pseudo code of the case study

The pseudo code of random search and GA HFVRP are given in the below algorithms. In these algorthims Matlog is used for obtaining some of the parameters and for obtaining Sweep and Savings algorithms for each vehicle type [19].

Algorithm 1−Random search algorithm Heterogeneous Fleet VRP

Begin
Objective function $f(x)$, $x = (x_1, x_2, \dots, x_d)$
Initial Parameters
(x_i, y_i), Q_k, q_i, f_k, $BestSol \leftarrow \infty$, $CurrentBestSol \leftarrow \infty$; $MaxIteration$
Initial Calculation
C $(Distance\ Matrix) \leftarrow Matlog \leftarrow (x_i, y_i)$
$TSP_{Sweep} \leftarrow Matlog\ (Sweep\ Algorithm) \leftarrow Q_k, C, q_i$
$TSP_{Savings} \leftarrow Matlog\ (Sweep\ Algorithm) \leftarrow Q_k, C, q_i$
$TSP_{Random} \leftarrow (Random\ Permutation)$
$TSP_{Initial} \leftarrow [TSP_{Sweep}; TSP_{Savings}; TSP_{Random}]$

$\{[Routes], [TotCosts], [TCL_p]\} \leftarrow$
$\boldsymbol{RoutingFunction}[Select\ \{Min(Q_k - D_k) * f_k\}] \leftarrow TSP_{Initial}$

$CurrentBestSol \leftarrow Assign\ Best\ Solution \leftarrow$
$\{[Routes], [TotCosts], [TCL_p]\}(solution\ space)$
$BestSol \leftarrow CurrentBestSol$
While $(MaxIteration)$
$TSP_{New} \leftarrow (Random\ Permutation)$

$\{[Routes], [TotCosts], [TCL_p]\} \leftarrow$
$\boldsymbol{RoutingFunction}[Select\ \{Min(Q_k - D_k) * f_k\}] \leftarrow TSP_{Initial}$
$CurrentBestSol \leftarrow Assign\ Best\ Solution \leftarrow$
$\{[Routes], [TotCosts], [TCL_p]\}(solution\ space)$
If $BestSol > CurrentBestSol$
$BestSol \leftarrow CurrentBestSol$
End If
End While
Print Results: $BestSol\{[Routes], [TotCosts], [TCL_p]\}$
End

Algorithm 2−Genetic Algorithm Heterogeneous Fleet VRP

Begin
Objective function $f(x)$, $x = (x_1, x_2, \dots, x_d)$
Initial Parameters
(x_i, y_i), Q_k, q_i, f_k, $BestSol \leftarrow \infty$, $CurrentBestSol \leftarrow \infty$; $MutRate, CrossRate, MaxIteration$
Initial Calculation
C $(Distance\ Matrix) \leftarrow Matlog \leftarrow (x_i, y_i)$
$TSP_{Sweep} \leftarrow Matlog\ (Sweep\ Algorithm) \leftarrow Q_k, C, q_i$
$TSP_{Savings} \leftarrow Matlog\ (Sweep\ Algorithm) \leftarrow Q_k, C, q_i$
$TSP_{Random} \leftarrow (Random\ Permutation)$
$TSP_{Initial} \leftarrow [TSP_{Sweep}; TSP_{Savings}; TSP_{Random}]$

$\{[Routes], [TotCosts], [TCL_p]\} \leftarrow$
$\boldsymbol{RoutingFunction}[Select\ \{Min(Q_k - D_k) * f_k\}] \leftarrow TSP_{Initial}$

$CurrentBestSol \leftarrow Assign\ Best\ Solution \leftarrow$
$\{[Routes], [TotCosts], [TCL_p]\}(solution\ space)$
$BestSol \leftarrow CurrentBestSol$; $Pop \leftarrow TSP_{Initial}$
While $(MaxIteration)$
$TSP_{New} \leftarrow StandartGA \leftarrow Pop$; $Clear\ Pop$

$\{[Routes], [TotCosts], [TCL_p]\} \leftarrow$
$\boldsymbol{RoutingFunction}[Select\ \{Min(Q_k - D_k) * f_k\}] \leftarrow TSP_{New}$
$CurrentBestSol \leftarrow Assign\ Best\ Solution \leftarrow$
$\{[Routes], [TotCosts], [TCL_p]\}(solution\ space)$
If $BestSol > CurrentBestSol$
$BestSol \leftarrow CurrentBestSol$
End If
$Pop \leftarrow TSP_{New}$; $Clear\ TSP_{New}$
End While
Print Results: $BestSol\{[Routes], [TotCosts], [TCL_p]\}$
End

3.4. The arrangement of the data according to the VRP structure

For the considered case study, it is assumed that there are n tourists, 4 vehicle types. Thus the indices for the previously defined parameters can be given as follows:

q_i	The number of tourists to be transported to the i^{th} hotel $(i = 2, \dots, n)$
Q_k	The capacity of the k^{th} vehicle type $(k = 1,2,3,4)$
m_k	The number of k^{th} type of vehicle $(m_k = \infty)$
t_k	k^{th} type vehicle model $(k = 1,2,3,4)$

An example distribution plan from the agents' database is considered in which n=183 tourists coming from the airport, p=4 routes planned as $\{R_1, R_2, R_3, R_4\}$ and k=4 vehicles $\{t_1, t_1, t_1, t_1\}$ used in the each route and their capacities of the assigned vehicles have been determined as {46, 46, 46, 46}. The only missing data in this analysis is the cost of the analysis performed by the agency. The cost of VRP analysis regarding Application Problem 1 has been shown in Table 2 in which the agency application solution has been found to be 2333.58.

Table 2. VRP analysis costs of application problem 1 in application

AS	RN	VT	O	D	VR
[1-2-3-1]	R_1	t_1	46	283.05	320
[1-4-5-6-7-1]	R_2	t_1	45	264.68	320
[1-8-9-10-11-1]	R_3	t_1	46	249.07	320
[1-12-13-14-15-16-17-18-1]	R_4	t_1	46	256.78	320
Total costs of routes / Total rent of the vehicles				1053	1280
Total cost of analysis					2333

AS: Application Solution; RN: Route Name; VT: Vehicle Type; O: Occupancy; D: Distance; VR: Vehicle Rent

From the agents' database, total of 8 problems are considered and VRP analysis have been generated from the distribution plans. The problems derived have been named using the numbers between AppP1 and AppP8.

3.5. Analysing the application problems by Genetic Algorithm

The application problems have been analyzed first by the standard GA method. For GA analysis, simple crossover and mutation have been applied. An elitist approach has been employed while choosing the generations. Total cost has been estimated as fitness value of the population for the each generation. 50% of the population having the minimum fitness value has been transferred to the next generation. The left part of the population has been produced again by crossover. The crossover ratio has been applied as 0.5 and the mutation ratio has been applied as 0.1. The population includes 500 individuals and 10 generations. The software codes have been developed in Matlab interface. There is no study regarding code optimization. Savings Algorithm, Sweep Algorithm have been calculated by using the functions of the distance matrix and the route costs Matlog[1] [19].

The initial population has been applied as it is suggested by Liu et al. Some of the solution space has been formed by Sweep Algorithm, the other part has been formed by Savings Algorithm and the left part has been formed random permutation. Savings and Sweep Algorithms can provide solutions for only single type of vehicles, so possible sets are formed by employing Sweep and Savings Algorithms individually for the each vehicle in the set of heterogeneous vehicle. Savings and Sweep Algorithms provide a single solution for the each vehicle if any demands of the customers do not excess any capacity of the vehicle. Thus, if there are k vehicles, Sweep Algorithm provides minimum 1 and maximum k set of solutions, and similarly, Savings Algorithms produce set of solutions between 1 and k. After the initial population has been formed, solutions have been produced by using GA approach.

By using the Heterogeneous Fleet VRP method for tourist collecting or distribution plan, it is aimed to suggest better solutions than the solutions of the human expert working for the local tourist agency (Application Solution: AS). Therefore, the term **"**deviation" between the Suggested Solution (SS) of the Heterogeneous Fleet VRP method and AS has been defined below as:

$$Deviation\,(\%) = \frac{(AS - SS)}{AS} * 100 \qquad (3)$$

The deviation (%) may have three different values. If it is negative, the solution of the suggested method is worse than the application solution; if it is positive it is better than the application solution; if it is zero; there is no deviation.

The cost of AS, the cost of SS provided by GA, the solution time of GA and deviation values have been shown in Table 3. It can be from the table that minimum 0% and maximum 35.16% positive savings have been gained by GA. The minimum and maximum solution times are 845 and 2228 seconds, respectively.

Table 3. Solution results of application problems by GA

	AppP1	AppP2	AppP3	AppP4	AppP5	AppP6	AppP7	AppP8
ST	2079	2000	1478	1223	2228	1131	1816	845
AS	2333	2310	1801	1453	3126	1453	2967	1283
GA	2333	2609	1771	1371	2952	1193	1924	959
%	0	11.47	1.70	5.63	5.57	20.26	35.16	25.22

ST: Solution time (second); AS: Application Solution; GA: Genetic Algorithm; %: Deviation

[1]Matlog: Logistics Engineering MATLAB Toolbox has been developed in North Carolina State University by Michael G. Kay.

3.6. The solution of the application problems by random search

The random search has been tested by forming a search space in two dimensions. Initial solution space has been formed with the same approach in the GA solution method. The populations have been created as 40 individuals and 500 individuals. While creating the search space, the seeding has been employed. Seeding process is defined as the sets created from Sweep and Savings Algorithms and these sets are also used in GA method.

Table 4. The solution of the application problems by random search

	Pop :40			Pop :500			SI	AS
AppP1	%	Cost	Period	%	Cost	Period		
	0	2333	1	0	2333	137	Random	2333
AppP4	**Pop:40**			**Pop :500**				
	%	Cost	Period	%	Cost	Period		
	6.11	1364	2	14.53	1241	85	Random	1453
AppP8	**Pop: 40**			**Pop: 500**				
	%	Cost	Period	%	Cost	Period		
	25.22	959	2	27.31	932	59	Random	1283

	Pop :40			Pop :500			SI	AS
AppP3	%	Cost	Period	%	Cost	Period		
	1.70	1771	2	1.70	1771	99	Sweep	1801
AppP5	**Pop :40**			**Pop :500**				
	%	Cost	Period	%	Cost	Period		
	5.57	2952	8	5.57	2952	161	Sweep	3126
AppP6	**Pop :40**			**Pop :500**				
	%	Cost	Period	%	Cost	Period		
	20.26	1193	1	20.26	1193	76	Sweep	1496

	Pop :40			Pop :500			SI	AS
AppP2	%	Cost	Period	%	Cost	Period		
	11.47	2310	4	11.47	2310	130	Savings	2609
AppP7	**Pop :40**			**Pop :500**				
	%	Cost	Period	%	Cost	Period		
	35.16	1924	5	35.16	1924	128	Savings	2967

SI: Solution Individual; %: Deviation; AS: Application Solution

Each population has been operated ten times for each application problem. The codes of the software have been developed in Matlab interface. There is no study about the code optimization. Savings and Sweep algorithms, the distance matrix and the route costs have been calculated by using the functions of Matlog[2] [19].

The solutions in Table 4 have been classified according to the individual that the solution is attained. The solutions of the application problems 1, 4 and 8 are attained by random individuals here. The solutions of the application problems 3, 5 and 6 have been attained by Sweep Algorithm individuals formed by the seeding**.** On the other hand, the solutions of the application problems 2 and 7 have been attained by the derived individuals from Savings Algorithm depending on the seed.

3.7. The comparison of the suggested solutions with the agency solutions

The problem of distributing or collecting the tourists to and from the hotels and the airports is a challenging problem in terms of NP-Hard class from the theoretical point of view. Namely, the solution space exponentially grows up. Therefore, heterogeneous fleet VRP will be quite advantageous for this issue.

The comparative table developed by the agency which is defined as AS is below with the data regarding GA, Random Search for 40 individuals and Random Search for 500 individuals.

When the solutions are analyzed, there is not a great deviation between the solutions of GA and random search. Only problem 4 is worse in terms of GA solution quality according to random search method. Furthermore, there is no deviation between the solutions in terms of solution quality. When the solution periods are analyzed, GA solution periods seem longer. However, when it is taken into consideration that 10 generations have been operated in GA method the solution period will be shorter although 10 operations are assessed for random search with 500 individuals. As a result, random search solution is a more effective method in terms of cost and speed for the tourist distribution problem.

[2]Matlog: Logistics Engineering MATLAB Toolbox has been developed in North Carolina State University by Michael G. Kay.

Table 2 . The comparative table of the agency, GA and random search solutions

	AppP1	AppP2	AppP3	AppP4	AppP5	AppP6	AppP7	AppP8
ST	2079	2000	1478	1223	2228	1131	1816	845
AS	2333	2609	1801	1453	3126	1496	2967	1283
GA	2333	2310	1771	1371	2952	1193	1924	959
%	0	11.47	1.70	5.63	5.57	20.26	35.16	25.22
ST	1	4	2	2	8	1	5	2
AS	2333	2609	1801	1453	3126	1496	2967	1283
RS1	2333	2310	1771	1364	2952	1193	1924	959
%	0	11.47	1.70	6.11	5.57	20.26	35.16	25.22
ST	137	130	99	85	161	76	128	59
AS	2333	2609	1801	1453	3126	1496	2967	1283
RS2	2333	2310	1771	1241	2952	1193	1924	932
%	0	11.47	1.70	14.53	5.57	20.26	35.16	27.31

ST: Solution time (second); AS: Application Solution; RS(PopSize):Random Search(1:40;2:500); %: Deviation

Another important thing is that some of the individuals are produced by Savings and Sweep algorithms and the remaining part of the individuals are produced randomly while forming the seeding, in other words, structuring the search space. When these eight application problems have been analyzed, it is seen that the solutions of 3 problems are obtained from random individuals and of 3 problems from Sweep and of 2 problems from seed of Savings algorithm. With the combination of random search, Savings and Sweep algorithms based on seeding, better performance and less solution time than the human expert have been attained. This means that the populations which started by the given seeding may guarantee a fast and high quality solution for many problems. Also, it is always possible to derive better solutions from random individuals by using larger populations or longer simulation times.

4. Conclusion

When logistic sector has been analyzed, it is seen that transportation business is an issue having quite high costs. The improvements to be performed in this area will not only have important contributions in terms of local and national economy, but also provide cost advantages in terms of companies.

Distribution or collection of tourists to or from hotels and from or to airports is basically a transportation problem. The solutions for this problem developed by operations research methods will provide important contributions to the companies, regional economy and countries' economy.

In order to visualize the economic aspect of the problem, Table 6 is acquired. In this table, the number of tourists who visited Turkey, Antalya and Alanya in 2011 have been taken from statistics [20]. The assumptions considered while forming Table 6 are as follows:

- All the transportation operations have been assumed to be performed with the vehicles for 46 seated.
- The rental cost for a 46 seated vehicle in 2011 is 320 TL.
- The average cost of 1 USA Dollar in 2011 is 1.820 TL.

Table 6. The economic aspect of tourist distribution

	Tourist numbers	Required Trip	Cost (TL)	Cost ($)	%10 Savings ($)
Turkey	31.456.076	683.827	218.824.640	120.233.318	12.023.331
Antalya	10.464.425	227.487	72.796.000	39.997.802	3.999.780
Alanya	2.500.000	54.347	17.391.304	9.555.661	955.566

The deviations between the solutions obtained by the algorithm of Fleet Size and Mixed VRP, and the solutions obtained by human expert for the agency have been shown in Table 7.

Table 7. Savings obtained by optimization technique

	AppP1	AppP2	AppP3	AppP4	AppP5	AppP6	AppP7	AppP8
%	0	11.47	1.70	14.53	5.57	20.26	35.16	27.31

As it can be seen in Table 7, it has been found that the minimum value of the results of the savings obtained from Equation (3) at the end of the optimization is 0% while the maximum saving is 35.16%. The provided average savings of the proposed methods for 8 applications of the local agency will be approximately 15%. When the saving is supposed to be 10% with a risk aversion point of view, instead of solving the problem of distribution using the account tables depending on human experience and intuition, the problem should be solved by using random search algorithm which has been developed for Fleet Size and Mixed VRP. This practice will provide the expected benefits in terms of an economic aspect such as:

- About 12 million dollar annual savings for Turkey
- About 4 million dollar annual savings for Antalya

- About 1 million dollar annual savings for Alanya

The above savings were calculated only for distribution of tourists from airports to hotels. When collection from hotels to the airports is also considered, these savings should be doubled. For this reason, the annual savings for Alanya will be approximately 2 million dollars. These are direct economic benefits. The optimization studies in this issue have other direct or indirect benefits below for the tourism destinations in addition to these savings:

- Labor force savings
- Less vehicle employment
  - Fuel savings
  - Decrease in traffic congestion
  - Decrease in the gas emission to the environment
  - Less damage to the historical and natural beauties
  - Less damage to the biological varieties and their maintenance
  - Decrease in air pollution
  - Decrease in wear and tear of the ways and bridges
- Increase in customer pleasure
- Increase of efficiency and productivity
- Eliminating the chaos and stress which will arise from planning
- And other benefits

Tourism has positive effects on the economy and development of countries. Moreover it is an important industry as it contributes to the employment. Using operations research methods for tourism issue will help increasing the service quality, improving effectiveness and productivity and increasing economic savings appreciably.

This is a study which provides practical results in a fast and effective way in application. User friendly computer programs may be developed that can offer service to the firms directly. Such kind of tourist distribution planning program not only helps to solve a difficult problem theoretically in an effective and fast way, but also eliminates the need of expertise. The same application may be solved with a broader planning organization from a single center for all Alanya agencies. In such a situation, solving the problem as a whole for Alanya will provide contributions depending on the scale economies and it will provide a bigger developing potential for the region. If these applications are applied to all the destinations in Turkey and all around the world, there will be quite important cost reductions and the pleasure of the tourists may increase.

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