ISSN XXXX XXXX © 2019 IJESC

Research Article Volume 9 Issue No.1

An Approach to Disabled Service Vehicle Routing Problem with Ant Colony Optimization Method

Yusuf Uzun
Assistant Professor Doctor
Department of Computer Engineering, Seydişehir A.C. Engineering Faculty, Necmettin Erbakan University, Turkey

Abstract:
Rehabilitation centers would wish it to be fast and the minimum cost of transportation problems in service for the disabled. Vehicle Routing Problem (VRP) aims to efficiently use by minimizing transportation costs of a vehicle fleet with a certain capacity efficiently. Ant colony optimization (ACO) is one of the meta-heuristic methods successfully applied to optimization problems such as vehicle routing problem.The aim of our problem is to minimize the total number of vehicles to be used and distance traveled. It has a certain capacity of each vehicle and a demand that must be met at a specific time period of each disabled. Each vehicle is obliged to make service for disabled people at a certain time period. This study was presented at the International Conference on Engineering and Natural Sciences (ICENS) in Sarajevo with different methods and parameters. In this study, ant colony algorithm metaheuristic method has been tried to reduce cost on vehicle routing problem.By using ACO method on the coordinate data of disabled people, routes were obtained at the lowest cost.

Keywords: Disabled, Ant Colony Algorithm, Optimization

I. INTRODUCTION

The meaning and approach undertaken for the disabled have showed changes in the historical process. In this approach, firstly the medical model has seen interest, later social model and the human rights-based model approach was accepted [1]. The medical is model predicting treating by repaired the defects in the human body and the disability is based on caused by people rather than a social phenomenon. The social model is indicated that prevent a problem with revealed socially rather than the person. The disability in this model is a product of the social structures and the environment that involved physical structure, social conditions and beliefs [2]. The remaining aspects in medical and social model have been filled by human rights model. In this model, the integration of the disabled with the society in which they live, emphasis has been on the fundamental rights and freedoms [3]. For to sustain the lives of persons with disabilities and can be a productive individuals in society must be made of a number of researches and regulations related to meeting educational, cultural, economic and social needs. According to World Health Organization report, 10% of the population in developed countries and 12% of the population in developing countries is made up of disabled people [4]. The lived of approximately 600 million people with disabilities in the world and this numbers are expected to increase to time [5]. According to the Disability Survey 2002 conducted by the Turkey Statistical Institute and Department of Administration for Disabled People, 12.29% of the total population in Turkey will be disabled citizens. Approximately 8.5 million people with disabilities are consisting chronic illnesses 9.7%, 1.25% of orthopedic, mental 0.48%, speech and language 0.38%, hearing 0.37%, blind and visually impaired 0.6% [6]. For people with disabilities by the Ministry of Family and Social Policy is to provide opportunities care in the family. However, is offered alternative models different organizations for the disabled that are not able to care by their families. Organizations providing rehabilitation service for people with disabilities desire quickly and the minimum cost of transport service problems. In this paper, has been studied minimal cost Vehicle Routing Problem with Time Windows (VRPTW) using Ant Colony Optimization (ACO) metaheuristic method. ACO, which studies artificial agent systems, takes inspiration from the foraging behavior of real world ants [7]. The work was arranged as follows: In Section 2, materials and methods method was explained. In Section 3, experimental study was presented. In Section 4, discussions of the study were described. In Section 5, conclusions were presented.

II. MATERIAL AND METHODS

Vehicle Routing Problem

Vehicle Routing Problem (VRP), by minimizing the costs of the vehicle fleet which has a certain capacity, is aims to be used effective stopping at various locations to provide services to people with disabilities. The aim of the problem is to minimize the number of vehicles to be used and the total travel distance. There is the capacity of each vehicle and a demand that must be met in a given time period of each disabled. Each vehicle is obliged to serve for disabled in a certain time window [8]. The VRPTW can be defined as follows. Let $G = (V, E)$ be a graph connected between two disabled consist of a disabled set of $n + 1$disabled which can be serviced within a specified time window, and a set E of arcs with non-negative weights d_{ij} and with related travel times, t_{ij}. The travel time t_{ij} includes a service time at disabled$_i$, and a vehicle is permitted to arrive before the opening of the time window, and wait at no cost until service becomes possible, but it is not permitted to arrive after the latest time window. Node 0 represents the rehabilitation center.

Each disabled$_i$, apart from the rehabilitation center, imposes a service requirement q_i that can be a delivery from, or a pickup for the rehabilitation center. The objective is to find the minimum number of tours, K^*, for a set of identical vehicles such that each node is reached within its time window and the accumulated service up to any node does not exceed a positive number *Q* (vehicle capacity). Another objective is often either to minimize the total distance traveled or the duration of the routes. The tours are starting and ending at the rehabilitation center [9].

Figure.1. Representation of the disabled and rehabilitation center on the map

Polar coordinate system is used to calculate the distance from a two dimensional plane. In mathematics, the polar coordinate system is a two-dimensional coordinate system in which each point on a plane is determined by a distance from a reference point and an angle from a reference direction [10].

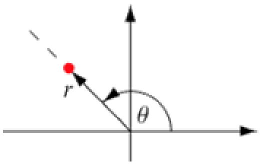

Figure.2. Representation of polar coordinate and angle

The following Equations 1 and 2 are used for distance costs.

$$Cost(i) = -\alpha B(i) + \beta E + \gamma((\pi/360)\Theta) \qquad (1)$$

$$B(i) = \sqrt{X(i)^2 + Y(i)^2} \qquad (2)$$

where *B* is distance between the disabled and rehabilitation centers, *E* ending value of the service time, *Θ* polar coordinate value of the disabled in two-dimensional space, α, $\beta$and γ is respectively 0.7, 0.1 and 0.2 are weight values. In the calculation of the time window corresponding to the distance is used Euclidean equation.

Polar coordinates *r* and *θ*, Cartesian coordinates can be converted as follows [11].

$$x = r \cos \Theta \qquad (3)$$

$$y = r \sin \Theta \qquad (4)$$

The conversion formula obtained according to these two equations is as follows.

$$r = \sqrt{x^2 + y^2} \qquad (5)$$

$$\Theta = \arctan \frac{y}{x} \qquad x \neq 0 \qquad (6)$$

If x = 0 and y > 0, θ = 90° (π/2 rad); y < 0, θ = 270° (3π/2 rad).

Ant Colony Optimization

Ant colony optimization has been formalized into a combinatorial optimization problem by Dorigo et al. [12]. ACO is using artificial ants to solutions the VRPTW problems.In Figure 3, the ACO algorithm behavior is described in pseudo-code. Algorithm consists of an initialization status and three components in the loop.

```
Set parameters, initialize pheromone trails
while termination conditions not met do
    Construct Ant Solutions
    Apply Local Search {optional}
    Update Pheromones
end while
```

Figure.3. the ACO met heuristic in pseudo-code

The main procedure of the ACO algorithm, via the loop construct, the loop of the three above discussed components of ACO algorithms: (i) construct ant solutions, (ii) apply local search, and (iii) update pheromones. The loop construct does not specify how these three activities are scheduled and synchronized. Otherwise, it does not say whether they should be executed in a completely parallel and independent way, or if some kind of synchronization among them is necessary. The designer is therefore free to specify the way these three procedures should interact [12]. Using ACO whose colony scale is *P*, an individual ant simulates a vehicle, and its route is constructed by incrementally selecting disabled until all disabled people have been visited.

The disabled people, who were already visited by an ant or violated its capacity constraints, are stored in the impossibledisabled people list (*tabu*). The decision making about combining disabled people is based on a probabilistic rule taking into account both the visibility and the pheromone information. Thus, to select the next disabledj for the kth ant at the *i*th node, the ant uses the following probabilistic formula [13]. The decision making about combining disabled people is based on a probabilistic rule taking into account both the visibility and the pheromone information. Thus, to select the next disabled$_j$ for the *k*th ant at the *i*th node, the ant uses the following probabilistic formula.

$$p_{ij}(k) = \begin{cases} \dfrac{\tau_{ij}^{\alpha} \ x \ \eta_{ij}^{\beta}}{\sum_{h \notin tabu_k} \tau_{ih}^{\alpha} \ x \ \eta_{ih}^{\beta}} \end{cases} \qquad (7)$$

where $p_{ij}(k)$ is the probability of choosing to combine disabled *i* and *j* on the route, τ_{ij} the pheromone density of edge (*i*, *j*), η_{ij} the visibility of edge (*i*, *j*), α and β the relative influence of the pheromone trails and the visibility values, respectively and $tabu_k$ is the set of the infeasible nodes for the *k*th ant. The 2-opt exchange method has been used for local search of the ACO algorithm. In the 2-opt exchange, all possible pairwise exchanges of disabled locations visited by individual vehicles are tested to see if anoverall improvement in the objective function can be attained. The updating of the pheromone trails is a key element to the adaptive learning technique of ACO and the improvement of future solutions. First, pheromone updating is conducted by reducing the amount of pheromone on all links in order to simulate the natural evaporation of the pheromone and to ensure that no one path becomes too dominant. This is done with the following pheromone updating equation;

$$\tau_{ij}^{new} = \rho \ \tau_{ij}^{old} + \sum_{k}^{K} \Delta\tau_{ij}^{k} \quad \rho \in (0,1) \qquad (8)$$

Whereτ_{ij}^{new} is the pheromone on the link (*i*, *j*) after updating, τ_{ij}^{old} the pheromone on the link (*i*, *j*) before updating, $\rho$the constantthat controls the speed of evaporation, *k* the number of theroute, *K* the number of the routes in the solution and *K*> 0and $\Delta\tau_{ij}^{k}$ are the increased pheromone on link (*i*, *j*) of route *k*found by the ant.Specifically, the strategyis written as:

$$\Delta\tau_{ij}^{k} = \begin{cases} \frac{Q}{K\ x\ L}\frac{D^{k}-d_{ij}}{m^{k}x\ D^{k}} & if\ link\ (i,j)\ on\ the\ kth\ route \\ 0 & otherwise \end{cases} \quad (9)$$

Where$Q$ is a constant, L the total length of all routes in the solution, i.e. $L=\sum_k D^k$, D^k the length of the kth route in the solution, d_{ij} thelength of edge (i, j) and m^k the number of disabled in the $k$throutes and $m^k > 0$.

The Dataset

In this problem has been assumed that 100 are disabled. The datasets used in this study are shown in the following Table 1. In this study, is used C101 dataset from Solomon's benchmarking problem sets [14].The C101 data set was thought to be a prototype of the data of people with disabilities.Total car capacity was considered to be 200. In this study, the main objective is tried to minimize total numbers of vehicles and the total distance. The various factors are highlighted in the data set. These; geographical data (X and Y coordinate values), a number of disabled are served by vehicle, time constraint percentages of persons with disabilities and in the form of positioning and frequency of the time window. The x and y coordinated values of place that the disabled lived are determined randomly over two-dimensional planes. The coordinate that there is rehabilitation center has been adopted central point (0).

Table.1. Disabled location and service information

Attribute	Data
Disabled number	continuous
Coordinate X	continuous
Coordinate Y	continuous
Requested time	continuous
Service start time	continuous
Service end time	continuous
Service time	continuous

Table.2. An example of the converted binary-coded values

Disabled number	X	Y	Requested time	Service start time	Service end time	Service time
1	45	68	10	912	967	90
2	45	70	30	825	870	90
3	42	66	10	65	146	90
4	42	68	10	727	782	90

III. EXPERIMENTAL STUDY:

In this study, ant colony optimization (ACO) algorithm approach in the disabled service vehicle routing problems was proposed. ACO algorithm is coded in Matlab programming. The flowchart of the approach used to obtain the optimum solution values is shown in Figure 4.

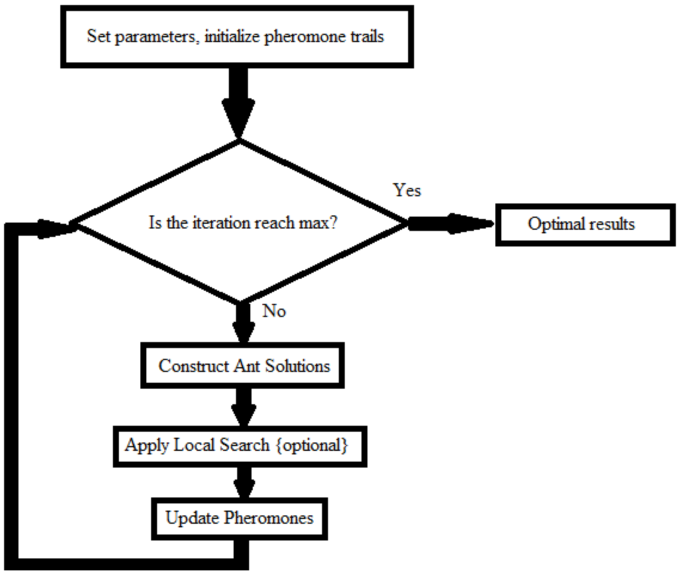

Figure.4. Flowchart for proposed the ACO method

The results obtained from experiments are given in Table 3

Table.3. The results of application

Method	The first distance	Distance	Number of vehicles	Total Travel Time
ACO	4566.5	3029.9	19	1577.8

In the ACO metaheuristic method, has been setting maximum capacity of vehicles 200 and the number of ants 20. In the performed study, is calculated as the minimum total distance 3029.9, the number of vehicles 19 and total travel time 1577.8. Routes of the vehicles are shown in Table 4.

Table .4.Vehicle's Routes Obtained By The Aco Method

Vehicles	Routes								
1	100	47	0	0	0	0	0	0	0
2	98	99	50	0	0	0	0	0	0
3	91	21	49	75	0	0	0	0	0
4	97	80	88	89	4	0	0	0	0
5	96	88	51	52	1	69	0	0	0
6	92	93	85	77	79	89	23	0	0
7	94	84	73	60	68	2	22	66	0
8	95	83	74	61	64	59	26	4	34
9	90	87	86	72	36	12	0	0	0
10	82	70	46	48	0	0	0	0	0
11	81	78	76	71	56	38	58	0	0
12	67	65	63	62	45	6	0	0	0
13	57	55	54	41	53	37	39	14	0
14	43	44	15	9	28	0	0	0	0
15	42	40	35	29	30	11	16	0	0
16	33	32	31	25	27	19	10	0	0
17	24	18	8	0	0	0	0	0	0
18	20	13	17	7	0	0	0	0	0
19	3	5	0	0	0	0	0	0	0

In Figure 5, is given the route information obtained by the ACO method. In this study, were obtained 19 routes for 100 disabled.

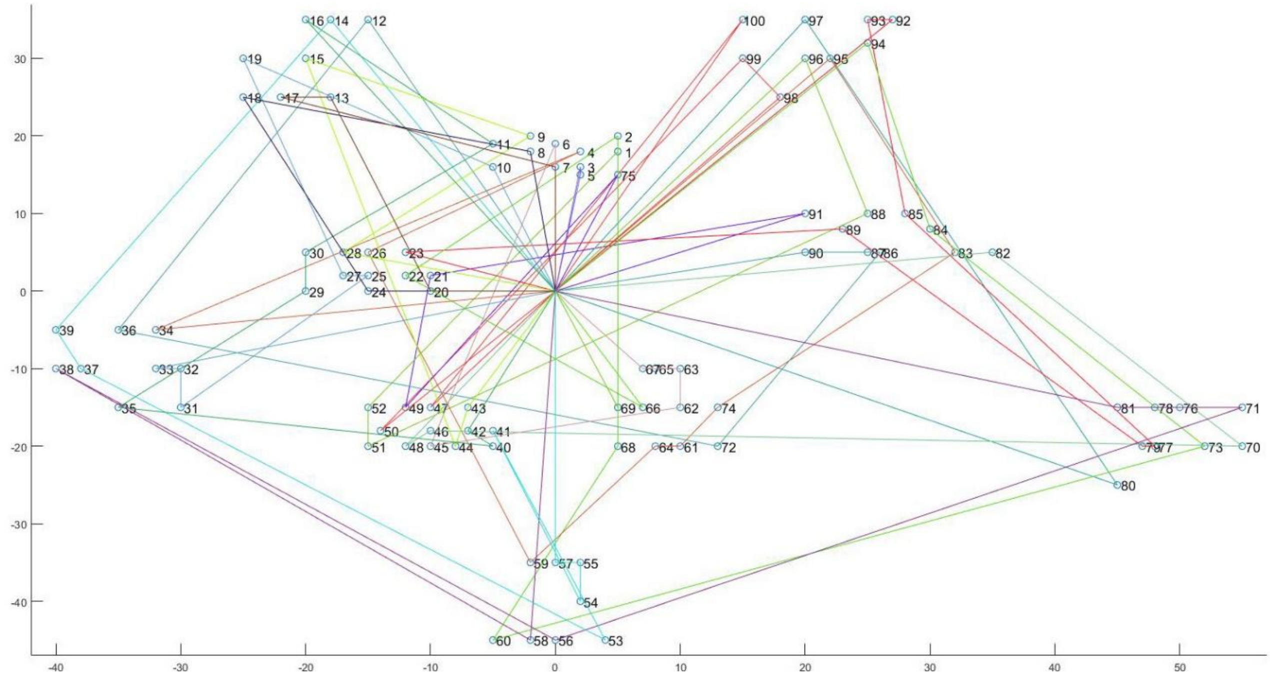

Figure .5. The routes obtained by the ACO method

IV. DISCUSSION

A number of unforeseen problems, such as traffic density, vehicle breakdown and the time of preparation for people with disabilities, can lead to problems in service.As a result of these variability and uncertainties, there is a need for route planning and management.It is very difficult to respond to changes in service requests as soon as possible. In this study, it has been investigated how estimation and tool routing process can be improved by using ant colony optimization method by using data of disabled individuals.A more effective and efficient working environment was provided by using ACO method in the disabled vehicle routing study. Researchers working on vehicle routing problems can easily and quickly make the necessary predictions and conclusions with this application.

V. CONCLUSIONS

Metaheuristic algorithms are currently one of the most effective methods of optimization applications in nowadays. In these methods, taking into account a starting solution is carried out a search strategy in the algorithm. Process be terminated with a specified stopping criterion and be presented to user obtained the solution.Vehicle Routing Problem is a combinatorial optimization problem that is substantially determining logistics costs encountered with the development of the route plan for the business. In this paper, has been studied minimal cost VRPTW using ACO metaheuristic method. In the study that conducted over the dataset is obtained minimum total distance, the number of vehicles was used and total travel time. In this study, rehabilitation companies will be able to plan vehicle weekly, monthly and yearly by using vehicle routes. Again, with the help of a software they can develop, they will be able to create this business more profitably. By making the assumptions correct, the routing reliability will be stabilized, thus preventing unnecessary operation of the vehicles and a significant increase in the rate of profitability. The aim of this study is to develop and develop different methods in the future.

VI. REFERENCES

[1] Toplumsal Haklarve Araştırmalar Derneği, "Mevzuattan Uygulamaya Engelli Haklarıİzleme Raporu 2013", İstanbul, 2014.

[2] S. Moore, Social Welfare Alive, United Kingdom, Nelson Thornes Ltd., 402, 2002.

[3] F. Subaşıoğlu, "Üniversitelerin Bilgive Belge Yönetimi Bölümlerinin Engellilik Farkındalığı Üzerine BirAraştırma", , 9(2), 403, 2008.

[4]A. Bilgin, "1 Nolu Sağlık Ocağı Bölgesinde 18-58 Yaş Engellilik Sıklığıve Engelliliği Belirleyen Etmenler", Sağlıkta Yaşam Kalitesi Sempozyumu ÖzetKitabı, İzmir, 2004.

[5]. Öz-Veri, Başbakanlık Özürlüler İdaresi Başkanlığı Hakemli Süreli Yayını, 75, 2006.

[6]. Öz-Veri, Başbakanlık Özürlüler İdaresi Başkanlığı HakemliSüreli Yayını, 28, 2006.

[7]M. Dorigo, G. Di Caro and L.M. Gambardella, "Ant algorithms for discrete optimization", Artificial Life, 5(2), 137-172,1999.

[8] J.F. Cordeau, G. Desaulniers, J. Desrosiers, M.M. Solomon, and F. Soumis, "VRP with Time Windows", The Vehicle Routing Problem, SIAM Monographs on Discrete Mathematics and Applications, SIAM, Philadelphia, 157-193, 2002.

[9] O. Braysy, "Local search and variable neighborhood search algorithms for vehicle routing with time Windows", ActaWasaensia 87, UniversitasWasaenis, Vaasa, 2001

[10] R.G. Brown and A. M. Gleason, "Advanced Mathematics: Precalculus with Discrete Mathematics and Data Analysis", Evanston, Illinois: McDougal Littell. ISBN 0-395-77114-5, 1997

[11] (2016) Polar Coordinates website. [Online]. Available: http://mathworld.wolfram.com/PolarCoordinates.html

[12] M. Dorigo and G. Di Caro, "The ant colony optimization meta-heuristic", In New Ideas in Optimization, D. Corne, M. Dorigo and F. Glover, Eds., McGraw-Hill, New York, 11, 1999.

[13] M. Dorigo and K. Socha, "An Introduction to Ant Colony Optimization", Technical Report TR/IRIDIA/2006-010, UniversitéLibre de Bruxelles, 2006

[14]. (2016) Dataset website. [Online]. Available: http://web.cba.neu.edu/~msolomon/c101.htm