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Proposing a New Method to Optimize the Routing in the Distribution of Vendors' Goods Using the Internet of Things (IoT)

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Extended Abstract

Distribution systems are a chain of businesses or intermediaries through which a product or commodity delivers to the customer. One of the most important concerns of customers and manufacturers is the improper distribution of the product to the right place and target customers, and it can be boldly said that the cost of each product for the customer largely depends on the costs of distribution of the product. On the other hand, the increase in transfers and movements of goods and the demand for speeding up these transfers, along with the reduction of costs related to these transfers, has caused many complexities and problems in this regard in the transportation network. Among the most important problems at present are the increase in traffic volume on various road / sea and air routes, increasing fuel consumption, wasting long time on high-traffic routes, increasing air pollution, and so on. In this study, a new stochastic algorithm (using a combination of hybrid genetic algorithm and artificial neural networks developed) to optimally select the route to prevent increased costs and reduce time and air pollution caused by traffic on busy routes while transporting goods. And we offer products from the place of production / factories to places of distribution. In this algorithm, IoT will be used to select the optimal path (using DNO GPS-V4 installation). By implementing the proposed algorithm, it can be concluded that the attention of the product production team to strategic issues can be increased in the long run. The number of customers and increasing the share of the company's products in the market will play an effective role.

Introduction

Distribution systems are a chain of businesses or intermediaries through which a product or commodity delivers to the customer. One of the most important concerns of customers and manufacturers is the improper distribution of the product to the right place and target customers. Proper distribution of goods can be a competitive advantage of an enterprise over its competitors. Also, the choice of distribution channel and method of distribution of goods is one of the most important options that managers of enterprises and producers should consider. Because the distribution system of goods, has a prominent and significant role in achieving sales goals in companies and manufacturers and exposes their products to buyers and consumers. When this is done correctly, positive results will be achieved. The most common distribution systems in most countries are usually divided into several categories, which are [1]:

Doi:

• Distribution of goods through wholesale distribution networks

• Distribution of goods through distribution companies and design of various sales networks

• Capillary distribution

• Distribution of goods through independent distribution.

Planning a supply chain distribution network to reduce costs or improve accountability is a difficult and dynamic task. Decisions intended for distribution network planning are tactical or operational decisions such as selecting the frequency of delivery to customers, setting inventory levels on different routes, deliverables, routing of transmission and distribution vehicles, determining the delivery time of products, and so on. One of the operational decisions that supply chain managers often face, is the issue of vehicle routing problem (VRP[1]). One of the most important problems of distribution management, especially in different sectors (such as: distribution of Fast-moving consumer goods (FMCG), reverse supply networks, solid waste management, newspapers, etc.). Determining the desired inventory levels in the warehouse or customers which leads to VPR which in turn causes IRP[2] inventory routing problem.

Such a system, which has inventory and transportation management (vehicle routing and delivery decisions), is known as IRP, which can represent the logistical performance of supply chain players. Therefore, linking and integrating transport activities with inventory management activities is critical to developing an IRP model that can represent logistics operations comprehensively. Because transport and inventory management are directly related to other supply chain activities such as production planning, resource planning, etc. [2].

The Internet of Things (IoT) provides an optimal integration of processes, data, and communications that are intelligently interconnected through the Internet. The goal of the IoT is to optimize human-to-human, machine-to-machine, and human-to-machine interactions that improve people's daily activities [3].

The current generation of vehicles is made up of many electronic components. In fact, vehicles have the highest density of electronic components among all consumer devices. Today, a wide range of technologies are used in the automotive industry. These technologies are classified into three different areas (including: safety and security, fuel efficiency / relocation, entertainment and communications).

In this study, with applying the Internet of Things (IoT) and using location sensors in vehicles, we optimize the routing and distribution of vendors' goods and we propose a new method to reduce pollution

[1] Vehicle Routing Problem (VRP)

[2] Inventory Routing Problem (IRP)

caused by consumed fuels while distributing goods optimally.

This research is organized in five sections. In the second section, we will review some related works. In the third section, we describe the proposed method in this research. In the fourth part of the simulation / implementation, we describe the proposed method and finally we will have the fifth section of the conclusion.

I. Related Works

The issue of vehicle routing is one of the most important issues in the distribution and logistics of the supply chain and includes a fleet of vehicles with a specific capacity, one or more warehouses, several demand centers and routes between warehouses and demand centers. In the supply chain distribution sector, each vehicle starts moving from a common group called the warehouse to meet the demands while referring to the places of demand (nodes). In the classical definition provided, each demand center is visited by one vehicle and the demand of each center is less than the capacity of the vehicle. Also, none of the vehicles are loaded more than Q capacity. The purpose of this issue is to: have the total number of transfers made, maximize the applicants' satisfaction with the supply of products requested by them or minimize unmet demand [4].

Changes in society and the market have changed the role of the consumer. Manufacturers must plan and execute service management processes using a combination of maintenance services using an experienced team to increase customer satisfaction [5]. When objects are able to both sense and communicate, they quickly become tools for understanding complexity and responding to the environment. Some of the studies conducted in the field of distribution of goods and products from the place of production / warehouse to retail outlets or by customers are given below.

Hosseini et al. [6] made a research for modeling and solving the problem of vehicle routing (VRP) in the supply chain distribution sector with regard to traffic restrictions. In this research, the issue of vehicle routing in the supply chain distribution network has been investigated by considering the real world conditions and existing limitations, including vehicle traffic restrictions. Khademi Zare et al. [7] evaluated the problem of routing multi-point vehicles and multi-product vehicles using fuzzy logic, multiple goals, and flexibility in determining terminal points. In this research, a new model of vehicle routing problem is formulated in the form of integer linear programming in which, unlike conventional models of routing problem, there is no need for the vehicle to return to the original warehouse after service. Also, due to the Np-Hard nature of the routing problem in multi-point mode and multi-product with fuzzy time window, multi-objective genetic algorithm with non-defeat sorting has been used to solve the model. Mohammadi et al. [8] presented a model and genetic metaheuristic algorithm for the problem of vendor routing by considering the work balance. In order to optimally allocate the route, these researchers did not only pay attention to the time parameters and the number of supermarkets in each route, but also considered the quality level of the store and the skill level of the sellers in their model. In this study, the aim is to determine a set of routes that balance the workload of vendors with respect to uniform service time. To solve the problem at the applied scale, the meta-innovative genetic algorithm has been used. Jie Yan et al. [9] proposed a multi-stage transportation and logistics optimization method to increase the consumption of renewable energy and save money during transfers. In the proposed method, batteries are charged in renewable power plants. The proposed logistics transportation concept is designed for the Beijing-Tianjin-Hebei regions. The results of the implementation of the proposed method in China show that the cost of energy required for transportation has decreased by an average of $ 0.045 per kilowatt hour. In 2018, when adopting the Vendor Inventory Management (VMI) strategy, Saif-Eddine et al. [10] considered the integrated Inventory Location Routing problem (ILRP) and formulated a mathematical model to minimize total supply chain costs. In this research, the improved genetic algorithm (IGA) was designed as NP-hard and used to solve the problem [10]. Rau et al. [11] presented multi-objective green cyclic inventory routing problem (MOGCIRP) to measure the impact of transportation and inventory management on cost and environmental issues. Proposed Multiple Discrete particle swarm optimization (PSO) and Exploratory Optimization for the Pareto MOCGIRP Complex Performance. The results show that inventory management activities significantly (22-27%) affect the total cost and emissions [11]. Burkhovetskiy et al. [12] evaluated a two-loop supply chain that required a periodic variable for finite planning. The costs related to the maintenance of each customer were examined in this study, the purpose of which was to determine the amount of delivery of goods for each customer in each period. When calculating the maintenance cost of each customer, the inventory list of goods in each period as well as the average number of requests in each period were considered. The researchers also developed a hybrid meta-exploratory method that was very effective and efficient [12]. Ikuo YOSHIHARA et al. [13] proposed a system based on the ACO basic algorithm with a good distribution strategy and information entropy. They then improved the ACO for TSP with a heuristic combination of local optimization. The results of their experiments showed that the proposed algorithm performed better than the ACO algorithm. In a study, Hlaing et al. [14] evaluated meta-heuristic algorithms in solving periodic problems. In this research, a new and innovative method for problem solving is presented in which an algorithm with a cover-up approach using local search based on the nearest neighbor method, has solved the problem of routing vendor routing. Evaluation of the results obtained from the proposed method indicated that the proposed method provides high speed and accuracy in the production of final routes.

II. The proposed method

This research work is based on two parts. In the first part, the developed hybrid genetic algorithm method is used to analyze and present the model of routing and distribution management of goods and in the second part, the artificial neural network is used to validate the proposed model. In this section, we first explain how to model the cost and then explain the two sections mentioned.

A. Cost model

Cost modeling includes modeling warehouse costs and modeling costs related to transportation using vehicles, which we describe below.

B. Modeling Warehouse Costs

In this research, there are two types of costs related to warehouse.

The first is the cost of moving goods / products to the warehouse, which indicates which warehouse was used in period p. Equation 1 is used to calculate the costs associated with moving goods / products [10].

Equation 1:

$$\sum_{p=1}^{P} \sum_{o \in ND} y_i^p \, . dc_o^p$$

In equation 1, y_i^p is a binary variable that specifies which product i is stored in the p period.

Another cost is related to the cost of inventory storage of products, which can be calculated by multiplying the maintenance cost for each product per unit time by the number of products in stock, as long as this amount remains in stock. Since all products are imported at the beginning of each period and shipped during the same period, the amount sent by each vehicle q_i is multiplied by the dispatch time of the vehicle est_{ojk}^p, which indicates the time Warehousing, multiplied by the amount of maintenance cost of each product per unit time expressed in Equation 2 [10].

Equation 2:

$$\sum_{p=1}^{P} \sum_{o \in ND} \sum_{k \in k_o} ((\sum_{j \in J_p \cup \{o\}/\{i\}} \sum_{i \in J_p} x_{ijk}^p . q_i). (\sum_{j \in J_p} x$$

In equation 2, x_{ojk}^p is a binary variable that indicates whether the vehicle k passes through a specific place (i, j) or not?

C. Modeling Transportation Costs Using Vehicles

Transportation costs using vehicles in this study include dispatching cost and routing cost. On the other hand, the cost of routing a vehicle is a linear function of distance traveled. Equation 3 calculates transportation costs using vehicles.

Equation 3

$$\sum_{p \in P} \sum_{0 \in ND} \sum_{k \in k_o} \sum_{j \in J_p} x_{ojk}^p . fc_k$$

$$\sum_{p \in P} \sum_{o \in ND} \sum_{k \in k_o} \sum_{j \in J_p \cup \{o\}/\{i\}} \sum_{i \in J_p \cup \{o\}} x_{ijk}^p . t_c . d_{ij}$$

In equation 3, d_{ij} is the distance between location i, j and t_c is the cost of transportation per unit of time, fc_k is the cost of sending the vehicle k [10].

D. Traffic Model and Load Balance

Load balance problems are generally divided into static and dynamic categories. Static algorithms assign processable tasks to accessible nodes. The main purpose of this algorithm is to reduce the overall execution time. Accordingly, the node selection process for submitting tasks is based on prior information about the node's features and capabilities. Static algorithms do not take into account the dynamic changes that occur at runtime in the properties of the node. In addition, they cannot adapt to the environment, while dynamic algorithms take into account the dynamic changes created and adapt to the environment.

In order to evaluate the load balance in the network, the load variance parameter is used, which is calculated according to Equation 4.

Equation 4 $$S_N^2 = \frac{1}{N}\sum_{i=1}^{N}(\Gamma_i - \bar{\Gamma})^2$$

E. Developed Hybrid genetic algorithm

In this study, we discuss about Inventory Location Routing problem (ILRP) in traditional vehicle routing problems in the NP-hard method. In this study, an improved genetic algorithm (IGA) has been used to solve ILRP. In this regard, in the first stage, the initial genetic algorithm is used to determine the number of generations and then in the second stage, the optimization process is performed in the entire initial population. If the total cost is reduced, the final answer of the genetic algorithm is obtained, and if the optimal answer is not obtained, the old improved chromosome is replaced by the new replication, and then GA is performed for the same number of generations on the improved population [10].

F. Chromosome Encoding

In the proposed method, the corresponding chromosome is divided into two sub-chromosomes: one sub-chromosome for dispatching time fractions and the other for paths. The first sub-chromosome consists of a three-dimensional array$(P^*|ND|\ ^*NK)$, where NK is the maximum number of available vehicles among the depots NK is $NK = max\{k_o\}$, each input, it changes between zero and one (binary value) and indicates the dispatch time of vehicle k in period p. The specified binary value determines the dispatch time of the vehicle according to the minimum and maximum dispatch time of the vehicle.

G. Chromosome Decoding

To decode the sub-chromosome segments and the binary value of the dispatch time, the route of each vehicle is checked to determine the maximum possible dispatch time, in other words, when the vehicle can be dispatched, refer to its customers and at the exact location at the end of the period that warehouse returns. The minimum possible time for each vehicle is Period's start. Deployment time fraction is the deficit between the minimum and maximum dispatch time.

H. Creation of Initial Population

To create the initial population, follow the steps which are shown in the flowchart figure 1. According to the flowchart of Figure 1, it can be said that the stages of creating the initial population are:

Step 1: Random fractional numbers for distribution below the chromosome are generated from the U distribution based on two-binary values (1,0). The actual transfer time is then calculated as Equation 5.

Equation 5:

Actual transfer time = start of period + (fraction number)* Pt

Step 2: Set p = p + 1 (number of new iterations in each period) and select a warehouse that has at least one unused vehicle at random.

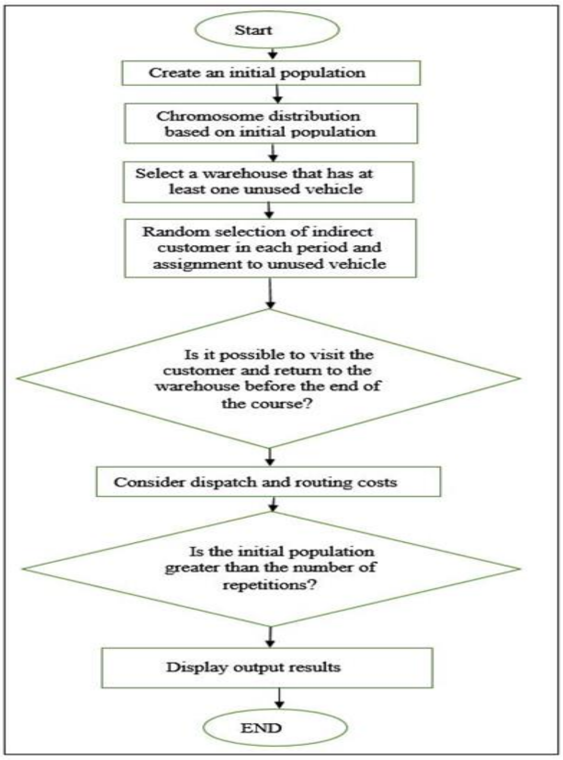

Figure 1:General flowchart of the initial population creation section

`Step 3: The indirect customer is randomly selected in each p period and assigned to the first unused vehicle, then it is checked whether it is possible to visit the customer and return to the warehouse before the end of the period or not. If it is possible to return, this step is confirmed and we are transferred to the next step of the algorithm execution, otherwise another client is selected to continue the algorithm execution process. If there is no other customer, we exit the algorithm.

Step 4: Customers (visitors) are selected in this step who can enter the route of the selected vehicle without violating the maximum capacity of that vehicle to form the C set.

Step 5: For each customer belonging to C, all the practical inserts (regulations) in the selected vehicle route are determined and the relevant cost (transfer + routing) is determined, then the lowest possible insertion is selected. If no possible degree is found, go to step 3, otherwise we exit the algorithm.

Step 6: If p <P, go to step 2, otherwise, go to step 7.

Step 7: Convert the sending time to the fractional number given by the relation.

I. Progress process

In the recovery process, two methods are applied, the resulting chromosomes are compared and the method that has the lowest cost is selected. In the first method, the chromosome successfully completes three stages of improvement, while in the second method, the cost of both chromosomes (before and after each stage of improvement) is evaluated, and the method that has the least cost completes the next stage of progress. (Figure 2).

III. Evaluation and Discussion of the Proposed Method

In most issues of routing and distribution optimization of goods, the purpose of assigning operations related to the product distribution process to the desired stations in order to optimize objectives such as minimizing the length of the transmission path as the first goal and minimizing the number of individual workstations (number of operators), is considered as the second target for a fixed time cycle. In this research, to apply mathematical modeling and genetic methods, MATLAB software has been used and part of the operation has been done in practice in one of the streets of a city by selecting 10 points in the city to distribute goods using a vehicle. In the following, we will explain both sections (simulation using MATLAB software and performing routing practically).

Table 3 :How to re-check the connections and applications of each wire in the DNO-V4 device

Application	Color	Pin	
9 to 38 watts of direct power	Red	1	
Land/ Soil	Black	2	
SOS chassis input one	Orange	1-3	
SOS chassis input two	Orange	2-3	
Vehicle power detection wire (this wire must be connected to the car switch wire)	Brown	4	
Positive engine	Red	Thick	Relay
Positive engine	Green	Thick	
Connects to the blue wire of the main cable	Blue	Thin	
Connect to the Negative wire of battery	Black	Thin	

IV. Simulation using MATLAB software

In this study, the integration operator operates in such a way that after selecting two chromosomes based on the principle of survival of the fittest, it cuts off the number of activities of one chromosome and the activities assigned to the other chromosome and leaves a new child with better properties than the parents creates itself. The mutant operator then occurs if the balance in the created child is disturbed by the number of activities performed and the number of activities assigned, and attempts to rebalance the new and better genes by shifting the activities of the side genes. And then the amount of suitability for the created children is calculated again and the steps are repeated until reaching the stop criterion, which in this particular problem is to create better answers than the numerical method. The results of the simulation by genetic programming method are presented in Figure 6.

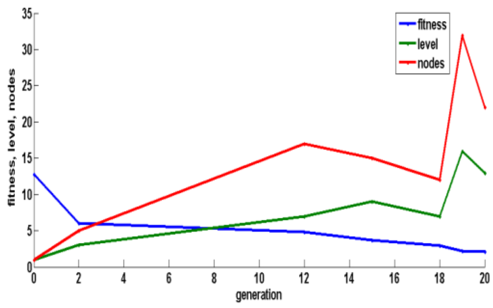

Figure 6:The Rate of Change of the Initial Population in Terms of the Fit Function to Determine the Objective Function

In order to generate the initial population taking into account the initial data (Figure 7), the initial population production is based on changes in the performance of the distribution lines to create the decision tree, which is considered with different combinations of input modes (Figure 8). After optimizing the input data (Figure 9), the decision tree is created according to the efficiency of the product distribution line (horizontal axis) and the product distributed among vendors (vertical axis) due to the combination of different modes and then the final model is created based on changes and it is obtained (Figure 10). Figure 11 shows the changes in product line management performance based on the initial test function. Despite the fact that the equations resulting from genetic programming are obtained randomly, the evaluation of two computational (best) and observational (test) functions shows that the program has a high accuracy in predicting and calculating line performance changes by considering the desired fit function. Shows itself. Selection of the best combination model in terms of product distribution line efficiency (Figure 12), calculation of routing changes and distribution of vendors' goods before and after the project taking into account the fit function (Figure 13), MATLAB program output results from genetic programming method for Determining the criteria (taking into account the test phase (T) and training phase (A), the average absolute magnitude of the deviations, the delay index of the psychological index and the efficiency of the broadcast path) are shown in Figure 14.

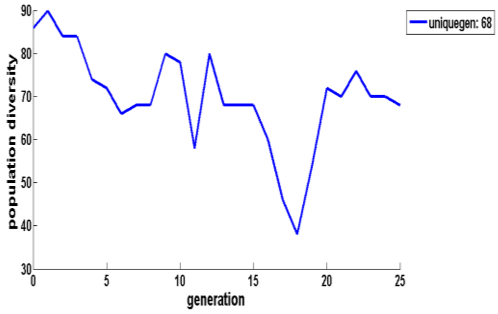

Figure 7:Generation of the Initial Population Taking Into Account the Initial Data

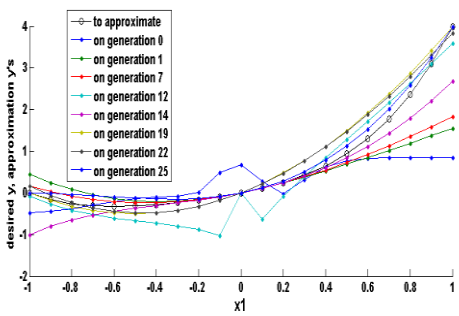

Figure 8: Generating different combinations of product distribution line performance based on input data to create a decision tree

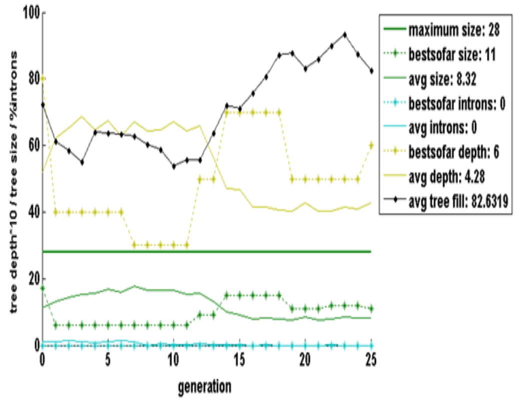

Figure 9 : Optimization of different combinations of product distribution line performance based on input data to create a decision tree

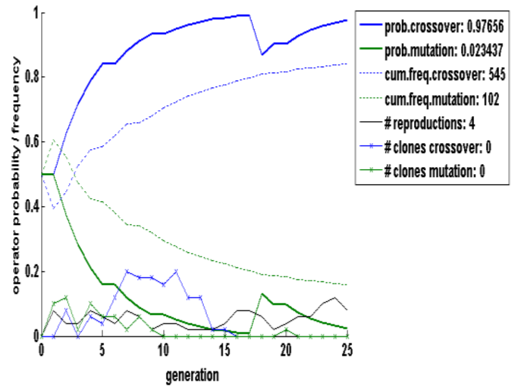

Figure 10: Creating a decision tree based on the efficiency of the product distribution line (horizontal axis) and the product distributed among vendors (vertical axis) due to the combination of different modes of input data

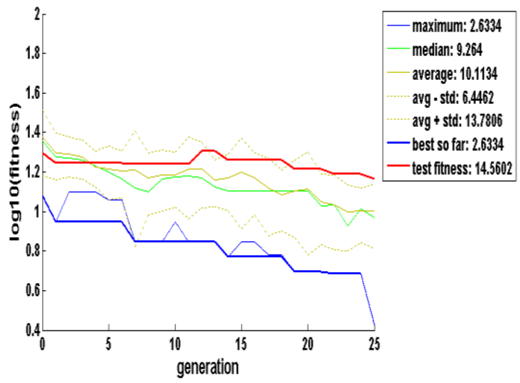

Figure 11 : Selecting the best combination model in terms of product distribution line efficiency

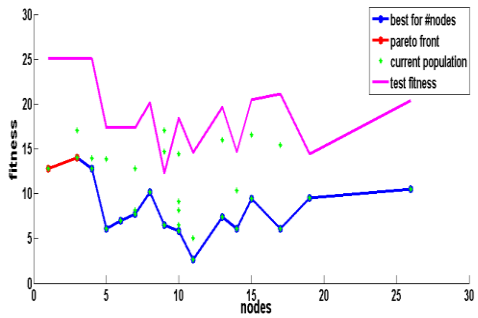

Figure 12 : Calculation of routing changes and distribution of vendors' goods before and after the project work with the fit function

MSE_A	MSE_T	RMSE_A	RMSE_T	R2_A	R2_T
2.7859	2.2859	1.5246	1.4246	0.99969	0.98679
2.7792	2.2792	1.5242	1.4242	0.993	0.9801
2.7725	2.2725	1.5237	1.4237	0.9863	0.9734
2.7658	2.2658	1.5233	1.4233	0.9796	0.9667
2.7591	2.2591	1.5228	1.4228	0.97291	0.96001

Figure 13 : Matlab program output results from genetic programming method to determine the criteria (considering test phase (T) and training phase (A), mean absolute value of deviations, psychological index delay index and line efficiency)

V. Exprimental Results

We select 10 points at random on the map and the goal is to find the best path between them. Using MATLAB software, we simulated the problem and entered 10 points. TSP gives us a series of optimal paths using a hybrid genetic algorithm developed. In this section, we show three of the suggested paths implemented in TSP as examples.

The first phase of our work is a simulation that includes 25 points that we implemented the TSP problem in MATLAB software and with coding, and because we wanted to implement the paths in real time, we put 10 points inside the problem. We choose the city to find the best route between them, and since MATLAB software has some implementation constraints such as squares, boulevards, one-way streets, dead end alleys, roundabouts, even and odd plans and. ., cannot be easily considered and therefore in practice we face limitations.

The beginning of all the routes from the desired company and the end of all those routes, after meeting all the selected points that have been numbered, is finally the same company.

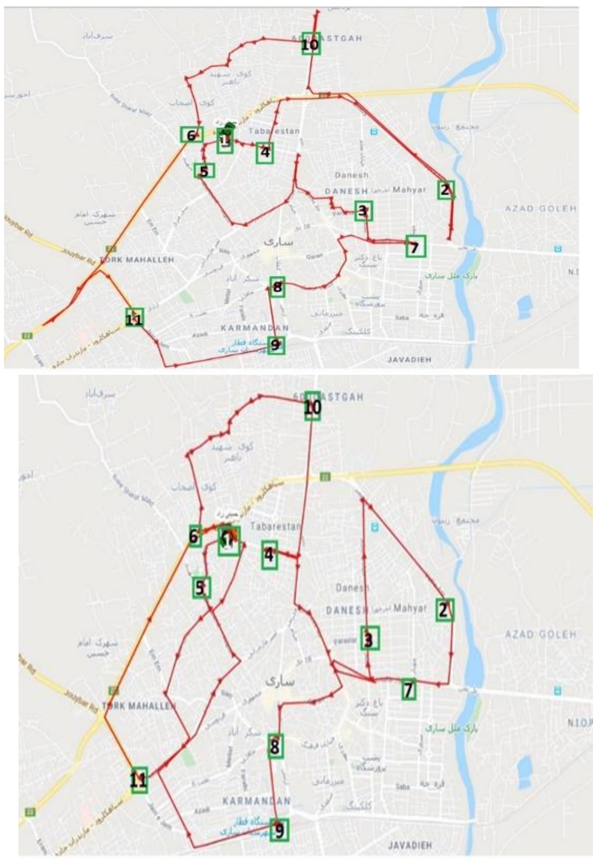

Figure 14:The output of DNO-V4 after traveling the first route in the order 1-5-3-7-8-9-11-6-10-2-4-1 (left to right)

Conclusion

In this research, a proposed method for routing and management issues in the distribution of vendors' goods with longer operating times than cycle times and regional constraints is presented.

This point of view may be due to the fact that in the planning process, the manager and his colleagues for line design are such that they first assign activities to workstations by applying prerequisite constraints (technical instructions for performing tasks). The decision is then made about the equipment to be assigned to the workstations to speed up the distribution system. After the installation of the selected equipment, studies are started to achieve the extent of distribution of the goods required by the sellers in the distribution network, which should meet the expected demand. Suggestions based on the findings of this study that the use of GPS positioning sensor and the method used, led to the management and optimization of the distribution of vendors' goods and routing using a new random algorithm and the use of the Internet of Things (IoT). It is recommended to use similar GPS systems in broadcast systems.

The method proposed in this research solves the problem only by using the cost criterion. It is suggested to create more diverse designs of methods such as bee, ant and ... algorithm that allow the possibility of considering more criteria simultaneously to solve this method.

Equip distribution and distribution systems with multi-purpose navigation systems and use them to minimize costs. Also equip distribution systems to vehicles with renewable fuel to reduce environmental pollution.

Also, as a field for future research, the modeling considered in this research can be used as a suitable basis for the development of innovative or meta-innovative methods for larger dimensions and those problems can be modeled and solved. Considering uncertainties about activity times or considering weights for different elements of objective functions can also be interesting contexts for future research. Due to the fact that a large part of marketing and distribution work is done by person and point to point, so it is possible to design its mobile application software to be installed on a mobile phone to make it possible to use the proposed method at the level Provincial and inter-provincial.

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