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OPTIMIZATION IN THE CAR-HAULING INDUSTRY

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Abstract: *This paper studies optimization opportunities in the U.S. car hauling industry specifically targeting idle miles. We developed a mathematical model that defines the optimal order of transportation tasks needed to minimize idle miles. Real data was collected from a U. S.car-hauling company to build the model. A numerical optimization using evolutionary algorithm and Excel Solver was performed on multiple scenarios. Significant improvement can be seen through route optimization. In one scenario the total route distance was decreased from 2997 km to 1897 km and the carrier's profit increased from $189 to $1291. In another scenario, the total distance of all routes was decreased from 2578 km to 1742 km and the negative profit of -$194 turned into a positive $648. Optimization effectively reduces idle mileage in the car hauling industry. Both profit maximizing and idle-cost minimizing produce nearly identical efficient routes.*

Keywords: *car hauling, route optimization, cost function.*

1. INTRODUCTION

One the main tasks of logistics specialist is finding the pathes for reducing the cost through the optimization of processes, which are the processing of transporation, storing, packing/unpacking and other operations occuring within the supply chain. In accordance to so-called "5S System", the way for optimizing is eliminating the waste [1]. One of five types of waste is "muda" – the activities with no add-value. In the frameworks of this research the problem of idle routes will be studied, which can be perceived as a particular case of no add-value. This research is the practical attempt to apply some numerical methods for optimizing this problem.

The research is planned to be focused on a narrow logistics branch in the given geographical conditions. It is the car-hauling industry in the United States of America. So, there will be some specific conditions regarding this very field. Although, the elaborated mathematical model can be applied to a wider range of cases.

The aim of this work is to analyze the logistics processes based on empirical data from American car-hauling company and to find out possible ways of optimization.

To achieve this scope, the following objectives are set up:

- To collect and organize the data required for the problem including the location of origin and destination of transported goods, the cost of transportation and the carrier's income for each load.
- To build up a mathematical model of the given logistical problem.
- To find the way of optimization using the numerical methods in logistics.

We define the object of the study as freight transportation. The research subject is the ways of minimization of idle routes.

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The problem of minimizing idle routes has universal character and can be found in almost every subdomain of logistics. Therefore, the topic can be recognized as a significant one, because the algorithm can be applied inclusively to the other fields of logistics.

The basic problem in truck logistics is minimizing the number of so-called “dead miles” or, using more scientific vocabulary, reducing the idle roots. The idle route is a route the truck makes without carrying the load, in other words, useful load weight. This problem has been studied in academic circles as Vehicle Routing Problem (VRP) [2].

According to data from the U.S. Department of Transportation and private fleet reports, the share of empty or unproductive mileage in U.S. trucking can reach 25–35% [3]. Among the reasons can be named asymmetric delivery patterns and limited backhaul opportunities.

Automobiles are high-value, customized products, so customers expect a high level of delivery service when purchasing a new car. Delivery service quality consists of delivery time, reliability, quality, and flexibility, all of which strongly influence customer satisfaction and the economic success of manufacturers. Distribution logistics plays a key role in achieving this service level because it connects production with the final customer. However, in the automotive industry, manufacturers often focus mainly on optimizing production processes rather than the entire value chain. As a result, logistics service providers frequently receive incomplete or delayed data for distribution planning. In addition, the actual number of vehicles requiring transport often differs from initial plans. Because of this uncertainty, transport planning usually begins only after vehicles leave the production line. This late planning reduces opportunities to optimize transportation processes. The situation is further complicated by weak integration between manufacturers’ and logistics providers’ IT systems. Fragmented and outdated information systems create inefficiencies, additional data-entry work, and higher risks of errors [4].

Based on these conditions provided for the problem, we can formulate the following research question: Is it possible to imporve the efficiency of car distribution processes using optimization methods?

2. LITERATURE REVIEW

To conduct the systematic literature review, several consecutive steps were followed. First, the research questions were clearly formulated. Next, relevant publications were collected from the Scopus database. After that, the initial pool of articles was refined through detailed reading and classification according to their primary themes. The selected studies were then examined in depth, their key scientific contributions were synthesized, and, finally, major research gaps and existing limitations in the field were identified.

For the analysis of the literature two key concepts were chosen: “Vehicle Routing Problem” and “optimization”. So, the request in Scopus database using its specific syntaxis will be the following: “ABS(Vehicle Routing Problem AND optimization) AND (LIMIT-TO (LANGUAGE,"English"))”, where ABS is the articles’ abstract.

We see a strongly increasing trend of research activity for VRP in the context of optimizing processes within the last 20 years (Fig. 1). We see that the absolute majority of the articles based on these key words are related to either Computer Science, Engineering or Mathematics (Fig. 2).

A Case Study of the Automotive Industry in Mexico proposes a practical solution to a logistics optimization problem involving the delivery of cars and vans from production facilities to dealerships under capacity and time-window constraints. The authors develop a two-phase heuristic algorithm: first constructing efficient delivery routes using an insertion procedure, and then determining feasible loading plans for auto-carriers. The method is designed to reduce total travel distance, loading/unloading operations, and transportation costs compared to conventional approaches. Experimental results based on real industrial data show that the algorithm performs effectively and supports decision-making in vehicle distribution planning. Overall, the study demonstrates how tailored heuristic optimization can improve routing and scheduling efficiency in automotive logistics operations [5].

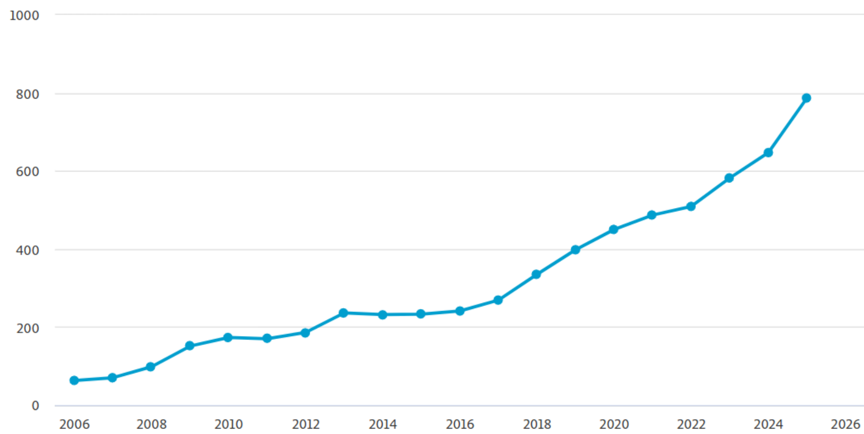

Figure 1. Dynamics of articles by year considering subject areas based on a search in Scopus database using topics "Vehicle routing problem" AND "optimization". (Source: www.scopus.com)

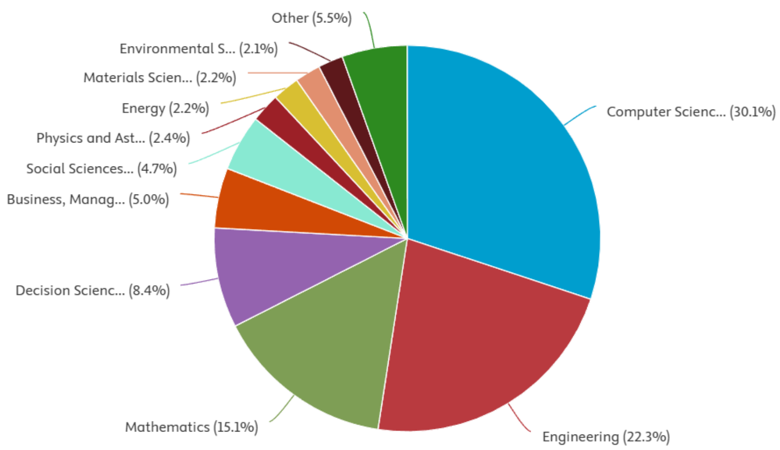

Figure 2. The articles classified by the scientific field considering subject areas based on a search in Scopus database using topics "Vehicle routing problem" AND "optimization". (Source: www.scopus.com)

Some scholars decided to use evolutionary and genetic approaches. For example, a research paper studies the Pickup and Delivery Problem (PDP) using evolutionary programming combined with mutation-management strategies. It proposes new mutation operators (such as Random-Relocate-Block and Combined-2) and applies reinforcement-learning-based selection strategies (including UCB1, Softmax, and Thompson Sampling) to improve route optimization performance. Experimental results show that the proposed mutation-management approach significantly improves route-length reduction compared to classical heuristics like nearest-neighbor and hill-climbing methods, demonstrating strong potential for logistics route optimization [6].

A research work analyzes how optimization techniques can support route planning in passenger-car distribution, especially in companies that rely mainly on staff experience rather than decision-support software. It presents two approaches to solving routing problems based on the Travelling Salesman Problem (TSP), which is one of the milestones of all the optimization research in general and for our current research: a permutation-based evolutionary method and the branch-and-bound method using the Little algorithm. The study demonstrates that these methods can be applied without specialized software and can improve route efficiency, reduce driver working time, and increase the economic performance of vehicle distribution systems [7].

A research team presents a conceptual platform designed to improve last-mile delivery efficiency using real-time data and machine-learning-based algorithm selection for solving the Capacitated Vehicle Routing Problem (CVRP). The proposed system integrates IoT-based travel-time updates and introduces a novel parameter measuring drivers' familiarity with destinations to enhance route assignment quality. The study highlights the potential of combining real-time data, heuristic selection, and driver knowledge into a unified decision-support platform, though full implementation and validation remain future work [8].

Based on this literature review, we can make a conclusion that the problem is not new for the academic field. It's been researched by many scholars using different mathematical approaches and programming algorithms. Nevertheless, there is lack of research focused on this specific topic regarding truck-based car-hauling logistics with its specific constraints like stochastic pick-up and delivery points, which are rarely coincided, different capacity of the transport units etc. Also, the majority of existing research paper don't take into consideration different carriers' revenue from shipping which is also a key factor in building the route.

3. PROBLEM DESCRIPTION

The basic units of the U.S. car-hauling industry are specialized car-hauling trailers usually driven by a truck. The open-source data about the exact amount of these vehicles operating countrywide are unavailable, but we can establish the minimum: 20000 companies registered on the most popular car-hauling loadboard CentralDispatch [9]. Each of them solve on daily basis logistical problems regarding making up the optimal and the most profitable routes, meeting the customer's needs and some legal restrictions. Some companies manage these problems independetly, some of them (especially, large ones) use outsource dispatch companies, including the ones situated abroad.

In the subdomain of car-hauling logistics there are some key restrictions inevitably reducing the effectiveness and increasing the number of "dead miles" that can be eliminated completely:

- Geographical imbalance between production centers (e.g., Michigan, Kentucky) and demand centers (urban dealerships nationwide).
- Strict delivery time windows tied to dealer operations and customers' requirements.
- Physical constraints (height, weight, and sequence loading restrictions).
- Special equipment constraints.

These factors create a complex optimization environment where minimizing idle routes requires integrated decision-making that combines vehicle routing, loading, and fleet scheduling.

The problem in this case is aggravated by the fact that the roots are unstable, so the truck is being sent every time to different locations. Often, the operating companies don't have large long-term orders for transportation big amounts of cars. Instead, they are forced to resort to short-term order (1-2 vehicle in a load). Therefore, eliminating the idle routes or to elaborate one general instruction for all the cases is not possible. Thus, it requires an algorithm which can find the optimal solution every time whenever the data input has been changed.

The complexity of the problem depends on the capacity of the trailer. In car-hauling industry there are used both open and enclosed trailers [10] that can haul from one to nine vehicles [11]. It's obvious that more capacity is, more variables must be taken into consideration. It is also important to emphasize the difference between the problem of a truck with one-vehicle capacity and multivehicle trucks. This difference has not only quantitative, but qualitative character. So, in the second case we must take in consideration not only idle routes between the points of unloading and loading, but also "dead miles" between points of origin or destination of different loads.

To solve the given problem of our research we should simplify it by making several assumptions:

- we don't take into consideration restrictions regarding weight and dimensions limitations of the transported vehicles,
- we don't take in consideration timeframes for each load assuming they all are available in the same time.

Therefore, summarizing, we have several variables in our problem.

- capacity of the trailer,
- point of origin (pick up),
- point of destination (drop off or delivery point),
- the total number of transport tasks,
- transportation costs and
- transporter's income.

As a sample of the problem was developed a simple model based on polar coordinates. The advantage of this approach is the clarity and demonstrativeness of received solution. If during the optimizations the routes form a circle-like figure, it will mean that the algorithm of optimization is working correctly.

The points of origin can be classified in the following way: business, private and logistics hubs (for transshipping). Business locations are mostly wholesalers and retailers. This category itself also can be divided into two subcatgories: those ones operating within the primary market and within the secondary one. Dealerships also can be divided into two categories in a similar way to auctions: franchised new car wholesalers/retailers and used car (independent from any franchise) dealerships. The last category seldom deals with rare or vintage old vehicles.

The primary market retailers are new car dealerships. Among the second category, there can be mentioned used cars used car wholesalers, tuning workshops and different types of used car auctions as well. The largest used car auctions are Manheim (82 "traditional" sites in more than 40 states and a less, but growing amount of “light-version” auctions) [12] and Copart (more than 200 locations across the U. S. and internationally as well) [13]. Manheim’s specialization is mostly run-and-drive used cars without serious defects as usual. Coparts deals mostly with inoperable or defected cars (for instance, those passed through car accidents). Alongside them, on the market of used cars in U. S. can be named such major auction companies like ADESA and Insurance Auto Auction. ADESA provides services similar to Manheim, meanwhile IAA also deals with crushed and other kinds of faulty cars. Also there can be mentioned Barrett-Jackson, Mecum Auctions, Auto Auction Mall and Brasher’s Auto Auctions [14].

Private locations are customers selling their cars to other people and companies or shipping them to another area because of changing the residence or by other reasons. Logistic hubs are the seaports and warehouses, where the vehicle is reloaded from the trailer to another type of transport (usually, sea ships). The same categories can be defined also for destination points. So, based on the previously mentioned types of location, there can be segregated several types of typical routes.

- Private to private transportation. Seldom, the objects of such kind of transportation are old collection cars, some manually assembled models and other types of rare and precious vehicles [15].
- Moving. The customer at both ends of the route is the same person, changing their place of residence temporarily or permanently.
- Dealer to private / private to dealer. It may be either just purchasing vehicle from a remote car retailer for some reason or transportation based on insurance reparation or changing the vehicle in accordance with the contract between the customer and the car dealer. Other factors also occur in daily practice.
- Auction to dealer. There is quite a popular business model in the US, which is based on buying used or inoperable cars at auto auctions for repairing and renovating.
- Dealer to dealer. There are different business schemes for exchanging new and old vehicles between different wholesalers and retailers without invoking intermediate link in the logistics chain like auction [16]. Also, moving the vehicles between the subdivisions of the same company is also an often-occurring case.

The researched problem belongs to the distributive field of logistics, one of four main logistic fields alongside purchasing, product and reverse logistics. The general problem can be defined as elaborating an adequate network strategy for a praticular case of network distribution [17]. There are two different models in distributive logistics. They are called shuttle model and circuar model.

The essence of the shuttle model (in some sources the terms “pendular model” or “back-and-forth model” are also used) is the continuously repeated movement between the distribution center and the points of destination. Thus, each delivery represents a simple operation with a constant point of pick-up and changing points of delivery. So, each iteration in this model represents a two-way route between the point of pick-up (e.g. a warehouse) and the point of delivery.

This model is quite simple for planning and allows it to have a predictable schedule, but as a reverse side of its simplicity it has several disadvantages. First of all, it is more expensive approach, because a transport unit makes all the way back empty, so the number of “dead” miles turns to be equal to the distance between warehouse and customer. Also, this model is less recommended in cases where high flexibility is needed. Concerning the case, we are studying now this model isn't so relevant, because it supposes a stable warehouse or another logistical node we build the entire model around. Meanwhile, we deal with lots of points of origin of different types, so our case is closer to the circular model.

Circular model (also known as "ring model", sometimes "loop model") represents another approach. In this case the route consists of multiple delivery and pick-up points forming a loop, with the transport unit returning to the point of origin. after completing the circuit. The circular model has some obvious advantages. In the frameworks of this work the main one is ability to optimize the route, minimizing the idle one. So, the logistic specialist in this case might be free to replace some points in the route for shortening the total distance.

The circular model also has several disadvantages. It requires a higher level of planning. So, it's more complex. It may cause delays in all the chain of deliveries if there occurred any problems at any point in the loop. Therefore, it may be considered less suitable for deliveries with critical timeframes, because in general, obviously, the schedule of pick-ups and deliveries gets less predictable.

In the frameworks of the current work there will be put a focus on the circular model, because in this case there appears a space for optimization decisions by changing the order of points of pick-up and destination.

4. MATHEMATICAL MODEL

For creating a mathematical model of idle route problem, we must define the basic parameter of what we are planning to have. So, basically there will be several input data (the data we know), output data (the data we want to know) and algorythm.

Consider a transportation planning problem in which a set of transport tasks must be executed by a single vehicle. Each task represents a shipment that starts at one location and ends at another. The objective is to determine the order in which these tasks should be performed such that the total empty travel distance (idle routing) between consecutive tasks is minimized.

The vehicle must execute all tasks exactly once, and after completing one task it must travel empty from the delivery location of that task to the pickup location of the next task.

The problem can be represented as a directed graph where each node corresponds to a transport task and edges represent possible transitions between tasks. The cost of an edge corresponds to the distance the vehicle must travel empty between the completion of one task and the start of another. The cost in this case will be defined just as a function of distance.

Let $J = \{1,2,\dots,n\}$ denote the set of transportation tasks. For each task $j \in J$, the following data are given: o_j is the postal code (location) where task j begins (pickup location), d_j is the postal code (location) where task j ends (delivery location).

Let $\delta(a,b)$ denote the distance between postal codes a and b. Using this distance function, the idle routing distance between two tasks is defined as

$$\forall j,k \in J, j \neq k:\;\; c_{j,k} = \delta(d_j, o_k) \tag{1}$$

where c_{jk} represents the empty travel distance if task k is executed immediately after task j.

To represent the start of the route, an artificial node is introduced: node 0 represents the starting depot of the vehicle. As an additional parameter we can define $c_{0,j}$ describing the distance from the starting location to the pickup location of task j. From the technichal point of view there we must mention there can be several solutions for calculating the real geographical distance between two ZIP code points on the map. For small amounts of data the manual method can be used: calculating distance between each couple of points on Bing.Maps or OpenStreenMaps. For bigger datasets more complex methods should be used. There are several tools to calculate distances between coordinates along roads (not straight-line). The easiest option is using GIS software like QGIS with plugins such as ORS Tools or OSRM plugin, which can compute routes and distance matrices. For automation, APIs like open route service, OSRM, or Bing Maps Distance Matrix API are commonly used. These allow batch calculations and integration into logistics systems. In Python, libraries such as openrouteservice clients or graph-based tools (e.g., osmnx) can be used to work with road networks. Overall, QGIS is best for quick visual analysis, while APIs like OSRM or openrouteservice are better for large-scale or automated logistics tasks.

The decision variable of the optimization problem is a permutation variable:

$$p = (p_1, p_2, \dots, p_n), \tag{2}$$

where p_h denotes the index of the task executed in position p of the schedule.

The permutation property requires that each task appears exactly once:

$$\{p_1, p_2, \dots, p_n\} = J. \tag{3}$$

Therefore, p will be representing the most optimal order of transport operation with the minimum idle miles.

The goal is to minimize the total idle distance travelled between consecutive transport tasks:

$$C = c_{0,p_1} + \sum_{h=1}^{n-1} c_{p_h,p_{h+1}} \rightarrow min. \tag{4}$$

The first term represents the empty travel from the depot to the first task, while the summation represents the empty travel distances between consecutive tasks.

The only one constraint is that p is a permutation of set J. This ensures that every task is executed exactly once. One of the most important restrictions of this kind of mathematical model is assumption that the cost of transportation depends just on the distance between the given points. So, we neglect other parameters like physical constraints of the roads, relief specifics, maximal allowed speed, as well as different gasoline prices in different geographical areas etc. Also, as it was mentioned in the introduction, in the frameworks of this research the assumption that time frame for each order doesn't exist. Although building Vehicle Routing Problem with Time Windows model is also possible, it is a potential future research direction.

5. Numerical Results

The input data in the built model has the following components:

- The ZIP codes of the locations. On the territory of the U.S. it's always a 5-digit number, where the first digit represents a broad geographic region of the country (e. g. Northwest or Southeast).
- The table of graphs represents the distance between each two points.
- The tasks, each of them being composed of two points out of the table.
- The income (carrier's payment) for each of tasks.

- The transportation cost. The cost will be considered directly proportional to the distance in order not to overcomplicate the model.

The carrier's profit will be calculated as the difference between the income and the cost. The cost has two components: the cost of the loaded route and the cost of idle ones. Therefore, the pure profit will be calculated in two steps: firstly, the profit is calculated just for the loaded distance, after that the pure profit is calculated as the difference between the profit and the idle routes cost.

The cost will be calculated, as assumed earlier, purely proportional, following the formula: \$0.38/km [18] + \$0.2/km other expenses (wear of tyres, lubricant etc.), therefore consisting \$0.58/km.

Based on a database of real-world pickup and delivery locations, a sample of 20 points was selected for further analysis. These points were chosen according to the following criteria:

- All locations are situated within one of four states: Maryland, New York, New Jersey, or Pennsylvania.
- Most of them belong to major urban agglomerations along the East Coast, including New York, Philadelphia, Pittsburgh, Baltimore, and surrounding areas.
- As a result, the network graph formed by these locations is relatively dense, with several clusters in which multiple points are located at short distances from one another.
- No locations are included that are an order of magnitude farther away from the main geographical cluster.

These criteria make the model sufficiently homogeneous so that the optimal solution is not immediately apparent, while at the same time complex enough to realistically reflect real-world logistical conditions.

For a network of 20 points, where the connection A–B is considered identical to B–A (an undirected graph), the number of edges is calculated as:

$$\binom{n}{2} = \frac{n(n-1)}{2}. \tag{5}$$

The distances between the points were determined by mapping the corresponding ZIP codes in Bing Maps. Accordingly, each distance was measured as the optimal route along the road network, as calculated by the routing algorithm employed by the platform.

The distances were calculated in km, though usually it's calculated in miles on the territory of the U.S. Therefore, Fig. 3 shows the obtained table of distances we calculated using the Bing Maps measurement tool.

In the case of scenario 1 there are 6 given tasks. Neither origin nor destination points are not repeated twice. So, let it be established:

- Task 1: from the point #3 to the point #6
- Task 2: from the point #5 to the point #1
- Task 3: from the point #2 to the point #10
- Task 4: from the point #11 to the point #13
- Task 5: from the point #20 to the point #19
- Task 6: from the point #15 to the point #18

ZIP codes	costs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
NJ 07305	1	0	45	295	603	94	63	613	56	364	543	81	294	45	128	184	161	135	157	145	158
NJ 07060	2	45	0	289	596	116	90	606	79	357	510	108	275	16	107	152	96	114	136	124	556
PA 17870	3	295	289	0	388	345	333	398	308	115	299	345	217	282	265	156	229	249	275	271	295
NY 14219	4	603	596	388	0	653	641	21	614	287	379	653	590	590	612	506	566	596	633	629	335
NY 11747	5	94	116	345	653	0	46	663	47	414	615	25	366	117	199	274	233	207	229	217	627
NY 11559	6	63	90	333	641	46	0	651	37	402	608	21	330	82	164	239	198	172	194	182	617
NY 14207	7	613	606	398	21	663	651	0	625	309	404	664	601	601	623	516	577	607	644	640	306
NY 10469	8	56	79	308	614	47	37	625	0	377	578	48	329	80	163	238	196	170	192	180	590
PA 17751	9	364	357	115	287	414	402	309	377	0	260	414	330	351	345	245	299	329	366	362	257
PA 15672	10	543	510	299	379	615	608	404	578	260	0	627	360	532	459	392	451	443	469	466	52
NY 11710	11	81	108	345	653	25	21	664	48	414	627	0	348	99	182	257	215	189	211	199	626
MD 21224	12	294	275	217	590	366	330	601	329	330	360	348	0	252	186	156	192	185	152	162	398
NJ 08817	13	45	16	282	590	117	82	601	80	351	532	99	252	0	87	163	121	95	117	105	579
PA 19116	14	128	107	265	612	199	164	623	163	345	459	182	186	87	0	90	33	14	55	48	505
PA 19518	15	184	152	156	506	274	239	516	238	245	392	257	156	163	90	0	50	74	101	94	441
PA 19440	16	161	96	229	566	233	198	577	196	299	451	215	192	121	33	50	0	23	82	78	496
PA 19090	17	135	114	249	596	207	172	607	170	329	443	189	185	95	14	74	23	0	82	68	487
NJ 08066	18	157	136	275	633	229	194	644	192	366	469	211	152	117	55	101	82	82	0	12	494
NJ 08096	19	145	124	271	629	217	182	640	180	362	466	199	162	105	48	94	78	68	12	0	511
PA 15656	20	158	556	295	335	627	617	306	590	257	52	626	398	579	505	441	496	487	494	511	0

Figure 3. The table of distances among the chosen ZIP codes. (own elaboration)

Also, we will establish the carrier's payment for each of the tasks as follows: Task 1: \$400; task 2: \$200; task 3: \$450; task 4: \$850; task 5: \$400; task 6: \$250. If the orders are executed in the nominal order, the pure profit will be rather small: \$189.

After the optimization is done, the pure profit is \$1291. In fact, the maximization of profit is executed to quite an impressive degree just by changing the tasks 3 and 4. To check visually if the route is really optimized, we will visualize the route on a real map (see Fig. 4 and 5).

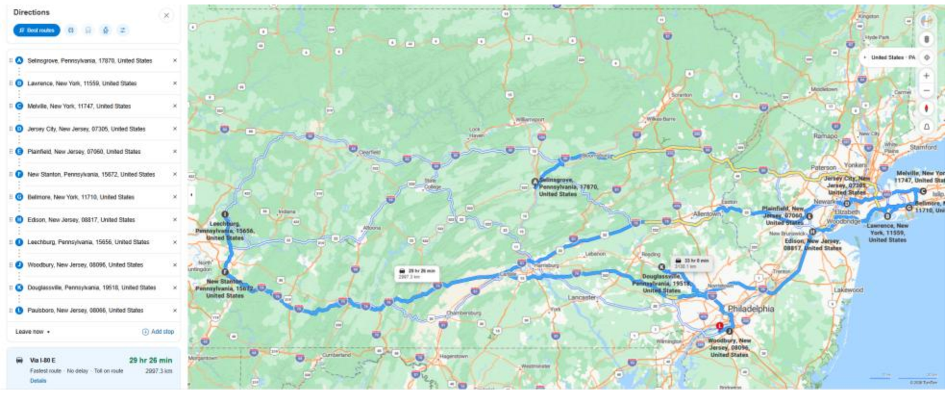

Figure 4. Unoptimized route of scenario 1 on Bing Maps. (own elaboration using Bing.Maps)

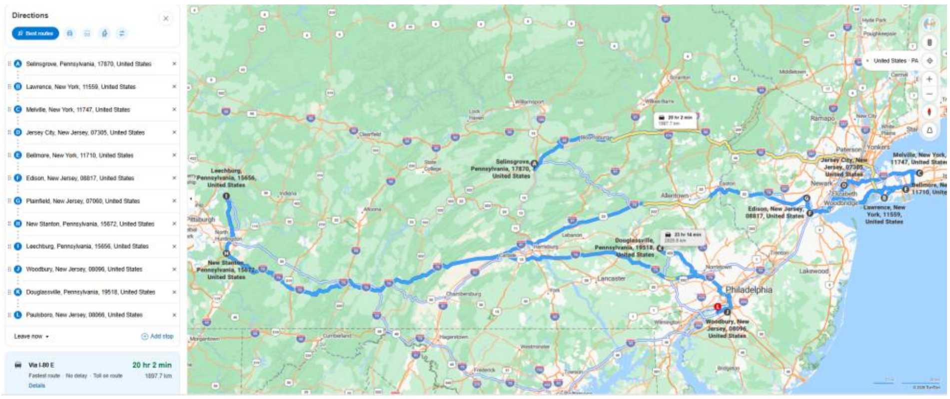

Figure 5. Optimized route of scenario 1 on Bing Maps. (own elaboration using Bing.Maps)

In addition, after checking the optimization on the online map, the overall route distance has been reduced from 2997 km to 1897 km.

In the second scenario we will introduce a new feature. There will be added so-called "round trips": the reverse routes with edged by the same points. Therefore, the task will look the following way:

- Task 1: from the point #3 to the point #6
- Task 2: from the point #6 to the point #3
- Task 3: from the point #2 to the point #10
- Task 4: from the point #11 to the point #15
- Task 5: from the point #16 to the point #19
- Task 6: from the point #19 to the point #16

Also, we will establish the carrier's payment for each of the tasks: Task 1: \$400; task 2: \$200; task 3: \$450; task 4: \$850; task 5: \$400; task 6: \$250.

In the unoptimized state the pure profit turns out to be even negative. Now, after we apply Excel.Solver, the situation will change the following way. In this case we will try another approach (minimizing the idle cost instead of maximizing the profit). According to our hypothesis, the efficiency of the solution must not change. As we see, the algorithm worked in the same way, allowing us to raise the pure profit from -\$194 to \$648. The proof of its correct accuracy can be easily seen on the map (see Fig. 6 and 7).

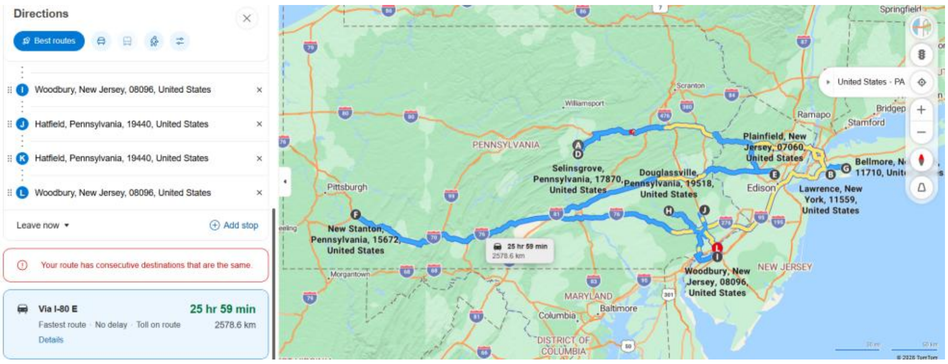

Figure 6. Unoptimized route of scenario 2 on Bing Maps. (own elaboration using Bing.Maps)

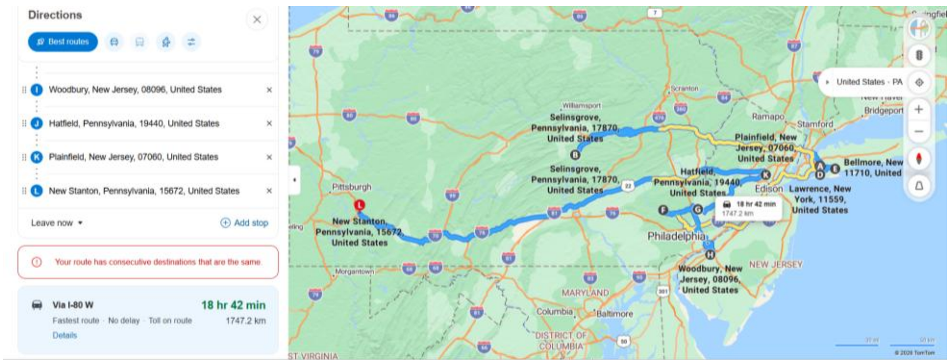

Figure 7. Optimized route of scenario 2 on Bing Maps. (own elaboration using Bing.Maps)

So, as we can see the added ‘round-trips’ didn’t confuse the algorithm, and the problem was optimized with overall route reduction from 2578 km to 1742 km.

6. Discussion and Conclusions

Based on the results of the research conducted, the following conclusions can be drawn:

- The Vehicle Routing Problem can be associated with the challenges of the American car-hauling industry.
- Evolutionary algorithms are successfully applied to route optimization tasks and to the reduction of idle roots.
- The application of optimization methods makes it possible to reduce the total route length by up to 33% and more.
- For fulfilling the aim of optimization can be chosen different strategies: either maximizing the carrier’s profit or minimizing the cost. In the given model the results won’t change.
- The efficiency of solving the problem of idle routes using the evolutional algorithms doesn’t depend on how many times one point occurs as the point of origin or destination.

Therefore, we can conclude that the aim of this research paper has been fulfilled. Although, there is a big field fort the further research work regarding this problem. For instance, the problem gets significantly more complex every time the capacity of the trailer increases. Meanwhile, the majority of car-hauling fleet in the U.S. consist of trailers for 2 and more vehicle, which makes this variation of the problem more actual.

Also, there can be introduced additional factors affecting the cost such as fuel price or fuel consumption varieties on different territories, which can make the model more practically appliable, but alongside with this, significantly more complex and harder to build.

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