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PSO, food delivery, TSP, Google maps

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FOOD DELIVERY BASED ON PSO ALGORITHM AND GOOGLE MAPS

Abstract

This article presents a solution to deal with the optimization of delivery routes problem for a mobile application focused on the restaurant sector, by using a bioinspired algorithm (PSO) to minimize delivery costs, maximize a greater number of deliveries and recommend an optional route for food delivery. Different computational experiments are carried out by using Google Maps (API) for showing the best delivery route. The results obtained are very promising for offering a good delivery service.

1. INTRODUCTION

Within the restaurant sector there are several problems and needs to be covered, but mainly there is a need for automating and managing the food distribution routes for different restaurants, which is why we are looking for a way to solve this need through technology and methodologies focused to find a solution through bioinspired algorithm. In particular, we use particle swarm optimization (PSO) that are basically focused on nature, since it is about emulating the native evolution of the species. This article presents the integration of a PSO algorithm to solve the problem of food distribution. A factor of customer loyalty is the delivery service, which contemplates the speed, that the product is not mistreated, and the temperature of the food, which are factors dependent on the efficiency with which the product is delivered prepared.

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The route planning problem is related to the problem of the traveling agent (TSP). To solve this problem, the geolocation of each person making an order to the different restaurants is taken into account. The distance from the restaurant is an important factor since a hot food order cannot take so long to be delivered.

Our approach was implemented as a module of the "Food Express" application, a mobile application focused on requesting food delivery and restaurant reservations, which was developed by Smartsoft America Business Applications S.A. of C.V. Food Express is available for Android and IOS operating systems.

The use of the application is quite simple, a user with the application on his smartphone enters the restaurant of his choice, enters the menu, selects his dish, adds a drink if desired or some type of dessert. After, the user accesses the cart and procced to the payment so that the restaurant receives the requested order. Subsequently, a delivery partner associated with the application receives a notification from the restaurant where the order to be delivered has to be collected. This way the dealer proceeds to deliver the food to the customer who requested the food from the application (Food Express, 2019).

Our proposal assumes that it is necessary to know the location of each user, since a static value is taken, that is, if the order is placed in motion the algorithm takes the longitude and latitude at the time the order is placed. These parameters are set from each user's mobile device. Once the longitude and latitude are obtained, they agree on the Google Maps through an application programming interface (API), to calculate the trajectory of the different points to apply the optimization algorithm, then generate the best trajectory with the conditions imposed by a particle algorithm.

The problem is important since at present, most of restaurants offer home delivery service for free, the vehicle in which they make deliveries is usually an motorcycle, which has a low fuel consumption, however, the implementation of this algorithm can further save gas costs and better manage delivery personnel, covering more orders for a single person. Google maps plays an important role for this project, since it is the one that facilitates the calculation of the coordinates of each user who requests an order and in turn returns an interface where the streets are located with addresses, local, to mention some google tools maps (Google Maps, 2019).

1.1. Problem

The application of technology in the restaurant sector has had an exponential growth with the use of different technologies that exist in the market. This article intends to add intelligence, efficiency, speed and reduction of gasoline costs for the delivery of orders to different consumers. That is why through a PSO algorithm in combination with the google maps interface, the following benefits can be offered for applications in the restaurant sector:

- To improve the performance of product deliveries,
- To propose a better recruitment of personnel for the distribution,
- To reduce delivery costs,
- To have better distribution control,
- To save delivering time.

2. STATE OF THE ART

The problem associated with the delivery of food focuses on the distribution of a point A to a point B, calculating a specific delivery time. Based on distance is how you can calculate the estimated delivery time. The necessary values for this calculation are latitude and longitude to an order to provide the user with an estimated delivery time and distance. The solution is to optimize and organize the routes of different food sites, in order to minimize delivery time, reducing the number of vehicles for deliveries (Bruno, 2019; Rodriguez & Piccoli, 2020; Singh, 2020).

Google maps (API) are generally used in web pages or mobile applications and for the use of GPS (Global Positioning System). A mobile application focused on the restaurant sector that uses Google maps tools and global positioning is known as "Without Apron" (Sin Delantal Mx, 2019) A Google interface with a map concept was used to select where the order is placed for distribution (Li, Lim & Tseng, 2019). The module was developed analytics, are some of its tools used for its development.

3. TSP

The problem of the traveling agent known for the abbreviation in English TSP (Traveling Salesman Problem), basically consists of a traveler who wants to visit *n* cites, all only one each city. Starting with any of them and returning to the same place you left. This problem can solve real-life situations that can be formulated differently. The problem of the traveling agent within the branches that helps solve problems within robotics, mechanics, automotive industry, logistics mainly focused on optimization problems (Rodríguez & Ruiz, 2012; Stockdale 2011; Archetti, Feillet, Mor & Speranza, 2020).

4. BACKGROUND

4.1. PSO

Within the bioinspired algorithm there is a very busy one for the route optimization known as PSO (Particle Swarm Optimization). This methodology arises when developed by Kennedy and Eberhart (1995), one of the hypotheses of each particle or agent that represents bees, ants or birds or some individual who is in a social group with a guided search, the particle the best solution you have found so far fulfills the correct role as leader.

The idea of the proposed algorithm is to obtain a particle solution that evolves in order to find a better solution in its path. Within the literature, the theoretical foundations of this method are the movement of each of the existing particles focused on a common objective which is conditioned by two factors: the fists are the nostalgia or autobiographical memory of the particle and the social influence from the group or the swarm (Fontana, 2004).

Each particle has an instantaneous position of the population in the N-dimensional space represented within the domain of the objective function that is proposed for a possible solution, *N* is the number of unknowns of the problem. In addition, the evolutionary process is diminished by moving each particle within the solution space with a speed that will be transformed according to its current speed, the particle memory and global information within the entire swarm.

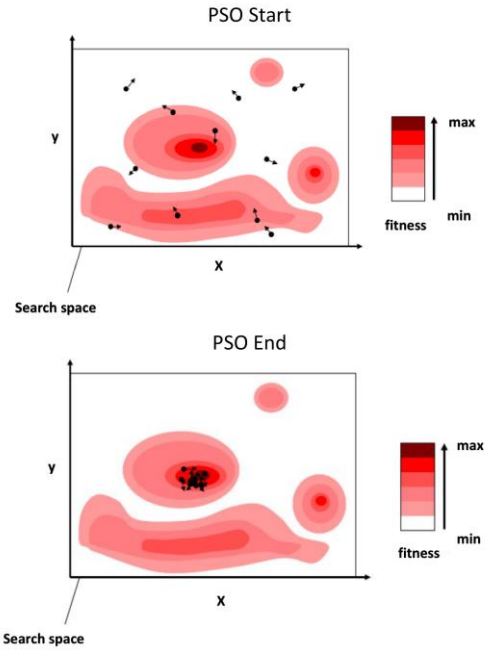

Fig. 1. Example of algorithm PSO start and end (Di Caro, 2012)

Within the search space, the particle is optimized using the fitness solution, which is the best solution space within the search space (Figure 1). At the beginning of the algorithm, the particles remain distributed in space, once the algorithm begins to run, the particles find and individual and group fitness solution to find a point where the solution is the most optimal for the particles.

The PSO consists of an iterative and stochastic process that operates on a cluster of particles. The position of each particles represents a potential solution to the problem that is begin solved. Regularly, a particle Φ_i is composed of three vectors each with two velocity values or well-known as fitness. The following values make up fitness:

- The vector $X_i = \{X_i1, X_i2,\ldots, X_in\}$ stores the current position of the particle in space. The size of this vector depends on the number of variables needed to solve the problem.
- The vector $\Phi\ Best_i = \{\Phi_i1, \Phi_i2,\ldots ,\Phi_in\}$ in stores the position of the best solution found by the particle so far.
- The velocity vector $V_i = \{V_i1, V_i2, \ldots, V_in\}$ stores the direction according to which the particle will move.
- The *fitness* X_i fitness value stores the agreement value of the current solution (vector X_i).
- The fitness *fitness* value $\Phi\ Best_i$ stores the agreement value of the best local solution found so far (vector $Best_i$).

5. EXPERIMENTS

A software was implemented for the optimization of food delivery routes for the restaurant sector, applying the PSO bioinspired algorithm which will benefit food deliveries optimizing time, gasoline costs and better delivery management, in addition, giving solution to the problem of the traveling agent which merges with the incorporation of Google maps tools, to have a pleasant visual interface for the end user.

The algorithm has the task of being better than the calculation of matrices of Google maps, working more efficiently and intelligently (Zhou et al., 2019).

The first activity is to carry out a conceptual design to be able to interpret the needs of the restaurant sector, to understand in an illustrated way the operation of the algorithm, as well as to solve the problem of the traveling agent, giving efficiency to the delivery. Then the geolocation of the client is needed to obtain its latitude and longitude, where food delivery will be made, that information reaches the application in which the orders for food delivery are generated.

Once the location is obtained, the web service is activated, where you will obtain the request of the different delivery points, obtaining the geolocation parameters of the users activates the PSO algorithm, where you find the best

delivery route for the restaurant. The restaurant obtains a recommendation of the algorithm within the Google maps interface, so that it visualizes its possible distribution trajectory. Figure 2 shows the possible solution through the PSO algorithm, using Google maps tools and operation of requests and interactions with all users.

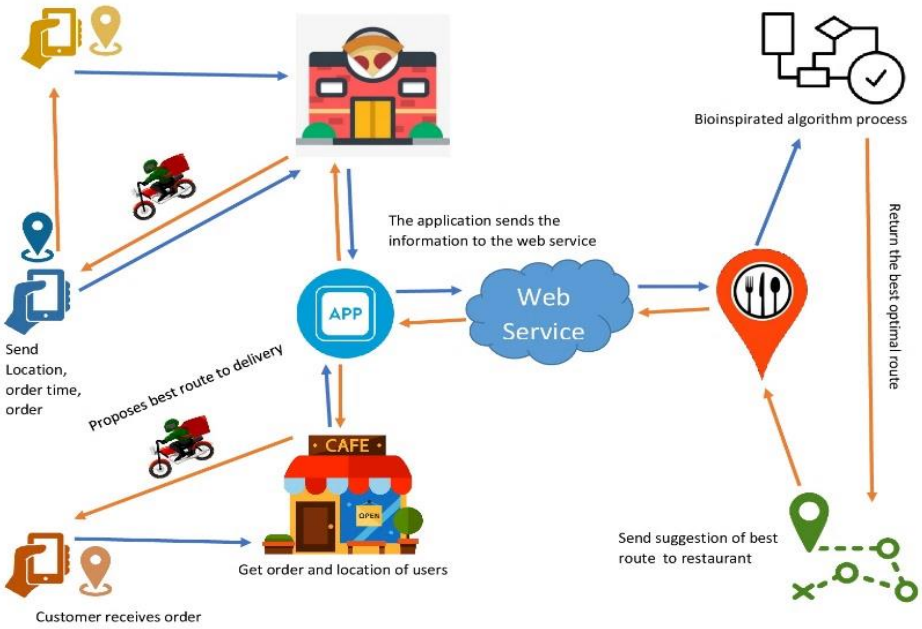

Fig. 2. Conceptual design of problem solving based on food deliveries

Once the conceptual design was established, the next step was to develop the interface where the global map of Google maps (API) is displayed, showing the location of the different delivery points. Executing the PSO algorithm with the delivery points yields a delivery recommendation, calculating the delivery time, algorithm iterations and delivery points. Some parameters for the algorithm have been established such as the size of the particles, the position of the particles, speed, the fitness particles to be able to execute the algorithm correctly (Chen, 2019; Paciarotti, Bevilacqua, Ciarapica, Mazzuto & Postacchini, 2019). Once the parameters are taken, the map is plotted on the map with the route proposed by the algorithm and the API.

The web service provides the opportunity to have better operability of data in a short amount of time, which provides the best execution of the algorithm. The PSO has the advantage of working with few elements, in this way the execution of the web service gives us the necessary speed to obtain data and the operations process. Using a protocol type SOPA (Simple Object Access Protocol). To give an example

of some data that the web service works in combination with the algorithm, the result of an order 3 deliveries by the same distributor is presented, with different orders located in Paris near the triumphal arch.

Where it contains data that serve to understand the order. The set of data that you save by distribution order, some of the data are: order number, delivery person, place of collection, customer, supplier, place of delivery, delivery time and cost of the order. With which the latitude and longitude can be obtained from the address with Google API methods (Figure 3). The web service returns an object or type Json with the values of the attributes already mentioned, as part of an array where the problem is already optimized.

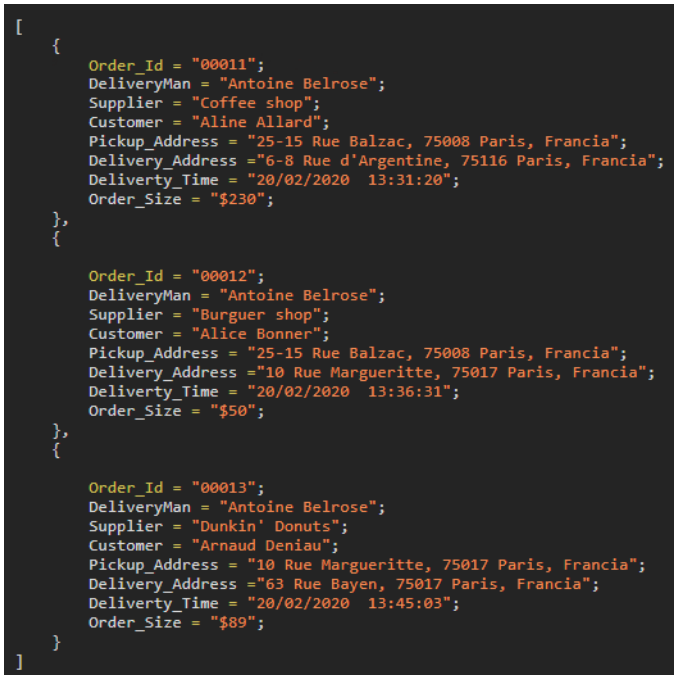

Fig. 3. Web service results.

Showing some small results that are delivery points, algorithm iterations, estimated travel time, delivery order based on orders to be delivery, total travel in kilometers and a proposed route for food delivery. Initially with him experiment a delivery with 5 delivery points was analyzed, using an iteration of 50 to find the best optimized path. The algorithm handles a particle speed that in this case is 0.1, with a solution space of 50. By applying the algorithm on the map, it generates a delivery recommendation to the dealer (Figure 4).

A test was carried out in the city of Paris, near the Eiffel tower within the fifteenth district in order to show the functionality of the algorithm in another city that is not Mexico.

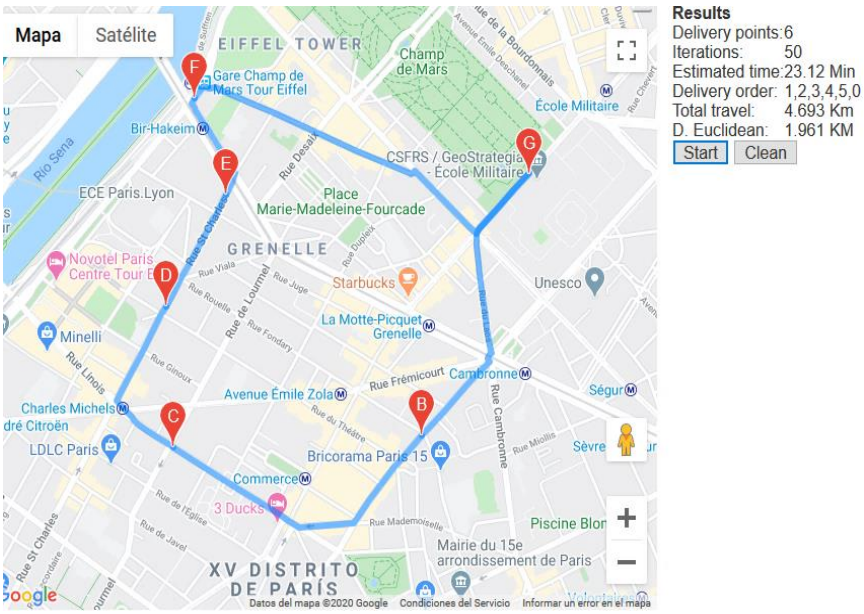

Fig. 4. Execution of the route optimizer with PSO algorithm (5 delivery points in Paris)

Six delivery points are shown because one is from the starting point, where the restaurant is located, that is why there has to be a return to the starting point. The path is drawn by Google library, the marks within the map are used by same library.

The following test was performed with 7 delivery points, 50 iterations in the search space to find the best optimal route. Based on the algorithm, you need a particle velocity that used a velocity of 0.1 for this test. One of the requirements to cover for this problem was to know the total distance of the route, this measurement is calculated using the API matrix, calculates the route on streets or the route of the distribution between the streets (Figure 5).

This test was carried out in the same way in Paris near the triumphal arch. A good delivery time was observed for the distribution points, since it did not exceed 30 minutes of distribution.

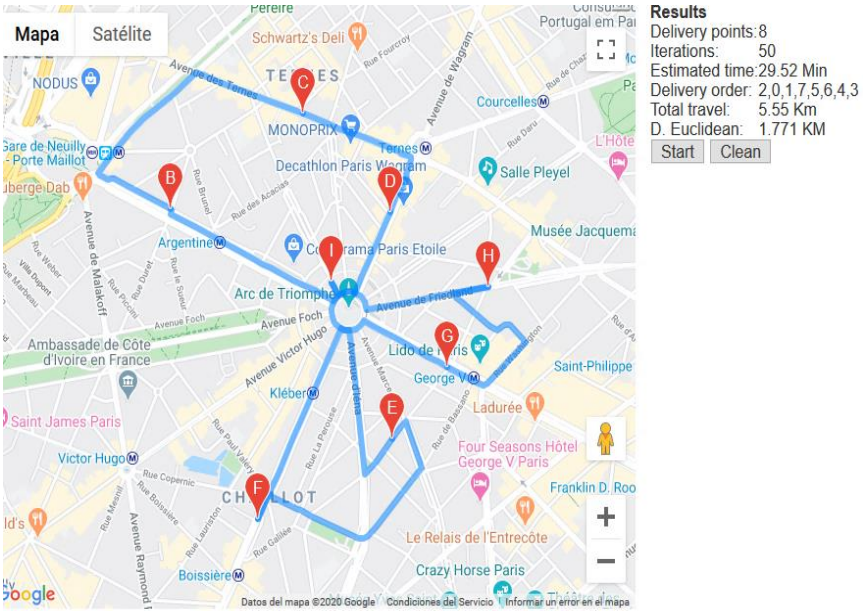

Fig. 5. Execution of the route optimizer with PSO algorithm (7 delivery points in Paris)

Next, the test is presented with a delivery of 9 orders, with 50 iterations at a speed of 0.1, since it is recommended in the literature. This test shows a greater number of deliveries, which is reflected in the estimated delivery time (Figure 6), so this number of orders is recommended as long as the orders are near the restaurant. Contemplating that they are meals that are served at a hot temperature, otherwise the different orders can be delivered in s slightly larger range than to the restaurant area.

A test presented with 9 delivery points shows that the delivery time can take more than 35 minutes, which up to this point the algorithm begins to have limitations for hot food deliveries. Even delivery points are feasible for cold dishes. This test was conducted in the capital of Poland, Warsaw. In order to demonstrate the functionality of the PSO algorithm, to visualize the effectiveness of the application.

To test the effectiveness of the PSO algorithm, an example was used with 15 delivery points within a radius of no more than 10 kilometers where the restaurant is located. In this case 10 kilometers of radius are not exceeded, remember that 16 points are displayed on the map (Figure 7) since one of them is the restaurant, where you have to leave and return. Once having the results, the delivery time that exceeds 47 minutes of delivery was analyzed, with a journey of 27 km, in this way you have an approximate of how much fuel the distributor will spend, in this way they are better managed expenses and reducing costs.

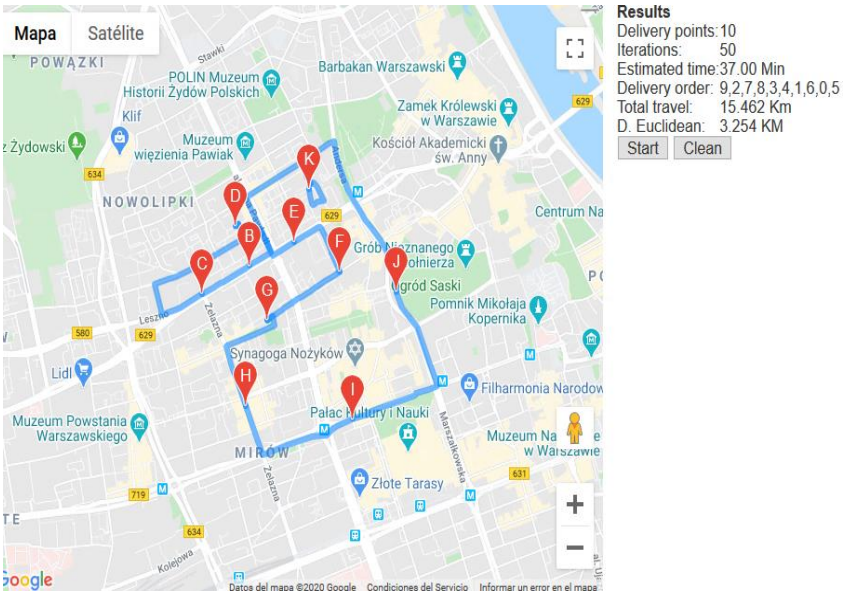

Fig. 6. Execution of the route optimizer with PSO algorithm (9 delivery points in Warsaw)

For this test location of Cracow was used, in order to understand the behavior of the algorithm with 15 delivery points. The more delivery points the dealer has, the road begins to be longer and with more total travel time, at this point the algorithm begins to increase exponentially over time.

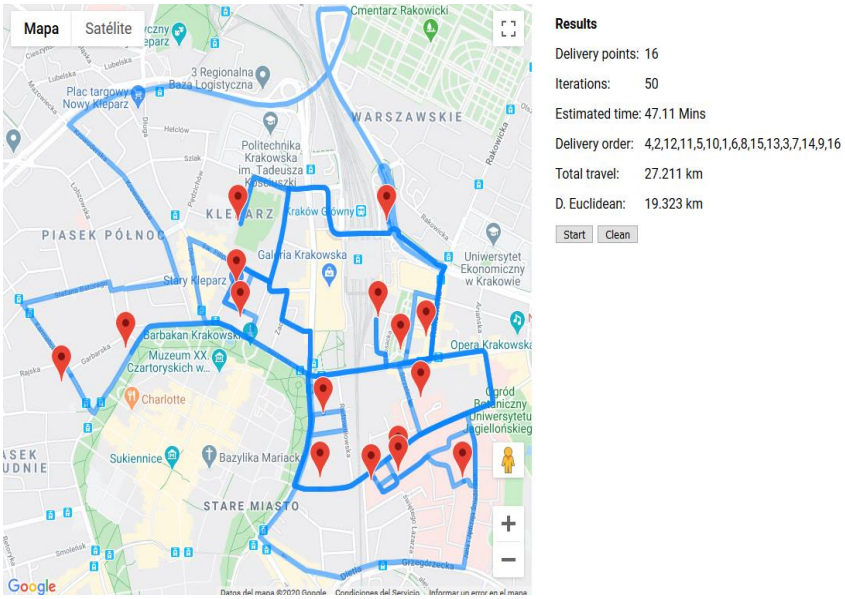

Fig. 7. Execution of the route optimizer with PSO algorithm (15 delivery points in Cracow)

Finally, an experiment was carried out with a number of 30 deliveries, at this point the deliveries already meet a long time, for the number of deliveries by a single deliveryman, in this case being an optimization for food service is too much delivery time. This number of deliveries for food is not recommended, it can be functional for another sector such as courier, logistics, to name a few. In this test the parameters of 50 iterations were taken with a speed similar to the previous tests of 0.1, with a search space of 30 particles.

The test was carried out in order to demonstrate a delivery time, to know an approximate route for the deliveryman. A possible delivery is presented on the map (Figure 8), but this may vary depending on unexpected streets of blockages.

Mokotow was the place where this test took place, it is the city with the greatest number of inhabitants of the city of Warsaw. Performing a test where 30 deliveries are made in less than an hour. Walking a total of 34 km, which would have to be done by a single distributed. Until this the algorithm fulfills its function of optimizing, however, the estimated delivery time is no longer feasible. Therefore, this number of deliveries is no longer efficient.

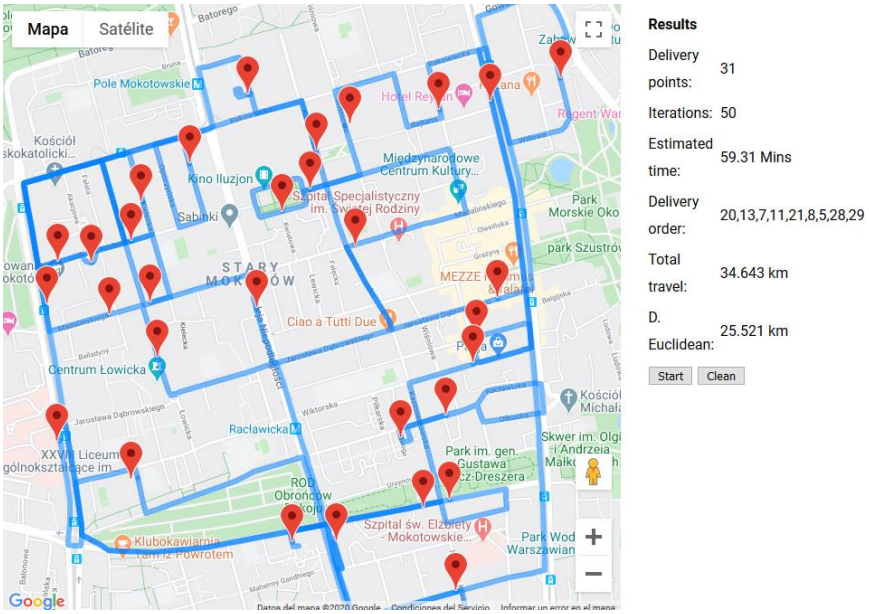

Fig. 8. Execution of the route optimizer with PSO algorithm (30 delivery points in Mokotow)

In addition, it should be mentioned that the execution time can vary if certain values that make the process more robust are modified, for example, if the particle size is change to a larger amount it may take a little longer since this algorithm is usually exponential.

6. CONCLUSION

This article proposes the development of a module for a mobile application in order to optimize food delivery routes to the restaurant sector through a particle swarm optimization algorithm, using the Google maps API. In order to propose restaurants a route where they can make different deliveries of orders in a single trip by delivery. Within the results obtained, the good functionality of the module can be concluded, the efficiency, speed of the algorithm can be affected in the device in which the PSO is executed.

Similarly, the benefit of this implementation seeks the adaptability of the different restaurants that offer home delivery service. The PSO algorithm can be exploited and overcome with implementations that seek an improvement of the algorithm through combinations of other methods such as fuzzy logic type I. Future work is the implementation of fuzzy logic and the PSO algorithm applying a natural language, giving each restaurant variables of how feasible the delivery to certain addresses and which is not as feasible depending on the distance and delivery points.

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