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Article

Genetic Algorithms Applied to Tourist Route Discovery

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Abstract: This work presents the application of a Genetic Algorithm (GA) to assist in planning tourist routes among cities in the Serra Sul Catarinense region, located in the state of Santa Catarina, Brazil. The region stands out for its altitude, climate, and natural beauty, offering strong potential for tourism development. The proposed solution is based on real distances between cities, obtained through Google Maps. Tests were carried out in scenarios ranging from 4 to 18 cities, and the results showed that the GA was able to reduce the total travel distance by up to 38% compared to the initial route. The use of this technique makes it possible to visit several points of interest in a more efficient way, facilitating tourist exploration of the region.

Keywords: Genetic Algorithm; Travel Salesman Problem; Trip Planning Application.

1. Introduction

Tourist experiences reveal increasing diversification, both in tourist interests and in movements on the supply side. Tourism is an important economic activity capable of generating income, employment, and moving a region's economy [1]. Ref. [1], in Serra Catarinense in Brazil the tourist experience concerns the rural environment endowed with primary attractions in the form of important and well-publicized landscapes and climatic resources. In addition, the cold is usually sought - usually in anticipation of snow - and also linked to sociocultural aspects and regional history.

In addition to the beaches, in Santa Catarina state, in Brazil, the mountains are also highlighted, such as the Serra Sul Catarinense, famous for adventure tourism, ecotourism, viewpoints, and climate. Rural tourism is one of the great attractions there; its landscapes with the customs of the countryside and the snow that falls in some cities mean that every year the region receives thousands of visitors in winter [2]. Most cities are at an altitude of over 1,000 meters, which means that, during the winter, frost and snow cover the landscapes with white [3]. Thus, access to these locations can be an impacting factor on the route taken, due to the displacement through altitude.

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Known as Planalto Serrano, there are 18 municipalities that make up the region and occupy an area of more than 16 thousand km², equivalent to 17% of the territory of Santa Catarina that form the Serra Sul Catarinense [2]. Despite being a region with great tourist potential, this same potential may not be being well used. Therefore, a tool capable of helping the tourist to visit places of interest within the shortest possible distance can be a facilitating instrument in the tourist exploration of the region.

Therefore, the objective of this work is to develop a Genetic Algorithm to find a route, based on the shortest distance, between a set of tourist cities (TCs) in the Serra Catarinense. For this, this work carried out the implementation of a GA in order to verify its feasibility in relation to providing a shorter route compared to the initial proposed route, without any optimization. Several works using genetic algorithms are found in the literature for various applications [4], [5], [6], and they are efficiently applied to route optimization problems [5], [7], [8]. The data used in the algorithm tests represent tourist cities in the macro-region present in the Serra Sul Catarinense.

2. Related work

This chapter aims to describe the related works to the theme of this project, focusing on the applicability to the desired results and each contribution of the works referenced throughout the project will be identified.

Ref. [5] the authors perform a comparison between two algorithms to solve the Traveling Salesman Problem (TSP), the first being Ant Colony Optimization (ACO) and the second a Genetic Algorithm (GA). In the proposed work, both techniques are applied using the same dataset and compared to determine the best one. Given the results, for the GA, it is necessary to select the best value for the configuration parameters such as population, crossover, and mutation. But, even so, through the experiments, the GA behaved better than the ACO for the proposed Traveling Salesman Problem (TSP).

Ref. [8] proposes a recommendation system for popular places, through an optimized travel sequence from selected locations using two popular metaheuristic techniques: ACO and GA. Based on the results and conclusions, the authors claim that both algorithms are suitable for reaching a solution. However, experiments suggest GA be a little better for the proposed system scenario. The GA provided considerably good results, being faster and offering shorter distance traveled.

Ref. [9] two algorithms were implemented for an automatic generation of tourist routes project. The developed algorithms are an adaptation of the A* algorithm with cuts, while the other one is based on the ACO. For the first implementation, two different heuristics were also tried. The first consists of selecting the path with the highest sum of scores for each point of interest. The second uses an approach similar to Simulated Annealing for the selection of each point of interest to solve the route. The results obtained from the experiments allowed to conclude that the A* algorithm with cuts, oriented to the heuristic of selecting the path

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with the highest score, presents favorable results for the defined metrics. This work is based on the development of a genetic algorithm to evaluate the impact of a travel planning application on a specific region in Serra Sul Catarinense.

3. Overview

3.1. Traveling Salesman Problem

The Traveling Salesman Problem (TSP) is one of the most prominent among a wide set of combinatorial optimization problems. The TSP study has attracted researchers from different fields and this is because, despite its simplicity, it is possible to find most of the issues that involve combinatorial optimization. Thus, it can be used as a tool for evaluating new algorithms and solution strategies involving different types of algorithms [10].

The objective of TSP is to define the shortest route between n cities. Thus, the salesman must pass through all cities only once, except where the journey begins and ends. Thus, the problem is defined as a set of cities (c1, c2, c3, ..., cN), and for each pair of distinct cities (ci; cj), a distance d(ci; cj). In order to determine the shortest route, passing through all cities and returning to the end of the trajectory, being the initial city [11].

The TSP belongs to the category known as NP-hard, which means that it has exponential complexity order. That is, the computational effort for its resolution grows exponentially according to the size of the proposed problem. Due to this, mainly in relation to the resolution time, the strategy for the TSP can be through heuristics that help to find a good solution for a problem [12]. On the other hand, the solution methods applied to real instances are, in general, heuristic, that is, they do not guarantee the obtaining of the optimal solution from the mathematical point of view [13].

3.2. Genetic Algorithm

Genetic Algorithms (GA) are very efficient in finding solutions. Thus, [14] managed to incorporate characteristics of natural evolution in an algorithm, making it possible to use it in artificial systems projects. GAs use methods related to natural selection and genetic recombination. The algorithm works by choosing solutions among those existing in an initial population of chromosomes and applying genetic operations, to create a new population. Each new population is inserted into a new generation. During the evolution process, the algorithm evaluates the new solution and each chromosome receives a fitness value, which represents the quality of the solution. Generally, chromosomes with higher scores are considered fit, while those with lower scores are discarded [15].

Fit chromosomes can undergo genetic changes in their characteristics through operations such as Mutation and Crossover. The determination of the number of generations varies according to the complexity of the problem and must be defined experimentally. Furthermore, the definition of a small population can cause a risk of not obtaining coverage

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in the search space [11]. On the other hand, a large population may require a greater computational effort to solve the problem to be solved. In the literature, the values found for the crossover probability are in the range of 60% to 65%. However, good results are usually achieved with a high crossover rate value (greater than 70%). As for the mutation probability, the values are in the range of 0.01% to 0.5% [15].

4. Proposed approach

4.1. Pre-Processing

For the development of this project, the selected tourist cities were defined using indications from the indicator booklet of the Macro region of Serra Catarinense of Sebrae/SC [2] and the work in [1]. In total, 18 cities were selected and organized on a map using Google My Maps [16], which are defined through markers in Fig. 1.

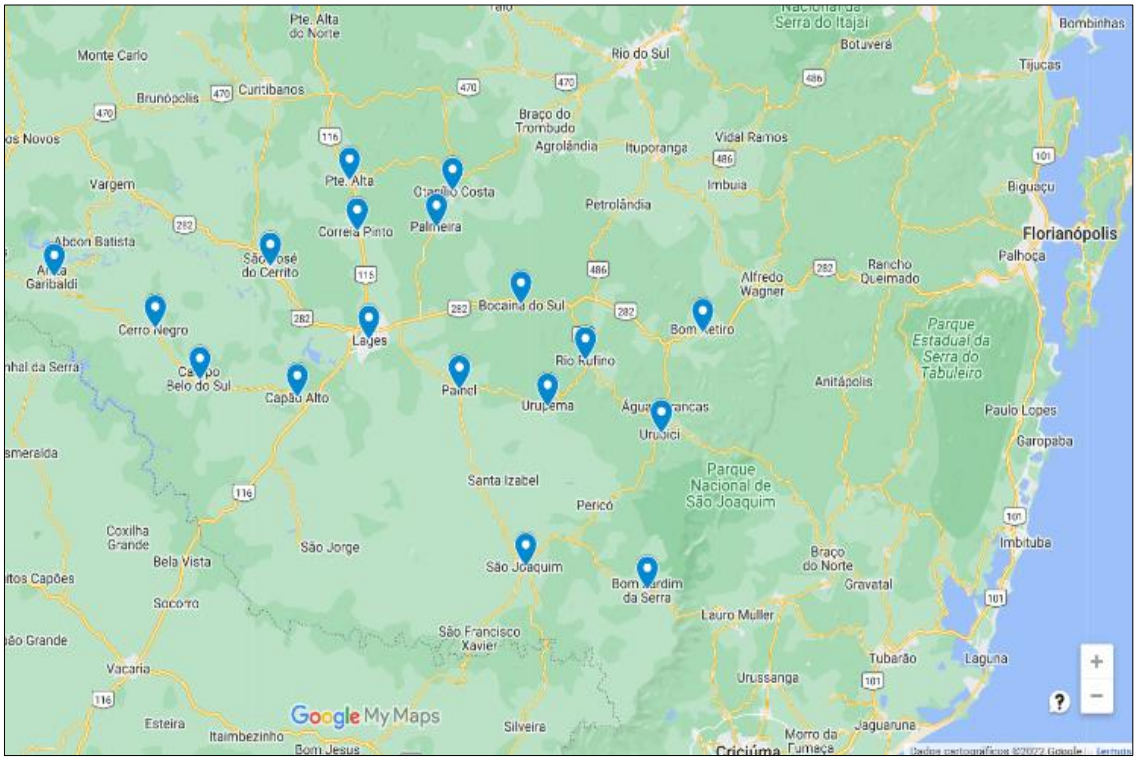


Figure 1. Selected tourist cities in the Serra Catarinense.

After the definition of tourist cities in Serra Catarinense, the mapping step was carried out, which consisted of a survey of the geographic coordinates (latitude and longitude) of the 18 selected cities. This mapping took place through a tool that converts postal addresses, cities, and specific points into geographic coordinates, known as Google Maps Geocoding API [17]. To facilitate the use of data by the GA, the coordinates were stored in the MySQL Database Management System, on the computer on which the experiments were performed.

The GA was implemented using the Java language. To help the execution of the algorithm, a distance matrix was created with a set of distances between cities, using the

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Google Maps Distance Matrix API [18]. Thus, for the application of this work, the distances between tourist cities are the distances calculated by Google Maps. Finally, the experiments were performed using a notebook model Dell(R) Inspiron (TM) 5490 equipped with an Intel(R) Core (TM) i5-10210U CPU @ 1.60GHz 2.11 GHz, 8GB DDR4 2666MHz RAM and 256GB of SSD storage.

4.2. Experiments and Evaluation

Genetic Algorithms (GA) are self-learning algorithms that use methods related to natural selection and genetic recombination. In this way, it studies the previous results to improve the performance of the algorithm, based on defined criteria. The algorithm works by choosing solutions among existing individuals in the initial population of chromosomes and then, applying genetic operations, creating a new population each generation. In this sense, an individual is defined by a real chromosome represented by a set of genes, which represent each possible solution and control the behavior of the Algorithm.

To carry out the experiments, the TCs were randomly defined. It was randomly organized independently, with different amounts of TCs. The smallest graph contained 4 points and the largest 18, these values being defined arbitrarily. Thus, understanding all TCs. And this way, the basic representation of the methodology used in this work can be describe.

In this way, for creating the initial routes as well as calculating the distances of these routes, each graph became a randomly ordered list. The generated list is equivalent to a proposed script, which is an individual used for execution in the GA, which starts from the first item, runs through the list, and ends at the point of origin, thus forming a cycle proposed in the TSP. Each list produced by the graph represents an individual from the problem population, which is then submitted to the algorithm. In practice, the GA defines the first city to be the same for all individuals for each run, thus resulting in the same starting point of the trip from start to finish of the run. In the end, the GA results in a list containing, therefore, the optimized route taking into account the TCs initially chosen, the final distance, and the time spent in the execution.

The fitness function was defined as the total distance of the route from a generated individual. Therefore, the shortest distance represents the best path. With elitism being used, the highest fitness value is passed on to the next generation. To validate the results of each experiment, the GA was run 50 times. The defined parameter to population size was 20, crossover rate defined as 70%, mutation rate was 0,1%, number of generations was 100, and elitism was used.

5. Experimental Results and Discussion

During this section, the results found and the discussions on the application of the algorithm to the proposed problem are presented. Thus, the objective of this work is to use GA to find a route, based on the shortest distance. Thus, at the end of the algorithm execution,

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a route is found. The generated path of a possible generated route was inserted in Google Maps, as a form of representation and is shown in Fig. 2.

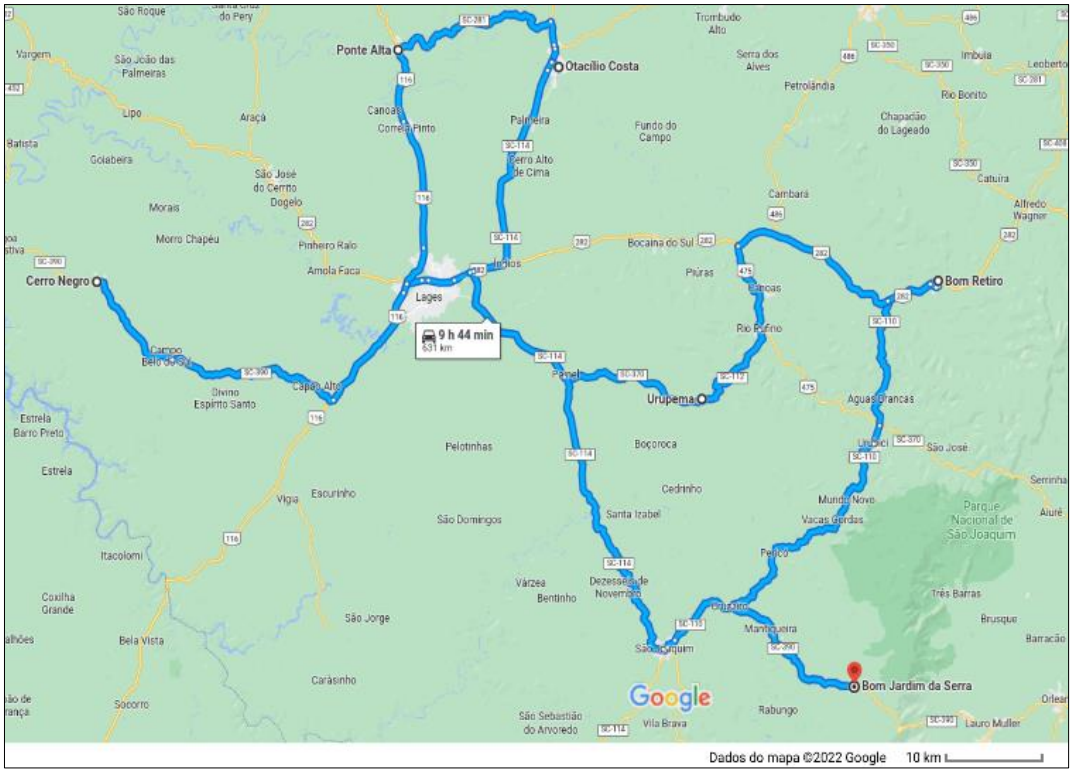


Figure 2. Generated route representation marked on Google Maps.

After the 50 iterations of the GA for each TC, it was possible to find the execution time in the search for the best script. The execution time refers to the time spent by the algorithm in finding a solution, that is, reaching the end of the execution, and finding the best individual or not. Fig. 3 presents the GA execution times in relation to the experiments, containing from 4 to 18 TCs. Therefore, based on the data, it can be seen that up to 10 TCs the GA generates results in less than 0.5s. For 14 and 16 TCs, the GA presented similar results, not exceeding the 0.7s mark. Furthermore, in all amounts of TCs, the algorithm presented results below 1.0s. It is noteworthy that the low execution time is an important factor in the application of optimized tourist itineraries.

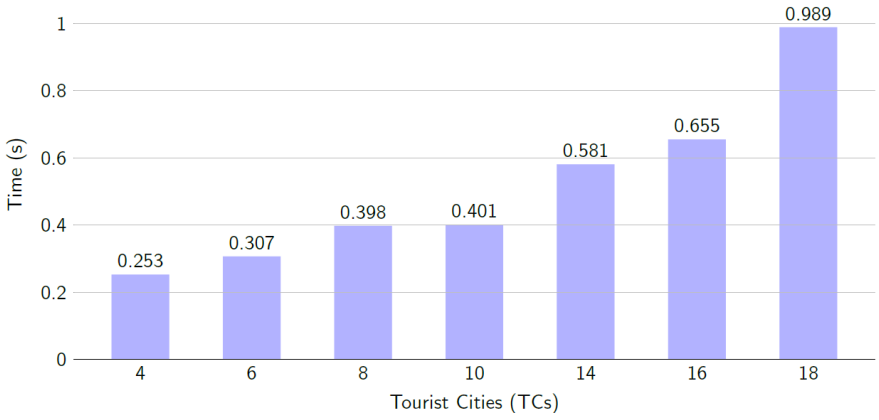


Figure 3. Execution time for each CT category.

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In addition to this result, it was possible to create a comparison between the initial distance and the average distance of the routes returned by the algorithm. In front of Fig. 4, it is shown that all GA run tests were efficient to optimize the initial distance, regardless of the place of origin. The smallest initial route reduction occurred with the amount of 4 TCs, resulting in a distance from 510 km to 403.34 km, with a difference of 106.66 km, which represents 20.91% less.

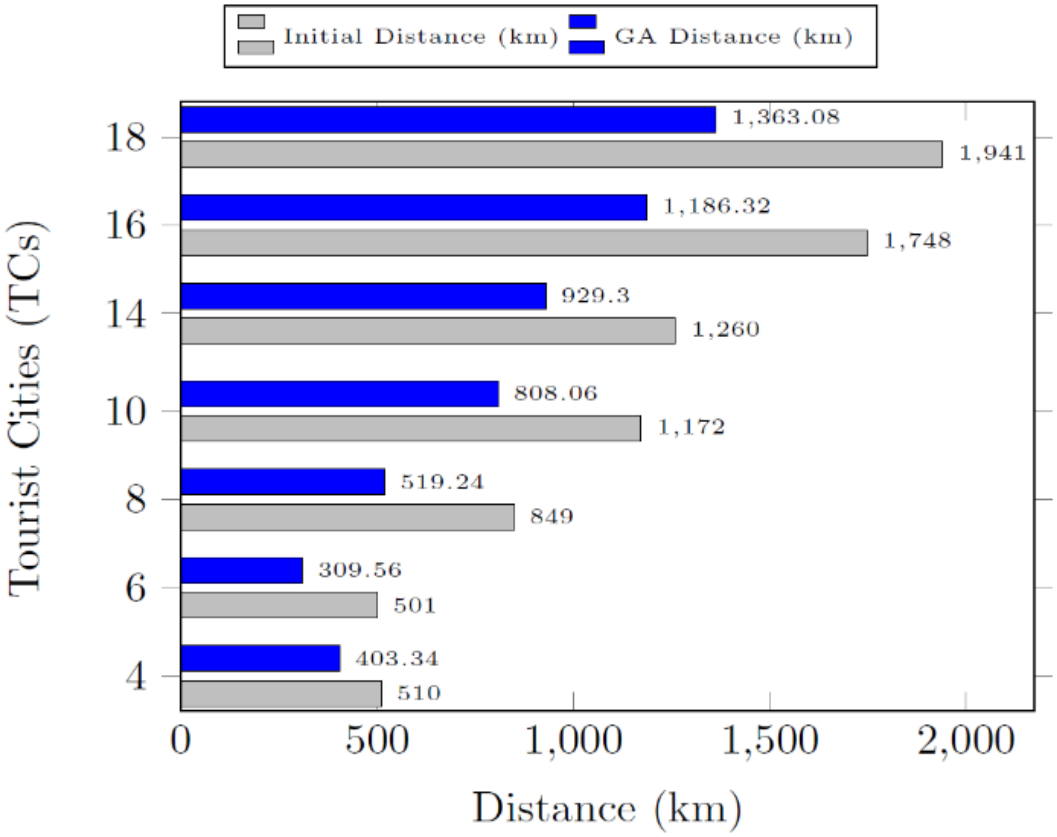


Figure 4. Comparison between the initial and final distances.

Considering the biggest reduction, the routes generated for 6 and 8 TCs were optimized in a very approximate way, 38.21% and 38.84%, respectively. For 6 TCs, the distance variation was from 501 km to 309.56 km, which represents a difference of 191.44 km. And for 8 TCs, the difference in distance was 329.76 km, ranging from 849 km to 519.24 km.

The average reduction of routes by the GA was around 31.02%, as can be seen in Fig. 5. It is also important to highlight that, for 16 and 18 TCs, the results showed a considerable difference in relation to distance, ranging from 561.68 km and 577.92 km, respectively.

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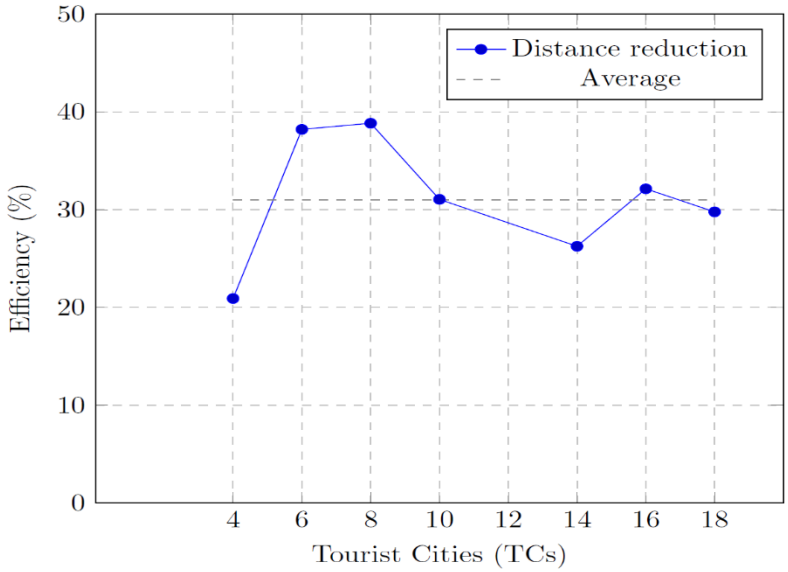


Figure 5. Comparison of AG efficiency for each CT category.

Still, in Fig. 5, it can be seen that the efficiency in generating routes was below average for 4, 14, and 18 TCs. On the other hand, mean reduction and distance difference implies that it was efficient in optimizing the initial routes, representing a representation of distance. This reduction offers benefits to tourists, such as saving time and money.

6. Conclusions

This work presented the application of a genetic algorithm in the solution of the traveling salesman problem in order to verify if it is able to develop an optimal route between a set of tourist cities in the Serra Sul Catarinense. For modeling the problem, existing tourist cities were used, considering the real distances between them raised from Google Maps.

Therefore, through the results found, it can be seen that the algorithm obtained very satisfactory results in relation to the objectives of this work. The developed GA was able to reduce the proposed initial script by up to 38.84%, with an execution time of 50 iterations, below 1.0s. In this way, the possibility of using the GA to calculate routes between tourist cities in the Serra Sul Catarinense region is proved. Increasing the number of tourist cities, considering other regions of Santa Catarina or the country, makes the expansion of this work relevant.

In addition, it makes possible the implementation of other algorithms and the performance of comparison to verify the effectiveness of both strategies. Thus, with the use of this algorithm and other tools, an application for recommending tourist itineraries can be developed.

Conflicts of Interest: "The authors declare no conflict of interest."

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References

[1] H. N. Lins, "Estilização do turismo: ensaio com foco na serra catarinense," in *Anais do II Encontro de Economia Catarinense*,

[2] S. C. SEBRAE, "Santa Catarina em números," *Florianópolis: Sebrae SC*, 2013.

[3] A. L. F. Perez, E. T. Fogaça, and E. Pozzebon, "Uma ferramenta de auxílio ao turismo da Serra Catarinense," 2003.

[4] L. Brisolara, M. Lorenzatto Braga, A. Braga, and P. Roberto Ferreira, "Parameter Tuning in Load Balancing Techniques for Wireless Sensor Networks through Genetic Algorithms," in *2019 8th Brazilian Conference on Intelligent Systems (BRACIS)*, Salvador, Brazil: IEEE, Oct. 2019, pp. 42–47. doi: 10.1109/bracis.2019.00017.

[5] M. Alhanjouri and B. Alfarra, "Ant colony versus genetic algorithm based on travelling salesman problem," *International Journal of Computer Technology and Applications*, vol. 2, no. 3, pp. 570–578, 2011.

[6] M. Dorigo and L. M. Gambardella, "Ant colony system: a cooperative learning approach to the traveling salesman problem," *IEEE Transactions on evolutionary computation*, vol. 1, no. 1, pp. 53–66, 1997.

[7] A. Aydin and S. Telceken, "Comparison of three search algorithms for mobile trip planner for Eskisehir city," in *2015 International Symposium on Innovations in Intelligent SysTems and Applications (INISTA)*, Madrid: IEEE, Sep. 2015, pp. 1–5. doi: 10.1109/inista.2015.7276791.

[8] S. Adhau, S. Shinde, T. Monghal, and V. Hole, "Globetrotter: An optimal travel sequence generator," in *2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA)*, IEEE, 2018, pp. 852–857.

[9] R. E. C. Pinto, "Algoritmos para geração de rotas com base na análise de contexto," Instituto Politecnico do Porto (Portugal), 2019.

[10] G. Reinelt, *The traveling salesman: computational solutions for TSP applications*, vol. 840. Springer, 2003.

[11] W. J. Cook, D. L. Applegate, R. E. Bixby, and V. Chvátal, *The traveling salesman problem: a computational study*. Princeton university press, 2011.

[12] T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to algorithms*. MIT press, 2022.

[13] C. R. Reeves, *Modern heuristic techniques for combinatorial problems*. John Wiley & Sons, Inc., 1993.

[14] J. H. Holland, *Adaptation in natural and artificial systems: an introductory analysis with applications to biology, control, and artificial intelligence*. MIT press, 1992.

[15] J. Tanomaru, "Motivação, fundamentos e aplicações de algoritmos genéticos," in *II Congresso Brasileiro de Redes Neurais*, 1995, pp. 373–403.

[16] "Google LLC," My Maps - About - Google Maps. Accessed: Jul. 09, 2025. [Online]. Available: https://www.google.com/maps/about/mymaps/.

[17] "Google LLC," Google Maps Platform Documentation | Geocoding API | Google Developer. Accessed: Jul. 09, 2025. [Online]. Available: https://developers.google.com/maps/documentation/geocoding/.

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[18] “Google LLC,” Google Maps Platform Documentation | Distance Matrix API | Google Developers. Accessed: Jul. 09, 2025. [Online]. Available: https://developers.google.com/maps/documentation/distance-matrix/.

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