

## Traveling Salesman Problem Applied to Postmen Routing in Artur Nogueira Road Network.

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### Abstract

This research created a software to minimize the routing to delivering mails. To do so, a graph is built manually, over an image map, in order to describe Artur Nogueira streets. Once the graph is done, shortest path and routing algorithms are used to routing postmen. The student Guilherme Almeida Zeni works at Artur Nogueira's Mail and has the goal to use the software in real situations.

*Key words: traveling salesman problem, route planning software, graphs.*

### Introduction

Traveling Salesman Problem, or TSP, models real situations, which purpose is, in the context of this research, setting routes for postmen to deliver correspondence and/or merchandise. This belongs to the class of NP-complete problems and, therefore, there are no efficient algorithms to solve it in accuracy unless  $P = NP$ .

Because of that complexity, to achieve the objectives of this work, it is essential to comprehend and implement several technics of combinatorial optimization, such as branch and bound, genetic algorithm, heuristics. Besides, to build a refined mathematical model that thoroughly describes the chosen road network, it is used a GPS navigation device to estimate time spent in deliveries and obtain distance values in near the reality.

At last, it is intended to verify the results obtained in the technological artefact, comparing to other routing methods results, for later experiencing it at the post office.

### Results and Discussion

To build and model the road network, it was necessary to get a digital map of the town and capture the sequence of points, the starting and the end, that compose every street.



**Image 1.** One of Artur Nogueira map excerpt.

Each point is described by a coordinate  $(x, y)$ , where  $x$  represents lines and  $y$  columns. In cases that the street is a curve, several line segments are used in the description.

After registering all the coordinates in a file, the streets were printed over the original map, using Bresenham's line algorithm, and the corners were generated mathematically, allowing calculate the vertices and nodes of a graph.

With the instance done, the shortest path problem was implemented and a brute-force algorithm applied to test all possible permutations to a specific route. As characteristic of this algorithm, its complexity is in order of  $O(n!)$ , which makes impractical to run in a more than 20 delivery points route. To solve that, it was implemented branch and bound, an algorithm that consists in a rooted tree which branches discard bad solutions before running brute-force. All algorithms, such as the software to generate routes, were developed in Java language and helped to apply TSP.

### Conclusions

A software was created successfully and a mathematical graph model constructed, allowing some algorithms being applied. In the next step, other algorithms must be used to improve results, so the routes generated by the software can be compared to the routes used by postmen.

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