ALGORITHMS TO FIND THE SHORTEST SAFE ROUTE TO PREVENT SEXUAL HARASSMENT

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ABSTRACT

Many people are concerned about street sexual harassment. This is a very important issue. When there is real danger, we think a lot about if we should go to a given place or if we shouldn't. Because of that, we'll try to develop an algorithm that gives people the most secure and shortest path to go to a given place. This carries lots of difficulties. For example, we must define very well the criteria to consider a certain place “secure”. We must define where we are going to obtain our data to apply these criteria, and how we are going to model the criteria into a path finding. And, of course, how we are going to make a path finding. What is the algorithm you have proposed to solve the problem? What quantitative results have you obtained? What are the conclusions of this work? The abstract should be **at most 200 words**. (*In this semester, you should summarize here the execution times, and the results obtained with the three paths*).

Key words

Shortest route, street sexual harassment, identification of safe routes, crime prevention

1. INTRODUCTION

Sexual harassment is a problem that exists in all countries of the world, many actions are considered sexual harassment, which range from catcalling to rape. The main victims of this problem are women.

1.1. The problem

On the other hand, we all like to spend as little time as possible on transport. Also, People who are new to the city, have no idea about the safe routes. Though people rely on google maps for planning their routes; yet it only provides the shortest path & give no consideration for safety of the path

1.2 Solution

To find the shortest path with the least risk of harassment between an initial node and a final node given by a user, we first created a graph with the data from the file "calles_de_medellin_con_acoso.csv", some of the edges did not have weight, so we used the mean, and then we set the final weigth considering the risk and distance. Finally, using Dijkstra's algorithm, we managed to find the solution. We use Dijkstra's algorithm because there are not anegative weights, and also, since Dijkstra's algorithm uses BFS (Breadth-First Search), it has a better run time than other type of algorithms.

1.3 Structure of the article

Next, in Section 2, we present work related to the problem. Then, in Section 3, we present the datasets and methods used in this research. In Section 4, we present the algorithm design. Then, in Section 5, we present the results. Finally, in Section 6, we discuss the results and propose some directions for future work.

2. RELATED WORK

Below, we explain four works related to finding ways to prevent street sexual harassment and crime in general.

2.1 Incorporating a Safety Index into Pathfinding

It considers both traffic safety, defined as "the ratio of the rate of deceleration to avoid a crash to the maximum rate of deceleration available", and travel time. They managed to develop the methodology for the index by using roadside crash mechanisms but struggled with limitations such as not all crash types being considered. Other conditions such as vehicle type and pavement were considered. They applied it to the shortest path search algorithm. A review of it based on the findings of previous articles considered it to be a good enough approximation for road safety.

2.2 Preventing Sexual Harassment Through a Path

Bresenham's line algorithm is a line drawing algorithm that determines the points of an n-dimensional raster that should be selected in order to form a close approximation to a straight line between two points.

The general idea behind this algorithm is: given a starting endpoint of a line segment, the next grid point it traverses to get to the other endpoint is determined by evaluating where the line segment crosses relative to the midpoint (above or below) of the two possible grid points choices.

Zooming back out to our problem at hand here, we apply these grid coverage methods to compute the average of risk scores of steps for each route to determine the best.

2.3 Route-The Safe: A Robust Model for Safest Route Prediction Using Crime and Accidental Data

The algorithm works this way: first the user enters the destination location. If there is only one route, that is the one we show to the user. On the other hand, if there is more than one route, we choose the safest route using the Knn regression model, and if there are several routes with the same score, the one with the shortest distance is chosen. That is the one that is shown to the user.

KNN regression is a non-parametric method that, in an intuitive manner, approximates the association between independent variables and the continuous outcome by averaging the observations in the same neighborhood.
The model suggests the safest route by selecting the route which has the lowest risk score. If more than one route has the lowest risk score it suggest the route which has the shortest distance.

2.4 Safety-aware routing for motorised tourists based on open data and VGI

In this article is also developed a safety index based on volunteered geographic information and governmental data, specially from police stations nearby. The primary data taken in account was of course crime data. They used it in LA and calculated the least dangerous path and the shortest one. The algorithm they used to find the paths with and without the index was the OPTICS algorithm. The algorithm orders points from the path as if they were linear. Then saves a relative distance for each point and calculates the density-based clusters in spatial data.

3. MATERIALS AND METHODS

In this section, we explain how the data were collected and processed, and then different alternative path algorithms that reduce both the distance and the risk of sexual street harassment.

3.1 Data collection and processing

The map of Medellín was obtained from *Open Street Maps* (OSM)[1] and downloaded using the Python API[2] OSMnx. The map includes (1) the length of each segment, in meters; (2) the indication of whether the segment is one-way or not, and (3) the known binary representations of the geometries obtained from the metadata provided by OSM.

For this project, a linear combination (LC) was calculated that captures the maximum variance between (i) the fraction of households that feel insecure and (ii) the fraction of households with incomes below one minimum wage. These data were obtained from the 2017 Medellín quality of life survey. The CL was normalized, using the maximum and minimum, to obtain values between 0 and 1. The CL was obtained using principal components analysis. The risk of harassment is defined as one minus the normalized CL. Figure 1 presents the calculated risk of bullying. The map is available on GitHub[3] .

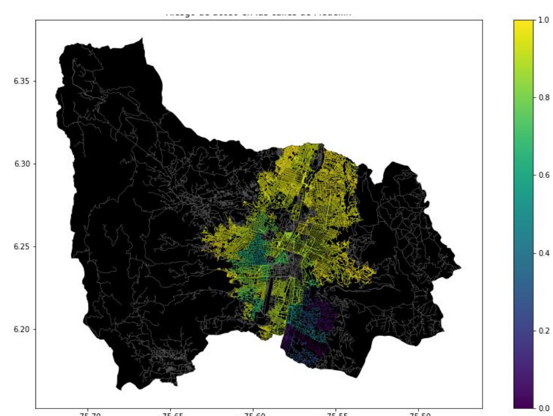


Figure 1. Risk of sexual harassment calculated as a linear combination of the fraction of households that feel unsafe and the fraction of households with income below one minimum wage, obtained from the 2017 Medellín Quality of Life Survey.

3.2 Algorithmic alternatives that reduce the risk of sexual street harassment and distance

In the following, we present different algorithms used for a path that reduces both street sexual harassment and distance. *(In this semester, examples of such algorithms are DFS, BFS, Dijkstra, A*, Bellman, Floyd, among others).*

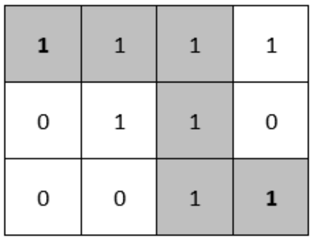
3.2.1 Find the shortest path in a maze

[1] https://www.openstreetmap.org/

[2] https://osmnx.readthedocs.io/

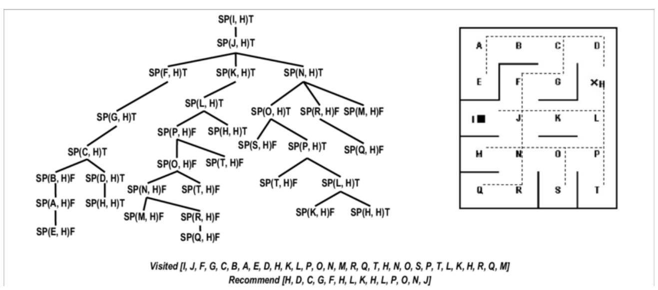
[3]https://github.com/mauriciotoro/ST0245Eafit/tree/master/proyecto/Datasets

It explores all four possible paths and recursively validates if they lead to the destination, starting from the given cell. Then updates the minimum path length each time it reaches the destination cell. It backtracks when a path doesn't reach its destination or has explored all possible paths from the cell. Its time complexity will be high because all paths are traveled.



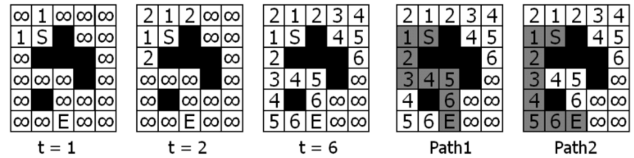
3.2.2 Shortest Path in Maze using Backtracking

This algorithm also uses backtracking to explore all possibilities. It simply checks whether a move is valid or not. If it is valid, it keeps moving until stuck, otherwise backtrack to the former cell and explore other possible moves to the destination.



3.2.3 Shortest path in a maze – Lee Algorithm

The Lee algorithm is one possible solution for maze routing problems based on Breadth–first search. It always gives an optimal solution, if one exists, but is slow and requires considerable memory. Following is the complete algorithm: Create an empty queue and enqueue the source cell having a distance 0 from the source (itself) and mark it as visited. The Loop till queue is empty. Dequeue the front node. If the popped node is the destination node, then return its distance. Otherwise, for each of four adjacent cells of the current cell, enqueue each valid cell with +1 distance and mark them as visited. And if all the queue nodes are processed, and the destination is not reached, then return false.

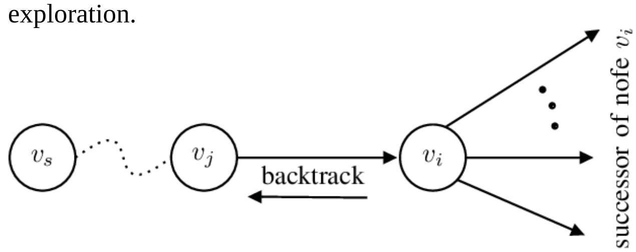


3.2.4 Pulse algorithm

Pulse algorithm consists of two phases:

(1) A bounding phase to compute a lower bound cost of every node with given consumed resources.

(2) A recursive exploration phase based on an implicit enumeration of the solution space to find the optimal solution. The bounding phase is also based on the recursive exploration.



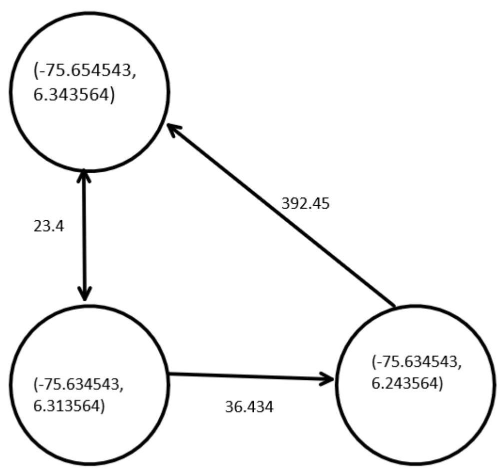
4. ALGORITHM DESIGN AND IMPLEMENTATION

In the following, we explain the data structures and algorithms used in this work. The implementations of the data structures and algorithms are available on Github[4] .

4.1 Data Structures

We used a graph of the information provided in the file "calles_de_medellin_con_acoso.csv", using the (x,y) coordinates as the nodes' names and the distance and risk as the weights

a)



[4] https://github.com/jcbermudec/ST0245-001

b)

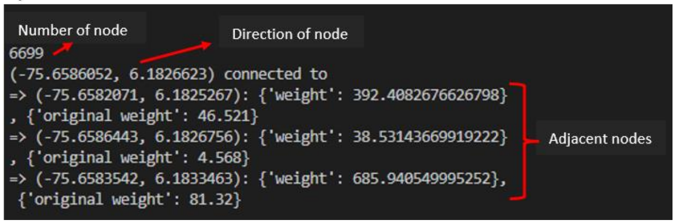


Figure 2: An example street map is presented in (a) and an example of one node representation as an adjacency list in (b).

4.2 Algorithms

In this paper, we propose an algorithm for a path that minimizes both the distance and the risk of street sexual harassment.

4.2.1 Algorithm for a pedestrian path that reduces both distance and risk of sexual street harassment

Before creating the graph, we realized that some edges had no weight, so we put the mean of all the weights. To calculate the new weight (considering the risk of harassment), we used: new_weight = distance * (risk * 10) and then create the graph with the "networkx" library. We traversed the graph with dijsktra's algorithm which works as follows: Instantiate a dictionary that will eventually map vertices to their distance from the start vertex. Assign the start vertex a distance of 0 in a min heap. Assign every other vertex a distance of infinity in a min heap. Remove the vertex with the smallest distance from the min heap and set that to the current vertex. For the current vertex, consider all of its adjacent vertices and calculate the distance to them as (distance to the current vertex) + (edge weight of current vertex to adjacent vertex). If this new distance is less than the current distance, replace the current distance. Repeat 4 and 5 until the heap is empty. After the heap is empty, return the distances and the path

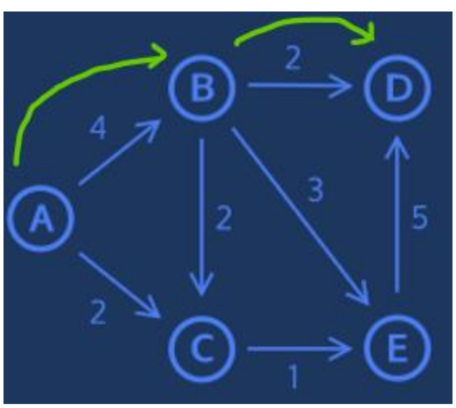


Figure 3: Example of calculating a path that reduces both distance and risk of harassment from A to D (please note that the weigth currently considers the risk and distance).

4.2.2 Calculation of two other paths to reduce both the distance and the risk of sexual street harassment

Explain the other two paths that reduce both distance and risk of street sexual harassment and make your own graph. Do not use graphs from the Internet, make your own. *(In this semester, the algorithm could be DFS, BFS, Dijkstra, A*, among others).*) The algorithm is exemplified in Figure 4.

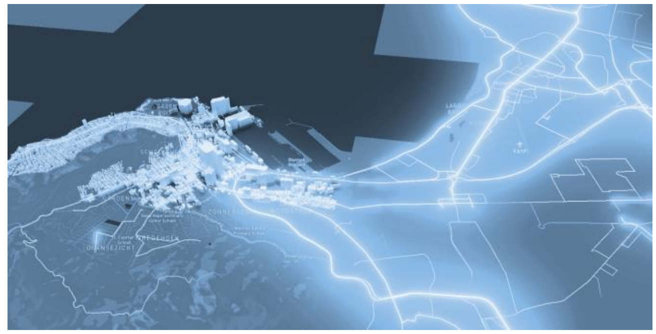


Figure 4: Map of the city of Medellín showing three pedestrian paths that reduce both the risk of sexual harassment and the distance in meters between the EAFIT University and the National University.

4.3 Algorithm complexity analysis

Explain, in your own words, the analysis, for the worst case, using the notation O. How did you calculate these complexities? Explain briefly.

Algorithm	**Time complexity**
Algorithm name	$O(V^2 * E^2)$
Name of the second algorithm (in case you have tried two)	$O(E^3 * V * 2^V)$

Table 1: Time complexity of the name of your algorithm, where V is.... E is... *(Please explain what V and E mean in this problem). No, do not use 'n'.*

Data Structure	**Complexity of memory**
Name of the data structure	$O(V * E * 2^E)$
Name of the second data structure (in case you have tried two)	$O(2^{E*} 2^V)$

Table 2: Memory complexity of the data structure name used by your algorithm, where V is.... E is... *(Please explain*

what V and E mean in this problem). No, don't use 'n'. That is, don't use 'n'. Not 'n'.

4.4 Algorithm design criteria

Explain why the algorithm was designed that way. Use objective criteria. Objective criteria are based on efficiency, which is measured in terms of time and memory. Examples of NON-objective criteria are: "I was sick", "it was the first data structure I found on the Internet", "I did it the last day before the deadline", "it's easier", etc. Remember: This is 40% of the project grade.

5. RESULTS

In this section, we present some quantitative results on the three pathways that reduce both the distance and the risk of sexual street harassment.

5.1 Results of the paths that reduces both distance and risk of sexual street harassment

Next, we present the results obtained from *three paths that reduce both distance and harassment,* in Table 3.

Origin	Destination	Distance	Risk
Eafit	Unal	??	??
Eafit	Unal	???	??
Eafit	Unal	??	??

Distance in meters and risk of sexual street harassment (between 0 and 1) to walk from EAFIT University to the National University.

5.2 Algorithm execution times

In Table 4, we explain the ratio of the average execution times of the queries presented in Table 3.

Calculate the execution time for the queries presented in Table 3.

Calculation of v	Average run times (s)
v = ??	100000.2 s
v = ??	800000.1 s
v = ??	8450000 s

Table 4: *Algorithm* name execution times *(Please write the name of the algorithm, e.g. DFS, BFS, A*)* for each of the three calculator paths between EAFIT and Universidad Nacional.

6. CONCLUSIONS

Explain the results obtained. Are the paths significantly different? How useful is this for the city? Are the runtimes reasonable to use this implementation in a real situation? Which path would you recommend for a mobile or web application?

6.1 Future work

Answer, what would you like to improve in the future? How would you like to improve your algorithm and its application? Will you continue this project working on optimization? Statistics? Web development? Machine learning? Virtual reality? How?

ACKNOWLEDGEMENTS

Identify the type of thank you you wish to write: to a person or to an institution. Keep the following guidelines in mind: 1. The professor's name is not mentioned because he or she is an author. 2. You should not mention the authors of articles that you have not contacted. 3. You should mention students, teachers of other courses who have helped you.

By way of example: This research has been supported/partially supported by [Name of Foundation, Donor].

We are grateful for help with [particular technique, methodology] to [First name Last name, position, name of institution] for comments that greatly improved this manuscript.

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REFERENCES

1. He, Z. and Qin, X., 2016, Incorporating a Safety Index into Pathfinding, Transportation, Research Record 2659. 343-364.
2. Ma, D., 2020, Preventing Sexual Harassment Through a Path Finding Algorithm Using Nearby Search, Omdena.
3. Gauri, V. and Sandeep, C., 2019, Route-The Safe: A Robust Model for Safest Route Prediction Using Crime and Accidental Data, ResearchGate.
4. Keler, A. and Damascene, J., 2016, Safety-aware routing for motorised tourists based on open data and VGI, ResearchGate.
5. Techie Delight, 2022, Find the shortest path in a maze, Techie Delight.
6. Techie Delight, 2022, Shortest path in a maze – Lee Algorithm, Techie Delight.
7. Pencil Programmer, 2022, Shortest Path in Maze using Backtracking, Pencil Programmer.
8. Li, J. and Han, X., 2019, Revised Pulse Algorithm for Elementary Shortest Path Problem with Resource Constraints, Seventh International Symposium on Computing and Networking.