UH Student Pedestrian Planning

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Abstract

We'll figure out the best sequence and path to see any given collection of UH campus structures. Our goal is to reduce the overall walking distance and time between each building along the route.

The nearest neighbor algorithm, a heuristic process that chooses the closest building as the next destination on the journey, is how we plan to approach our problem. They key results will be the optimal order of buildings to visit and the route between them for the pedestrian.

1 Introduction

Everyone is aware that getting around campus can be extremely difficult and confusing, no matter how long you have been here. The main goal is to provide optimal order and route for visiting more than one building at UH.

We will talk about how we will approach the problem and what tools we used to visualize the results to the user.

Our results display the campus map and then the walking path between the chosen start and destination buildings. We are hoping that this tool will help ease the hassle of getting around on campus!

1.1 Background

Regular map tools like Google Maps or Apple Maps can help, but the intricacies of a university campus demand a level of detail beyond what these mainstream applications currently offer. The nuances of every sidewalk and pathway are often overlooked in their databases. Additionally, they struggle to keep pace with the dynamic nature of a campus environment, where construction projects,

*Code: Simulated Annealing, Genetic Algorithms and Google Map API Visualization, Writing Report: Data Methods Experimentation

†Discussion, Powerpoint, Proposal, Report: Introduction and Background

‡Discussion, Code: Nearest Neighbors, Matplotlib visualization, custom route program, Powerpoint, Proposal,

closed sidewalks, and temporary pathways can change frequently, especially throughout the semester.

In response to these challenges, this project aims to redefine the standard mapping experience for individuals on their devices. By going beyond the limitations of Google Maps and Apple Maps, our goal is to provide users with a much more accurate and up-to-date representation of the campus. This includes real-time information about active sidewalks, ongoing construction, closures, and temporary routes. The objective is to empower individuals to navigate the campus efficiently and confidently, enhancing their overall experience and ensuring they have the most reliable guidance to get to their destinations the fastest way possible.

2 Data

The data we are working with for our project is a list of buildings in the University of Houston campus, along with their coordinates of the front doors. This data is a type of spatial data, which is data that describes the location and shape of objects in a geographic space.

We created this data ourselves by using Google Maps to find the buildings of the University of Houston and getting the coordinates of the front doors for our pedestrian route optimization project. We used the right-click feature on Google Maps to get the latitude and longitude of any point on the map.

We are working with 40 data points, each representing a building on the campus. Each data point has two attributes: the name of the building and the locations of the front door. The locations are given as a pair of numbers, indicating the latitude and longitude in decimal degrees.

We did not have to do any preprocessing to use this data in our project, as it was already in a suitable format for our analysis. We stored the data in a Python list of dictionaries, where each dictionary has two keys: “name” and “locations”. This way, we can easily access and manipulate the data using Python code.

Building Name	**Location (Latitude, Longitude)**
Science & Engineering Classroom Building (SEC 105)	(29.7237384, -95.3453009)
Science and Research 1	(29.7226705, -95.3450538)
Science and Research 2	(29.72374, -95.3450258)
Agnes Arnold Auditorium	(29.722485, -95.3439333)
Agnes Arnold Hall	(29.7221257, -95.3440745)
Graduate College of Social Work	(29.7227346, -95.3438379)
Philip Guthrie Hoffman Hall	(29.7215626, -95.3436278)
Technology Annex	(29.7225764, -95.3431086)
College of Technology	(29.7233165, -95.3426471)
Science Building	(29.721472, -95.3444812)
Lamar Fleming	(29.7216126, -95.3457797)
Science Teaching Laboratory Building	(29.7217413, -95.3465766)
Charles F. McElhinney Hall	(29.7211884, -95.3463007)
Fred J. Heyne	(29.7205173, -95.3461482)
Roy G. Cullen	(29.720123, -95.3447752)
Ezekiel W. Cullen	(29.7204262, -95.3438134)
Stephen Power Farish Hall	(29.7209729, -95.3450941)
M.D Anderson Library	(29.7210345, -95.3426496)
Central Power Plant	(29.7221216, -95.3420521)
Sudent Center North	(29.7206588, -95.3407791)
Student Center South	(29.720015, -95.3410593)
Conrad N. Hilton College of Global Hospitality Leadership	(29.7193072, -95.3413211)
Visitor Information Booth 1	(29.7193333, -95.3402617)
Cullen College of Engineering 1	(29.7229759, -95.3416759)
Cullen College of Engineering 2	(29.7233323, -95.3411237)
Engineering Lecture Hall	(29.7226926, -95.3408213)
Durga and Sushila Argrawal Engineering Research	(29.7222087, -95.3397947)
Michael J. Cemo Hall	(29.7217541, -95.3400119)
Classroom and Business Building	(29.7217344, -95.3409179)
LeRoy & Lucile Melcher Hall	(29.7210647, -95.3398822)
John M. O'Quinn Law Library	(29.7231958, -95.3386322)
University of Houston Law Center	(29.7238762, -95.3385035)
Gerald D. Hines College of Architecture and Design	(29.7242445, -95.3416015)
Blaffer Art Museum	(29.7249899, -95.3422375)
UH School of Art	(29.7244166, -95.3424494)
Jack J. Valenti School of Communication	(29.7240351, -95.343768)
Cynthia Woods Mitchell Center for the Arts	(29.724584, -95.3438086)
Moores School of Music	(29.7254492, -95.3442273)
Moores Opera House	(29.7254499, -95.3442279)
Greenhouse	(29.7231087, -95.3448654)

Table 1: List of UH Buildings

3 Methods

Our approach for solving the problems that we set up in the introduction was to use a combination of nearest neighbors, genetic algorithm, and simulated annealing for route optimization of all the buildings on campus. We used these techniques to find the most efficient and optimal path or sequence of locations for each building, minimizing the total distance traveled by pedestrians.

We chose these algorithms because they are simple yet effective methods that can handle complex and dynamic routing problems. Nearest neighbors is a heuristic algorithm that finds the closest location to each building and assigns it as the next destination. This way, we can avoid unnecessary detours and reduce travel time. Genetic algorithm is a population-based optimization technique that mimics the natural process of evolution. It generates a population of random solutions and evaluates their fitness based on some objective function (e.g., distance, time, cost). Then, it applies genetic operators such as selection, crossover, and mutation to improve the quality of the solutions and produce better ones. Simulated annealing is another population-based optimization technique that simulates the physical process of annealing. It starts with a high temperature and randomly explores different solutions. Then, it gradually decreases the temperature and accepts worse solutions with some probability to escape from local optima. We applied these techniques iteratively until we reached a satisfactory solution or met some termination condition (e.g., maximum number of iterations, minimum solution quality). We believe that our approach is right because it leverages existing ideas and skills built up during this semester to tackle our problem of choice. We have learned how to formulate routing problems using mathematical models such as Traveling Salesman Problem (TSP), Vehicle Routing Problem (VRP), or other variations. We have also learned how to implement heuristic algorithms such as nearest neighbors, genetic algorithm, and simulated annealing using Python code. We have also learned how to evaluate and compare different algorithms based on their performance metrics which is distance and time.

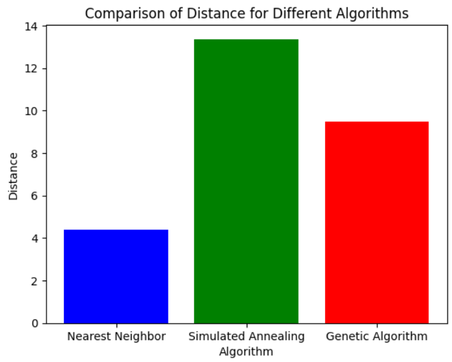
4 Experiment

In our google colab file[1] We demonstrate the efficacy of our approach in solving the problem of optimizing the order of buildings, we conducted comprehensive experiments, comparing three prominent algorithms: Nearest Neighbor, Simulated Annealing, and Genetic Algorithm. Our aim was to evaluate their performance based on the total distance traveled to visit all buildings.

4.1 Comparison of Distances

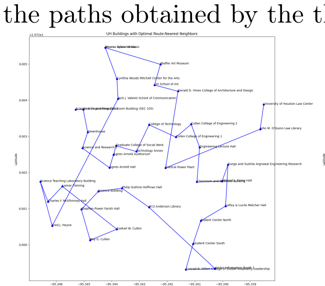
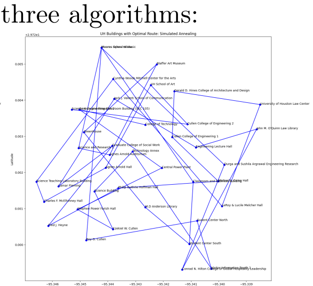
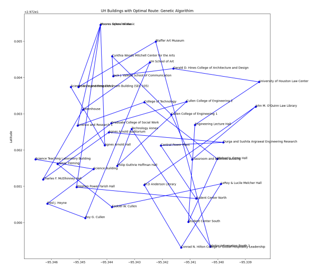
We implemented each algorithm and computed the total distances obtained by traversing through the given 40 buildings on our campus. The distances achieved by each algorithm were as follows:
Nearest Neighbor: 4.399160123618925
Simulated Annealing: 13.363536227428746
Genetic Algorithm: 9.473170783406184
These distances showcase the solution quality provided by each algorithm in terms of the total distance traveled. We used these metrics to compare the performance of the algorithms.

[1] `https://colab.research.google.com/drive/1SJBB4OIUjrpNk3TT563NwHccBAmJQ3mL?usp=sharing#scrollTo=XEor9Gy8iF22`



4.2 Visualization of Paths

To visualize the optimal paths generated by each algorithm, we plotted the routes taken to visit the buildings using Matplotlib. Below are the visual representations of the paths obtained by the three algorithms:

The visualizations clearly depict the paths taken by each algorithm to visit the buildings. These visual representations help in understanding the routes chosen by each method and visually comparing their effectiveness in optimizing the order of buildings.

5 Conclusion

Among the algorithms tested, Nearest Neighbor showcased remarkable efficiency in generating the fastest route to traverse a set of buildings. Its simplicity and ability to quickly determine the nearest unvisited building from the current location allowed for the rapid generation of a route.

Utilizing the insights gained from the Nearest Neighbor algorithm, we develop a versatile program capable of dynamically generating optimal routes for various scenarios. This program allows users to input any starting and destination buildings, enabling the generation of efficient routes tailored to specific requirements. We then utilize the Google Maps API to visualize to the user the walking route on a the live map of UH

Figure 1: User inputted route with starting building as Greenhouse and destination buildings as Student Center South, College of Technology, Lamar Fleming, UH School of Art, Moores Opera House

5.1 Future Extensions

Integration with Navigation and Logistics Systems Expanding the application scope, we envision integrating this routing program with navigation and logistics systems. This integration could be beneficial for delivery services, transportation planning, tour management, and more. By incorporating real-time data and optimization strategies, it could streamline operations and minimize travel distances.

5.2

Our project's outcomes highlight the efficiency of the Nearest Neighbor algorithm in generating fast routes and pave the way for the development of a versatile routing program adaptable to different scenarios. The future extensions and applications outlined aim to leverage these insights for broader use in navigation, logistics, and optimization domains.