School Coach Network Optimization Project – 2024 – Tom Williams

For my A-Level Coursework I decided to solve a problem which hit close to home, so I made an application which could take student locations, and generate a suitable set of routes to get them to school. I struggled with changes to my own coach route due to traffic, roadworks and a dwindling number of pupils in my area attending my school.

The application used records of student home addresses (randomly generated for the purpose of the project), and went through a process of 3 algorithms to create the route map:

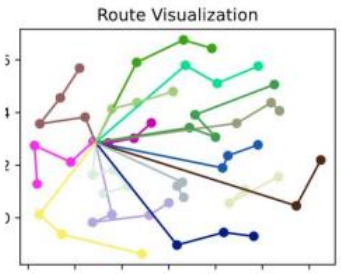
- Hierarchical Clustering Algorithm (Homes to Stop Clusters)
- Generic Greedy Routing Algorithm based on distance (Stops to Routes)
- **Genetic Algorithm** (Optimizing Routes)

The project was completed using Python, and its associated libraries including Tkinter for GUI, MatPlotLib for graphing, and Folium for real world visualization.

My custom genetic algorithm was by far the trickiest part of the project and involved many hours of tinkering. My initialization involved taking the output of my greedy routing algorithm and copying the solution many times to generate my *population.* Each *chromosome* was mutated to create variation, and then they began performing my complex crossover, where a certain combination of stops (*nodes)* would be replicated in the sister *chromosome.* The reproduction produced 2 daughter chromosomes which would now share genes. Then a mutation stage occurs in most of the new generation to ensure variation. In the final selection process, some *chromosomes* are filtered out according to a *fitness function.* This score based system took into account total network distance, total number of coaches, angular deviation from straight path, and other penalties. Over many generations, the algorithm produces a useable route map which could be used as a guide for real world planners.

The project taught me a lot about project management, and mainly was my first large OOP project. The project scored 96% overall based on Analysis, Design, Technical Solution (100%), Testing, and Evaulation.

OUTPUT ROUTE AND STUDENT DATA



Students.csv Snippet:

```
Student ID, Bus Route Index,
Geocoordinate X, Geocoordinate Y
328,1,51.436582,-0.352998
406,1,51.436935,-0.350604
276,1,51.439431,-0.350996
375,1,51.436582,-0.352998
438,1,51.438423,-0.347752
564,1,51.439227,-0.348629
525,1,51.432154,-0.352718
118,1,51.433711,-0.34457
695,1,51.432629,-0.346234
347,1,51.432154,-0.352718
```

Routes.csv Snippet:

```
St Margarets,TW10 6AB,51.45765575,-
0.30177331249999995,16
Twickenham,TW1 3BA,51.4510995,-
0.31929225,8
Isleworth,TW7 7QT,51.457945625,-
0.3328914375,16
Hounslow West,TW4
5EU,51.4568685625,-0.378072625,11
Hanworth,TW13
5JJ,51.445600062500006,-
0.38630318750000003,16
```

FITNESS OVER GENERATIONS (GA)

1	800023.5458
2	800565.7052
3	800840.3561
4	802827.6257
5	804125.0181
6	804540.9291
7	807681.9418
8	809266.4935
9	809851.6926
10	811742.713
11	809979.0607
12	811917.0118
13	812533.8881
14	813395.7735
15	814996.5543
16	815283.215
17	815283.215
18	816503.4896
19	815487.7735
20	816537.4585
21	816594.5008
22	815692.9411