**Project 4: TSP using**

**Genetic Algorithm**

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1. **Introduction** (What did you do in this project and why?)

For this project, I used Python through Visual Studio Code and the command line to run and compile the program. This project is using a genetic algorithm to find an optimal path to hit every city and return to the first. I used Python because it is what I am most familiar with for projects like this. This is the same language I used for the last projects, so a lot of the code was reused such as the file parsing code and the GUI formatting functions.

1. **Approach** (Describe algorithm you are using for this project)

My approach to the problem was so strip out the data from the files provided, make an object based on a class I made that holds the number, the x, and the y coordinates for each of the cities. I reused the parsing method and functions from the previous projects. I first made an initial population of 100 paths. I then sorted them by distance and calculated the fitness score of each. I then took a percent of the best in the list. I played around with the amount I took but ended up using the best 25 out of the 100 in the list. After I found the best 25, I then picked two random cities from it and bred them during this breading process, to cut down on the number of mutations and to avoid excessive fluctuation, I added a while loop that checks if the child that was just bred has a distance greater than the previous generation. If it does, it will bread again until it is less than the previous population. It will, however, pass if it is the distance is the same as the previous generation. If it is for a certain amount of times, it will stop. I used the crossover method which takes a random length from the first parent and puts it into the child then the second parent populates the rest of the child. After repopulating the new population of bred member, I then put it through mutation. I tried many mutation rates, but I found 10% to be the most efficient with my algorithm. Originally, I had it at 2% but it took a lot longer to get to a good result. After I was done with mutation, I repeated the process of finding the best, breading a new population, and mutating that population. Because of my breading methods, I decided to experiment with different number of generations. The sweet spot I found was 100 generations. Anything more than that wouldn’t change the distance. After I found the best path, I used the matplotlib library to return a visual representation of the path. I also took the distance over time array and plotted a simple x y graph also using matplotlib to show the improvement over the generations.

1. **Results** (How well did the algorithm perform?)
   1. **Data**

I used the city data provided and implemented my genetic algorithm to find an optimal path visiting all cities and return to the starting city. I then used the matplotlib Python library to generate a visual representation of the path.

A close up of a map

Description automatically generated**Results**

A screenshot of a cell phone

Description automatically generated

-------------------BEST PATH---------------------

-------Path-------

[70, 94, 83, 74, 17, 39, 41, 86, 23, 34, 46, 55, 61, 19, 53, 3, 21, 38, 66, 37, 89, 75, 36, 7, 85, 24, 92, 71, 1, 43, 72, 30, 73, 95, 15, 79, 68, 81, 20, 60, 6, 40, 98, 56, 64, 59, 33, 13, 51, 97, 29, 25, 84, 31, 4, 35, 88, 50, 5, 58, 44, 78, 67, 65, 96, 52, 100, 63, 32, 91, 28, 45, 22, 27, 57, 9, 80, 82, 62, 87, 77, 14, 2, 42, 26, 76, 48, 49, 12,

18, 11, 47, 69, 90, 10, 8, 54, 16, 99, 93]

-------Distance-------

**1198.87608221**

-------Time Elasped-------

1484.62099981 seconds

1. **Discussion** (Talk about the results you got and answer any specific questions mentioned in the assignment.)

While my program was not perfectly optimal or efficient, it still achieved a result that was close to it. The best score I’ve heard was around 800 so I was less than 400 off of optimal. With more optimization, I could probably achieve it. I would have to try a few different genetic algorithms methods but the one I use is consistently good. Not perfect, but still good. While my algorithm took around 25 minutes, after conversation with my classmates, this seems to be a normal thing. Before optimization of it, my program took around 45 minutes at least.

I learned a lot about genetic algorithms. I originally knew nothing about them so this was my first time working with them so I had to wrap my head around the theory and process of it. It took me a while to initially understand the process, but I understood it in the end. The biggest problem I had was optimization in terms of time and which data to pull. I originally tried to take the first 10 instead of the first 25 but I didn’t have enough variety in sample size so it wouldn’t breed as well. If I did this project again, I would try a completely different approach to the project. While this was time consuming, now that I understand the processes, I would definitely try to do this again if given the chance. Genetic algorithms are an efficient way to solve problems like this with a large dataset. It wouldn’t be as efficient if used on a small dataset but the bigger the dataset, the better it would be compared to other approaches.

1. **References** (If you used any sources in addition to lectures please include them here.)

Matplotlib library and documentation: <https://matplotlib.org/>