MUCP Design Portfolio

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Overall Accomplishments

- Managed and worked together in a multidisciplinary project consisting of 5 students to produce a framework for evaluating alternative Toronto Waterfront Marathon routes that are proposed to and adopted by Canada Running Series for the 2024 marathon.
- Created a script using ArcPy to analyze and evaluate route performance, which provided the team an easier way to objectively quantify and communicate the performance, strengths, and weaknesses of a route with concrete data.
- Created network models using VISSIM and VISUM to allow the team to simulate traffic and measure the impact of road closures which helps to identify and propose a marathon route that optimally minimizes traffic congestion.
- Developed technical communications and writing skills by simplifying the technical processes of GIS scripts and code to people with no relevant technical background in both verbal and written communications, which allowed the entire team and external stakeholders to understand and contribute to the process easily.

Achievements Breakdown

1. *Teamwork & Management in a Multidisciplinary Project*

Through this project, I have had the opportunity to work in a multidisciplinary team of 5 students.

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
1	Milestone 1: Initial Planning					
1.1	Initial Meetings & Scheduling	All + Community Parts & Teaching Team	9/8/23	9/27/23	19	100%
1.2	Identify Project Scope & Requirements	All	9/25/23	10/6/23	11	100%
1.3	Identify Preliminary Plan & Timeline	All	10/9/23	10/11/23	2	100%
1.4	Conduct Literature Review & Initial Research	All	9/25/23	10/6/23	11	100%
1.5	**Assignment: Project Requirements**	All	10/2/23	10/13/23	11	100%
2	Milestone 2: Design Alternatives & Proposal					
2.1	Race Day Observation & Summary	All + David	10/13/23	10/20/23	7	100%
2.2	Research on Alternatives	All	10/23/23	11/10/23	17	100%
2.3	Contraint Identifications	All	10/23/23	11/10/23	17	100%
2.4	Finalised Design	All	11/8/23	11/10/23	2	100%
2.5	Feedback on Chosen Design	All + Community Partners, TA	11/10/23	11/10/23	0	100%
2.6	Refine Project Plan & Timeline	All	11/6/23	11/15/23	9	100%
2.7	**Assignment: Design Proposal**	All	10/30/23	11/17/23	17	100%

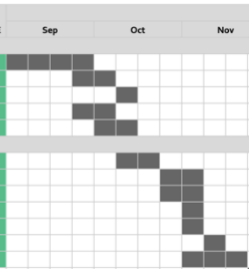

Figure 1 Snippet of Gantt Chart from MUCP Project

One skill that I have gained working in a group is project management techniques like Gantt Chart through the workshop on project management. This allows me to make sure that the team collaborates effectively and that we are meeting deadlines while working independently on different parts of the project based on our specialties. As learned in the design thinking course workshop, making a Gantt Chart for the project (snippet in Figure 1) also demonstrated my understanding in the design process as the tasks cover all the stages of the process from problem identification, to exploring possibilities then selecting one, and finally result evaluation and communication. Also, the course workshops on working in multidisciplinary teams and community-engaged learning has allowed me to reflect on how my technical skills can apply in the design thinking process and complement the work of other disciplines. This is best reflected through communicating the results of my work. Since most of my

work is completed in code or a specialized software, they are not the best format to communicate results to external clients, as shown in Figure 2. Therefore, being able to work with students from architecture allow me to learn to explore better ways of communicating results visually, as shown in Figure 3. Essentially, this project allows me to learn about how different disciplines can complement one another in the real world by working with people from other disciplines.

```
Baseline,0.75,2.0,1.4,1.5,4.0,2.0,0.25,1.25,0.75,1.2,1.2,0.25,1.38
Proto 1.1,1.75,1.25,0.4,0.5,1.0,1.0,1.75,1.5,2.0,0.3,0.3,1.5,1.1
Proto 1.2,2.0,1.25,0.4,0.25,1.0,1.75,2.0,2.0,2.0,0.3,0.3,1.5,1.23
Proto 2.1,1.0,1.25,1.0,1.25,2.0,1.75,1.0,1.25,0.75,0.75,0.75,2.0,1.23
Proto 2.2,1.25,1.25,1.0,1.75,2.0,0.25,0.75,2.0,0.75,0.75,0.75,1.5,1.17
Proto 2.3,1.5,1.75,1.6,1.0,2.5,1.75,1.5,1.25,2.0,0.9,0.9,1.5,1.51
Proto 2.4,0.25,0.25,1.4,2.0,3.0,1.0,1.25,1.25,2.0,1.2,1.2,1.75,1.38
Proto 2.5,0.5,1.75,1.0,0.75,3.5,1.0,0.5,1.25,2.0,0.75,0.75,0.5,1.19
```

Figure 2 Project result in CSV format

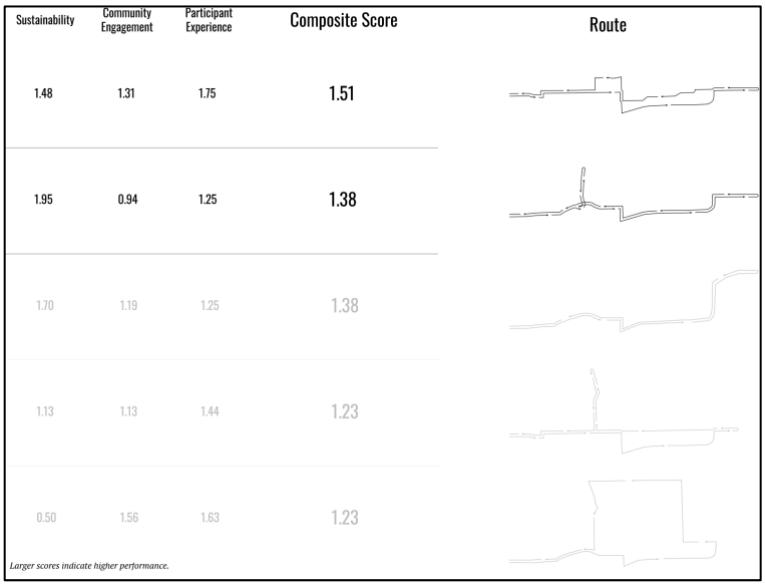

Figure 3 Result Communication with Better Visuals

2. GIS Route Analysis & Evaluation Scripting

My primary contribution to this project was leading and developing GIS scripts for route analysis and evaluation. The work allows me to apply my knowledge learnt in both my GIS courses and my Computer Science skills to create a dynamic, flexible scripts for route evaluations that can be easily extended or modified in the future. The GitHub Repository is linked here.

Using my GIS knowledge, I was able to figure out the best methods for calculating a certain metrics. For example, I used buffer to count the features, such as subway stops and points of interests that are within a certain distance of the route. Also, I used the select by attribute and select by location features to filter out and count relevant metrics such as areas of business improvement areas overlapped with the route. However, this project did not just allow me to apply my existing skillset, it also allowed me to extend upon my GIS skills, specifically in using ArcPy for GIS scripting in Python. Essentially, instead of relying manually on the ArcGIS Pro software to run everything, I decided to do that in Python. Figure 4 shows a code snippet for calculating number of places of interests intersecting the route. Learning to write GIS model via Python makes it easier to

modify it in the future, as only the variable in the codebase needs to be changed without opening the ArcGIS Pro software at all. It makes the work easier to maintain and modify in the future when requirements change.

```
# Count number of POI feature that intersects with RouteBuffer
# using the Select Layer By Location tool
POIFeature = dataFolder + "Places_of_Interests\\Places of Interest and Attractions - 4326.shp"
POIIntersectionRes = arcpy.SelectLayerByLocation_management(POIFeature, "INTERSECT", RouteBuffer, "", "NEW_SELECTION")

POIResult = int(arcpy.GetCount_management(POIIntersectionRes).getOutput(0))
result["Number of Places of Interests"] = POIResult
```

Figure 4 Code Snippet for Calculating Number of Places of Interests Metrics

```
if "Error" in result:
    print("Script ended in " + str(round((time.time() - scriptStartTime), 2)) + " s. with error:")
    print(result["Error"])
    exit(1)
else:
    print("Script ended successfully in " + str(round((time.time() - scriptStartTime), 2)) + " s.")
```

Figure 5 Error Checking Code

Since I wrote the GIS model and methods as a script, I was also able to use my programming and software design skills learned from my Computer Science courses to improve on the script. For example, I added error checking in the script to make sure that it will be easier to debug in the future in case errors happen as shown in Figure 5. Throughout the script, I also documented the code with comments that describe what each part of the code is doing to keep the code easier to understand. I also created a README file with instructions to run the scripts. Lastly, I was able to apply some of the data analysis skills using the pandas library that I learnt from my prior courses to create a script that ranks and calculate composite scores for the routes. The rank function is shown in Figure 6.

```
def Rank(df: pd.DataFrame) -> pd.DataFrame:
    df_T = df.T # transpose dataframe to get metrics in rows, routes as columns

    if 'weight' not in df_T.columns:
        df_T['weight'] = 1 # if weights are not specified, give equal weights of 1

    # Seperate weight column and remove from metrics column
    wt = pd.DataFrame(df_T['weight'])
    df_T = df_T.drop(columns = ['weight'])

    # Rank route performance in each metric (ascending rank in value)
    ranks = df_T.rank(method = 'max', axis = 1)

    # weight the ranks by multiplying with the weights
    ranks = ranks.mul(wt['weight'], axis = 0)

    # untranspose dataframe
    ranks = ranks.T

    # rename columns to include "Ranks" suffix
    ranks = ranks.rename(columns = lambda x: x + " Weighted Ranks")

    # calculate average rank as score. performance increasing in score
    ranks['Overall Weighted Score'] = ranks.mean(axis = 1)

    return ranks
```

Figure 6 Ranking Function using pandas library

Overall, in this project, I was able to have the opportunity to apply and combine my skills in GIS and Computer Science into a real life project, which have been a great learning experience since I was used to learning these skills separately from one another.

3. *Traffic Modelling*

One other skill that I developed was traffic modelling using VISSIM and VISUM. This is a completely new skill that I have not learned in prior courses before. One of the skills that I learnt is to construct a basic network in VISSIM by setting up links, connectors, turn movements. An example of a network created is shown in Figure 7.

Figure 7 Simple network Created in VISSIM

The other skill that I learnt in traffic modelling was how to make use of VISUM to simplify the process of network creation in VISSIM through OpenStreetMaps. Specifically, I export an interested section of a map from OSM (Figure 8) and imported it into VISUM (Figure 9). Using VISUM, I then converted into a VISSIM-compatible format to import it into VISSIM (Figure 10). These steps allowed me to quickly create a network model using open source data without having to create the network from scratch, which saves time and effort of the development process.

Figure 10 OSM Map Export

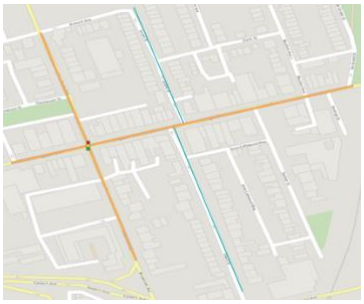

Figure 8 VISSIM Version of the Map

Figure 9 VISUM Version of the Map

4. *Technical Communications & Writing*

Lastly, I gained valuable technical communications and writing skills through this project. Since my primary work is technical in nature, I had to explain and simplify my work and processes when communicating with my teammates and community partner to make sure that they can effectively understand the framework without knowing the low-level technicalities. For example, instead of showing them my code and explaining what it does in low-level details, I simply describe the process on a high level in a step by step process, from how the data is collected, what the model

does, to what our metrics and result mean. I also created a diagram (Figure 11), which is also attached in the README document of the code repository for project transition and handover purposes to illustrate the high level overview of the GIS evaluation steps. The diagram was designed so that it can capture the essence of the script without going into the technical details.

Figure 11 High Level Steps Overview of GIS Route Evaluation Script Processes for External Communications and Handover

Furthermore, when writing the final report and describing the GIS metrics calculations, instead of using technical terms like the specific GIS functions and methods used, I simply described how each metric is calculated, as shown in Figure 12 below:

Metric	Description
Number of high traffic intersections↓	A high traffic intersection is defined as an intersection in downtown Toronto with above average car traffic in the *Traffic Volumes at Intersection for All Modes* data from Toronto Open Data. This metric counts the number of high traffic intersections within a 100m of the route.
Business Improvement Areas Coverage↑	This metric sums up the total areas of business improvement areas covered within 100m of the route.
Number of Trapped Condominiums↓	This metric counts the number of condominiums inside the area enclosed by the route.
Number of Residential Zone↓	This metric counts the number of residential zones intersecting within 100m of the route.
Number of Subway Stations↑	This metric counts the number of TTC subway stops that are within 100m of the route.
Number of Places of Interest↑	This metric counts the number of places of interest that are within 100m of the route.

Figure 12 Description of how each GIS metrics is calculated

Therefore, in this project, I had the valuable opportunity to describe and explain technical concepts both verbally and textually in a simplified way, which can be more easily understandable by people with no technical background. I believe that this will be a very useful skill in the industry, where I might be working with people from different background. Having a flexible communication skill and the ability to explain processes on a high level will be useful to make sure that my works are communicated effectively and efficiently to all stakeholders.