Written Document 1: Graphics Proposal

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1.0 Introduction

This document elaborates on the graphics to be implemented in Milestone 2. Three types of Geographic Information Systems(GIS) will be analyzed, based on their key features that increase usability and responsiveness. For this purpose, examples of city, traffic density and pandemic maps have been selected. Based on our SAR analysis, the detailed design is specified in the Proposal section. Finally, we will be elaborating on the testing techniques and metrics to measure the usability and responsiveness of the overall design.

2.0 State-of-the-Art Review

In this section we will review three state-of-the-art GIS's and features used to improve usability and responsiveness.

2.1 Google Maps

In this section, we will be discussing the use of colour scheme and clear indication of features in Google Maps that increases usability.

2.1.1 Colour Scheme

Google Maps provides intuitivity using colour coding (Figure 1). Different tones are used to provide more information. For example lighter tones of gray are used to indicate boundaries of cities, whereas darker tones are used for private properties. Freeways, highways and smaller roads are in orange, appearing lighter in their respective order. By demonstrating relationships between colour patterns, Google Maps enables easy visualization [1]. Furthermore, studies show that when a user knows the colour of the search item, it takes less time to locate [2]. Therefore, by categorizing similar features under specified colours, Google maps provides a visual intuition that increases usability.

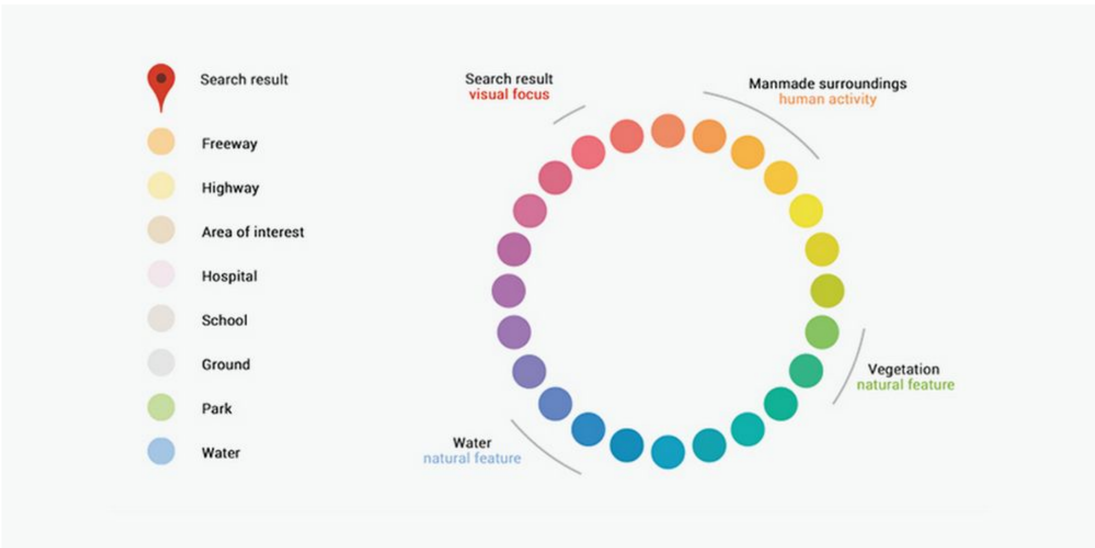

Figure 1: Color Scheme of Google Maps [3]

2.1.2 Avoiding the Clutter

Displaying a certain amount of information is an effective technique to manage the clutter in multi-scale maps [4]. Google Maps achieves a clear interface by being selective on visualizing the names and features in appropriate fonts depending on users' viewing capacity. When fully zoomed out (Figure 2), we can see the names of the countries and oceans in bold. As we get closer, the country names disappear and names of the relatively smaller features, such as cities and national park names, appear. With every zoom in, any information that is no longer applicable, fades away by switching to a lighter colour and disappears, as relatively smaller features, start to appear in detail (Figures 3 and 4). Hence, ensuring the maps readability relies on the correct sized display of the names and features according to scale [5].

Figure 2: Fully zoomed out view in Google Maps showing larger lands and oceans. [6]

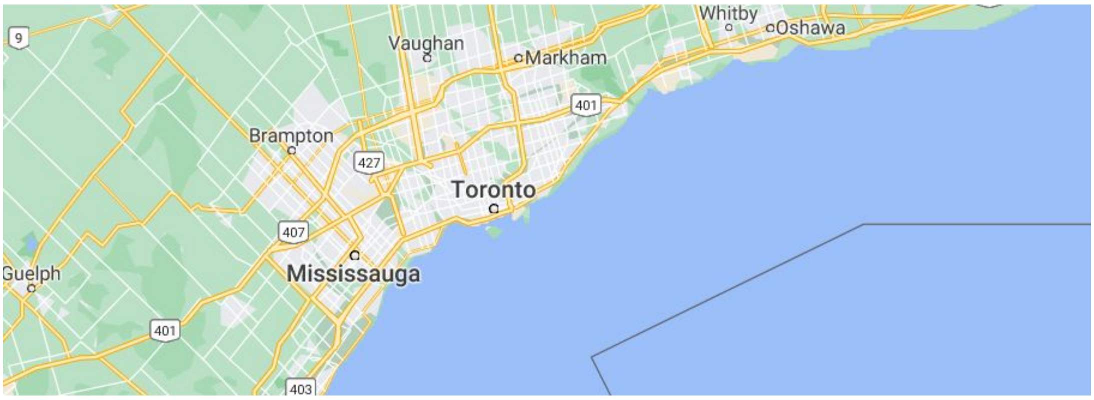

Figure 3: Zoomed in view of Ontario, CA in Google Maps, displaying some names of the cities. [6]

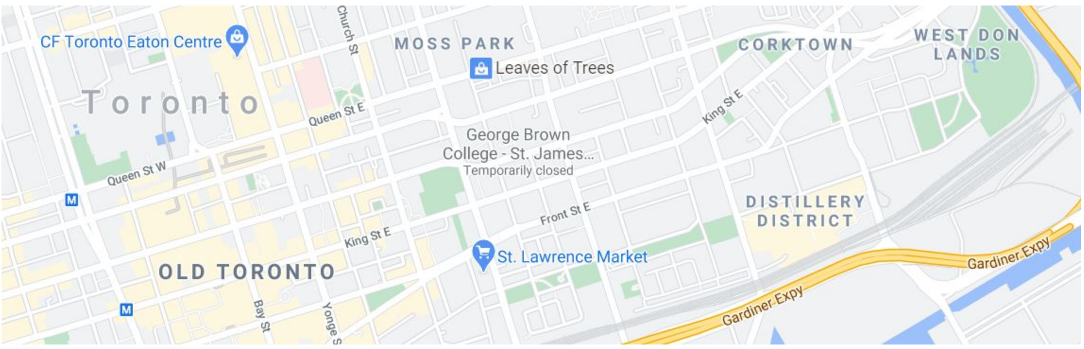

Figure 4: Zoomed in view of Downtown Toronto, showing smaller features such as streets and POI names.[6]

2.1.3 Indication of Points of Interests (POI)

Coding symbols by a colour and texture are much easier to find than symbols coded by texture alone [2]. By marking the searched point with a unique symbol in a bright colour, Google Maps provides a clear indication of a certain point. Compared to before, the 'after search' state indicates the result with its own symbol in vivid red. Hence, by highlighting any search point uniquely, users can easily locate the results.

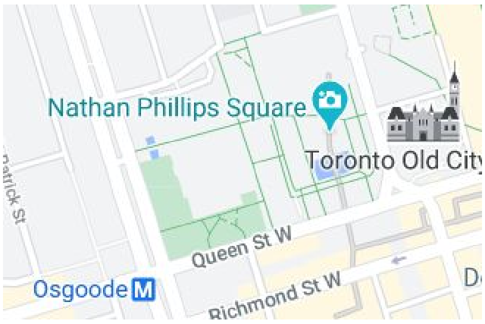

Figure 5: POI before search[6]

Figure 6: After searching Nathan Phillips Square[6]

2.2 Istanbul Metropolitan Municipality (IMM) Traffic Density Map

The IMM Traffic Density Map by ISBAK displays traffic for users to take alternative routes to traffic-dense ones [7]. Additionally, it can display POIs chosen from a drop-down menu. This section discusses three methods used for this map to function.

2.2.1 Display of Traffic

Purpose of the traffic density map is to present the traffic density information through colour [7]. Streets are coloured based on their current traffic densities (Figure 7). A legend for colours is provided underneath the map (Figure 8). Lighter colors and green are used for low traffic while darker colors and red are used for high traffic. There are different colours for closed streets and streets without available data.

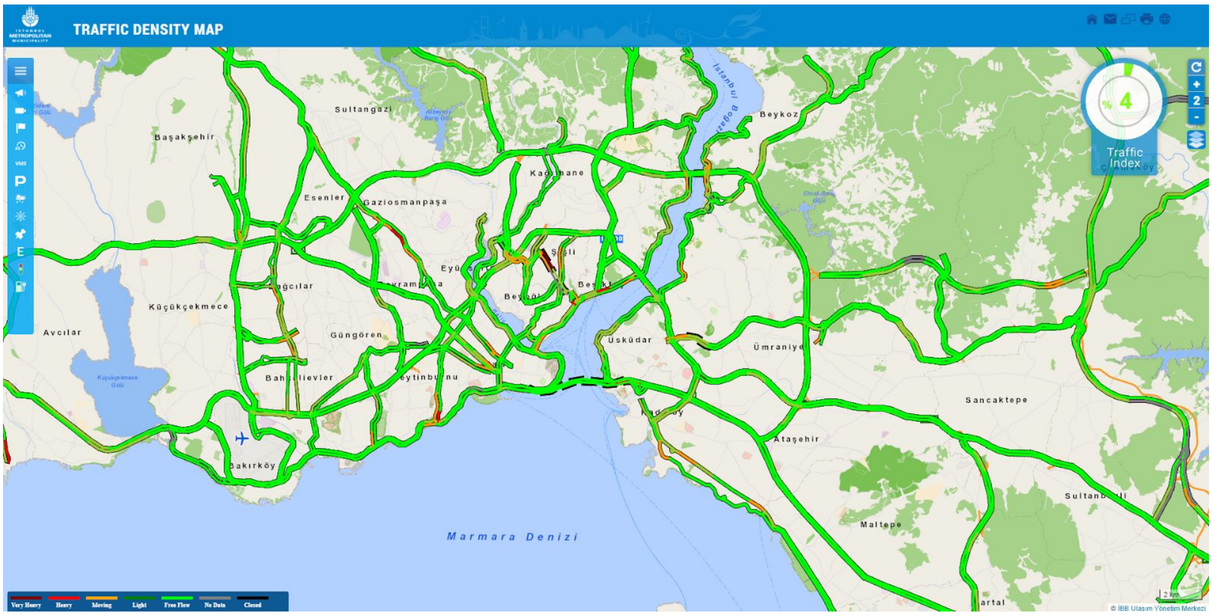

Figure 7 The full view of IMM Traffic Density Map [8]

Figure 8: The legend for the colors of streets [8]

Colours and brightness are used for traffic densities instead of text, requiring less words on screen. This allows for less clutter that increases readability. Usage of colours matches traffic lights; green means go and red means stop. This allows users to understand which roads are congested and which are free intuitively. Moreover, using red for heavy traffic triggers an avoidance response [9] in humans, making users avoid these roads, which in turn can reduce the traffic. Colour use allows easier quantitative judgement (car speed) while changing brightness allows easier qualitative judgement (better/worse routes) [10].

2.2.2 Drop down menu

On top left of the screen, there is a drop down menu button. The options of the menu can be clicked to display chosen information. They are displayed as images with mouse-over text (Figure 9.) Clicking the menu button again closes it.

Figure 9: The drop down menu, unclicked on the left and clicked on the right with mouse hovered on an option [8]

With this feature, IMM map provides an easy interface to select items to display on screen. Usage of icons and text together increases the usability by resulting in faster and more accurate selections [11]. It also covers a very small portion of the screen as text isn't always displayed and the menu can be minimized.

2.2.3 Display of POI

When an option is chosen from the menu, POI icons appear on the map . Multiple options can be chosen with each one superimposed onto the current map (Figure 10).

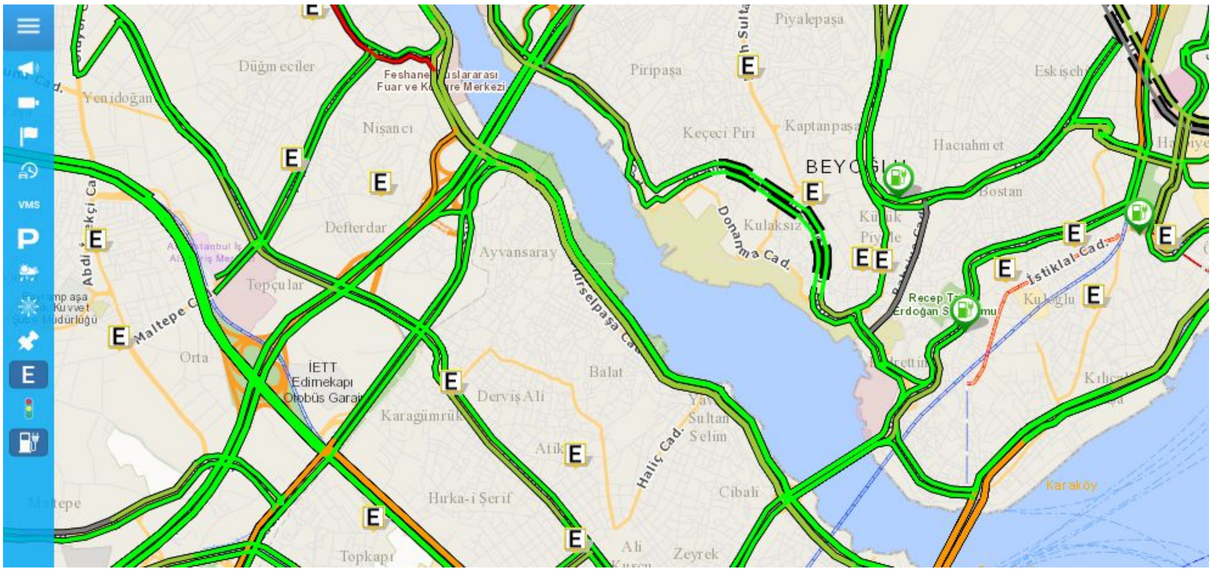

Figure 10: Both pharmacies and electric vehicle charge stations shown on a section of the map [8]

This feature allows users to see where each POI of a type is located. Multiple POI types can be shown which increases user control over what they want the map to display. Loading POIs one-by-one instead of all at once reduces the time map takes to load and increases responsiveness.

2.3 Johns Hopkins University (JHU) COVID-19 Map

The JHU COVID-19 Map was created to increase awareness about the COVID-19 pandemic and share aggregated data. It displays the number of new cases per day, at each reported location.

2.3.1 Ability to Pan and Zoom

Zooming into relevant portions of the pandemic map is crucial in delivering information effectively. Maps of various scales date back thousands of years [12]. However, the ability to change the map's scale on the fly is a valuable feature which increases usability immensely.

In the JHU COVID-19 Map, the user is able to zoom in and out, as well as to move around using familiar controls. These are:

-Pinch to zoom in and out
-Scroll up and down to zoom in and out
-Drag to pan
-Click and drag to pan
-Plus and minus buttons to zoom in and out (Figure 11)

The ability to zoom and pan, along with the controls used being familiar, increases usability. Further, for users who cannot do the pinch gesture or operate a mousewheel, plus and minus buttons increase accessibility.

Figure 11: Pandemic map plus and minus buttons [13]

2.3.2 Zoom Level Based Downsampling

The map assets used are downsampled when at a zoom level where they would not provide any benefits to the user. For example, at the widest zoom level, only national borders and continent names are shown (Figure 12). As the user zooms in, gradually, further details are shown (Figure 13.) In the highest zoom level, even individual buildings are shown to the user in great detail (Figure 14.) Considering there are an estimated 1.7 billion buildings on Earth [14], just storing all the buildings' coordinates in 32-bit floating point numbers would take up around 122GB of memory. Even if this was possible via memory paging, responsiveness would suffer severely.[15]

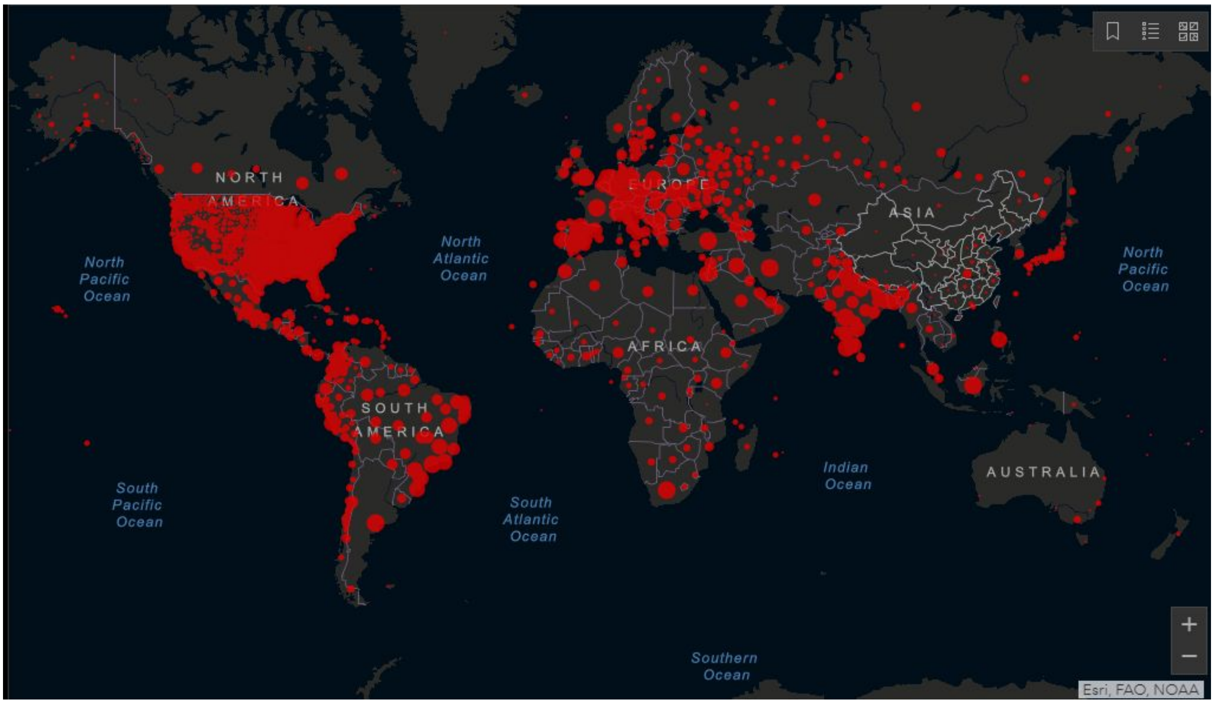

Figure 12 Pandemic map at lowest zoom level, showing continent and ocean names only [13]

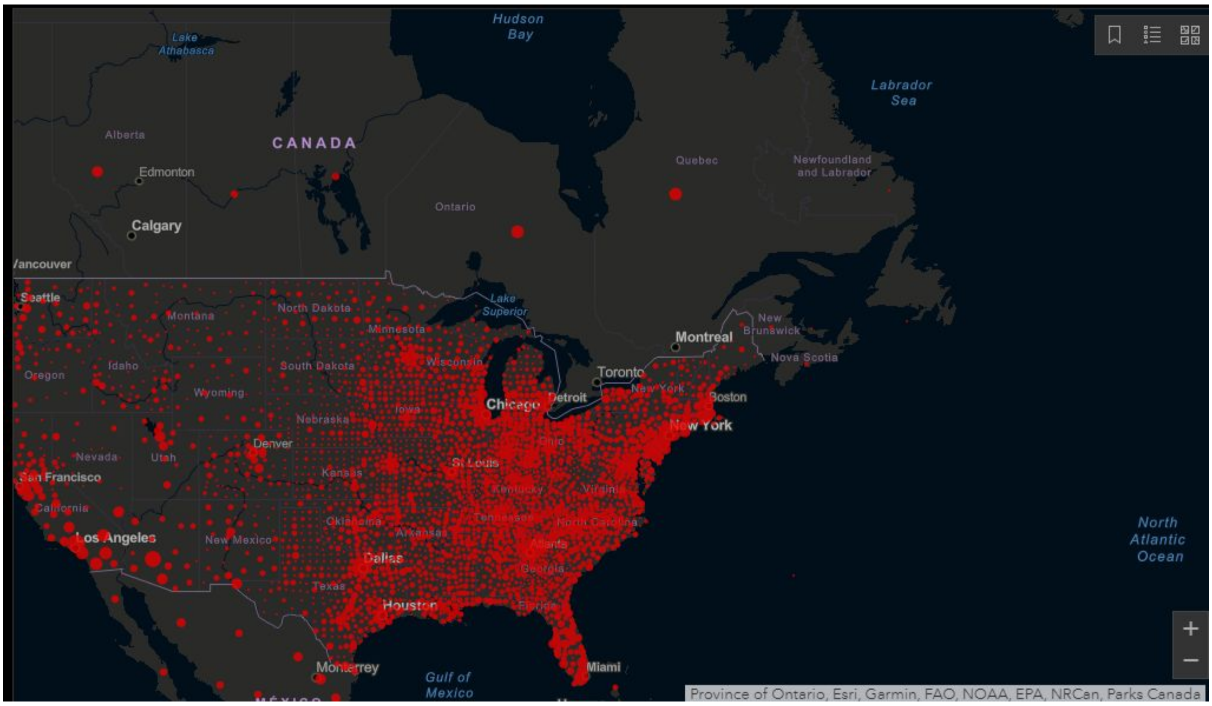

Figure 13 Pandemic map at intermediate zoom level showing nations, states, provinces and major water bodies [13]

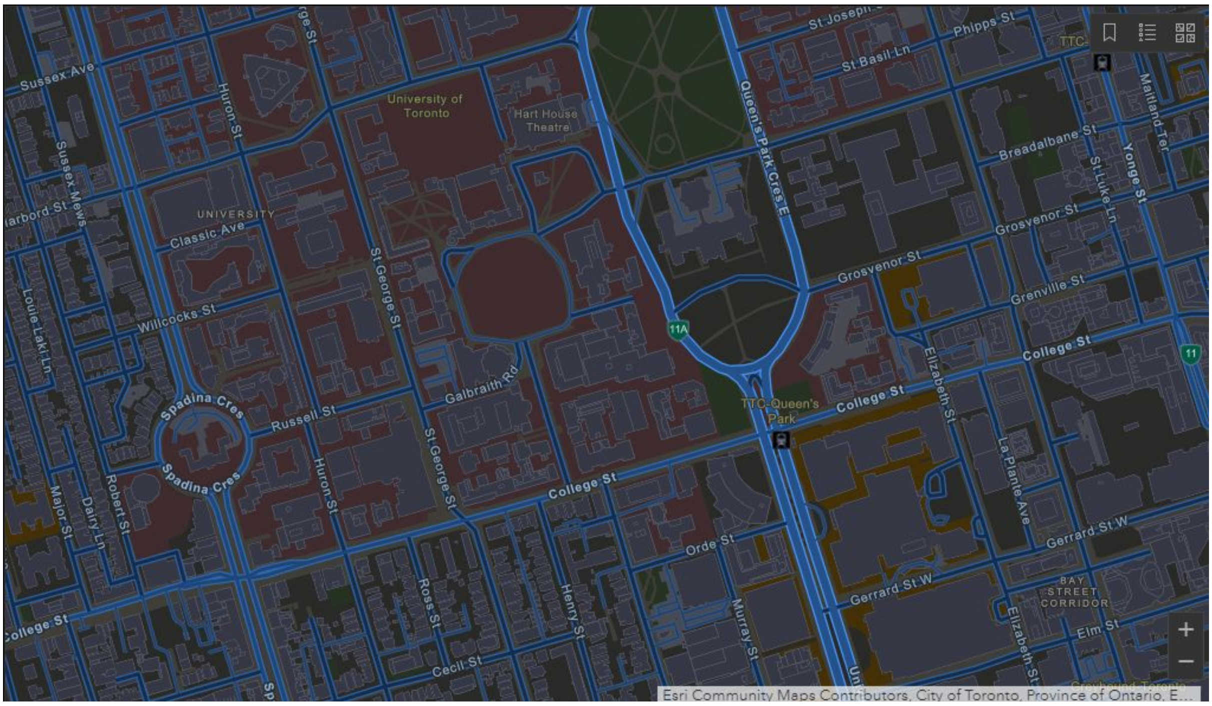

Figure 14 Pandemic map at highest zoom level, showing individual building outlines [13]

Also, hiding insignificant details reduces clutter and makes the map easier to view. Looking at the map at a province level but seeing individual building outlines would be useless at best and distracting at worst.

2.3.3 Icons Unaffected by Zoom Level

Even though the map can be zoomed in and out, features that are not part of the geography stay the same size relative to the screen (Figures 15 and 16). Therefore, these features are visible in all zoom levels. If the features stayed the same level with respect to the geography, they would either be unreadable at large scales or too large at small scales.

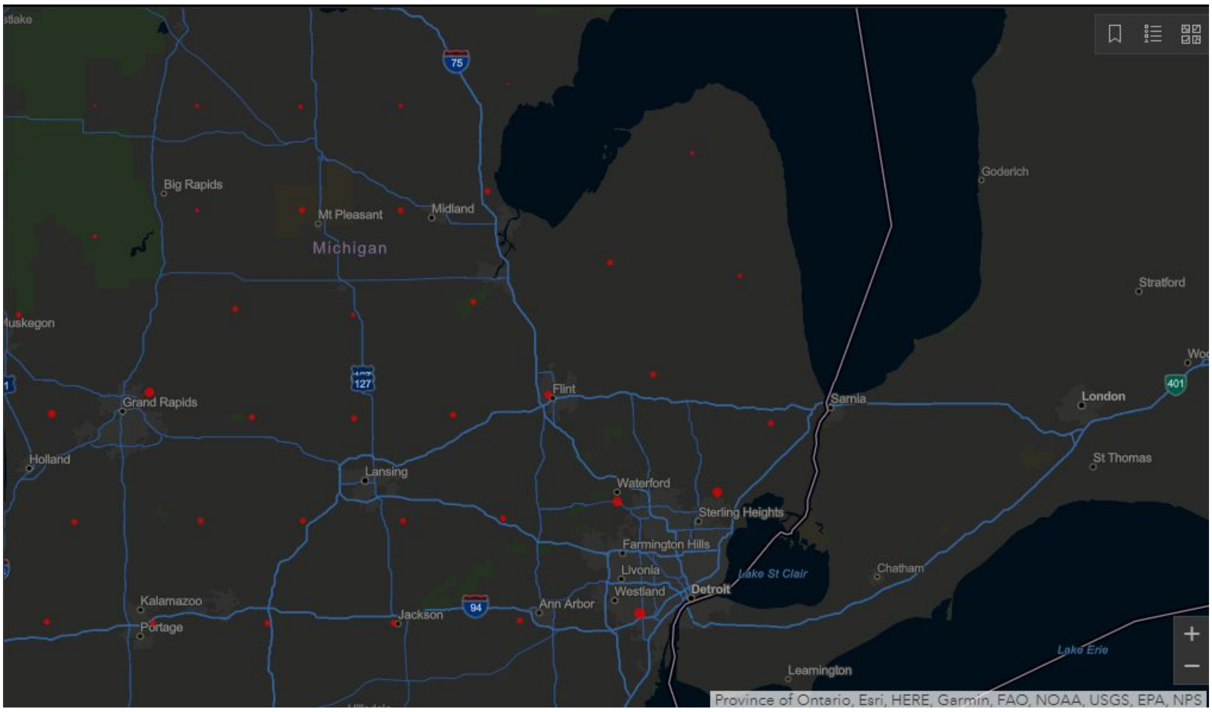

Figure 15 Pandemic map at high zoom level [13]

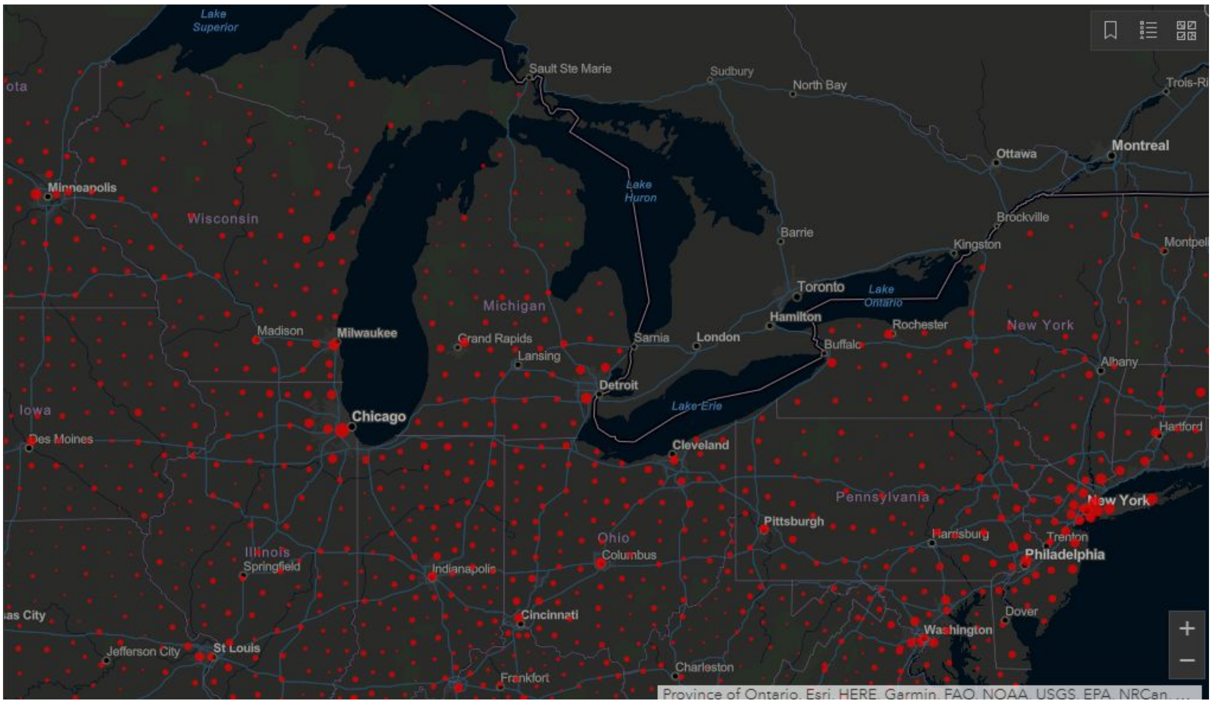

Figure 16 Pandemic map at low zoom level [13]

3.0 Proposal

We used our findings from the SAR to design our GUI. As seen on Figure 17, our design follows the colour scheme of Google Maps discussed in 2.1.1. To create interrelations between colours, the POI icons with similar purposes are indicated with the same colour. The search result has its own unique icon and colour. This enables users to easily locate POIs and search results. Universal symbols are used to provide accessibility. Additional information will be displayed when the mouse is hovered onto the point.

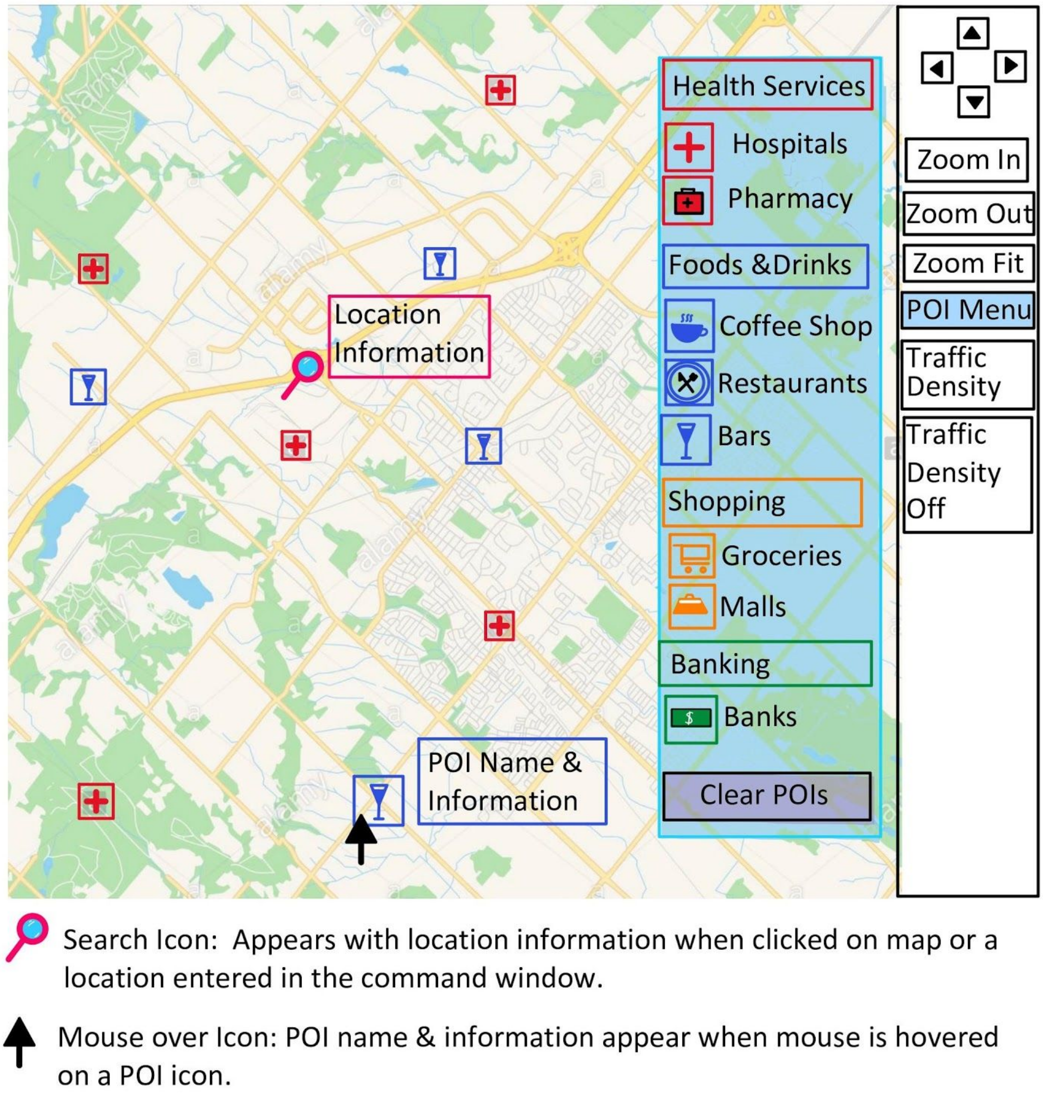

Figure 17: Prototype of dropdown POI menu and overlayering of icons with search and hovering features. Base map: Empty vector map of Milton, Ontario, Canada. [16]

To enable display of common and important POIs, we will implement a drop down menu. Icons and mouse-over text allow easier navigation. Multiple POI types will be selectable to be displayed simultaneously (Figure 17).

Another feature will be to display traffic density data. This data will be shown similar to IMM map: lighter, green colors show less traffic; and darker, red ones show more. Thus users can choose routes with less traffic to travel faster (Figure 18).

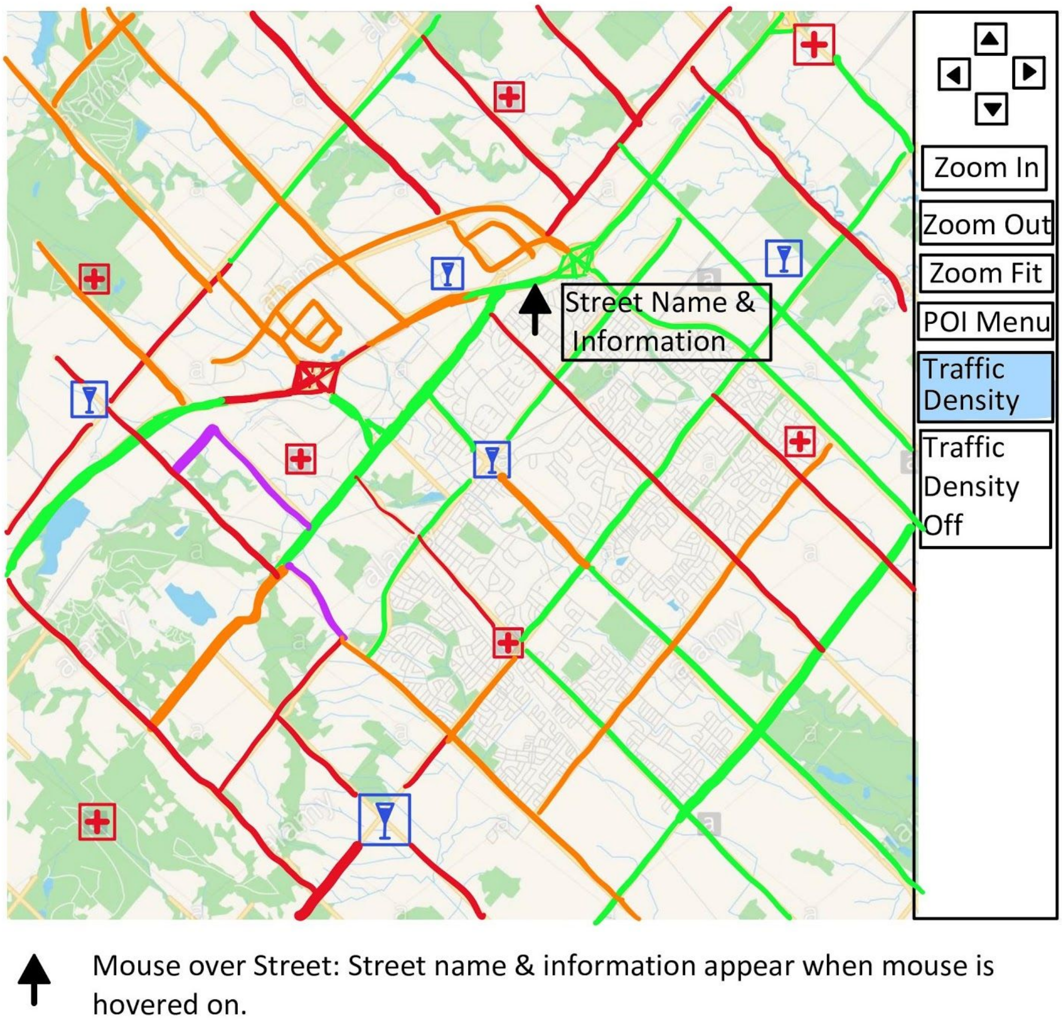

Figure 18: Prototype of traffic density interface overlaid on icons, also showing the hovering features. Base map: Empty vector map of Milton, Ontario, Canada.[16]

In order to minimize clutter, we will select the amount of information to be displayed as discussed in 2.1.2. Further, the data for higher zoom levels is unloaded when the user zooms out. This way, we plan to limit the memory use of the program, leading to better responsiveness.

4.0 Testing

In this section we will be discussing techniques to be used to measure our designs responsiveness and usability.

4.1 Testing Responsiveness

We will test response time limits for each time-critical input using the industry standard timing of 0.1s for instantaneous response [17]. Then, we will create unit tests for each to be run 1000 times with different maps and see if the performance is satisfactory.

4.2 Testing Usability

We will be testing important aspects of the UI, using the hallway testing method [18] with metrics shown in Table 1 to see if they follow usability guidelines. We will also use the *Observations* method [18] of determining usability when testers are completing their tasks.

Task	Metric
Hide/show traffic overlay	Time taken by testers, number of steps
Finding desired POI	Time taken by testers, number of steps
Feeling of ease of use	Qualitative comments from each tester

Table 1: Tasks and metrics to be used to measure usability of our design.

5.0 Conclusion

For our graphics, we will implement features inspired from multiple State-of-the-Art GIS's to increase usability and responsiveness. We will use colors, icons, traffic density displays, menus and zoom options to achieve this purpose. We will then test responsiveness and usability of our GIS, using unit tests in conjunction with qualitative tests. Plans discussed in this proposal are suspect to change through an iterative development process.

6.0 References

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7.0 Attribution Table

Section	Names		
	Ege Feyzioglu	Deniz Uzun	Kerem Serdar Ozturk
1.0 Introduction	ET	WD, ET	
2.1 Google Maps SAR	ET	RS, WD, CR	
2.2 IMM Traffic Density Map SAR		ET	RS, WD, CR
2.3 Johns Hopkins University SAR	RS, WD, CR, ET		
3.0 Proposal	WD	WD, PR, ET	WD, ET
4.0 Testing	WD	RS	RS, ET
5.0 Conclusion		MR, ET	WD, ET
6.0 References	CR	CR	CR
Overall Document	FP	FP	FP

RS – Research

WD – Wrote Draft

MR – Major Revision

ET – Edited for grammar and spelling

CR - Cited references in IEEE format

PR - Prototype

FP – Final proofread of complete document verifying for flow and consistency

Note: Word count is 1592 without titles, figure explanations, citations and their reference numbers embedded in text.