A New City Map

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1. Introduction

Maps have been made for thousands of years. Their makers, the cartographers, have fascinated people with their creations and the scope of their usage has been vast. As much as cartography is science, it is also art. While this interpretation of the fruits of their labour depends greatly on those who are observing, even more important is how the cartographers themselves are framing their creations. As Marcel Duchamp so very nicely put it, “Anything can be art, but everything is not already art. What makes something art is the act of framing it as art”.

The maps have historically often given a distorted view since the maps present the world through the lenses of the cartographer. There are a wide range of reasons why this phenomenon occurs. There are objective logical reasons such as the difficulties associated with projecting an ellipsoidal earth onto a flat piece of paper. There are also subjective reasons such as their lack of knowledge, his or her biases, the explicit needs of the audience or their general feelings about the geographical region being described.

The integration of non-spatial data with the base spatial data has brought along a new category of maps. These new maps are not just conveying geographical information, but also some other pieces of data. In cartographic literature, it is known as thematic cartography [6].

Road layouts give us a picture of the day to day flow we humans have through the landscape. The streets often differ greatly from wide to narrow, short to long, straight to curved. Bound together with intersections we get a network as we know as the street map, and although they are relatively Spartan on their own, they can indeed be an ingredient in the creation of a piece of art. Since cartography centers around interpretation of spatial information through visual mediums, we believe we can take aspects of cartographical interfaces and modify them through an artistic process to enable viewers to experience familiar geographical areas being transformed into an artistic interpretation.

In this paper, we want to look at how street maps can be used for making abstract art. Could an end user utilize this tool to make art out of their own neighborhood? What kind of non-spatial data can be encoded into the street map to enrich the street map?

2. Related Work

Today there are many different cartographers who love to make maps with non-spatial data. One of them is the graphical designer Paula Shcer [1]. She is making maps with many different data visualizations. One is a map of the US that includes counties and zip codes. This map illustrates how some little counties have many zip codes while many big counties have only a few. Another is a demographic map that shows the age of people and racial and ethnic background (fig. 1). Paula makes use of color, and markers to emphasise these factors, creating a vibrant cartographical representation. The painting for Paula is not the most practical way to encode the information, but most artful and expressive.

Figure 1. The US with states, and zipcodes

The next project is not per se art, and isn't made for it either, but shows one of the ways OSMnx [2] has been utilized. The road curvature map [11] is made by a curvature algorithm which glued together consecutive road segments and determined their orientation relative to each other. Through this method, it determines the curviness of the roads and encodes it with a multi-color gradient as shown underneath. The purpose of this program is to determine roads which are optimal for motoring enjoyment, particularly for motorcyclists.

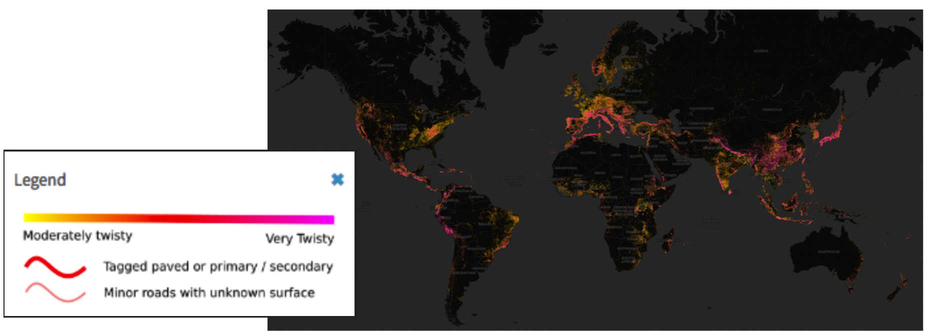


Figure 2. Road Curvature Map

Another interesting piece of work was introduced by Michael Batty. His work focused mainly on visualizing the general concept of movement within cities, London being the city of choice for his study[9]. Batty introduces two main spatial models which focus on transit flows in high density cities and generalized flows of people from a nation perspective respectively. This visualization helped to influence the way in which we conceptualized the visualization of road networks in an artistic way by helping us understand the role of visual contrast and its qualities for emphasis and visual clarity. Figure 3 below illustrates Batty's findings with respect to the city of London. The illuminated road pathways bring emphasis to the street networks and transit hotspots within the city. The nature of this image could be interpreted to have artistic qualities however the purpose of this visualization is mainly to bring emphasis to the topic at hand and aid readers in understanding the underlying context of the question at hand. We could then conclude that the purpose for this visualization is utilitarian in nature as opposed to being created strictly motivated by the pursuit of aesthetic and artistic qualities.

Figure 3. Road Networks in London with high volumes of movement

As for combining art and scientific data, many practitioners are contributing to applying art to data visualization[13]. One of the art visualizations is the “Wind Map”[14] (seen in Figure 4). It uses scientific data to represent the movement of the air. From an artistic perspective, it represents the emotional meaning that changes from day to day.

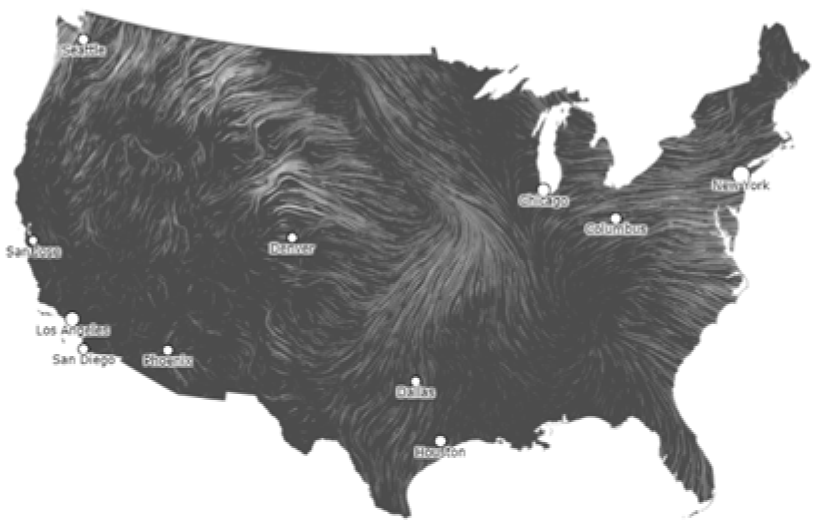


Figure 4. The Wind Map

Finally, a paper which influenced the development of our visualization is R.Wettel’s “Visualization of Software Systems as Cities” [12]. In this visualization, Wettel and Lanza leverage the city as a metaphor to represent a software system. This visualization presented a creative, yet artistic way to encapsulate the various moving pieces of an object oriented software package. Code City, the interface (seen in Figure 5), generates an interpretive and visually pleasing atmosphere and allows users to use existing experience/understanding of a certain topic (cities) to bring life to a potentially more abstract topic (software systems). We seek to leverage the same theme where we use a familiar and digestible medium (art) to help bring more life to an otherwise potentially opaque/specialized topic (road network/neighborhood layout.) Code City, through its various metaphoric interpretations leverages multiple factors to build out the city based visualization, and likewise our visualization will leverage multiple environmental factors to influence its output.

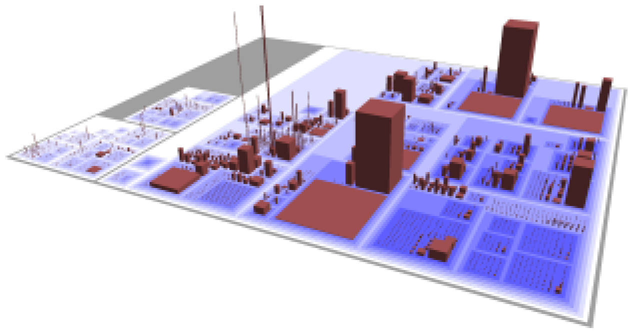


Figure 5. Code City

The vast majority of entities presenting road data in the visualization space present this data as a means of enabling users to interpret an underlying subset of information from a practical perspective. This information is therefore often presented in a utilitarian and pragmatic way. Spatial information is often aggregated and filtered in such a way that it presents only the information that is relevant to the user at a given moment. We seek to present a nuanced and generalized solution that works to convey road/neighbourhood information through an artistic lens while influenced directly by the spatial data at hand.

3. Data and Task Abstraction

3.1 Datasets and Data Abstraction

Primarily, the dataset used is derived from OpenStreetMaps (OSM)[7]. In OSM, any combination of roads, walkways, bike paths, or trails can be returned for a given area. The data are thus divisible for driving, cycling, and/or walking. The structure is that of a graph, where, for example, in the driving network, the edges represent roads and the nodes represent connection points or intersections between roads. In the case where an intersection is a roundabout or holds some structure, that intersection then consists of edges with nodes connected to each of the incoming roads. In the case where roads are separated in direction by a median of reasonable size, each direction is represented as an edge. In most cases, a road with lanes going either in one or two directions without a median is represented as one edge.

Each edge holds attributes that describe the road. These attributes are shown in Table 1. Because OSM is curated by the open-source community, not every attribute is available for each edge. All edges have at minimum: the origin node and destination node. Each node holds attributes that describe the connection or intersection. These attributes are shown in Table 2. In this case, these attributes are always present.

Attribute	Attribute Type
origin_node	int, ordinal
destination_node	int, ordinal
oneway	bool, categorical
lanes	int, quantitative
name	str, categorical
highway	str, categorical
maxspeed	int, quantitative
length	int, quantitative
geometry	LineString

Table 1. Edge attributes presented in OSM data.

Attribute	Attribute Type
latitude	float, quantitative
longitude	float, quantitative
street_count	int, quantitative

Table 2. Node attributes presented in OSM data.

Additionally, OpenStreetMap holds a large corpus of amenity points of interest. These amenities range in use from sustenance, to education, to healthcare, and more. A full list of amenity categories is listed in Table 3. Within each category, there are a number of subcategories, saved as a dictionary of category keys and more specific subcategory values. A representation of these subcategories is shown for the broader category of "Education" in Figure 6. Most of these amenities are represented as **point** or **area** marks.

All cities are different, but in the bounds of Vancouver, BC, Canada, there are 22,668 edges, 7,606 nodes, and 9,965 amenities. In a neighborhood within Vancouver, for example, Kitsilano, defined as 1km radius from a center point in the neighborhood, there are 522 edges, 163 nodes, and 613 amenities.

Amenities
Sustenance Education Transportation Financial Healthcare Entertainment, Arts & Culture Public Service Facilities Waste Management

Table 3. Amenities present in OSM data. All amenities are string categorical values.

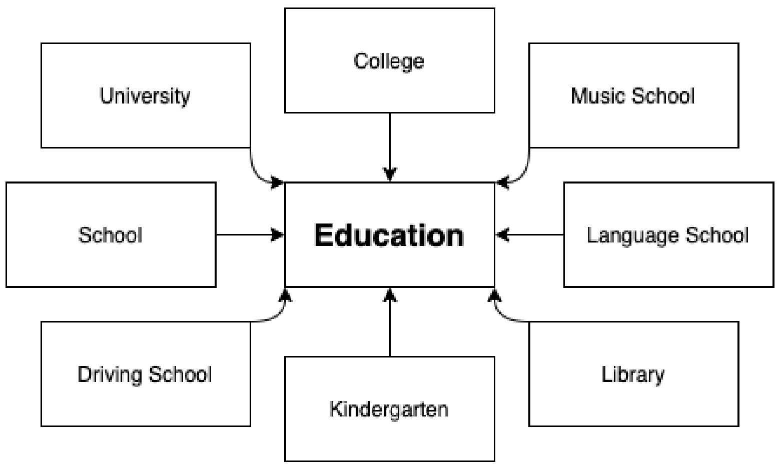


Figure 6. Subcategories of amenities for the "Education" category in OSM.

3.3 Tasks and Task Abstraction

An end user would use this visualization to create art from their neighborhood in order to foster a personal connection. Through this visualization tool, the end user would be able to define their home neighborhood and create abstract art pieces from the streets and intersections that comprise this place. The abstract art is created by separating the edges of the specified neighborhood and rearranging them randomly or according to predefined styles.

Outside of the domain of road networks, this visualization implementation could be extrapolated to any domain with line or shape structures that wish to allow their users to connect with the underlying dataset. At its core, the task follows the abstraction action definition of Analyze > Consume > Enjoy. An end-user may not seek out art created through the rearrangement of roads but could be satisfied by the creativity of the visualization and create art for many important locations in their life. Alternatively, the same visualization may follow the abstraction action definition of Query > Compare in which a user is converted from simply an enjoyer into someone interested in the comparison of art produced for different neighborhoods around the world.

4. Proposed Solution

4.1 Implementation

We have identified a proposed technical solution, and it is in the process of being refined. To enable users to interact with our visualization, we have created a single page web application using the React framework leveraging Typescript as our language of choice. Typescript is effective in that it should allow us to keep our application type-safe and adherent to current mainstream application development best practices. In this application, we are using Mapbox[5] along with the react-map-gl[10] wrapper which helps to facilitate access to Mapbox functionality such as capturing user input and displaying the output art. Mapbox will also allow users to actively engage with a cartographical interface which should provide them with the context of what we are trying to achieve. For our current visualization interface, please see Appendix A Figure 2.

To access the OpenStreetMap data which serves as the basis of the artistic visualizations we are going to display, we are using OSMnx[2], a library developed to allow users to easily access and manipulate OpenStreetMap data. This library will allow us to fetch, curate and store the data we are going to require to generate artistic visualizations for each neighborhood. We are currently working on a mechanism to cache/preprocess a subset of spatial data to improve processing speed. To complement this library, we are planning to use FastAPI[4] to serve as the data access layer. FastAPI will act to facilitate data exchange via REST endpoints to the UI layer of the visualization. Since FastAPI is Python-based, it should seamlessly integrate with OSMnx.

We are currently exploring multiple options when it comes to creating the artistic visualization of the neighborhood. Leveraging D3.js[3] to create the output artistic visualization and directly render it in-app by providing the library with our curated data is one option currently being considered. Another option would be to render visualization in the backend layer via OpenCV[8] and deliver the output via image format to the user interface. This approach would separate the UI layer and the data processing layer completely and may result in better performance at the cost of additional overhead in formatting the output on the UI layer. The output processed art will be delivered to our web application via FastAPI and we are still addressing the technical challenges of each option for artistic visualization [Appendix A, Fig 1].

4.2 Scenario of Use

Our end user is looking for a gift for a friend. She knows that her friend loves art, so she is looking for something different and interesting. Our end user and her friend used to be roommates and loved walking around their neighborhood of Kitsilano, so she would love to find something that brings in this personal connection. She finds this visualization tool and creates art through the following steps:

1. The end user enters the address she would like to center her art around or places a pin to choose it on the map. She also can optionally choose the style of art for her neighborhood piece from a predetermined list of styles.
2. The system draws a 1km radius around this point to define the road edges and nodes that will be incorporated into the art piece.
3. Within the 1km radius, the areas of interest and unique characteristics of the neighborhood are retrieved by the system to influence the position of the edges as well as other channels such as color, width, or smoothness.

4. The edges and nodes are separated into distinct pieces and rearranged according to the chosen style, or randomly by default. Points of interests, amenities, and features of the road edges help define the color and line weights of the final art pieces. For example, roads near parks may be green while large arterial roads may be wider in line width.
5. The end user is able to download their art as an image, create a new piece from the same location, or create a new piece from a different location.

4.3 Illustrations

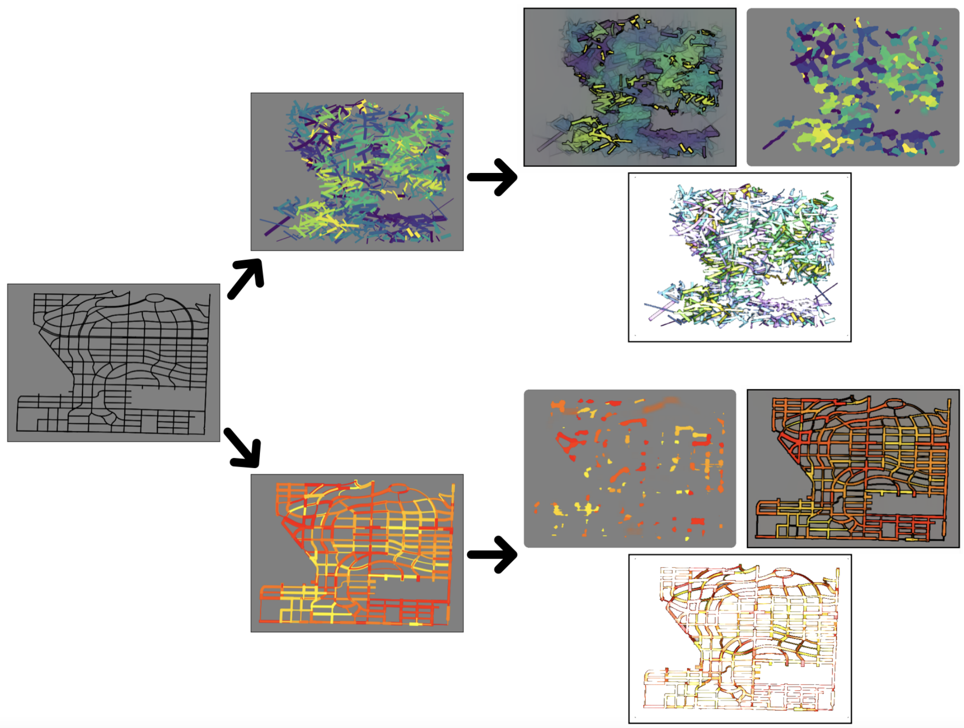


Figure 7. A first illustration draft of how a neighborhood layout may be transformed into art.

The above illustration (Figure 7) shows an example of creating art from only the road network of a user's neighborhood (excluding the points of interest). In this example, the neighborhood of Shaughnessy in Vancouver, BC, Canada is shown transformed in two ways. The top example shows a random rearrangement of the street layout and a distribution of color and line widths for each road. The bottom example shows the same neighborhood only with the distribution of colors and line widths, but the shape of the neighborhood is preserved. Each of these examples are then transformed into different styles which could be determined by the user's preference for art style. In both of these examples, the colors and line widths are determined randomly as opposed to based on features inherent to the local area or road edges.

5. Milestones

We plan to spend about 320 hours together towards the project. Table 4 provides a rough estimate of the project's tasks. Application development will be handled by Hongyang, David, and Niels. Data science work will be handled by Madison. Research, development, and literary responsibilities will be shared by all of the members of the group.

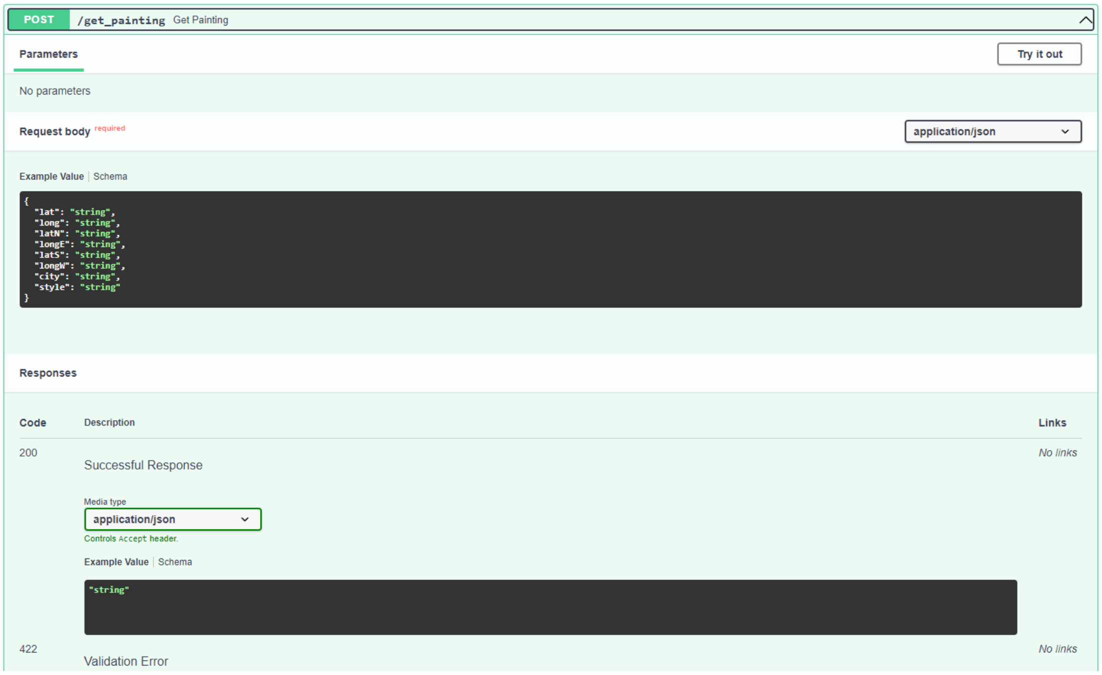
Task	Hours per person (Estimated)	Deadline	Description	Current Status and Comments
Pitch	3	Sep 29	Raise ideas, search for the dataset, create slides, and rehearse pitch(ALL)	Complete
Pre-proposal meetings	4.5	Oct 13	Finalize group, get the dataset(Madison), brainstorm project topic and define the topic(All), meet with Tamara(All), update the topic(ALL)	Complete
Proposal	3	Oct 21	Write the project proposal(ALL)	Complete
Implementation	10	Ongoing	Learn selected tool(ALL)	90% Complete, still finalizing visualization display workflow therefore still potential fluctuations in our stack
	3.5	Oct 23	Clean and analyze data(Madison)	Complete for baseline artistic rendering, additional data being evaluated for more granular control of artistic rendering output
	6	Oct 25	Determine image generating methods(ALL)	Ongoing 70%, still evaluating which approach is optimal for displaying the output art.
	3.5	Oct 27	Finish the requirement analysis of the display layer project(Niels, David, Hongyang)	Complete
	10	Nov 3	Design and implement baseline single page application(Niels, Hongyang) Implementation of baseline data service layer Python backend (David)	Ongoing, react application created and work on map and rendering has begun Ongoing 80%. Discussing the final decision on how we want to display the output art on the

			Process the data and image generation in Python (Madison) **Will be collaborative**	front end. Ongoing, initial data processing and image generation for multiple categories of art is complete. Currently adding additional factors into influencing the output art.
	6	Nov 7	Finish the first draft of the project(ALL)	Ongoing, 75% complete
Project Report Update	3	Nov 16	Update project report(ALL)	Complete
Peer Project Review	4	Nov 17	Prepare the project demo, review peer project, and get suggestions(ALL)	Not Started
Refined impleme ntation	10	Nov 28	Implement image generating methods(Python: Madison, React: Niels, Hongyang, David)	Not Started
	3	Dec 10	Polish implementation(add features, improve feasibility, etc.)(Niels, David, Hongyang), prepare demo(Madison)	Not Started
Final presentati on	6	Dec 15	Prepare and rehearse presentation(ALL)	Not Started
Final paper	8	Dec 17	Finalize paper(ALL)	Not Started

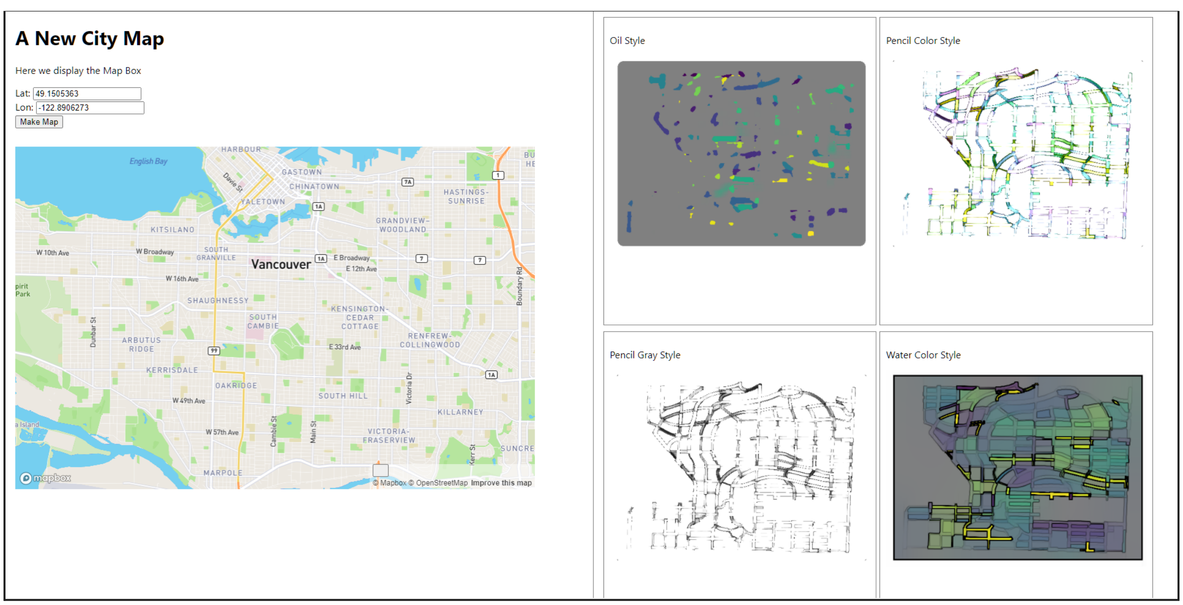
Table 4. A rough estimate of the project's tasks with additional comments

6. Appendix A

6.1. Fig 1. FastAPI implementation



6.2. Fig 2. Front End implementation, work in progress



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