# A New City Map

David Chen, Hongyang Yang, Madison Lore, Niels Semb

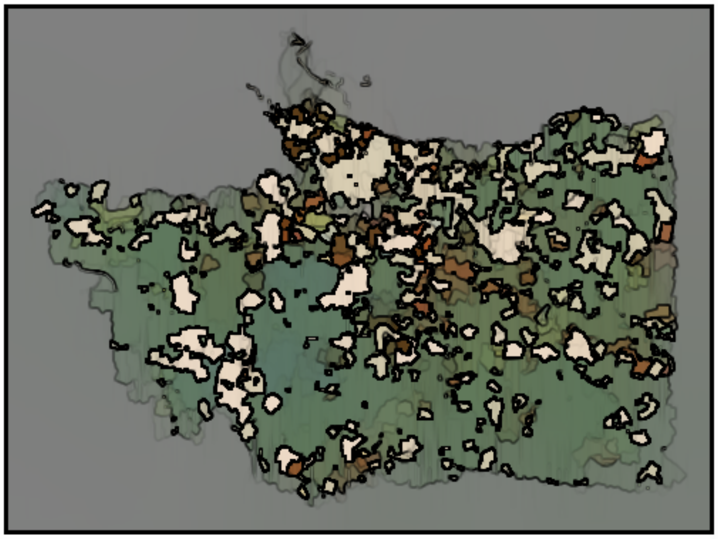

Fig. 1 Artistic rendering of Vancouver, Canada. Each color represents a land use or amenity type. The beige represents more retail areas while the green represents more residential.

**Abstract**—In this paper we seek to understand how street maps can be used for making efficient, tailored, abstract art. Often art pieces require a tradeoff between cost-effective automation and personalization. Either the piece has little relation to the buyer, or it requires a large amount of money and time to personalize it. We propose a visualization solution to this dilemma by creating streamlined art pieces based on a user's input location or address. The output includes a choice of three art styles: oil, watercolor, or color pencil. The spirit of the neighborhood surrounding the location is preserved through color encoding local amenities and linewidth encoding the type of roadway. A coordinated, juxtaposed layout of the interface allows for easy comparisons between art styles and to the originating map. All together, this solution allows an end user to inquisitively compare art from different neighborhoods or cities, or simply enjoy the efficient and personalized generation of abstract art from locales around the world.

**Index Terms**—visualization, cartography, cartographic art, abstract art , computer generated art

## 1 Introduction

Maps have been made for thousands of years, by people of civilized and primitive societies [2]. 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, and was primarily a form of art until the late eighteenth century [2]. Maps seek to render the space as a two-dimensional surface, flattening the space into a digestible form [11, 2]. While the interpretation of the fruits of cartographers' labor depends greatly on those who are observing, even more important is how the cartographers themselves are framing their creations. As Marcel Duchamp, a French artist, 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".

Maps have historically often given a distorted view, since they present the world through the lens 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. In some contexts, for example the colonization of indigenous land, maps were a tool to manage the dispossession of native people and land. Here, the distortion came in the simplification of information and assimilation of information into the Euro-centric Cartesian grid [11]. In response to this, a new field of counter cartography, or counter mapping, has emerged to protest the history of state led cartography [18]. Counter maps show the non-spatial aspects of a place and can better represent the feeling one has in a place. However, the integration of non-spatial data with the base spatial data has brought along another new category of maps, referred to as thematic cartography [15]. These new maps are not just conveying geographical information, but also some other pieces of data. These maps can bridge the gap between the benefits of traditional geographic mapping through spatial grounding and the benefits of place-based counter cartography traditionally used by indigenous groups.

Today, road layouts give us a picture of the day-to-day flow 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

- *David Chen, Hongyang Yang, Madison Lore, and Niels Semb are with the University of British Columbia.*
- *E-mail: davidchen14855@gmail.com, hyang98@student.ubca.ca, mlore@student.ubc.ca, Nielssolesemb@gmail.com*

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, we draw from counter and thematic cartography methods of conveying information and feelings about a place. While this approach is not new in nature, we find that artistic maps (i.e. maps for purposes other than wayfinding) are often not tailored to the end user in a locally relevant way, and if they are, they are too expensive for a common person to commission. This trade-off means that most people are unable to own artistic maps of their neighborhoods, cities, or favorite places.

In this paper, we want to look at how street maps can be used for making inexpensive and efficient, locally relevant, 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 make maps with non-spatial data. One of them is the graphical designer Paula Scher [1]. She creates maps that encode various data pieces, such as a map of the United States that visualizes counties and zip codes. In this, she allows the user to explore the relationships between county sizes and amount of zip codes. Similarly, another map is a demographic map that shows the age of people and racial and ethnic background. Scher makes use of color and glyphs to emphasise these factors, creating a vibrant cartographical representation. Work like Scher's shows that information can be conveyed in an artistic and meaningful way, which may appeal more to certain audiences than more efficient cartographic methods.

Through art or otherwise, colour is an important piece of how you emotionally connect with and understand your surroundings. In "Affective Palette" [21] they explain how a colour system can increase the affective connection between environmental data and its original source. Here, end users are enabled through the workspace ColorLoom to automatically extract color palettes from natural pictures. The ColorLoom team present how these palettes when utilized strategically, can create an effective visual framing for communication. These findings gave us inspiration regarding how colour should be mindfully selected from the environment.

In another vein, data can be encoded into geographic representations to convey information for the end user to gain knowledge. For example, a road curvature map [9] is made by an algorithm which glues together consecutive road segments and determines their orientation relative to each other. Through this method, it determines the curviness of the roads and encodes it with a multicolor gradient. The purpose of this program is to determine roads which are optimal for motoring enjoyment, particularly for motorcyclists. In this sense, the created map is presenting the information in a more efficient, but less artful manner. Similarly, work by Batty focused on visualizing the general concept of movement within cities, London being the city of choice for his study [3]. Batty introduced two main spatial models which focus on transit flows in high density cities and generalized flows of people from a nation perspective. This visualization helped to influence the way in which we conceptualized the visualization of road networks illuminating the role of visual contrast and its qualities for emphasis and visual clarity.

As for combining art and scientific data, many practitioners are contributing to integrating art into data visualizations [20]. One of the art visualizations is the "Wind Map" [23]. 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.

Centinic's "Understanding and Creating Art with AI: Review and Outlook" [7] provides a solid foundation in the field of Artificial Intelligence (AI) generated art pieces. In this paper, neural networks seem to be the premier medium for which model AI driven art generation is based. Although these learnings helped satisfy our curiosity when it came to fully AI generated art, they did not provide a usable framework which could fully generate geographic based art that satisfied our requirements. This knowledge did prove invaluable when we pursued the use of OpenCV filtering to generate our artistic representations of our visualizations since it served as the foundations for the models employed in this paper.

Finally, a paper which influenced the development of our visualization is Wettel's "Visualization of Software Systems as Cities" [24]. 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, 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 metaphorical interpretations, leverages multiple factors to build out the city-based visualization, and likewise our visualization will leverage multiple environmental factors to influence its output.

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 and 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 OpenStreetMap (OSM) [17]. 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. Because OSM is curated by the open-source community, not every attribute is available for each edge. For the purposes of this paper, we are interested only in the geometry describing the physical location of the edge and the highway classification describing the volume of traffic expected for the edge.

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 Figure 2. Within each category, there are several 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 2. Most of these amenities are represented as point or area marks. We will treat them as point marks, described by their longitude, latitude, and categorical name.

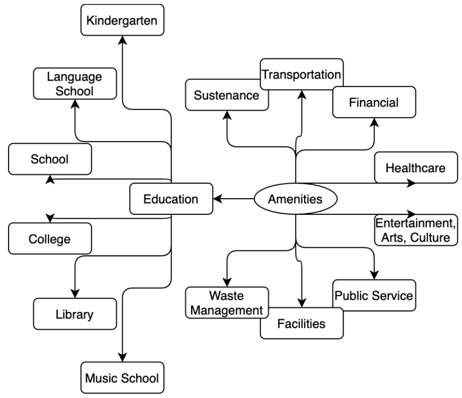


Fig. 2 Amenities present in OSM data. All amenities are string categorical values. Subcategories of amenities are shown for the “Education” category.

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 1 km radius from a center point in the neighborhood, there are 522 edges, 163 nodes, and 613 amenities.

### 3.2 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 amenities that comprise this place. The abstract art is created by separating the edges of the specified neighborhood and assigning them colors and widths 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 reimagining 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 or different art styles for the same neighborhood.

## 4 Proposed Solution

In this section we describe the implementation of the final visualization, the underlying framework for creating the road art, and a proposed scenario of use for an end user.

### 4.1 Implementation

To enable users to interact with our visualization, we have created a single page web application using the React framework leveraging JSX as our language of choice. JSX 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 [14] along with the react-map-gl [19] 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. Our visualization interface is shown in Figure 3 and Figure 4.

To access the OpenStreetMap data which serves as the basis of the artistic visualizations we are going to display, we are using OSMnx [4], 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 require to generate artistic visualizations for each neighborhood. To complement this library, we are using FastAPI [8] 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.

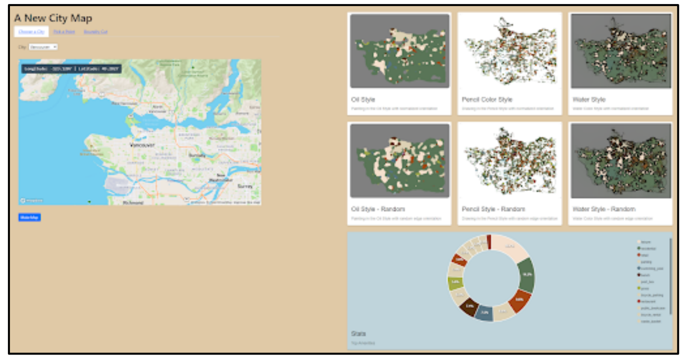


Fig. 3 A screen capture of the visualization interface.

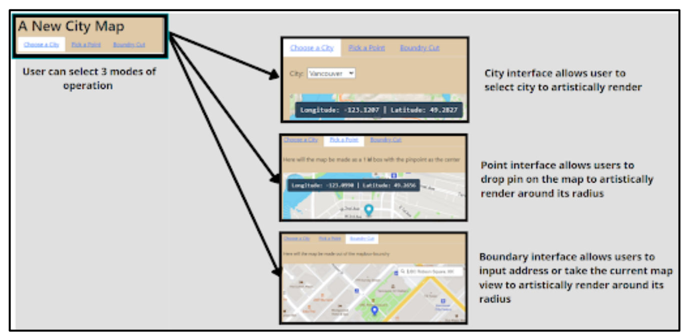


Fig. 4 The user can select one of three operations to generate the map: 1) a map of a whole, preprocessed city; 2) a map of a 1 km box around a pinpoint selected on the map; 3) a map of what is shown in the Mapbox display potentially around a user entered address.

In the python backend, we pre-process a great deal of data that we extrapolate from Open Street Maps. The data is collected, curated, and enriched with the information required to generate the visualization. Based on this pre-processed data, we render the visualization in the backend layer via OpenCV [16] and deliver the output via image format to the user interface. Leveraging the built-in HTML/JS based image rendering functionality, we can extrapolate and display the raw uncompressed image which comes as an output of OpenCV. This approach separates the UI layer and the data processing layer completely and results in better UI performance at the cost of additional overhead in formatting the output on the backend layer. The backend generation of the art happens in our created Python class. The class takes in either a longitude, latitude coordinate point or a bounding box and retrieves all the roads and amenities relevant for art creation (with a 1km radius added to single dropped pin coordinates). It then assigns the colors and linewidths for each road segment. Some of the art styles are labelled “Random”, where a rando amount of tilt is applied to the road segments for more scrambled art pieces. This is to deliver a more abstract look to the art pieces. The resulting road layouts are rendered using OpenCV [16] and delivered to our web application via FastAPI in PNG format shown in Figure 5. D3.js [5] was evaluated for generating SVG based images which our implementation can support, but ultimately our default output format was chosen to be PNG based on ease of integration.

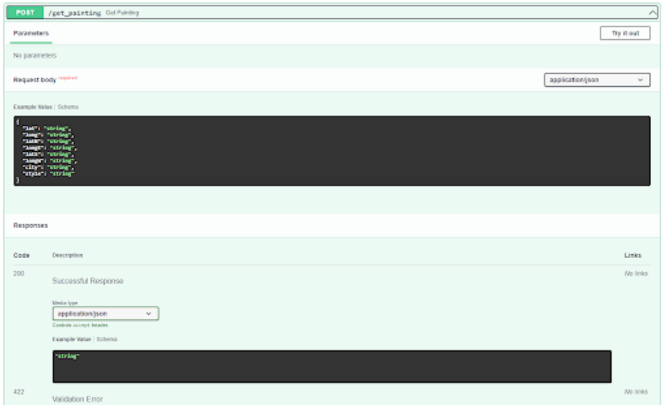


Fig. 5 FastAPI interface showing resulting road layouts delivered in PNG format.

### 4.2 Underlying Framework

The underlying framework is comprised of two complementary pieces: the backend that creates the map art and the front end that interacts with the end user.

#### 4.2.1 Map Art

We initially sought to capture the spirit of a geographical area by using art as our medium. We derived that this intangible spirit is greatly influenced by the physical constructs and contents of the area in question. To visualize this through an artistic lens we had to develop a unique idiom which leveraged the data we had available on hand, and moulded it in such a way which it could be considered art. To accomplish this, two main criteria must be met: 1) what is generated could be interpreted as and defined as art, and 2) that the resulting visualization is directly influenced by the cartographical and geographical data we had collected. According to Davies, art in this context, by definition, is "achievement in realizing aesthetic goals, and either doing so is its primary, identifying function or doing so makes a vital contribution to the realization of its primary, identifying function" [6]. We sought to follow this model at every step of our solutioning process, making sure that the art we create satisfies the perceived aesthetic needs of the user while also bringing them knowledge encapsulated in the visual representations.

The most basic element of this visualization is the road segment. These road segments are close to the concept of line marks in our visualization in that they are the main display unit used to convey information from the data. If we frame a map based geographical location as a graph network, the road segments would represent the edges which we would need to travel along to get from one location to another. In this sense they form the arteries of a neighborhood and therefore are the optimal choice as marks in expressing the data associated with the neighborhoods they permeate. Alternative mark choices such as intersection nodes were evaluated as well, however we noticed that using these marks did not support some of the channels we wanted to employ for artistic representation. Intersection nodes could only be represented as points in the artistic rendering, which made them easily drowned out by the other aspects of the artistic filtering we employ to satisfy our first objective, thereby rendering them less useful in conveying information.

In order to capture the spirit of a geographic area, we extrapolate data regarding the contents and amenities of the area in question, such as parks, retail space, or residential homes. From this data, we determine from prevalence and proximity the category under which our item, the road segment, falls. To convey this information in an artistic way, we decided to leverage the color channel. Color is used very frequently in both visualization and artistic depictions. It can direct the user's focus and allow them to make subconscious associations with their repertoire of knowledge [22]. This proves useful as we would like to convey the overall feel of the neighborhood to the user without bombarding them with explicit information like text, instead, relying on the implicit nuance of art to deliver this information. Especially given the artistic nature of the output, color chosen purposefully can invoke certain emotions of the end user. To determine which colors are mapped with which amenities, we relied on the work of cartographers to guide our decision making. In order to reduce the cognitive load, we opted to follow standard practices of Geographical Information Systems (GIS) mappers [12] to define colors related to amenities such as retail, residential, or leisure land. Additionally, within the standard practices, different color schemes are available for different purposes. For example, a mapper may use Jewel tones for a map that is distinctive or Muted tones for a map that "create[s] a 'quiet' feeling" [13]. Ultimately these color schemes may be chosen by the user, but as a default we have chosen Earth tones to better align the user with their environment, the goal of the visualization.

Roads represented by lines form the basis of the art piece. Since the identification of the first known map in 6th century BCE, humans have increasingly standardized the depiction of roads and buildings. Some of the oldest maps, including the Peutinger map from the 4th century BCE, show the importance, or traffic volume, by way of line width [10]. The wider the line mark depicting the road, the more important or higher the volume of traffic, a trend that continues today in maps and atlases online and offline. In keeping with convention in order to ease the cognitive load on the user, we too have based the line widths of the road segments based on roadway classification, in descending order: highway, secondary, tertiary, residential, and linking roads.

The final choice in art creation comes in the image filtering choice of oil, pencil, or watercolor art styles. These options are chosen for their diversity in utility, and each individual style has positive and negative aspects. The oil paintings are best utilized for showcasing the cohesion of an area. The color swaths blend nicely to create smooth edges and remove the boundaries created by streets. The watercolor paintings are best utilized for showing the density of each amenity as the transparent nature of watercolor painting emphasizes the layering created by more of the same amenity. Individual roads or areas of certain amenities, for example retail areas, are more distinct than the oil painting, making it less cohesive but more able to showcase the overlapping layers of a neighborhood. Finally, the color pencil paintings are best utilized for showing the diversity of amenities in an area. The colored amenities representing the road segments are best preserved in this style and allow for a greater patchwork of color to come through.

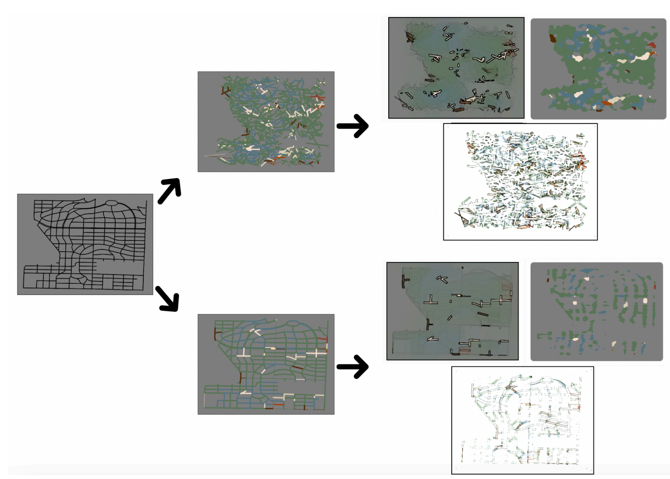

Fig. 6 An illustration of how a neighborhood layout may be transformed into art. The user can choose first if they want to preserve the shape of the road network (bottom) or not (top). Then, of the three choices from either shape preservation or randomization, the user can choose between watercolor (top left), oil (top right) or pencil (center bottom).

The above illustration (Figure 6) shows an example of creating art from only the road network of a user's neighborhood. In this example, the neighborhood of Shaughnessy in Vancouver, BC, Canada is shown transformed in two ways. The top example shows a rearrangement of the street layout and the assignment of color and line widths for each road. The bottom example shows the same neighborhood only with the assignment 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 examples, the colors and line widths are determined based on features inherent to the local area or road edges, as described by the encoding schema above.

#### 4.2.2 User Interface

The user interface is organized according to the benefits of our stated tasks of the end user: Enjoy and/or Compare. The map on the left is meant to anchor the user in a familiar space, geography. By always keeping this view available, it allows the user to juxtapose the geographic map with the artistic map in a coordinated fashion. Similarly, the organization of the art boxes on the right of the display share axes vertically and horizontally allowing the user to see the same data in the varying art styles. Because of the coordination, shared data, and shared embeddings in the underlying channels (excluding the art style), the cognitive load for the user is quite low and allows them to enjoy the creation with little explanation or reasoning needed. Additionally, a user can compare between the map and each individual art style easily, allowing them to see the land use that comprises a location as well as small differences in between the styles.

When a user inputs an address or chooses a pinpoint on the map, the surrounding area used to comprise the art is consistent. That is, a 1km radius is always drawn around the point. This consistency, along with the permanent placement of the differing artistic styles, again help to orient the user in comparing between art renderings.

The bottom tile in the user interface is a pie chart. This chart is meant to provide the user with a breakdown of the information regarding the color scheme present in the art itself. Our goal for this implementation is to show the relative contributions of various types of factors influencing the visualization at a glance. We select the top 15 most prevalent factors (some of which fall under the same category) to display in order to reduce clutter on the pie chart. Some factors share the same color since they fall under the same category when it comes to their distinct factor type. The pie chart medium is perfect for this use case since it is large enough to support recognizing the factors briefly and intuitive enough to help users recognize specific factors relative to the whole right away [15]. A similarly sized bar chart would have taken much more screen real estate to make it legible. Hovering the different factors brings about a popover which provides more distinctive information, and a legend detailing each factor is present on the right-hand side. Due to the prolific nature of pie chart interfaces, this interface gives the user a good idea about the quantitative aspects of the art in a quick and intuitive manner.

Finally, the low computational time of rendering the art is crucial to enjoyment and comparison. A scalable rendering framework ensures that the latency between choosing a point or location of interest and viewing the art is consistent. For choosing a point, because the size of the art is always only a 1km radius, the number of roads is fairly consistent.

### 4.3 Scenario of Use

Our end user, Emily, is looking for a gift for a friend. She knows that her friend loves art, so she is looking for something different and interesting. Emily 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. Emily enters the address she would like to center her art around or places a pin to choose it on the map.
2. The system draws a 1km radius around this point to define the road edges and amenities 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 and linewidth.
4. The edges are separated into distinct pieces and rearranged according to six different styles (oil, watercolor, color pencil; shape preserved or random). 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. Emily can download her art as an image, create a new piece from the same location, or create a new piece from a different location.

## 5 Milestones

We originally planned to spend about 320 hours together towards the project but spent closer to 350 hours. Appendix A Table 1 provides a rough estimate of the project's tasks and work schedules. Application development was handled by Hongyang, David, and Niels. Backend class construction work was handled by Madison. Research, development, and literary responsibilities was shared by all members of the group.

## 6 Discussion and Future Work

In our implementation, it was our intention to showcase a way in which we can deliver information about an area from a cartographic perspective in an artistic way. We were generally successful in meeting this objective but there are notable areas of improvement which could supplement this project to meet these objectives in a more comprehensive way.

Our current implementation displays information about a neighborhood or city to the user. It considers a variety of different factors like amenities and road importance for which an appropriate visual representation is assigned. The artistic aspect of the visualization allows us to deliver information in a more abstract way and express the connection between users and their neighborhood in a different way from traditional flat numerical approaches. This implementation is potentially suitable for delivering information to those who are both creatively and logically inclined.

This implementation is not without shortcomings, however. One major shortcoming of this visualization was the difficulty in conveying a larger amount of information without overloading the user's cognitive load. Since OpenStreetMap provides us with a great deal of data with which to work, we initially started with many different encodings and ideas like tilt of the road segments as well as intricately granular displays of points of interest on the visualization. This led to information overload and art renderings which, although artistic, failed to meet our objective for being able to convey information in a way which was digestible. In response to this we reduced the number of encodings to ones which were core to our mission of allowing users to better understand their neighborhood. This means that we unfortunately had to leave out a great deal of supplemental information in our visualization which may have enriched it from the perspective of completeness. Another major challenge in this implementation is the time it takes to render large datasets, like those of a full city rendering. The large processing time comes in the randomization of the street orientations, which occurs when the shape of the streetscape is not preserved. In scenarios where the target area on the map is relatively small, everything can be computed in a timely manner, however as the number of line segments increases, so does the computational time. To mitigate this issue, we preprocess our data quite rigorously and as such we can currently only render maps from cities which we preprocess. Each preprocessing step is on the order of minutes, depending on the size of the city and grabs all the data required for the map in one step. For example, this preprocessing step for Chicago, USA with 76,000 road segments takes 16 minutes, with the majority of the time (14 minutes) spent extracting the amenities of the area. This information is then kept on disk to be used during our art generation step.

In the future, if we are able to iterate further on this visualization, there are multiple avenues we could explore in terms of improving our application. From a rendering perspective, we could work on improving the time it takes to render large datasets i.e., generating maps for large cities or even provinces. This processing cost is attributed not only to the time it takes to get data via OSMnx but also the processing time required to label each line segment with the appropriate values for display. The most promising solution seems to be selective rendering and caching of important line segments. As areas become denser or locations of interest become larger (e.g., whole city), a smart implementation could utilize the road importance classification (e.g., highway versus tertiary road) to selectively render quicker. The tradeoff would be less detailed maps, but at larger scales, smaller roads are often lost anyway because of the blurring applied to the art pieces.

Another aspect we could improve on given the opportunity would be the artistic rendering system. If we could design a novel rendering system, we may be able to exert even more control over the intricacies of the rendering process and optimize for the style of art rendered. A custom style would greatly benefit the output of the visualization in that it would allow us to more seamlessly encapsulate information within the art itself while catering to the preferred artistic styles of the end users. Finally, our visualization currently deals with road networks and their surroundings. If we wanted to extend that, we could also work towards gathering information for nature trails, terrain, and bodies of water. This implementation would serve users who live in more rural areas better than our current implementation and would also provide more factors for influencing the artistic renderings for those who live in urban areas as well. More additions would also be welcome but once again would be subject to the constraint of being able to convey information without greatly cluttering the interface.

## 7 Conclusion

In this paper, we reimagined how street layouts could be transformed into art pieces in an automated fashion. Through the use of road segments and points of interest amenities extracted from OpenStreetMap (OSM), we created three variations of abstract art based on a user's input location or address. Each road segment was colored based on the amenities most adjacent to it, with the color scheme following standard Earth tone cartography practices. The overall layout of the interface reflected one that would allow the user to easily compare the street map with each of the artistic styles as well as with art generated from other locations through consistent placement and scale. Further work on the underlying data structure would allow for selective rendering to consciously standardize the image generation. All of this together allows the end user to inquisitively compare art from different neighborhoods or cities, or simply enjoy the generation of abstract art from locales around the world.

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## APPENDIX A

Table 1. Workshare of project with estimated and actual milestones.

| Task | Description | Estimated Hours and Completion | Actual Hours and Completion |
|---|---|---|---|
| Pitch | Raise ideas, search for the dataset, create slides, and rehearse pitch (ALL) | 3 / Sept 29 | 3 / Sept 29 |
| Pre-proposal meetings | Finalize group, get the dataset (Madison), brainstorm project topic and define the topic (All), meet with Tamara (All), update the topic (ALL) | 4.5 / Oct 13 | 5 / Oct 13 |
| Proposal | Write the project proposal (ALL) | 3 / Oct 21 | 3/ Oct 21 |
| Implementation | Learn selected tool (ALL) | 10 / Dec 15 | 10 /Dec 15 |
| | Clean and analyze data (Madison) | 3.5 / Dec 15 | 10 / Nov 25 |
| | Determine image generating methods (ALL) | 6 / Oct 25 | 6 / Nov 15 |
| | Finish the requirement analysis of the display layer project (Niels, David, Hongyang) | 3.5 / Oct 27 | 3.5 / Oct 27 |
| | Design and implement baseline single page application (Niels, Hongyang)<br><br>Implementation of baseline data service layer Python backend (David)<br><br>Process the data and image generation in Python (Madison)<br><br>**Will be collaborative** | 10 / Nov 3 | 12 / Dec 1 |
| | Finish the first draft of the project (ALL) | 6 / Nov 7 | 10 / Dec 1 |
| Project Report Update | Update project report (ALL) | 3 / Nov 16 | 4 / Nov 16 |
| Peer Project Review | Prepare the project demo, review peer project, and get suggestions (ALL) | 4 / Nov 17 | 4 / Nov 17 |
| Refined implementation | Implement image generating methods (Python: Madison, React: Niels, Hongyang, David) | 10 / Nov 28 | 10 / Dec 1 |
| | Polish implementation (add features, improve feasibility, etc.) (Niels, David, Hongyang), prepare demo (Madison) | 3 / Dec 10 | 4 / Dec 15 |
| Final presentation | Prepare and rehearse presentation (ALL) | 6 / Dec 15 | 4 / Dec 15 |
| Final paper | Finalize paper (ALL) | 8 / Dec 17 | 8 / Dec 16 |