

TECHNICAL UNIVERSITY OF DRESDEN

MASTER THESIS

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# The Derivation of Digital Embroid Styled Maps

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*A thesis submitted in fulfilment of the requirements  
for the degree of Master of Cartography*

*in the*

Institute of Cartography  
Faculty of Environmental Sciences

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# Declaration of Authorship

I, Lin Dong, declare that this thesis titled, 'The Derivation of Digital Embroid Styled Maps' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

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Date:

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TECHNICAL UNIVERSITY OF DRESDEN

# *Abstract*

Faculty of Environmental Sciences

Master of Cartography

## **The Derivation of Digital Embroid Styled Maps**

by Lin Dong

Recent developments in web based and mobile cartography are strongly driven by technology. Digital maps are often presented in a stereotyping design. So far, less focus were set on transferring the variety of map styles available with traditional maps into the digital form.

An interesting approach for simulating a handcraft-like look for web maps is presented by Stamen with the Watercolor map. There are also promising designs with sketchy rendering within information visualization domain and NPR field in computer graphics.

The aim of my research is to create a digital embroid styled map as example of simulating traditional artistic map style. Therefore geodata from OpenStreetMap are pre-processed firstly in ArcGIS, then preliminary rendered in TileMill, and at last, the artistry effect is further rendered by GIMP.

So far, a prototype has been created and introduced in this thesis, an automatic workflow is currently under development.

# *Acknowledgements*

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# Abbreviations

<b>GIMP</b>	<b>G</b> NU <b>I</b> mage <b>M</b> anipulation <b>P</b> rogram
<b>ICA</b>	<b>I</b> nternational <b>C</b> artographic <b>A</b> ssociation
<b>ICC</b>	<b>I</b> nternational <b>C</b> artographic <b>C</b> onference
<b>NPR</b>	<b>N</b> on <b>P</b> hotorealistic <b>R</b> endering

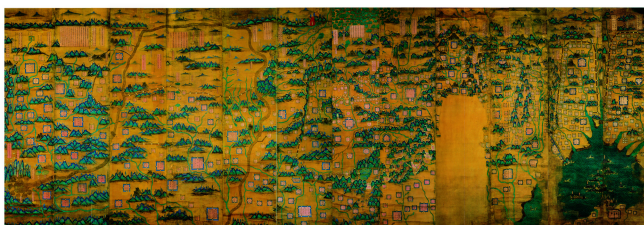


# Chapter 1

## Introduction

### 1.1 Inspiration

For the first section in the very beginning chapter of the whole thesis, the following figures, together with the background introductions of which, are involved to serve as an inspiration.



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FIGURE 1.1: Anonymous (around 1567). Nine Garrisons Map of the Ming Dynasty, Liaoning Provincial Museum, PRC

The “Nine Garrisons Map of the Ming Dynasty” shown in Figure 1.1, which was created around the year of 1567, got discovered on a folding screen<sup>3</sup> in the Palace in Shenyang, China, in 1949. This map is a reproduction of the cognominal black and white military map, which had been widely utilized in the border agencies of Ming Dynasty at that time. However, nowadays the so-called reproduction has been standout from all the other “Nine Garrisons Maps” by several particular and interesting characters it possesses.

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<sup>1</sup><http://maps.stamen.com/watercolor/>

<sup>2</sup><http://stamen.com/>

<sup>3</sup>A type of free standing furniture. It is normally used to decorate and divide the space of living room, as well as to block the cold wind and sight lines from outside.



FIGURE 1.2: Left: Sue Fish. *Stitching Street Map*. Right: Christian Science Publishing House(1935). *Maparium*, Mary Baker Eddy Library in Boston, Massachusetts.



FIGURE 1.3: Image taken from the online map “Watercolor”<sup>1</sup> by Stamen Design<sup>2</sup>

Firstly and obviously, the map is well colored and more exquisite than normal military maps. Second, as mentioned before, it was mounted on a folding screen in the Palace, which was the temporary Imperial Palace of the Qing Dynasty before the emperor of Qing ended the domination of Ming Dynasty and took over its capital, “the Forbidden City” in Beijing today. It makes sense to elicit from the second character that the map was once used by the emperor and then got abandoned with the Palace in Shenyang when the war of conquests came to an end. Then, as the last but not least character, there are two kinds of languages (one is Chinese, the other is Manchu language) on the map, and it was found out by historians that Chinese is the original language on it, while the Manchu letters were added afterwards. Considering this character together with the previous two features, some historians drew an inference as below. The army of Qing occupied one garrison of Ming and obtained a black and white military map called “Nine Garrisons Map” from the commander captured by them. For the detailed military information of each border garrison of Ming it contained, the map was highly valued by the conqueror. Therefore, the emperor of Qing ordered to color and to add translation to the map, and then got it mounted on the folding screen in the living room. The mounted map not only acted as a decoration of the emperor’s room, but also considered as an inspiration for the planning of military tactic by the very ambitious conqueror.

The images presented in figure 1.2 are serendipitous discovery for me. I just encountered them when I was browsing the Web. It was on the Facebook when I first saw the left photo of the stitching street map created by Sue Fish <sup>4</sup>, who got such introduction on her Facebook: “Sue Fish completed a Foundation Degree in Stitched Textiles at Eastleigh College in Hampshire in 2012. She likes to work in different media and has taught Art in Middle schools for many years.” Is she an artist? I’m not sure, since there is hardly any search result about art occurred when I enter her name in Google, but as the introduction on her Facebook, she has taught art for many years after all. In a blog <sup>5</sup> contains her work, I got some sentences that she has been “exploring street maps for inspiration... she enlarges the street map and develops the pattern with free machine embroidery”. As to the right photo in the figure, it is from the website of National Geographic <sup>6</sup>. It has recorded the renovation of the Christian Science Mapparium, an

<sup>4</sup><https://www.facebook.com/pages/Suefishgrafics/465530630167288>

<sup>5</sup><http://neufworks.wordpress.com/2013/03/03/sue-fish-is-stitching-streets/>

<sup>6</sup>[http://photography.nationalgeographic.com/photography/enlarge/stained-glass-map\\_pod\\_image.html](http://photography.nationalgeographic.com/photography/enlarge/stained-glass-map_pod_image.html)

enormous stained glass globe, in Boston, Massachusetts. As introduced in “The History of the Mapparium<sup>7</sup>”, there have been several points in the Mapparium’s history where the discussion of updating the map did arise. The final time was in the 1960s, when it was finally decided that the Mapparium was a priceless work of art and history, and so should never be updated.

The image in figure 1.3 was derived from the online Watercolor map created by the Stamen Design. Although there is no label on the map, a search box is provided to enable the map readers to “find” a specific location by entering either the geographic coordinate or the name of it. Meanwhile, there are minus and plus buttons supplied on the interface for the adjusting of zoom level. In addition, the online map also support and encourage the map users to share it by clicking the “image” button to make a customized image of their favorite place or to generate a piece of HTML code for embedding the map in their own webpage by clicking the “embed” button.

## 1.2 Motivation and purpose

To elaborate the motivation and purpose, it is necessary to refer to those images introduced in the Inspiration section first.

The stitching street map created by Sue Fish has the ability to attract the viewers at the first sight. However, on scrutinizing attentively, it is apparent that, as a map, this stitching work is poor in the quality and visualization of geographic data. For instance, there is neither label nor scale stitched on it; moreover, the irregular road width and the seemingly randomly allocated colors for the blocks have nothing to do with classification or categorization. Nevertheless, the map is still valuable for the inspirations I have derived from it. First, it comes in the form of embroidery, which has refreshed my thought of map. Secondly, the stitching work impresses me that it is the characteristic art design contributes greatly for an appealing and attractive map, and what’s more, encourages me, the map reader, to get more involved with the content of the map. This work of Sue fish also reminds me about the definition – “Cartography is the art, science and technology of making maps, together with their study as scientific documents and

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<sup>7</sup><http://www.marybakerredylibrary.org/research/mappariumhistory>



works of art (I.C.A in Meynen 1973<sup>8</sup>)”. This definition implies that art, as one vertex of the Cartography triangle, is no less important than technology and science.

Respect to the Nine Garrisons Map and the Maparrrium, different from the stitching map, both of them are real maps, though created through some artistic processing from their original version. Comparing to the work of Sue Fish, the attributes of the map objects in these two maps were persisted in a much larger degree during their transferring from the original paper maps to new media; and that is the qualified and valuable map data equips a map with the quality of relevant. Therefore, it is the Nine Garrisons Map, rather than a more exquisite art work, got mounted on the folding screen in the living room of the ambitious conqueror of the Qing Dynasty. This judgment is supported by the abandon of the map after the victory of Qing, as the data it contained were not valued anymore. However, once dismissed by its outdated data, this Nine Garrisons Map has been revalued in the modern Chinese society for the art work had devoted to it. Meanwhile, the Maparrrium has also been considered as valuable for the similar reason in the modern Western society. Despite the cultural differences between Chinese and Western society, it can be argued that the glamour, which results from the artistic effort, of a well-designed map will not vanish with the obsoleting of its data.

Considering the Three Assumptions of Modern Cartography – Cartography is relevant, Cartography is attractive, Cartography is modern – mentioned in the presentation given by Georg Gartner (President of the ICA) on the ICC 2013 , as I understand, map as the production of Cartography should also possess these three characters. Although the stitching street map is attractive enough, it is not that relevant on the aspect of map data; while the Nine Garrisons Map and the Maparrrium meet the requirement of attractive and had been relevant before, but they have lost relevance to the modern Cartography. Then, there comes the Watercolor map. The Watercolor map is considered as attractive for its special watercolor effect, and the adopting of the OSM data has ensured the relevant property of it in some degree. Finally, no matter for the utilizing of the crowdsourcing data or for the tile server established by it, the Watercolor map deserves the description of “modern”.

In the end of this section, a conclusion is drawn that, it is the stitching street map that inspired and motivated my fancy about an artistic map style with individual look and

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<sup>8</sup>Meynen, E. 1973. *Multilingual Dictionary of Technical Terms in Cartography*. Stuttgart: International Cartographic Association.

feel, while the Nine Garrisons Map and the Maparium together made me aware that the qualified geographic data of a map should be preserved after an artistic rendering; and the Watercolor map has exhibited a successful attempt for me, which impelled my idea to take into action. Generally speaking, my purpose is to design and create a web map with individual artistic effect and feel.

### 1.3 Research Questions

Before implementing any practical work, there is a requirement to list out some research questions.

- Is there any specific requirement on artistic map design?
- What are the characteristics of the embroid map style?
- What is the theoretical workflow to achieve the required effect?
- How to implement the theoretical workflow in practice?
- Is it possible to create an automated workflow which can be executed directly by computer? If it is possible, how the workflow would be like?

### 1.4 Thesis Structure

The thesis is consists of 5 Chapters. In the first Chapter, an inspiration section comes before the introduction of motivation and purpose, while some research questions and the thesis structure are explained.

In Chapter 2, there involves the literature review section and a rough introduction for several artistic styled maps.

Then, the first three questions will be answered in the third Chapter, which followed by the Chapter 4.

In the fourth Chapter, not only the fourth research question will be speak of, along with some problems encountered during the implementation work, but also the last research question will be answered in the aspect of theory.

At last, a conclusion of what have been achieved in this thesis, together with a discussion about potential future work, will be given in the fifth Chapter.

## Chapter 2

# Literature Review

### 2.1 Cartography & Art

Cartographers have always been concerned about the appearance of maps and how the display marries form with function (Field, 2012). Accordingly, “map creation has historically involved much artistry” (Field, 2009). Therefore, as . . . stated, maps themselves often feature highly artful qualities.

The above statements were corroborated by various appealing traditional paper maps emerged during the analogue era. However, along with the developments of cartography, especially the recent web based and mobile cartography, which are strongly driven by technology, some modern maps (e.g., in GPS car navigation) tend to focus on their task such as supporting navigation and only as a secondary aspect on their aesthetic character. (Kent, 2005). Concerning this trend in cartography, both Keates (1989) and Robinson et al. (1995) are clear that a successful map should be aesthetically pleasing and that visual efficiency creates clarity. Keates(1984 p.43) also appealed that “I like to draw attention to the fact that there are realms of human experience which are not - and never will be - products of science; and although few of us can aspire to create them, we can - and should, enjoy them”, yet Huffman(2011) suggests that what is missing from a lot of cartography is humanity. In view of the above statements and suggestions, it seems that most products of modern cartography are not successful enough for the lack of aesthetic and humanity, both of which are inextricably linked with art.



Comparing to the ignoring of art factors in map creation of modern cartography, in the area of art, artists in increasing numbers have taken up the map as an expressive medium (Wood, 2006). As Caquard (2009) introduced, Artists make use of mapping and mapping techniques to comment on our world in a critical, ironic, utopian or imaginative way. The media they use range from textile creations to drawings/paintings, from photography to media installations. Cosgrove (2006) also mentioned that in the creative worlds of the arts, maps and the processes of mapping have proved astonishingly fertile material for artistic expression and intervention. Referring to the statements by Field (2009) that “design and beautiful maps are one area in which we see a convergence of art and cartography” and “we recognize a beautiful map and see it as much a work of art, influenced by sensible design, than just a tool to understand geography”, the artists seemingly have taken over the work of creating beautiful and interesting maps from cartographers. Moreover, the productions of artists are apparently more successful, at least, in the aspects of aesthetic and humanity.

Nevertheless, most of the maps created by artists can only be considered as map art than real maps. It is true that beautiful maps are often that are most appealing but at their basic level, they are tools (Petchenik, 1985). The essential purpose of map-making has always been the creation of the most exact reflection of reality or the graphically true representation of space (Papp-Váry, 1989), whereas artwork (e.g. the work of Sue Fish) often simplifies and abstracts its subjects (Healey, 2004). As a kind of scientific visualization, map “is mostly concerned with visualizing large multivariate scientific datasets to facilitate analysis”, while the map art created by artists is always focus on representing subjective matters. Joyce Kosloff, an artist, said “The maps... were a kind of structure to put my content into”.

Besides the differences in the motivation and content aspects of map creation, map art has been distinguished from real map by the attitude of map readers towards it. “We collect these cartographically inspired artworks because they appeal and they ‘look good’ and they ‘look good’ because of the artistic treatment of the subject matter.” Field (2009) claimed. Map art production, as an art work, is treasured for its aesthetic appeal, while the relevant geographic data is the essential for a real map to be approved. This opinion can be supported by our attitude for old maps (e.g. the Nine Garrisons Map and the Maparrium). Old maps are interesting primary because of their quaint “artistic’ nature. Their “science,’ if there is any, is outdated and not important (Krygier,

1995). Arthur Robinson also notes that "[t]he older is a flat or a globe map, the more likely it is to be called an art object" (Robinson 1989).

However, along with the emerging of various map arts in art area, despite the difference between map and map art, there is a fact that the boundaries between cartography and art has become less defined, which suggests an increasing amount of hybrid practices that incorporate maps and different forms of art (Caquard, 2009). Additionally, Kuhn (1977) argued that whether in the realm of products or of activities, what are ends for the artist are means for the scientist, and vice versa. The argument implies that both of art and science can benefit from borrowing experience from each other. Some art historians argue, for example, that Piet Mondrian, during the latter part of his life, was at least in part inspired by maps or city street layouts to some of his well-known abstract works (Schoenholz Bee and Heliczer, 2004). Meanwhile, to develop their visualizations, some scientists are turning to literature on fine arts techniques as well as nonphotorealistic rendering work or even visiting art galleries to observe master artwork (Healey, 2004). As the artists are converging attentions to maps, it might be advantageous for cartographers to take a chance to involve more art elements and experience into modern map making procedure, while the basic functions as navigation tool of map are reserved. After all, as Kent (2005) claimed, there is, of course, no reason why we cannot make tools that are also beautiful to use.

## **2.2 Advantages of Artistic Styled Map and Relative Findings in NPR Area**

The involving of artistry makes map more attractive, and "attractive things make people feel good (Norman, 2004)". This might be the most direct and apparent positive effect of artistic design on map, while the advantages of an artistic styled map may not be limited to it. Some research results from the NPR (Non-Photorealistic Rendering) area of computer graphics are suggesting at least two more potential contributions of artistic style to map.

First, "artistic images have the capacity to "emphasize specific features of a scene, expose subtle attributes, and omit extraneous information [GG01]", which implies that appropriate artistic style may enhance the efficiency of information representation.

Secondly, application of artist techniques may create more aesthetically pleasing images which may engage the viewer’s attention and encourage extended exploration; for instance, the application of sketchy style. Wood J., et al. (2012) had talked about the “ability to invite activity participation” of sketchy style, which “were found to be less artificial and more interesting, and were more inviting for people to discuss designs or suggest changes.”

As “maps were made to build understanding, to offer a judgment or, perhaps, to create an emotional response (Field, 2012)”, both of the enhancements in representation efficiency and viewer involvement are favorable.

## 2.3 Related Map Works

This section is comprised of the following images of three different artistic map works, together with corresponding discussions.

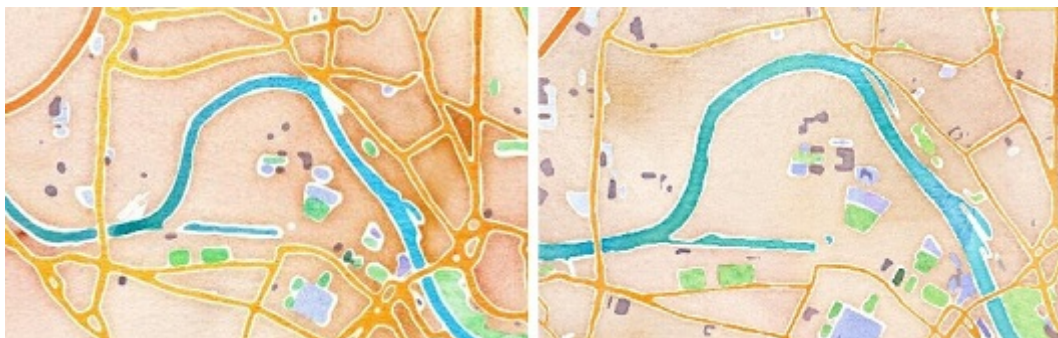


FIGURE 2.1: Screen shots of the Watercolor map under different zoom level.

While all of these maps share the same data resource of the OpenStreetMap, the rendering methods, as well as the data format, applied by each of them are dissimilar.

The screen shots shown in figure 2.1 are taken from the Watercolor map, which has been introduced roughly in the first chapter. For the generating process of the map, Stamen had posted a play-by-play on their official blog<sup>1</sup>. Although the original data derived from the OpenStreetMap is vector data, all of the styling work is carried out in raster space; therefore, images are initially rendered out in Mapnik from the vector data, and

<sup>1</sup>[http://content.stamen.com/watercolor\\_process](http://content.stamen.com/watercolor_process)





FIGURE 2.2: The centre of Paris with Île de la Cité, without any simplification/abstraction applied to the map graph



FIGURE 2.3: Screen shot of the Crayon map.

the afterwards styling operations (image splitting, the adding of Perlin noise, Gaussian blur, antialiasing et.) are applied in order.

In figure 2.2, it is “The centre of Paris with Île de la Cité<sup>2</sup>” from Tobias Isenberg (2013). For the rendering style, as Isenberg introduced, “we take inspiration from Tarrbell’s (2003) previously mentioned Substrate simulation”, “It employs densely drawn coloured lines, placed perpendicular to the main (black) lines on one of its sides. These lines have a length that varies randomly and they fade out towards the end. This creates an effect that is reminiscent of watercolour painting”. Normally, there requires a simplification/abstraction of the map graph before the applying of rendering, but the image here “is shown with only the rendering applied and without any additional map graph simplification”.

The image in figure 2.3 is a screen shot of the Crayon map<sup>3</sup>. This web map utilizes the GeoJSON layers loaded from the OpenStreetMap<sup>4</sup>, and the crayon drawn style of the map is created based on the Crayon-Canvas<sup>5</sup> library, which is authored and released by “Nick Mapmeld<sup>6</sup>” on GitHub.

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<sup>2</sup><http://www.maneyonline.com/action/showImage?doi=10.1179/1743277412Y.0000000007&iName=master.img-013.jpg&w=239&h=216>

<sup>3</sup><http://crayonmap.herokuapp.com/#map=15/40.449396/-80.021560>

<sup>4</sup>OpenStreetMap.us

<sup>5</sup><https://github.com/mapmeld/Crayon-Canvas>

<sup>6</sup><https://github.com/mapmeld>

## Chapter 3

# Theoretical Work

Since there are few essays about artistic design of modern map, and, as Dent, et al. (2009, p. 19) suggested, “map design is the aggregate of all the thought processes that cartographers go through”, it is necessary to introduce the work of theoretical part in detail. Thus, in the starting section, those map works introduced in the last section of chapter 2 are analyzed for summarizing the requirements/standards of successful artistic map; then, based on the declared evaluating standards, a discussion about the characteristics of my map style is carried out in the second section. In the last section, a theoretical work flow for the designing of embroid map style is generated to conduct the afterwards practical operations.

### **3.1 The Requirements/Standards of successful artistic map**

Currently, as it was introduced in the chapter of “Literature Review”, the artistry aspect of the map is dismissed by modern cartography to a certain degree. Under this situation, quite few artistic styled map products, with even fewer corresponding essays, are available. Consequently, there is nearly no existing clear standard or specific requirement for the design of modern artistry map, while the standards/requirements are necessary for constructing a qualified product. Therefore, an attempt is made in this section to figure out, at least, some evaluation standards for the design of artistic digital map.

The work in this section starts with an analyzing of the advantages, as well as short comings, of those three artistic maps shown in the figures (Figure 2.1, Figure 2.2 and Figure 2.3) of last chapter.

As introduced previously, the styling methods of Watercolor map is based on raster space, while the other two maps implement their rendering procedures directly on vector data. For the decision of applying all the styling in raster space, the Stamen gives three reasons – “the main reason was to have access to the overlaps of objects, but there are a couple of really great side benefits: the process doesn’t increase in time for denser areas (i.e. cities, which is mostly what people look at), and it’s entirely deterministic (important when you’re stitching together tiles)”. However, some of the raster image processing methods employed in the process can impair the quality of map in spatial data. For instance, the applying of Gaussian blur and Perlin noise, for the purpose to create a fuzzier and wobblier outline effect, causes some topological problems in map graph, which can be partly reflected by the comparison between screen shots in Figure 2.1. In those two images in the figure, there depict the same water body under different zoom levels. In the right image, the water body is shown as a unit under zoom level 14, while in the left screen shot, taken under level 13, a gap exists and splits the unit into two parts. This change in graph leads to the topological inconsistency of the map object. Additionally, to achieve a more artistry effect, an extra workload of map graph generalization has to be involved before the styling process. This can be exemplified by the representation of transportation network in the map. Under identical zoom level, the road network density of the Watercolor map is much lower than its data resource – the OpenStreetMap; correspondingly, a considerable amount of spatial information has been removed with the eliminated road sections. As a result, the quality and value of the map as a navigation tool have been weakened by the decreasing in both of the quality and quantity of spatial data.

The Crayon map in Figure 2.3 achieves the crayon-like effect by applying the “Crayon Canvas”, a library for HTML5 Canvas to render vector tiles in crayon style. The exploiting of the library enables the automatic immediate rendering of map data, which not only can save effort of preprocessing, but also ensures the map to keep up with the updating of the data resource. Despite the convenience it brings, the method of rendering vector map tile by means of HTML5 Canvas library still has its limits and disadvantages. First, as the library itself is based on JavaScript, the final appearance of

the rendering might vary with the change of web browser. Secondly, comparing to raster based rendering, the pure vector based styling manner tends to have a less deterministic performance. The indeterminacy is mainly represented in the processing time between different map tiles (the rendering time is in proportion to the object density of each tile) and the filling of polygon objects. The indeterminacy for the filling of polygon objects can be figured out from the screen shot by checking the river area, where the seams between the map tiles are quite obvious. Besides from the indeterminacy, the map will become more and more crowded and will even suffer an overlapping problem with the decrease of zoom level, since there is no map generalization involved during the change of the scale.

Comparing to the aforementioned two maps, which are typical tile based multi-scale web maps, “The center of Paris” in Figure 5, as a single static map image, requires no consideration about zoom level variation during our analyzing of it. Although there is no additional map graph simplification included during the styling procedure, “the rendering of lines within the maps simple black lines removes much of the information such as type or importance of its associated map element”, its author recommended in the essay. Thus, not only the map graph generalization, but also the choice of rendering method can result in the abstraction of map data.

By considering the analyses above together with the relationship between the art and cartography, which was discussed in the “Literature Review” chapter, a list of elements for evaluating the artistic map is generated as below.

1. Preserving degree of the resource map data: This standard is quite important, since spatial data is the base for a map. When evaluating a map by it, the preserving in both of quality and quantity of map data should be considered. Meanwhile, it is essential to be aware that besides the map generalization operations, some artistic rendering techniques can also influence the preservation. After all, under most situations, art factors are against the requirement of data preserving with their inherent randomness and abstractness.
2. Deterministic: The deterministic here, though embodies several sides (i.e. the deterministic of map graph, the deterministic of processing time, etc.), is mainly decided by the data type on which the rendering methods are based. Normally, the map image rendered in raster space is entirely deterministic, whereas the map stylized directly from



vector data is hardly comparable to it in this aspect, especially when the target map is tile based.

3. Degree of automation: This item describes the independent degree of the rendering progress from human effort.

4. Browser compatibility: For web maps, often read by the map viewers through web browser, the alteration for web browser or the settings of it may result in the variation of map appearance. The influence tends to be more significant on the map like the Crayon map, which has shift part, or even the whole, rendering work to the client web browser.

And for multi-scale map, there is an additional criterion – the stability of the representation effect (i.e. density of map object, rendering style, etc.) under different zoom levels.

## 3.2 The evaluation of the embroid map style

The idea of generating an embroid map style is inspired by traditional Chinese embroidery. During the exploration of the feasibility and realizing of the map style, the advantages together with short comings of the concept have been perceived gradually.

First of all, in real embroidery, there exist several stitches, and each of them is appropriate to a specific type of graph. For instance, within the graph of area, all the stitch lines share the same stretch direction, but for the representation of line object, the stitching direction needs to follow with the stretching of the line. To simulate the appearance of the area object in embroidery, raster based styling methods can achieve an ideal effect. However, for the analog of the embroidering of line object, the vector information of the graph is essential; therefore, the vector based rendering manners are preferred to generate an expected result. In view of the above discussion, both of raster and vector based methods will be employed during the generating of the embroid map. Secondly, considering the final purpose of creating an multi-scale artistic styled map, it is necessary to process all the texture images applied for raster based rendering into seamless images. At last, since the transformation from vector space to raster space is more convenient than the other way round, all the vector layers will be transformed into

raster image right after the rendering is finished. As a result, the final product will be represented in the form of raster image.

To analyze the feasibility of the realizing concepts, as well as the differences between the embroid style and the previously introduced artistic maps, there needs a comparison of these four maps. And it can be figured out that, the embroid map, at least on the representation of area objects, performs better than the Crayon map in the aspect of deterministic. Moreover, as mentioned before, the raster based final product enables a better web browser compatibility than most vector based maps. Meanwhile, the embroid art style itself is more appropriate for a precision representing of graph in detail than many painting styles (including the watercolor style). Thus, the embroid map style is expected to achieve a better depiction of map graph. This character implies that the embroid map style has the capacity to preserve the resource spatial data.

### 3.3 Theoretical Work Flow

Although the target is to create a multi-scale web maps, which is generated by automatic work flow, considering the complexity of creating automatic work flow together with the lack of experience, it is better to figure out a single static map image as a prototype of the map style. After that, further modification can be applied on it easily. The automatic workflow will be created based on a refined version of the prototype.

The whole theoretical work flow of the prototype can be represented as the following graph:

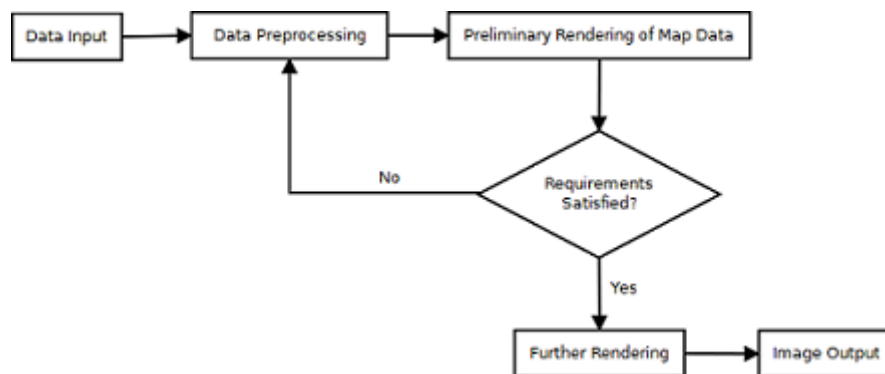


FIGURE 3.1: Theoretical work flow of embroid map.

## Chapter 4

# Implementation

In this chapter, the practical workflow of a prototyping of embroid styled map is introduced, while the possible realizing method for the automatic rendering procedure gets discussed in the last section.

### 4.1 Preparation Work

#### 4.1.1 Data Acquiring and Employed Software

The resource map data of the embroid map is in the format of “.shp” and downloaded from the GEOFABRIK<sup>1</sup>. It is notable that, the data is an “extended shapfiles” supplied by GEOFABRIK. Normally, this version is richer in features than the free version. Hopefully, the data of Dresden, the area on which the rendering is applied, is released as an example and therefore, can be downloaded freely. An introduction document<sup>2</sup> of the data format is also free for download (a copy of this file, together with the data can be find in the CD attached to this thesis).

The whole rendering workflow is realized under multi-software environment. The pre-processing of the map data is carried out in the ArcGIS, and the preliminary rendering and stylizing of the map is completed by operations in TileMill<sup>3</sup>, at last, the artistic

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<sup>1</sup><http://www.geofabrik.de/data/shapefiles.html>

<sup>2</sup><http://www.geofabrik.de/data/geofabrik-osm-gis-standard-0.6.pdf>

<sup>3</sup><https://www.mapbox.com/tilemill/>

styled map is rendered out by GIMP<sup>4</sup>. Except the ArcGIS, both of the TileMill and GIMP are open source software.

### 4.1.2 Source Material Gathering

1. An tutorial on YouTube<sup>5</sup>: This tutorial is created in the environment of PhptoShop and teaches you how to generalize an embroidered logo from a raster image. I got some inspiration from it for the creation of brush and texture.
2. the background picture “White Cotton<sup>6</sup>”: This is a free licensed image and will be utilized as the back ground of the embroid map.

## 4.2 Data Preprocessing in ArcGIS

As introduced in the document for the data format, the acquired data set of Dresden is stored by a collection of 26 shapfile layers. Within this collection, there are seven point layers, eight line layers and the left eleven layers are for polygon features.

### 4.2.1 Selection of Shapefile Layers

In consideration of the amount of data layers, it is necessary to select out the relevant layers for our project first, and then the processing of each layer can be carried out.

Since the data in point layers are extracted out from the other layers and represented in the form of point, they will not be taken into account. For those eight line layers, only two of them — the layers named “gis.osm\_roads\_v06” and “gis.osm\_waterways\_v06” — are necessary in normal navigation map. From all of the polygon layers, the layers of “gis.osm\_water\_v06”, “gis.osm\_buildings\_v06” and “gis.osm\_landuse\_v06” are selected for further processing.

In addition, considering that we have decided to create a prototype first, to speed up the whole prototyping progress, only the features located in the city center area of each layers are selected by rectangle in ArcMap.

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<sup>4</sup><http://www.gimp.org/>

<sup>5</sup><https://www.youtube.com/watch?v=7sylQ64xISk>

<sup>6</sup><http://uniquehomeriview.com/vienne-silk-wallcovering-white-sand.html>

### 4.2.2 Classification and categorization

After the selection progress of last section, two line layers together with three polygon layers are adopted for afterwards processing.

By checking the attribute table of each layer, there are several feature classes exist in the layer for road (“gis.osm\_roads\_v06”) and layer for land use (“gis.osm\_landuse\_v06”). To preserve the information, a classification for road features and a categorization on layer of “gis.osm\_landuse\_v06” are implemented. All the road sections in original layer are classified by the “maxspeed” attribute and extracted into three individual layers, while the land use blocks are categorized as four types (nature, recreation, residential and retail) and allocated to corresponding sub-layers. Both of the classification and categorization are applied through the option “select by attribute” in the attribute table of each layer.

After comparing the line layer of waterway (“gis.osm\_waterways\_v06”) and the polygon layer of water (“gis.osm\_water\_v06”), there makes a discovery that the large rivers in waterway layers are also recorded in the layer of water as polygon. Then, this kind of line sections is removed.

At last, for a convenient describing in subsequent sections, all the layers are renamed by a more succinct name, and the table in Figure 4.1 illustrates the correspondence of the original and new names of each layer.

## 4.3 Preliminary Rendering of Map in TileMill

The main reason for employing the TileMill in the process of preliminary rendering is my individual preference for its rendering style. Therefore, it is all right to alter to any other map rendering software.

During the rendering in TileMill, both of the polygon layers and line layers are symbolized and exported all together as a single raster image at first. Then, each of the line layers is exported individually in SVG format, while the parameters for the bonding box (13.7258,51.0484,13.7515,51.0583) and image size (4000 X 2451) keep the same.

gis.osm_waterways_v06	watetways
gis.osm_water_v06	water
gis.osm_buildings_v06	buildings
gis.osm_roads_v06	roads_0
	roads_30
	roads_50
gis.osm_landuse_v06	landuse_nature

FIGURE 4.1: Table for the original and new names of map layers.

The processing result of this section is consisted of four SVG files and one raster image, which is shown as below:



FIGURE 4.2: Rendering result in TileMill.

## 4.4 Further Rendering in GIMP

Both of the artistic styles for vector data and raster images in the map are rendered out in GIMP, while different brushes and rendering methods are applied.

### 4.4.1 The Preparing of Brush and Seamless Background Texture

As there is no available free embroidered texture for utilizing, we have to generate our own textures, and a proper brush style is essential for the generating of texture. In this section, one of the self-generated embroidered brushes is introduced as an example.

Here it is the procedure of the creation of the brush for area object rendering: Firstly, create a new image in GIMP, and set the parameters of the image as what is shown in figure 4.3.

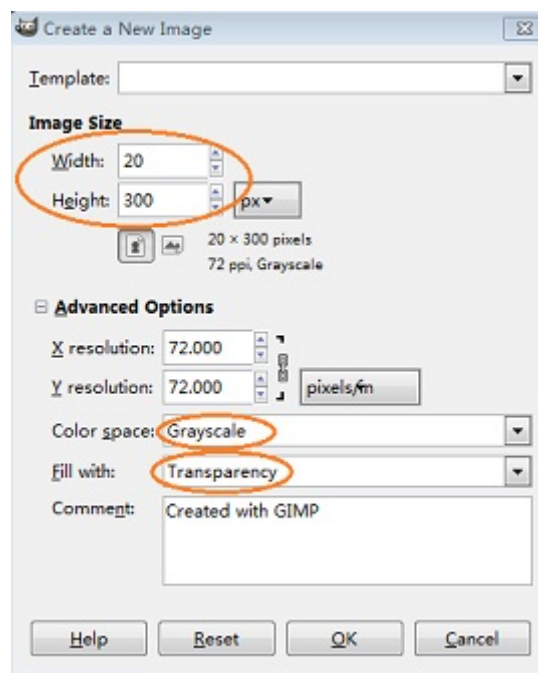


FIGURE 4.3: Setting of new image in GIMP.

Then, as shown in Figure 4.4, select the “Rectangle Select Tool” in “Toolbox” and draw a narrow rectangle with it in the image.

Next, make sure that the foreground color is set to black, then click on the “Bucket Fill Tool” and fill the selected area with black. (Figure 4.5)

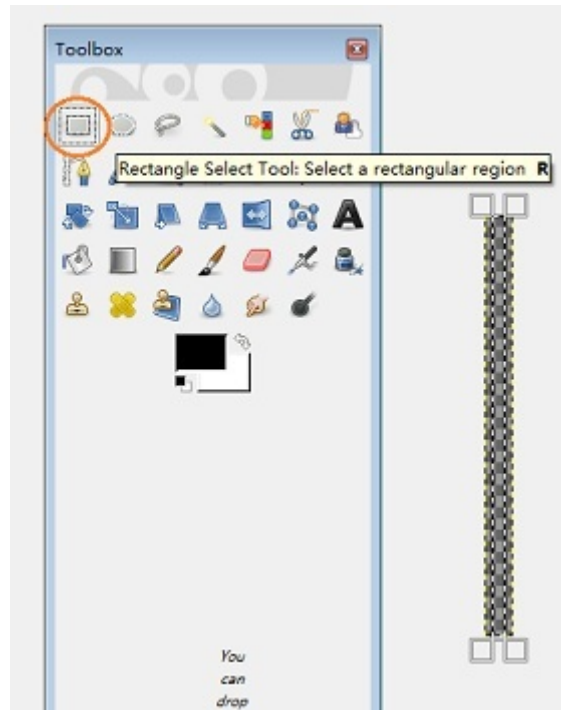


FIGURE 4.4: Brush creation (step 1).

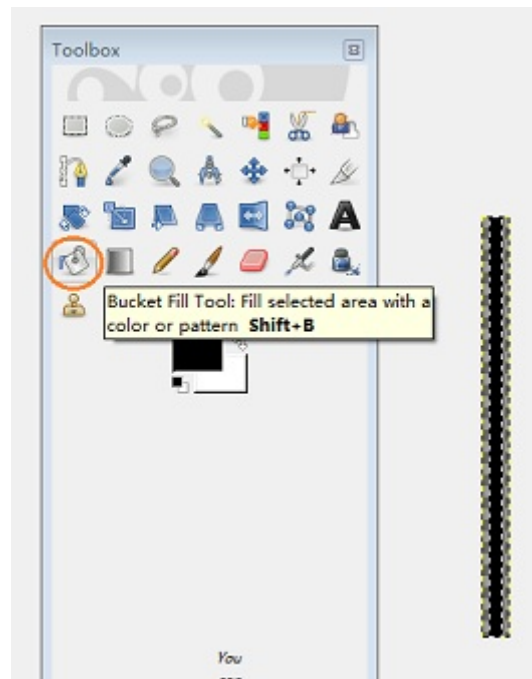


FIGURE 4.5: Brush creation (step 2).



Then, click on the “Erase Tool” and select a brush style with fuzzy edge in appropriate size. At last, erase the solid rectangle in the way shown in the figure 4.6.

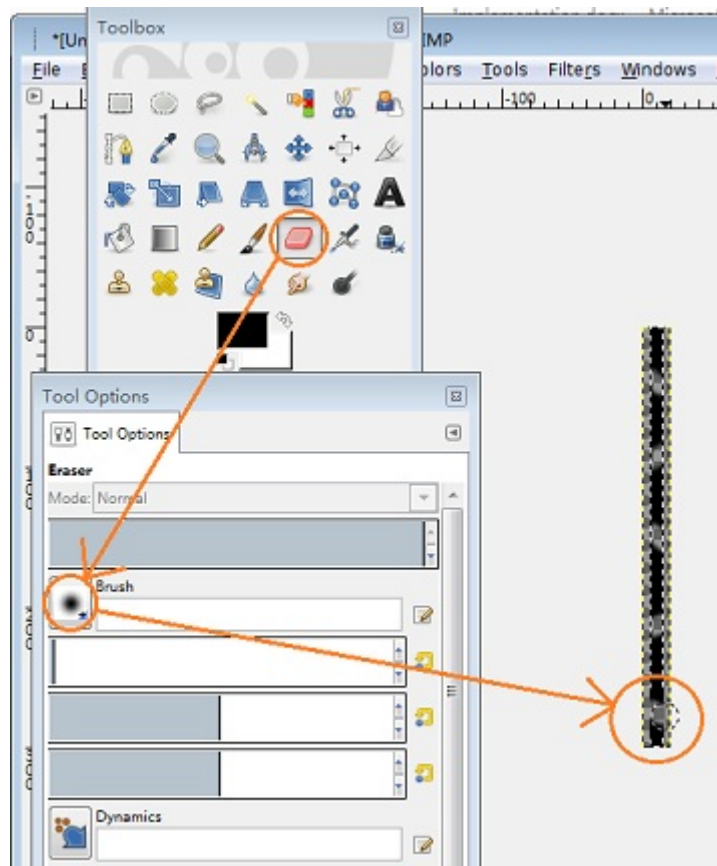


FIGURE 4.6: Brush creation (step 3)

So far, the image for brush has been created, and then it has to be saved in the format of “.gbr” under the GIMP brushes folder.

For the method to generate the seamless texture, there are several tutorials online, for example, the tutorial<sup>7</sup> on YouTube. In addition, both of the brushes and the seamless background textures have been given in the CD attached to the thesis.

#### 4.4.2 Rendering of Area Object

For the rendering of area objects, it is notable that, though the rendering method is based on raster space, the generating progress of the texture for rendering is based on vector.

<sup>7</sup><http://www.marybakereddylibrary.org/research/mappariumhistory>

Firstly, we need to preprocess the raster image (the one shown in Figure 4.2) rendered out by TileMill. The preprocessing include the splitting up of the image by color and the adding of mask. Taking the extracting of layer for buildings as example, just like what is shown in Figure 4.7, select all the building objects (rendered in grey color by TileMill). The “Select by Color Tool” is the ideal tool to accomplish this progress. When the tool is chosen, click on any building object image, then, all the pixels of the same color will be selected at once.

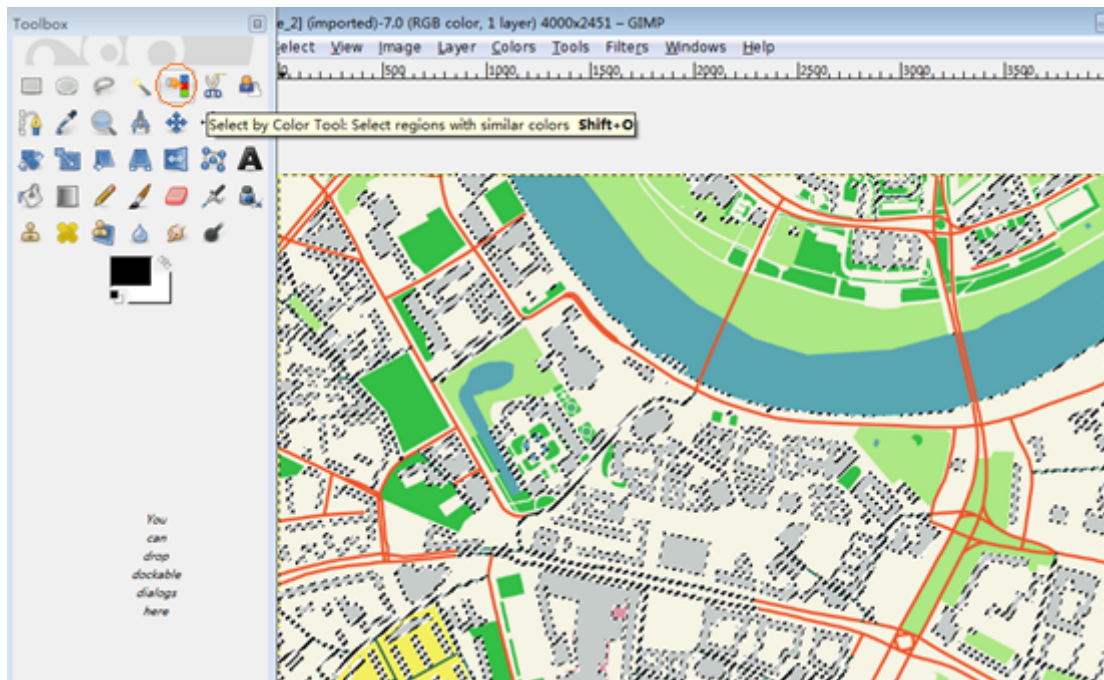


FIGURE 4.7: Splitting the image up by color (step 1).

Next, find the “Edit” item in the menu bar, and click on the “Copy” option in the drop-down menu of it, and right after this operation, click “Paste”. Then, as shown in Figure 4.8, there exists a “Floating Selection” layer in the “Layers-Brushes” window. Now, double click on this layer and rename it with “buildings”, so that it will change into a real image layer, containing the copy of the selected objects – the buildings.

Now, a mask is added to the layer, as shown in Figure 4.9, by right clicking on the target layer and selecting the “Add Layer Mask...” option. In the dialog window, check on the “Layer’s alpha channel”.

After the preprocessing of the image, there comes the tricky part of the project, the creation of the texture.

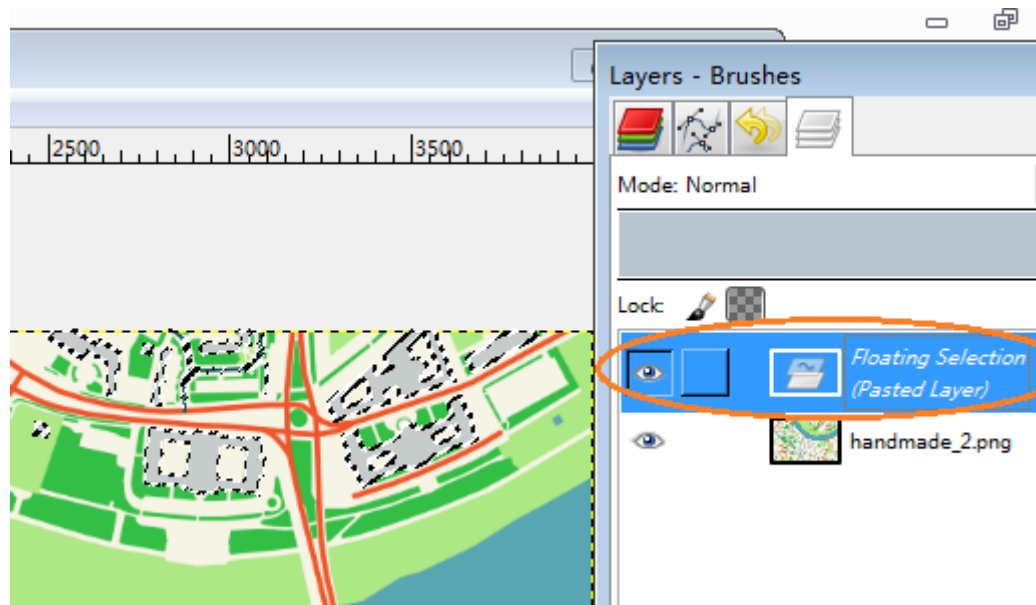


FIGURE 4.8: Rename the "Floating Selection" and transfer it into a real layer.

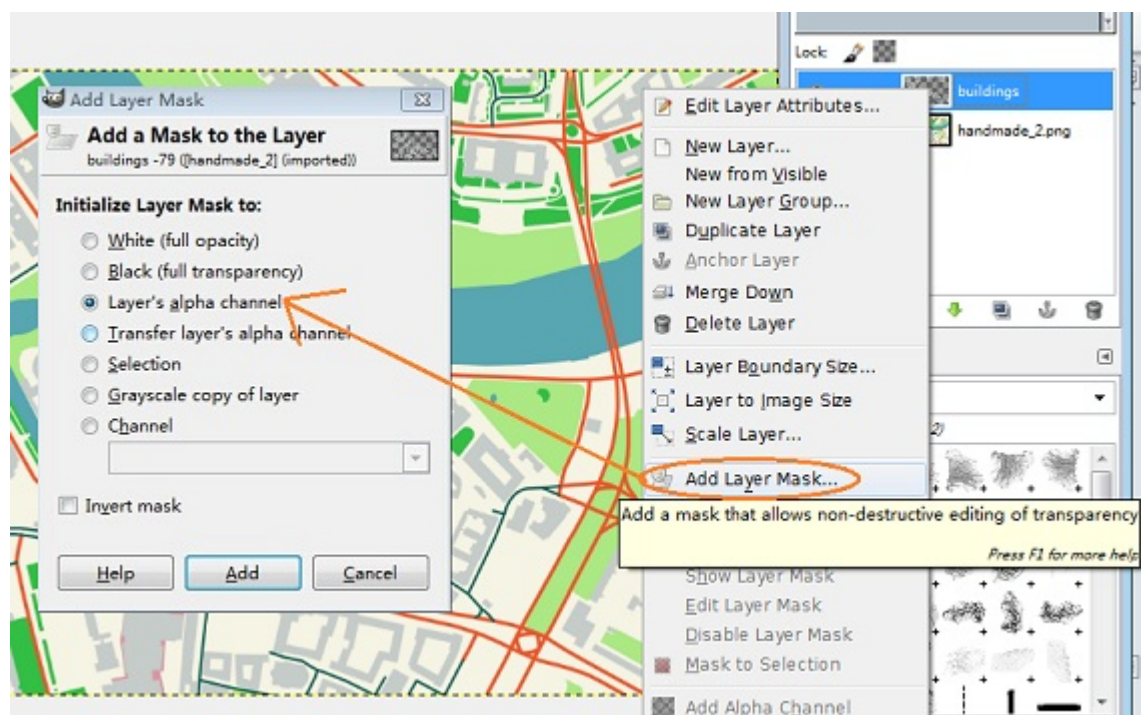


FIGURE 4.9: Add layer mask.

To create the texture, we need to shift from the current "layers dialog" tab to the "path dialog" tab first and work with the "Path Tool". Just draw a set of randomly by the tool arranged parallel paths like figure 4.10.

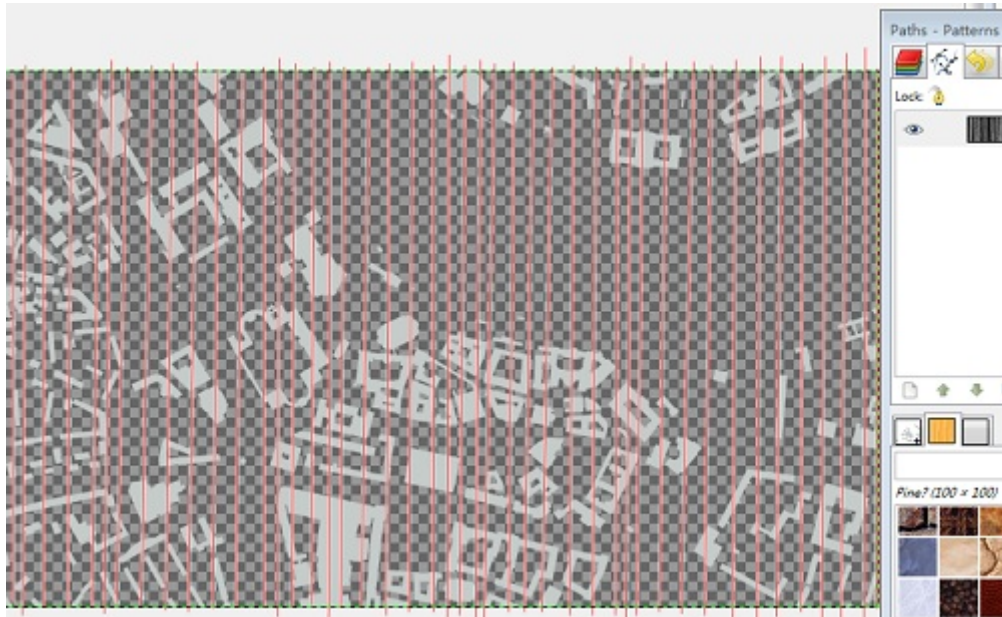


FIGURE 4.10: Add path by the "Path Tool".

Then, shift back to the "layers dialog" tab and make sure that it is the layer of buildings, not the mask of it, is selected. If you select correctly, the icon for the layer in the dialog window should look like the screen shot in figure 4.11, there is a white bonding box surrounds the layer icon.



FIGURE 4.11: Make sure that it is the image, not the mask, is selected before applying the stroke.

Next, shift to the "paths dialog" tab again and right click on the path icon and select the "Stroke Path..." option in the pop up menu as shown in Figure 4.12. Then, select the option of "Stroke with a paint tool" and chose "Paintbrush" as paint tool while make sure the "Simulate brush dynamics" is checked on.

It is notable that there needs a setting of the "Paintbrush" before the applying of stroke, and the figure 4.13 supplies a reference for it. The brush used here is the one got introduced in last subsection.



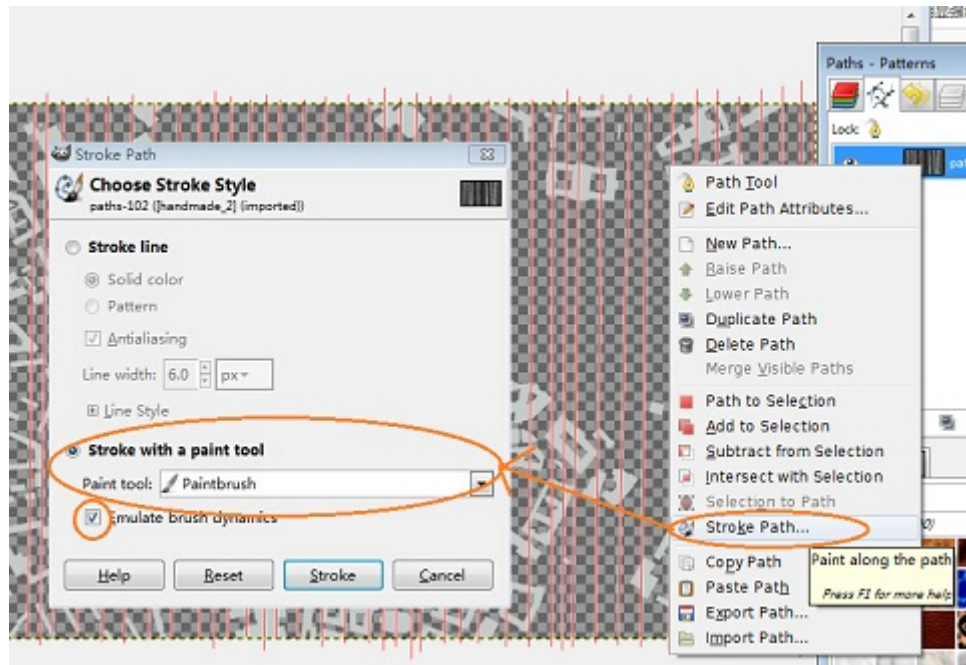


FIGURE 4.12: Set up the parameters in the "Stroke Path" dialog.

Normally, the stroking progress needs to repeat for several times with three different color shades (same color only different shades like the color sets in Figure 4.14.) to achieve a natural effect.

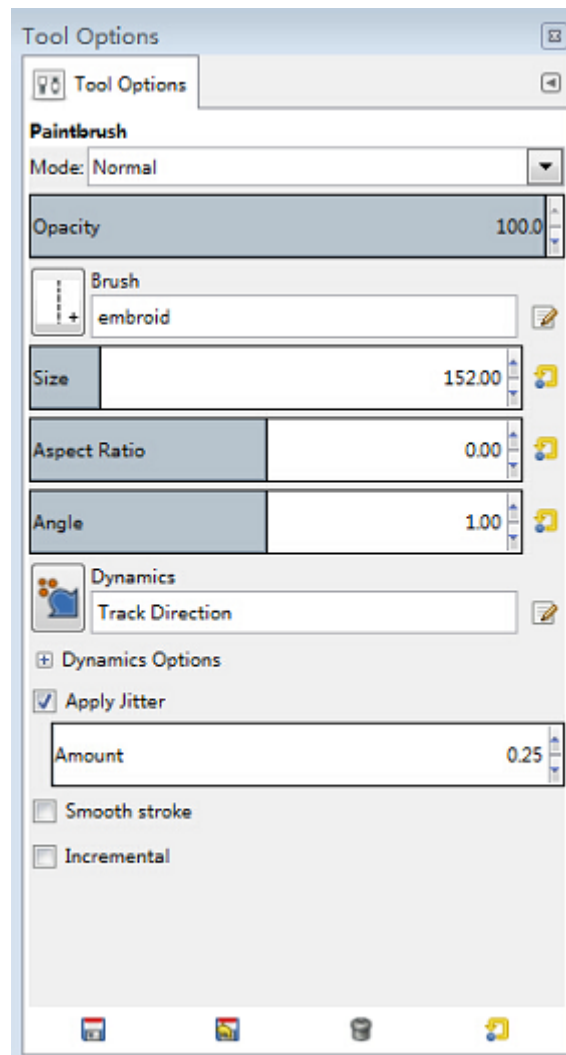
Now, the rendering progress of single layer is introduced and what is left to do is to repeat this flow on other area object layers extracted out by color.

#### 4.4.3 Rendering of Line Object

The rendering of line object is totally vector based. However, the stroke of the path has to be applied on a raster image. The brush, named "middle2" used for its rendering is different from the one applied on area layers.

For the line objects, there is no need to split the image up, and the progress in this section is more about the setting of the parameters of the "Paintbrush". The following figure 4.15 just supplies a reference of the parameter.

And for the setting of "Stroke Path" dialog, the "Emulate brush dynamics" should not be checked.



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FIGURE 4.13: Set up the parameters of brush for area object.



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FIGURE 4.14: Three different colors shades.

## 4.5 Result and concept for the Realizing of Automatic Workflow

As to the automatic work flow, a tutorial<sup>8</sup> about automatic editing is given in the official web site of GIMP. In this tutorial, an example, written in Python and can be used as plugin directly in GIMP, is given. The working principle of this plugin is to automate the inputting and outputting steps for the file in a predefined folder, while

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<sup>8</sup>[http://www.gimp.org/tutorials/Automate\\_Editing\\_in\\_GIMP/#motivation](http://www.gimp.org/tutorials/Automate_Editing_in_GIMP/#motivation)

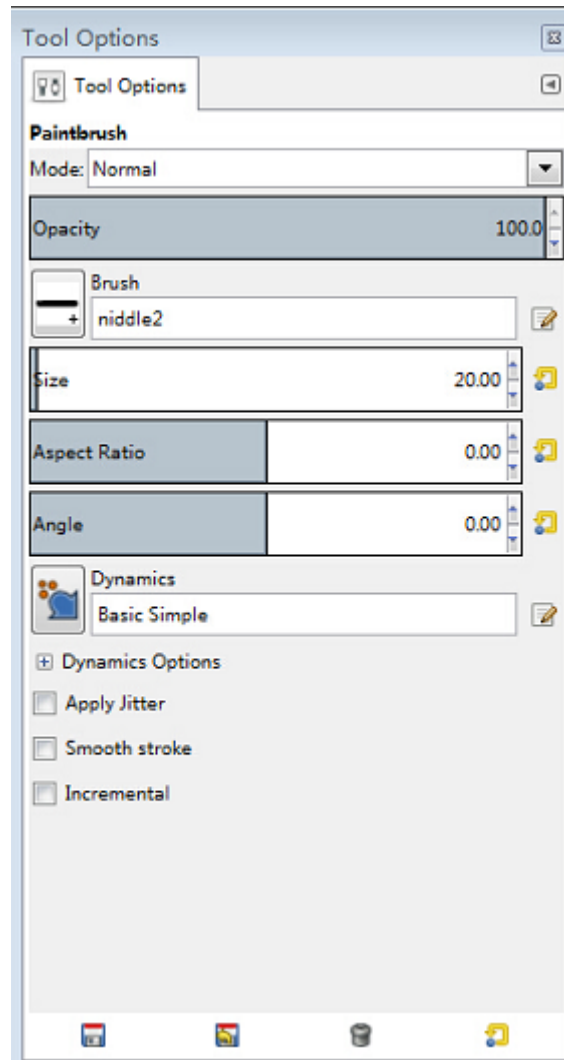


FIGURE 4.15: Set up the parameters of brush for line object.

the operations on image are defined and coded in XML files. The plugin will execute through the XML file to execute corresponding operations on inputted files. Therefore, this plugin is independent from any specific image processing operation. The work of creating automatic workflow in GIMP is only about describing the whole workflow in the “Python Console” provided in GIMP and transfer the code into XML file. For specific operation order (i.e. image resizing, selecting of brush, adding mask, etc.), a reference is supplied in the GIMP Library Reference Manual<sup>9</sup>.

<sup>9</sup><http://developer.gimp.org/api/2.0/libgimp/index.html>



FIGURE 4.16: Result image.



FIGURE 4.17: Enlarged view of part of the image.



# Chapter 5

## Conclusion

### 5.1 Result Discussion

By comparing the whole map image (Figure 4.16) and a detailed view of part of it (Figure 4.7), it is not hard to see that the latter is more vivid and comes with a stronger feeling of embroidery than the former. Therefore, it is reasonable to believe that this art rendering style has the ability to achieve a good effect of expression for detail, and this confirms the analysis in theoretical part of the thesis. However, notably, same as other artistic maps mentioned in the thesis, there is no map label or any other descriptive text available in the map image. As a result, the information carried by text of resource map is still absent.

Besides the difference in visual effect between the whole and partial views, the effect of the rendering manners varies with the type of map graph. From the result maps, especially the partial view, the rendering effect for line objects is better than area objects in the aspect of detail and realism. One defect for the styling of the area object is its too one-dimensional look. Therefore, the adding of shadow and inner glow effects is desired.

As mentioned, the original purpose of this project is to generate an artistic styled multi-scale web map, while automatic workflow is involved during the rendering procedure. So far, the artistic style has been defined and a prototype has been generated out. By this prototype, the feasibility and effect of the rendering method, as well as the style itself, is affirmed. Though the automatic workflow is still in under development, the method for the creation of it has been generated.

## **5.2 Future Work**

Since only part of the purpose has been achieved now, the work in the future is mainly associated with the refining of current design and the realizing of the automatic workflow.

In addition, based on the experience gained in the generating of this embroid style, there is a chance to generate more artistic styles; for instance, inspired by the Maparrium introduced at the beginning of the thesis, we can try to create a stained glass style for digital map in the future.

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