

Vancouver Crime Map

Rex Chang

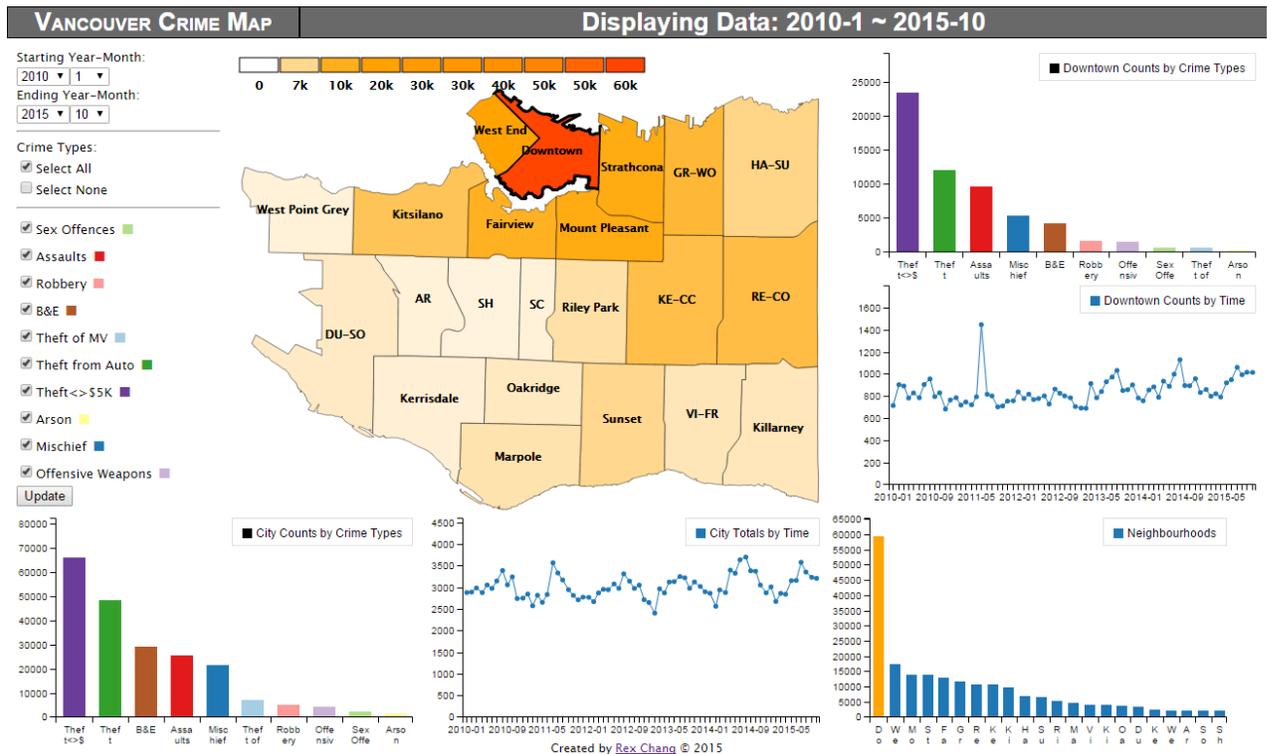


Fig. 1. Vancouver Crime Map interface.

Abstract — Residents of a city are generally interested in learning more about the crime statistics in the city and in the neighbourhoods they reside in. For the city of Vancouver, the raw crime count data are available online through the Vancouver Police Department website, but visualization tools available were lacking to provide an overview with flexible options to look at crime statistics in the city as well as in the different neighbourhoods. The Vancouver Crime Map was designed to provide a direct visualization of the raw crime data to give the users the overview of the crime rates in the city and the details on demand.

1 INTRODUCTION

Residents in a city are generally concerned with the crime incidents occurring in the city neighbourhoods, and, as a Vancouverite (resident of Vancouver) myself for 10 years, I would say that we are no exceptions. While we may gather crime incident information from news reports of sources such as CBC and the Vancouver Sun, the City of Vancouver makes the city crime statistics available on the Vancouver Police Department (VPD) website for anyone to access and use. For busy citizens wishing to review some data quickly, VPD releases annual reports summarizing crime statistics for people to review. For instance, one of the latest reports as of 2015 was the annual report of 2014 [1], in which the following statement was made:

“Overall, crime fell in 2014, with violent crime falling 11 per cent.”

While hearing such a summary statement may be sufficiently assuring, for some of the more concerned citizens, they may feel the needs to review additional data for verification. Alternatively, VPD also releases raw crime data that can be accessed for additional

analysis. However, these data are generally in the forms of incident counts over certain periods of time, which are pure numbers in text, and therefore less insightful to interpret. Although some of the released reports and few online visualization tools available offered visual representations of yearly crime rate changes, they generally pertain to the city as a whole, and the more specific info pertaining to individual neighbourhoods are not directly visible. The Vancouver Crime Map aims to bridge the gap of the raw data and the full summary of city crime statistics, by collecting and processing the crime data and visualizing them to provide general users better understanding, analysis, and comparison of crime incident statistics in the neighbourhoods of Vancouver.

2 RELATED WORK

There have been many applications of visualizations in the field of criminology, mostly with the focuses on forensics and crime analysis. While the focus of the Vancouver Crime Map is to inform the general public and does not largely overlap those of the related works, numerous visualization techniques had been employed and studied for their appropriate uses in this area, and the analysis and demonstrated uses in those related works are useful in the visualization design in this project.

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2.1 Academic Works

M. Andreson conducted case studies specific to the crime statistics in Vancouver [2] [3]. He studied the spatial dimension of automotive theft, breaking and entering, and violent crimes in 1996 to synthesize and assess the two common spatial theories of crime: the social disorganization theory, and the routine activity theory. The level of details required is defined at the Vancouver neighbourhood level, so the granularity of the data analyzed is similar to that of this project. However, the data used were from the VPD CFS (Call-for-service) database, which included specific locations and times of the alleged crime activities. Consequently, the reported counts might not represent the actual criminal activity data. These numbers were further processed as crime rates per census tract, per 1,000 persons, per 1,000 ambient population in the different neighbourhoods, and displayed spatially as choropleth maps for the 3 different crime types. The derived data and the visualizations allowed the author to discuss the validity of the theories in terms of actual demographic and geographical information of the criminal activity.

The TASC (Textual Analysis of Similar Crimes) system [4] utilized natural language processing to derive data from raw investigation reports, and the data were further visualized to support crime investigation analysis. There was a great detail of discussion of the effectiveness of visualization and interaction techniques in the graphical representation of crime data, including focus+context, details-on-demand, and brushing-and-linking. While the TASC system focused on textual visualization, the case studies in this paper suggested the potential usefulness in comparing similarities and differences in crime data, which is what the Vancouver Crime Map hoped to enable the users to do for the Vancouver crime statistics.

In the web-based crime analytics system of newspaper articles [5], similar data mining and machine learning techniques as TASC were employed to assist crime investigations in Sri Lanka. Unlike TASC, the auto analyzer further derived 3 sets of data for visualization: (a) hot spots of crime activity represented as neighbourhood district regions with color encoding indicating the frequency values on a choropleth map; (b) crime comparison of different types of crime as a pie chart; and (c) crime patterns as the time-series plot to represent changes in frequency of crime types. The system allowed user selection of crime types and the years to display in the graphs. The graph and diagram representations made the system simple to use for crime analysis processes used by either law enforcement officers or any other interested users, including the general public.

2.2 Other Works

The Vancouver Police Department periodically releases crime statistical reports offering additional visualizations to support their summaries. Notably, in the report released for the year range of 2009-2013 [6], various bar charts and line charts of city crime counts were employed to illustrate the alleged declining crime rate in Vancouver. VPD also generated "Crime Maps" and made them available online [7], which showed weekly aggregated counts of property incidents with color encodings on a geographical view of Vancouver neighbourhoods. These crime maps were static graphs and replaced when new weekly data were available; therefore, accessing previously released data and comparing them appear to be challenging for the general public.

During the last implementation phase of the Vancouver Crime Map, VPD released their latest crime visualization tool called GeoDash [8] on December 8, 2015. The tool addressed some of the issues of the Crime Maps by offering a fully interactive map with individual crime incidents marked. The interface allowed the users to navigate the map and look at these incidents in detail, including zooming in to examine the incidents in the neighbourhood view on the map. Neighbourhood-specific incidents can be queried up to 4 weeks in the past, while city crime trends were made available as time-series line charts up to 24 months in the past. While VPD GeoDash provided effective ways for the general users to visualize

crime incidents, the information displayed was fairly low-level and localized to the specific incidents marked. The crime trend options provided some high-level overview info, but the data represented the whole city in general and the options to analyze specific neighbourhoods and crime types were not flexible.

Thematic maps, such as choropleth maps, were generally employed for crime visualizations for the masses. The San Francisco Crime Map [9] displayed crime counts of different neighbourhood blocks using colors, with different saturation levels indicating different crime frequencies. The data allowed the author to generate interesting findings in the analysis, such as that certain areas did not have higher crime rates as previously perceived, or that certain areas had higher auto theft rates so cars should be parked elsewhere. It is with the same intention that the Vancouver Crime mapping can be used to derive these findings by the general public. While the San Francisco Crime Map was a static graph, the London Crime Mapping [10] offered geographical view of London with zoom-in and zoom-out interactions to enable different levels of details. In addition, each region focused and clicked on generated linked pop-up views of additional comparison info, such as changes in the crime rates since last month, or crime rate trends comparing to the previous year. These interaction techniques appeared to provide a more seamless transition to display comparison data as opposed to a separate comparison view.

Oakland Crimespotting [11] and San Francisco Crimespotting [12], both by Stamen Design, visualized crime statistics in the corresponding regions with much granular controls and details. Crime incidents were marked on the map on the street level with different colors representing different types, and the times of the incidents were included. The system leveraged this detailed level of raw data to give users controls over the time ranges of the day to display the incidents. In addition, a constant overlay of incident count histograms was displayed, acting as a visualization of information itself and also as a control over the date range of display. CrimeReports [13] implemented a similar visualization solution, with emphasis on providing more details for each incident. The additional information could be accessed in the incident pop-up, and the system also allowed filtering of crime incidents based on user selections of date ranges and crime types. While the Vancouver crime data publicly available from VPD are not of the level of detail, the clever uses of visualization in these projects were considered for the design of the Vancouver Crime Map.

3 DOMAIN AND DATA

3.1 Main Dataset

The domain of interest was the crime incident statistics released by the city government of Vancouver on the VPD website. VPD released crime count data dated back to the year of 2002, and the latest data were generally released up to the previous month of the accessed date. At the time of this writing, monthly statistics were available from January, 2002 to October, 2015.

The raw data from VPD were basically tabular in nature. Each item had a data value representing the crime count, which was essentially a quantitative number. The attributes of each item included time information, the crime type, and the neighbourhood. The time attribute can be as specific as a particular month in a year, such as the month of October in the year of 2015. Therefore, the full range of time data available accounted for 166 months of monthly crime counts. The crime types included 10 categories: Sex offences, assaults, robbery, B&E (breaking and entering), theft of MV, theft from auto, theft <> \$5K, arson, mischief, and offensive weapons.

The original raw data included crime count reports for 24 neighbourhoods, but upon examining some city neighbourhood info [14] and geographical zones [15], two neighbourhoods were specially processed: (a) Stanley Park is generally not regarded as a residential neighbourhood, so its crime counts were ignored in the data processing; (b) Musqueam is an Indian band with its own crime

count reports, but neighbourhood-wise it is generally regarded as part of the Dunbar-Southlands; therefore, its crime counts were merged with that of the Dunbar-Southlands. In addition, the Central Business District is generally referred to as Downtown, so the corresponding data were labelled as the Downtown neighbourhood. The final collected data included 22 neighbourhoods. For the purpose of this project, the crime data for the whole city of Vancouver would account for all 22 neighbourhoods.

The total number of distinct items in this dataset was therefore: $166 \times 10 \times 22 = 36,520$ crime counts.

3.2 Exclusion

At the time of the project inception, the intention was to include the property crime incident data from the Vancouver Open Data Catalog (VODC) [16]. The dataset was different from that released by VPD, that it included lists of specific property crime incidents and their info. The raw property incident record, as accessed at the time of project proposal, was essentially a Table item with the type of the crime, the date of the incident, and the hundred block address as the Table attributes. The crime types included are: B&E, Mischief (over, and under \$5000), Theft from Auto (over, and under \$5000), and Theft of Auto (over, and under \$5000). The hundred block addresses were addresses accurate to the hundredth digit.

The main difficulty encountered during project implementation was that the data obtainable from VODC were only up to March 2015, and not updated for the majority of the implementation stage. E-mails were sent to VODC asking for updated incident lists, but were met with no responses. With the property incident data out-of-sync with the monthly crime counts, I found it difficult to properly integrate the views that provided a seamless navigating experience. In addition, the relevance and usefulness of incident data was questionable given that it was out-of-date for eight months. With regrets, I excluded the data in the final implementation of the project.

Incidentally, the data available from VODC underwent an overhaul after the release of GeoDash, which was mentioned and analyzed in the Related Works section. Not only was the information now up-to-date, the data formats also included geocoding data not available previously. Had the data been available earlier, the design choices would have potentially included these incident data as a part of the visualization solution.

4 TASK

The project intended to provide visualizations that faithfully reflected the crime count data made publicly available. Even though the data can be further analyzed for uses such as studying crime patterns in the city of Vancouver, the focus was to provide a more visually understandable overall representation of the data for general consumption. Therefore, I surveyed about 10 other Vancouverites regarding what questions they wished to answer given that the crime count data were available. Two questions emerged from the survey results, which can be translated to two goals: (a) To understand what generally is happening in the city/neighbourhoods in terms of crime rates; and (b) To understand what the crime rate difference is over time, or among different crime types, or among different neighbourhoods. The goals suggested the following tasks that the visualization solution should support:

- A. Analyze crime rates in the city and in the neighbourhoods
 1. Discover crime trends
 2. Discover features in crime frequencies
 3. Discover crime count distributions
- B. Search in crime count data
 1. Lookup specific crime counts
 2. Browse crime counts within groups of certain crime attributes
 3. Locate certain crime counts within different groups of crime attributes
 4. Explore crime counts in the city

C. Compare crime statistics

1. Compare crime statistics of different times
2. Compare crime statistics of different crime types
3. Compare crime statistics of different neighbourhoods

5 SOLUTION

Since the Vancouver Crime Map aimed to visualize crime counts for both the city and the individual neighbourhoods, I decided to provide a constant overview of the whole city and the neighbourhood zones, and the users could make selections to bring up additional details on demand. There were three major visual components in the interface layout: The overview as a geographical map, the details as charts, and additional controls that allowed the users to make selections. There was also an additional component embedded in the interface interaction and layout that linked all the components together. The different components will be discussed in detail in the following sections.

5.1 Overview – Geographical Map

The crime counts of the city of Vancouver as defined in the Vancouver Crime Map consisted of crime counts of 22 neighbourhoods. Since each neighbourhood had specific geographical attributes of its zone boundary, it was a natural design choice to translate the geographical attributes to visual maps and represent the crime counts accordingly. The geographical longitudes and latitudes of boundary points were available as KML or SHP files on VODC [15], which can be translated to a GeoJSON file and a visual map of 22 zones was generated based on the data, as shown in Figure 2.

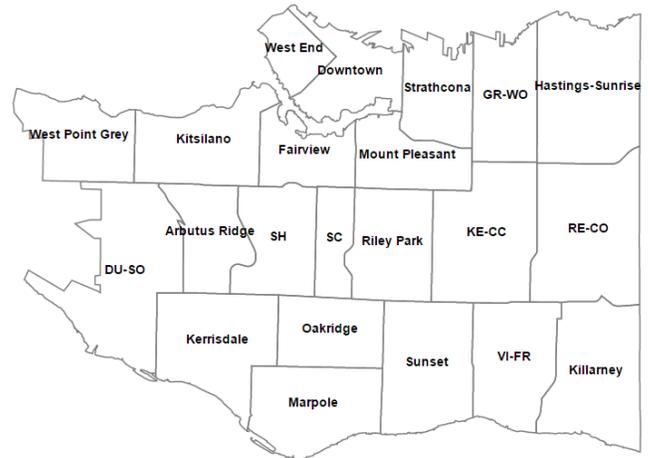


Figure 2. Geographical visualizations of 22 neighbourhoods.

The crime counts of each neighbourhoods given a specified time range and a selection of crime types could therefore be translated to color encodings to fill the different zones on this map, with the level of saturation relatively proportional to the crime count value.

Originally I decided to create a thematic (choropleth) map with discrete color quantiles. However, during the implementation, I found out that the Downtown neighbourhood often had crime counts much higher than all other individual neighbourhoods. For instance, for all crime types in the month of October, 2015, Downtown had 1014 incidents, while the West End with the 2nd highest crime count had only 272. There were 12 neighbourhoods with counts under 100. If a quantile scale was applied directly with 9 distinctive buckets, the Downtown crime count values could dominate the whole scale, and squeeze most colors of the other neighbourhoods to the lower end of the scale, as shown in Fig. 3. While this representation was accurate, the usefulness of the fill colors was marred because 13 neighbourhoods shared the same color.

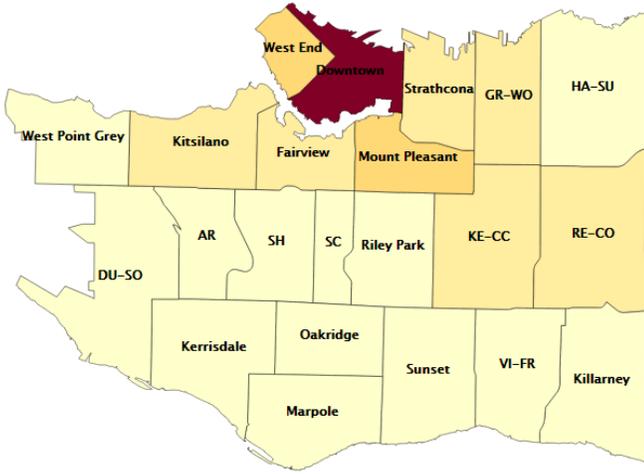


Fig. 3. Crime counts including all crime types in October, 2015. 9 distinct buckets were used using YlOrRd colors on ColorBrewer.

Therefore, I decided to use a linear color scale with tweaked proportionality to accommodate the frequent disproportional crime counts of Downtown. I defined the scale to consist of three segments: 0% – 25%, 25% - 75%, and 75% - 100%, and different colors were defined as the segment boundaries: “White” at 0%, “Orange” at 25%, “DarkOrange” at 75%, and “OrangeRed” at 100%. This scale allowed distinction among neighbourhoods of low crime counts, while still keeping those with higher crime counts in sight with a different color segment on the same spectrum of saturation levels. Because of the modified linearity, a legend was created to suggest the different color segments on the color scale. Fig. 4 showed the choropleth map using the modified color scale with the same set of data as Fig. 3.

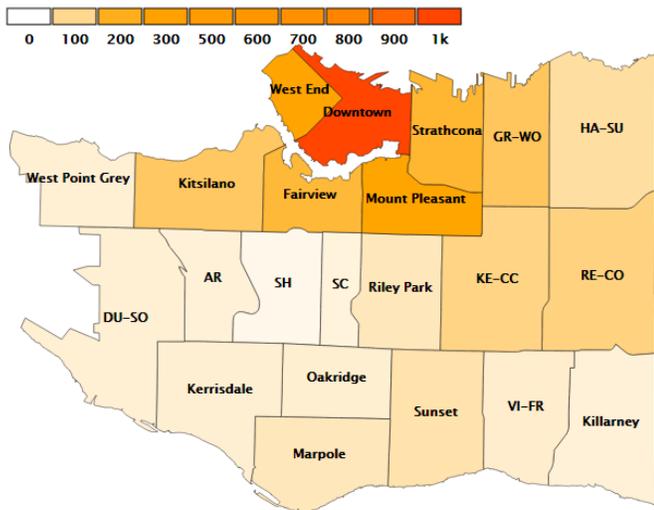


Fig. 4. Crime counts including all crime types in October 2015. Tweaked linear color scale used as fill-colors. Legend added.

I also considered cases when the disproportional crime counts did not exist based on the user selection. Since the modified color scale was essentially a linear scale (non-quantile) from “White” to “OrangeRed”, with a long middle segment of “Orange” to “DarkOrange”, proportional crime counts could still apply properly using this scale. For instance, Downtown had only 4 counts of arson in October, 2015, and other neighbourhoods had counts of 0, 1, or 2.

The choropleth map for this set of data was shown in Fig. 5, where different counts were relatively distinguishable even though the Downtown crime count was not significantly higher than the others.

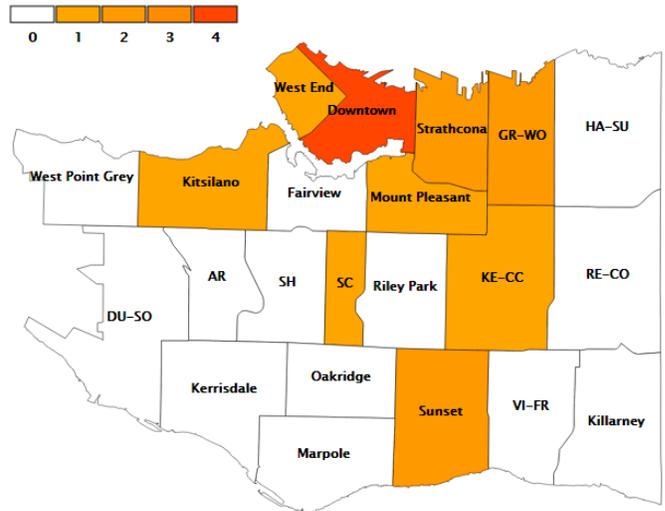


Fig. 5. Crime counts of arson in October, 2015.

The geographical map additionally allowed the users to hover over different neighbourhoods to see the actual crime count values, as shown in Fig. 6. Combining the visual information provided by the color saturation, the legend, and the crime count values on hover, the users could have an overview of the crime counts of different neighbourhoods in the city and an understanding of how the crime count of one area was different from the others.

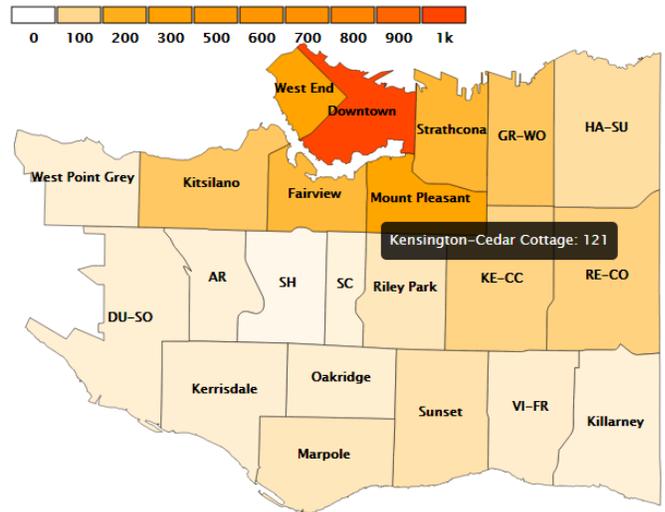


Fig. 6. Crime counts of KE-CC on hover.

5.2 Details – Charts

While the geographical map provided an overview of the city crime data that gave the users a sense of how different each neighbourhood crime count was, the details were not completely integrated in the map for fear of visual clutter. Therefore, I decided to include few separate visualizations in the Vancouver Crime Map to augment the geographical map. Since comparing crime data was one of the main tasks that the visualization should support, I decided for the separate visualizations to be in the forms of comparison charts to provide means of comparing data, as well as to display details on demand.

5.2.1 Comparison over Time

When the user wished to discover trends and compare crime data over time, crime counts of different time attributes would need to be plotted. Since time ranges were continuous, it made sense to plot the crime count values sequentially on an xy chart, with the x-axis representing the different time attributes, and the y-axis representing the crime count value. After the data points were plotted, a line was plotted to connect the points to allow the user to see changes of the crime counts and identify patterns and features. The plot illustrated in Fig. 7 was essentially a time-series chart.

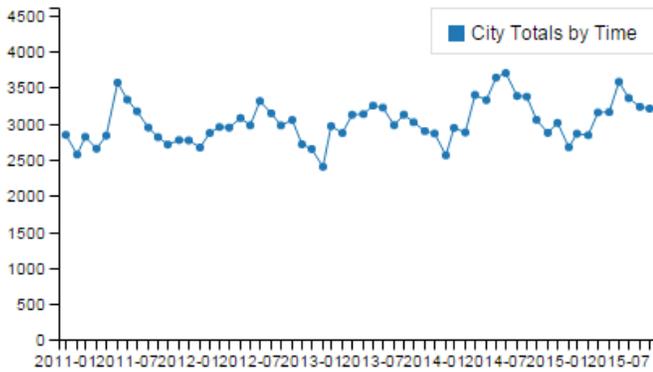


Fig. 7. Time-series chart of city totals of all 10 crime types from January, 2011 to October, 2015.

The chart could be generated for either a single neighbourhood or the whole city summing up all counts for all 22 neighbourhoods. The actual crime count value and the corresponding time could be accessed by hovering over the data points, as shown in Fig. 8.

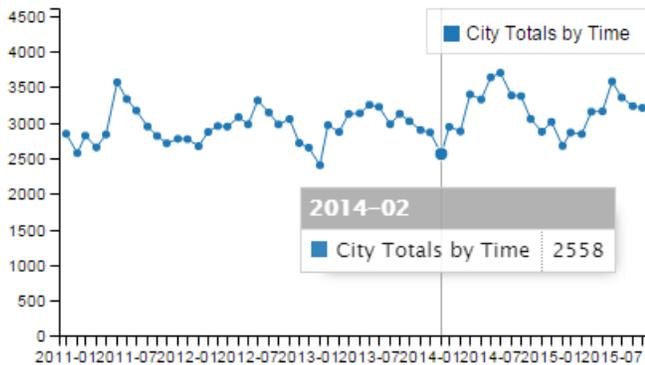


Fig. 8. Accessing the crime count value and the time of one data point on the time-series chart.

5.2.2 Comparison among Crime Types

Since each crime type was essentially a different category of different crime incidents, I decided to include a bar chart for comparing crime counts of different crimes. Each crime type would occupy a bar of distinct color, and the respective crime count value was reflected by the height of the bar. The bar chart would display the crime counts in descending order for the users to see the difference and the ranking of each crime type. Similar to the time-series chart, the bar chart could be generated for either a single neighbourhood or the whole city. In addition, the crime count value and the crime type of each bar could be accessed by hovering the cursor over each bar, as illustrated in Fig. 9.

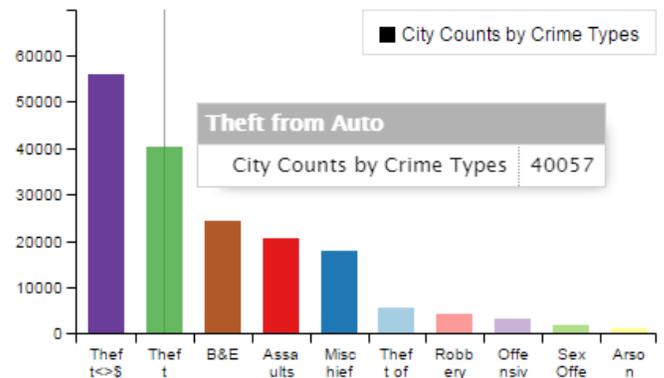


Fig. 9. Bar charts of each crime types in the city from January, 2011 to October, 2015, displayed in the descending order of crime counts. The data were accessed by hovering over the green bar.

5.2.3 Comparison among Neighbourhoods

Even though some comparison of neighbourhood crime counts could be made from the coloring of the geographical map, the number of the neighbourhoods and the color scale employed may still made it difficult for the users to distinguish small crime count differences of different neighbourhoods. Because each neighbourhood could be considered as a different category, I decided to include an additional bar chart with each bar linked to one of the neighbourhoods, and the bar height reflecting the corresponding crime count. Similar to the crime type bar chart, the bar chart data were sorted in descending order for the users to see the difference and the ranking more easily, as illustrated in Fig. 10. This bar chart contained shared data with the geographical map, but additional details of rankings more visually apparent.

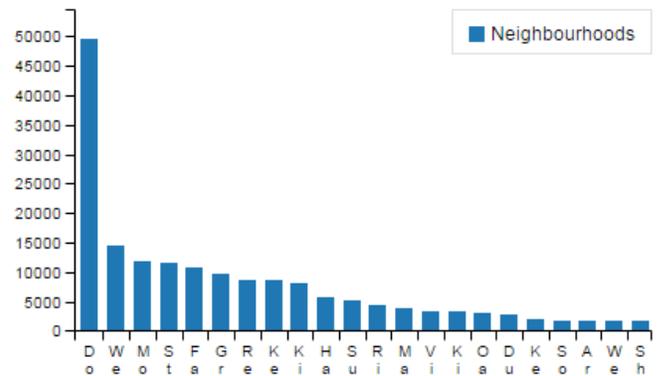


Fig. 10. Bar charts of each neighbourhood in the city from January, 2011 to October, 2015, displayed in the descending order of crime counts.

5.3 Controls – Selections

In addition to the geographical map and the charts, the Vancouver Crime Map provided the users selection controls to change the crime count values visualized. The selection controls included both the time ranges and the crime types, which allowed filtering of the displayed crime count data by altering the selection of the two attributes.

The time range selection included two sets of two fields in the forms of year-month, which defined both the starting year-month and the ending year-month. The controls were in the forms of dropdown menus for each attributes. The user could, for instance, select 2002-01 as the starting time and 2015-10 as the ending time, and the resultant data would include all 166 months included in the dataset. The user could alternatively select 2015-10 for both the starting and the ending year-months, and the data displayed would be of one

month only. The year-month forms would update automatically upon changing one field to ensure that no illegal selection was made.

The crime type selection control consisted of 12 checkboxes, including all 10 crime types, and 2 additional ones to select/deselect all crimes types. The user could, for instance, decide to include all 10 crime types in the displayed data by checking all 10 checkboxes, or alternatively query data for a single crime type by checking just one.

There was an Update date button that, upon clicking, updated all the displayed data in the visualization according to the user selection. I decided not to interactive updating while the user was making changes to the selection, for two reasons: (a) The users may want to keep the previous data in sight while making changes to the selection; and (b) For larger selections of either time ranges and crime types, the updating time might be long enough to disrupt the workflow of the user. Therefore, it was a design choice to include the Update button, so the user could control when to update the map display and see the changes reflecting the selections. This choice introduced another problem that the selection displayed might no longer reflect the displayed data, especially the time range. Therefore, I included additional labels to inform the users of the time range displayed. The overall control panel was shown in Fig. 11.

The screenshot shows a control panel with the following elements:

- Starting Year-Month: 2011 | 1
- Ending Year-Month: 2015 | 10
- Crime Types:
 - Select All
 - Select None
 - Sex Offences
 - Assaults
 - Robbery
 - B&E
 - Theft of MV
 - Theft from Auto
 - Theft <-> \$5K
 - Arson
 - Mischief
 - Offensive Weapons
- Update button

Fig. 11. Selection controls to choose and filter time ranges and/or crime types.

5.4 Interactions and Layout – Linking Views

With all the map and the charts combined, the Vancouver Crime Map consisted of six varying visualizations. My final design utilized two mechanisms to link the views together and offer the users a more seamless experience to complete the tasks.

5.4.1 Juxtapose Views

I had considered different layouts, initially a separate page to display the comparison charts from the geographical map. However, the information density appeared to be lacking and I started to look at ways to combine views. I also considered including comparison views as pop-ups within the geographical map, but realized the amount of information that could fit into the pop-up was limited, and the pop-up itself would visually occlude the geographical map overview. In the end, I decide to juxtapose the different charts outside the geographical map, placing them side-by-side to keep the geographical map constantly in sight while displaying the chart in an arrangement that allowed constant comparison and contrast. The final layout was essentially having the charts surrounding the geographical map, with the bottom charts pertaining to the city totals, and the side charts pertaining to the neighbourhood selection. Since the neighbourhood bar chart pertains to both the city and the individual neighbourhood, it was placed at the corner intersection of the bottom grid and the side grid. The layout was illustrated in Fig. 12.



Fig. 12. Layout as grids of the geographical map and the comparison charts: Control+Map grid on the upper left corner, City Total grid on the bottom, and the Neighbourhood grid on the side.

5.4.2 Select and Linked Highlighting

The Vancouver Crime Map additionally allowed the user to make neighbourhood selections by clicking on the neighbourhood zones in the geographical map. Upon clicking, the neighbourhood grid would display the corresponding charts for the neighbourhood selected. This selection mechanism allowed the user to look at info specific to the neighbourhood of interest. To provide additional visual cues of the selection, the neighbourhood border would be bolded, and the neighbourhood bar chart would have the bar of the selected neighbourhood changing its color to orange. The highlighting ensured that the user would be aware of the selection when navigating the visualization as a whole.

6 IMPLEMENTATION

6.1 Data Cleanup

Aside from the data processing described in the Data section, the original cleanup of the data was more challenging than expected. First, the raw data available from VPD were in the format of PDFs, and the tabular data embedded were not immediately extractable from the PDF files. The Tabula tool [17] were utilized to extract all the data and put in the TSV format. However, not all documents were created consistently, and some manual work were tediously performed to deal with inconsistent documents to extract the data properly.

I then wrote a tool in Python to parse through the TSV files and created the JSON files for use in the Vancouver Crime Map. Most of the data processing described was done at this stage. There were two passes: The first pass was to create the JSON file corresponding to the TSV file, and the second pass was to compile the individual JSON files into a single JSON file for ease of use. I also ran additional passes for both neighbourhood-based queries and crime-based queries for more efficient generation of different charts, as well as ensuring that every attribute in the dataset was consistent. This extra step had proven to be useful because I identified various types and mislabelling in the initially generated set of JSON files.

6.2 Implementation Details

Most of the Vancouver Crime Map was implemented using D3.js, including mostly the geographical map, the selection control, and linking the data to the charts. I used additional libraries to handle some of the sub-implementation tasks more effectively:

- JQuery.js – Used for easier event monitoring and combined effectiveness with D3 to select various DOM objects for manipulation
- Queue.js – Used to better manage asynchronous loading of the data JSON files

- D3-tip.js – Used to incorporate the hover info
- D3-legend.js – Used to create reactive legends on the geographical map
- C3.js – Used to create different charts; I still needed to make use of D3 to make up for limitations in the original library, such as category coloring and linked highlighting
- Colorbrewer.js – Used to test out different color scales. Not used in the final implementation but was used extensively during design phase.

7 RESULTS

The Vancouver Crime Map was specifically designed to support the users to complete the tasks as described in the Task section. The results were summarized in the following sections.

7.1 Scenario

John lives in the Dunbar area of the city, and wished to learn more about the overall crime statistics in the city of Vancouver, and also the Dunbar neighbourhood.

He launched the Vancouver Crime Map, which defaulted the views to display data in the latest month of October, 2015. He saw that Downtown had the highest crime count in the city, and Dunbar had relatively low. The top three neighbourhoods were Downtown, West End, and Mount Pleasant, and the top three crime types in the city were Theft < \$5K, Theft from Auto, and B&E.

Concerned about his own neighbourhood, he clicked on Dunbar-Southlands, and the neighbourhood charts showed up on the side. The top three crime types were the same as the city totals, but B&E was higher. (Figure 13)

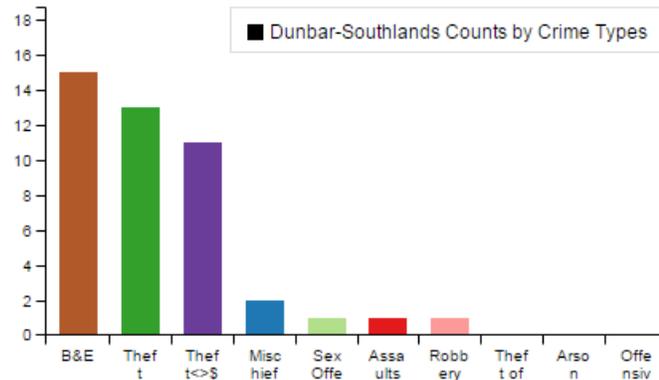


Fig. 13. Dunbar-Southlands Counts by Crime Types, October, 2015.

Interested in learning about the crime trends, he specified the time range of 2010-01 to 2015-10, and updated the map. The time-series chart was updated to reflect the crime pattern in the neighbourhood. (Figure 14)

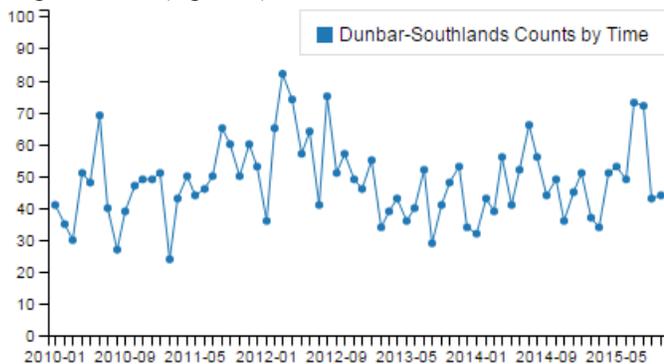


Fig. 14. Dunbar-Southlands Counts by Time, 2010-01 ~ 2015-10.

Hovering over the chart, John found out that the crime rates were generally higher in the months of July, as seen in the years of 2012-

2015. He speculated that it was during the summer vacation times and there were more planned B&E incidents in the area. He decided to make note of this and be more vigilant in the upcoming summer.

While looking at the neighbourhood chart, he noticed that there was a similar pattern showing in the city totals, as shown in Fig. 15.

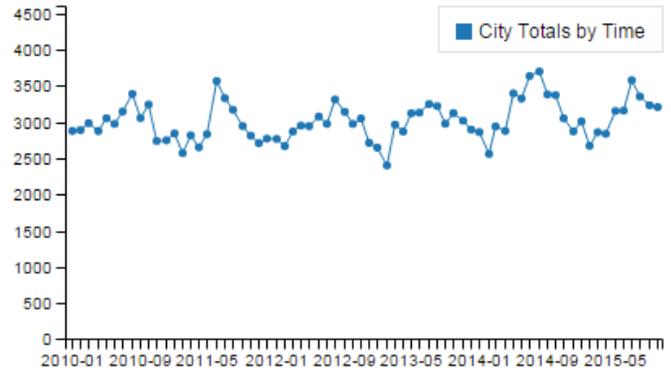


Fig. 15. City Totals by Time, 2010-01 ~ 2015-10.

The patterns he discovered in the Dunbar neighbourhood appeared to be city-wide, since the city totals chart showed high crime counts in the months of July and August in all five years of 2011 to 2015.

John also noticed the neighbourhood bar charts at the corner, which showed that his neighbourhood had relatively low crime counts, while Downtown had really high crime counts in comparison, as shown in Fig. 16.

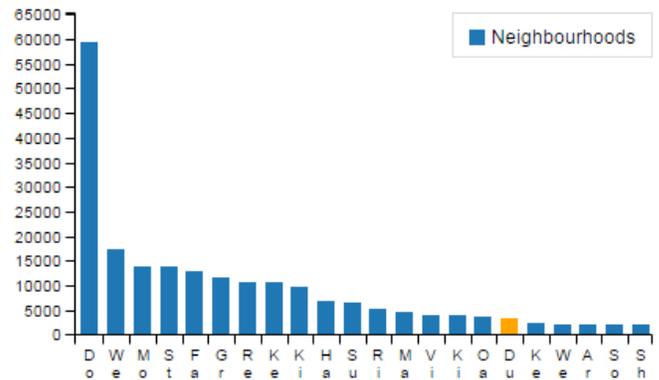


Fig. 16. Neighbourhood Bar chart with Dunbar-Southlands highlighted.

He decided to look at Downtown details by clicking on the Downtown neighbourhood on the map, as shown in Fig. 17.

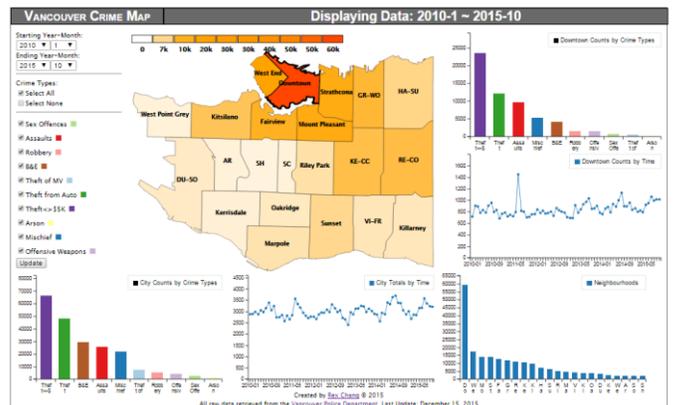


Fig. 17. The Vancouver Crime Map, 2010-01 ~ 2015-10. Downtown selected.

The time-series chart for Downtown had an interesting spike, as shown in Fig. 18.

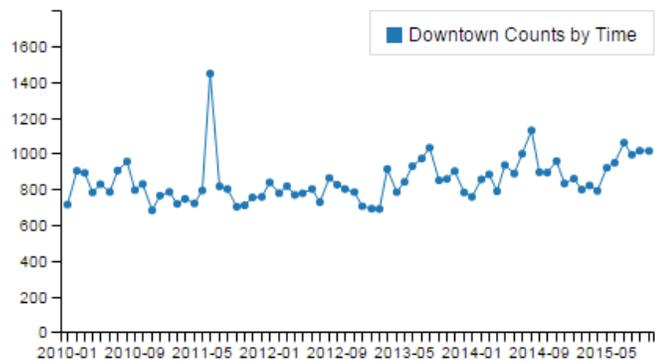


Fig. 18. Downtown Counts by Time. 2010-01 ~ 2015-10.

John decided to look at the spike, so he hovered over the data point, as illustrated in Figure 19.

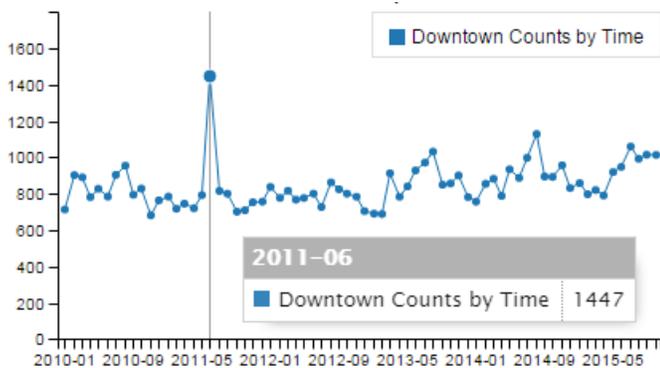


Fig. 19. Downtown Counts by Time, 2010-01 ~ 2015-10. Data point of 2011-06 displayed.

The crime count was twice as high as the average at the time, so he wondered what happened in that year. Being in Vancouver for many years, he remembered that it was the Winter Olympics and there was a riot in Downtown that likely contributed to the spike of the month.

He found the exploration the crime statistics in the city interesting, and was also satisfied that he was able to learn a few things or two about crime patterns in his neighbourhood.

7.2 Evaluation

The Vancouver Crime Map was uploaded onto my website, and could be accessed at <http://rexchang.com/vancouver-crimemap/>. I had asked people to play with the tool and provided feedbacks. Most of the comments received were positive, indicating that this was an interesting way to explore crime statistics in the city of Vancouver. Many used the tool and commented with discussions on crime patterns observed in the city or in the specific neighbourhoods, and speculated reasons. A friend of mine working in the property insurance had considered using the tool in his line of work.

8 DISCUSSION AND FUTURE WORK

The Vancouver Crime Map was created initially to bridge some of the gaps not offered by the existing tools. There were some hard design choices that had to be made before the final implementation.

In general, it was not possible, nor feasible to come up with a tool that replaced all the other tools in terms of the level of details visualized. On one hand, fitting too few data into the visualization

could cause a low information density that was no more helpful than raw data; on the other, fitting too many data into the visualization could cause visual clutters. The delicate balance was in the final design decisions, which were made with domain expert or user evaluations, as well as walkthroughs by the designer. The solution may not be perfect, but they were based on the user needs and the target tasks were achievable.

The release of the GeoDash was somewhat surprising as it provided a much richer visualization comparing to those previously available. In addition, it was almost exactly what I had in mind when initially thinking about the visualization property incident data. Nevertheless, the project direction was altered due to the lack of updated data to focus more on providing an overview based on raw crime data. The end result augmented well with the other tools available to the Vancouverites.

Since the Vancouver Crime Map focused more on the visualization based on raw data, there were comments regarding the deficiency of derived statistics. These data could be included in future iterations of the work to provide a more useful experience to the user.

I also observed in some cases when first-time users of the Vancouver Crime Map were mesmerized slightly when being presented by the map and the charts. Only after playing with the different components of the tool for a while, these users picked up how the data were displayed and linked. Since the tool was designed for use by the general public, more intuitive and helpful visual cues could be included as a guidance to use the tool to ease the initial learnability challenges present for some users.

There were also comments asking to include more data and more details, such as sub-neighbourhood data, or crime data of other cities. Depending on the availability and the format of the raw crime data, the Vancouver Crime Map solution may be extended to include these additional data in the future.

On the technical side, the linked highlighting implemented in the current version was sufficient in indicating the neighbourhood of interest. However, the implementation was rather minimal. D3.js by default did not provide easy ways to link SVG elements together unless everything was coded from scratch. I was able to implement a global controller that governed the linked highlighting, but I suspected that the use of a different framework may be more efficient, such as AngularJS that allowed two-way data binding. There was insufficient time to rework the backbone framework, which could be done in the future.

The current implementation of loading JSON files and performing all the calculations on the client side was sufficient, but I started seeing performance issues when updating all charts given large time ranges. The re-implementation to include a server-side database might alleviate the issue in the future.

9 CONCLUSION

The Vancouver Crime Map provided a way for the user to visualize the raw crime count data in the city of Vancouver. The tool aimed to faithfully represent the raw data while providing a constant overview and details on demand. There were various other visualization tools available that displayed different levels of details. The Vancouver Crime Map was designed with the intention not to replace the tools, but to augment them by bridging some of the gaps in terms of the level of details provided. In addition, this tool could be potentially used for general public consumption, which in turns allows more Vancouverites could be more aware of the crime statistics in the city.

REFERENCES

- [1] The Vancouver Police Department, "2014, Year in Review," January 2015. [Online]. Available: <http://vancouver.ca/police/assets/pdf/annual->

- reports/2014/2014-annual-report.pdf. [Accessed 18 December 2015].
- [2] M. A. Andresen, "A spatial analysis of crime in Vancouver, British Columbia: a synthesis of social disorganization and routine activity theory.," *The Canadian Geographer*, vol. 50, pp. 487-502, 2006.
 - [3] M. A. Andresen, "Crime measures and the spatial analysis of criminal activity.," *British Journal of Criminology*, vol. 46, no. 2, pp. 258-285, 2006.
 - [4] I. Jayaweera, C. Sajeeva, S. Liyanage, T. Wijewardane, I. Perera and A. Wijayasiri, "Crime analytics: Analysis of crimes through newspaper articles.," in *Moratuwa Engineering Research Conference (MERCOn)*, 2015.
 - [5] C. Ku, J. Nguyen and G. Leroy, "TASC - Crime report visualization for investigative analysis: A case study.," in *IEEE 13th International Conference*, 2012.
 - [6] The Vancouver Police Department, "Vancouver Crime Statistics - 2013 Key Performance Indicators," 2014. [Online]. Available: <http://vancouver.ca/police/assets/pdf/reports-policies/2013-year-end-kpi-report.pdf>. [Accessed 18 December 2015].
 - [7] The Vancouver Police Department, "Vancouver Crime Maps," [Online]. Available: <http://vancouver.ca/police/CrimeMaps/>. [Accessed 18 December 2015].
 - [8] The Vancouver Police Department, "VPD GeoDash Crime Map," [Online]. Available: <http://geodash.vpd.ca/>. [Accessed 18 December 2015].
 - [9] L. Kesteloot, "San Francisco Crime Map," October 2003. [Online]. Available: <http://www.teamten.com/lawrence/projects/sfcrime/>. [Accessed 18 December 2015].
 - [10] Metropolitan Police of London, "London Crime Mapping," [Online]. Available: <http://maps.met.police.uk/>. [Accessed 18 December 2015].
 - [11] Stamen Design, "Oakland Crimespotting," [Online]. Available: <http://oakland.crimespotting.org/>. [Accessed 18 December 2015].
 - [12] Stamen Design, "San Francisco Crimespotting," [Online]. Available: <http://sanfrancisco.crimespotting.org/>. [Accessed 18 December 2015].
 - [13] Public Engines, "CrimeReports," [Online]. Available: <https://www.crimereports.com/>. [Accessed 18 December 2015].
 - [14] City of Vancouver, "Areas of the City," [Online]. Available: <http://vancouver.ca/news-calendar/areas-of-the-city.aspx>. [Accessed 18 December 2015].
 - [15] City of Vancouver, "Open Data Catalogue - Local Area Boundary," [Online]. Available: <http://data.vancouver.ca/datacatalogue/localAreaBoundary.htm>. [Accessed 10 October 2015].
 - [16] City of Vancouver, "Open Data Catalogue - Crime Data," [Online]. Available: <http://data.vancouver.ca/datacatalogue/crime-data.htm>. [Accessed 18 December 2015].
 - [17] Tabula Technology, "Tabula," [Online]. Available: <http://tabula.technology/>. [Accessed 18 12 2015].