Lab1: Descriptive Paper of ODU Spring 2019 CS411 Team Silver Project

Crime HotSpot

CS411W Spring 2019 Team Silver
Professor: Thomas Kennedy
Author: Kenneth Watson
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1. Introduction

Above all else, Crime HotSpot will be an interactive geographical map. A typical use case for a geographical map is finding out where to go or how to get to a location of interest. Another common use case is as a backdrop for analyzing and presenting statistical data related to a geographic area. In some instances, it could be both of these things, such as a crime map. In the context of existing products and the proposed product, a crime map is any geographical map that presents on top of it statistical data regarding criminal activity. Law enforcement has been one of the primary users of such maps, producing them in software and analyzing them to better understand problem areas and efficiently allocate resources (NIJ, n.d.). However, this type of information could also benefit the public. As humans, intuition and keen observation help indicate what areas might be safe and what areas should be avoided due to crime or other potential dangers. For some people, the level of uncertainty inherent in this method is not acceptable. Local hearsay might or might not help either, due to potential bias and opinion. This uncertainty could be lessened if fact-based data and statistics are readily available to use for this purpose. A data-driven approach might also help in cases where someone is considering moving to or staying in a certain area. There would be no need to scout a location in person if there was data showing that the location is generally unsafe. An adequately informed public could also be a boon to law enforcement, with such a scenario perhaps leading to fewer crime incidents. Nevertheless, designing a crime map for use by the public provides challenges that need to be properly addressed in order to make such a map effective.

There has already been progress in developing crime maps for public use. Such maps are often developed for a specific locality, likely due to the task of having to coordinate with law enforcement to retrieve raw crime data. Team Silver studied a portion of the maps and services offered for Hampton Roads areas and identified issues that could prevent effective use of these products. These include trouble differentiating violent crimes from nonviolent crimes and information overload caused by cluttered interfaces. The first problem was found in applications that did not target the crime mapping market specifically but provided some form of such functionality as part of a broader set of features. These software products mainly targeted home buyers and people looking to relocate. In those cases, crime was one of multiple factors that affected what was relayed on the map and there was no indication as to what types of crimes were considered. There is nothing inherently wrong with this method, as an overall indication of criminal activity could still prove useful for providing an impression of an area. However, Team Silver reasoned that, if it was within the ability of the application developer to differentiate the types of crimes shown to the user, it would be best to do so. More detailed information allows users to consider all factors before taking action, such as buying a house. Violent crime and property crime might rank higher for home buying users than other crimes such as fraud, shoplifting, and disorderly conduct.

In web applications geared towards true crime mapping, Team Silver found cluttered interfaces as the more common issue. This problem could be a direct result of having a more detailed presentation that distinguishes between crime types. Interfaces such as the one in **Figure 1**, are busy, tricky to navigate, and may leave a false impression. Not all of the crimes presented could be violent, but the sheer amount of crimes could give the impression of a dangerous place. Even with date filters, this common behavior in public crime maps could make it hard to effectively process the information presented. Crime HotSpot seeks to be a solution to some of these issues.

Figure 1. Screen shot of crimes for the city of Norfolk, Virginia. Reprinted from Helping You Build a Safer Community in CrimeMapping.com., 2018, Retrieved from CrimeMapping.com

The ideal solution would provide context to the data presented. In other words, crime types are differentiated from one another. For the best user experience, it should also be possible to filter crime types based on user input. Thus, what is shown on the map is relevant to the user's concerns. However, all of these aspects should be implemented in a way that keeps visual clutter to a minimum. This is where the proposed product, Crime HotSpot, comes into play.

2. Product Description

Crime Hotspot will be using a heatmap display. This display will provide the aforementioned characteristics. Traditionally, heatmaps work by color coding data points and overlaying these points across a geographical map. From the user's perspective, the brightness or shade of each color conveys how concentrated a particular area is with regard to the data, as seen in **Figure 2**. This is a boon to crime mapping. Without the clutter of dozens of icons, colored "heat" will instead serve the purpose of showing how high the crime level is in an area and how risky it is according to user preferences. Since the application will be solely web based, the team will develop product features and infrastructure in the standard web development languages of HTML, CSS, and JavaScript. Since the product is a full stack application, requiring a robust front and back end, Team Silver chose to use the popular MEAN stack collection of frameworks for development. These frameworks are mostly JavaScript based and include MongoDB, Express.js, AngularJS, and Node.js. The MEAN stack allows the team to work in a tightly

coupled ecosystem of JavaScript constructs, permitting more time to learn the concepts of full stack development.

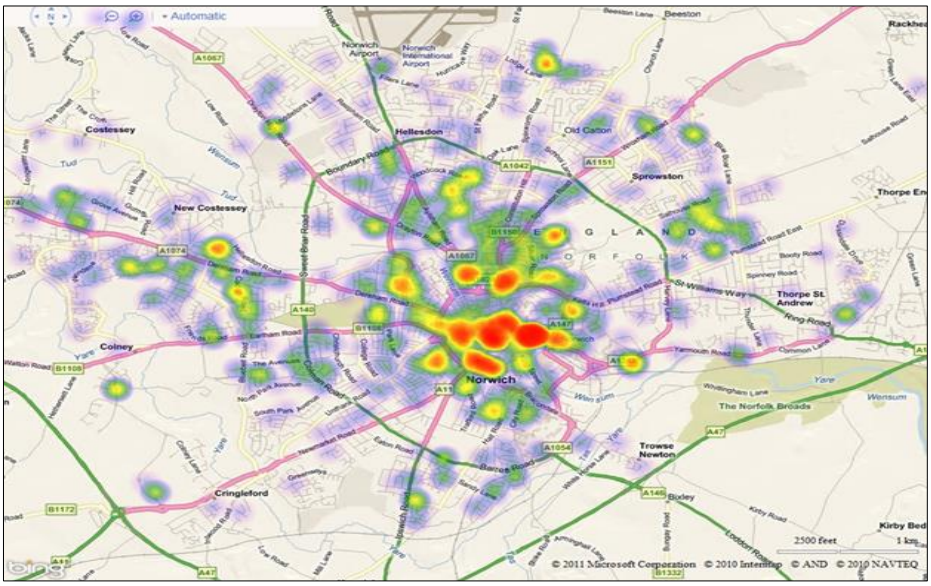

Figure 2. Example of a heatmap, with the red areas depicting a hotspot which where there is higher density of crimes. Reprinted from "Heat Map" by Microsoft, 2011, Retrieved from alastaira.files.wordpress.com/2011/02/image24.png.

2.1 Key Product Features

2.1.1 Crime Statistics

In depth crime statistics and analytics are planned for the real world product. In keeping with the clutter free design philosophy, these statistics will not be entirely visible by default. Since the crime map is the focus of the application, supplementary analytics would be placed either below the crime map or on a separate page or menu item. The analytics section would include pie charts, graphs, and more detailed statistics gathered from crime data. For example, a line graph might show the monthly occurrence rate of violent crime over the course of a single year. This section would also be the area where a user might have access to live crime updates coming from local news sources. This sub-feature would further enhance the goal of keeping users well informed and with the most up to date information possible. The feature would also act as a balance to compensate for the latency involved in gathering and entering raw crime data into the database.

2.1.2 Geographical Crime References

One point of difference between Crime HotSpot and its competition is that it will hide the exact location of the crimes used to generate the heatmap. There will be no icons that pinpoint an exact location and any supplementary information exposed to the user will not include an

address. Team Silver decided that the privacy of individuals in and around the sight of a crime was an important consideration and outweighed the benefits of informing Crime HotSpot users. An example of a reason why would be to protect home owners who were victims of a crime. They might not want their street address known to other potential criminals.

2.1.3 Crime Heatmap

The Crime HotSpot application has the goal of making it quick for anybody to gauge danger or risk. Upon looking at the heatmap, users should know in an instant what areas are safe and what areas should generally be avoided. By default, a red area would indicate that a region has had a higher concentration of violent type crimes, whereas cooler colored areas might indicate less crime or less severe crime. Accessibility is another important aspect to the heat map interface, and having options supporting color-blind persons is planned. This would manifest itself as including different color combinations for the heatmap drawing.

2.1.4 SafetyScore

SafetyScore is Team Silver's planned design for how the heatmap is calculated "under the hood." A key difference that separates Crime HotSpot from similar products (and the reason for the branding) is that this calculation, and its factors, is displayed to the user. It represents the general safety level of an area, on a scale of one to five. A value of five means an area is extremely safe whereas a value of one would mean an area is extremely unsafe. For users curious about how the score was calculated, they can hover their pointer over the area and get some quick information about it. Such information would include breakdowns on the number of crimes of each type, their weights when being calculated, and the relative population density of the area. These factors are also heavily tied to the filtering options available to the user to control the SafetyScore calculations and the resulting heatmap. Since each user might have unique priorities when it comes to crime (e.g. violent crime vs property crime), filters would allow control over what types of crimes have higher weights assigned to them, date ranges for crimes, and time of day to name a few. Ideally, filtering functionality would be implemented with buttons and sliders, and would be flexible enough to handle a multitude of crime types.

2.2 Major Components

Figure 3 introduces the main functional components of the Crime HotSpot application and their relationships. Each component is either a software or hardware interface, or both. The focus is on the primary Crime HotSpot website, Google Maps API, dynamic application server, and the MongoDB database. GIS technology is abstracted away by the Google Maps API. The API is therefore the interface to that technology. Additionally, while the mobile app is planned for the real world product, it is not important to the core application and will not be included in the prototype. **Figure 4** conveys the overall approach Crime HotSpot will use for implementing core algorithms and further clarifies the communication between major components.

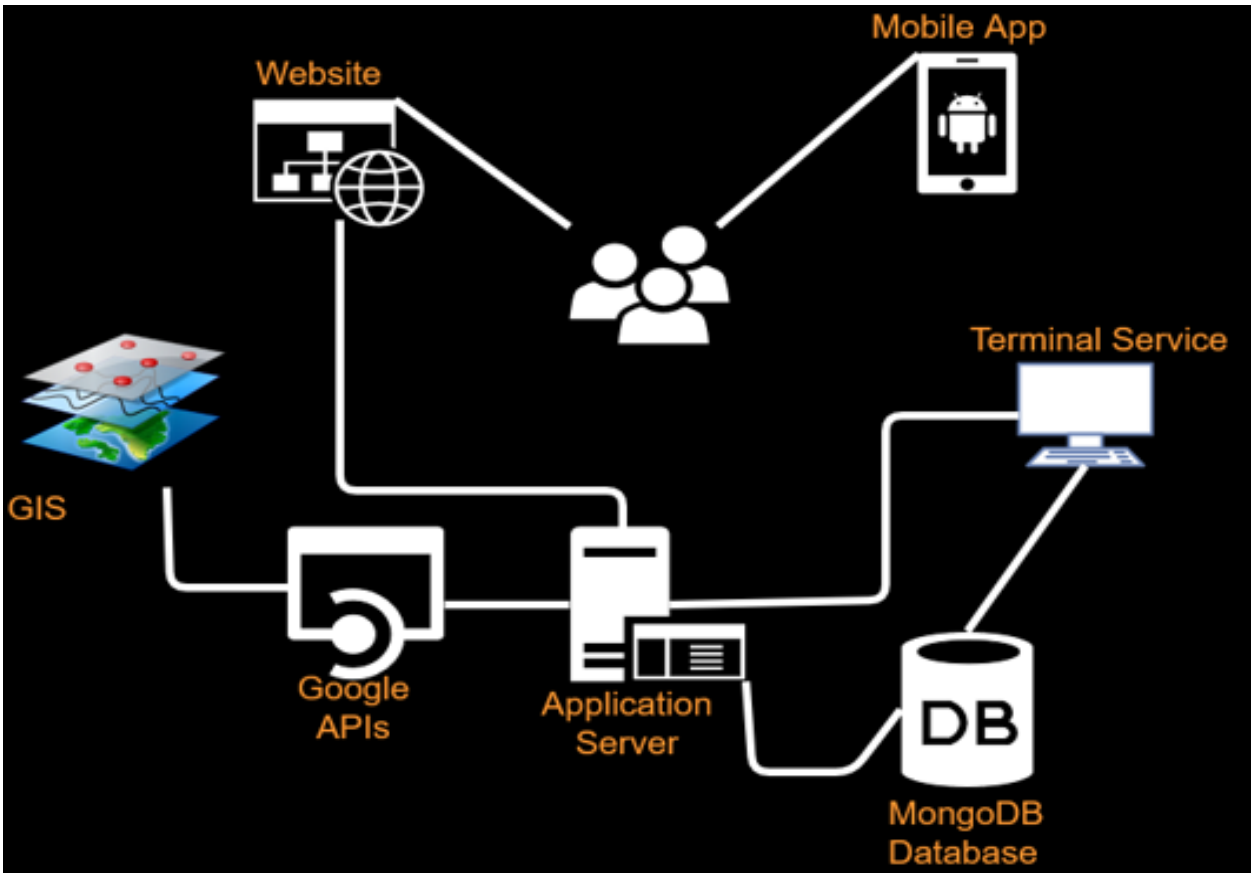

Figure 3. Major Functional Components. This diagram illustrates the relationships between the main application components. Reprinted from "Presentations" by Crime HotSpot, 2018, Retrieved from https://www.cs.odu.edu/~cpi/old/410/silverf18/presentation

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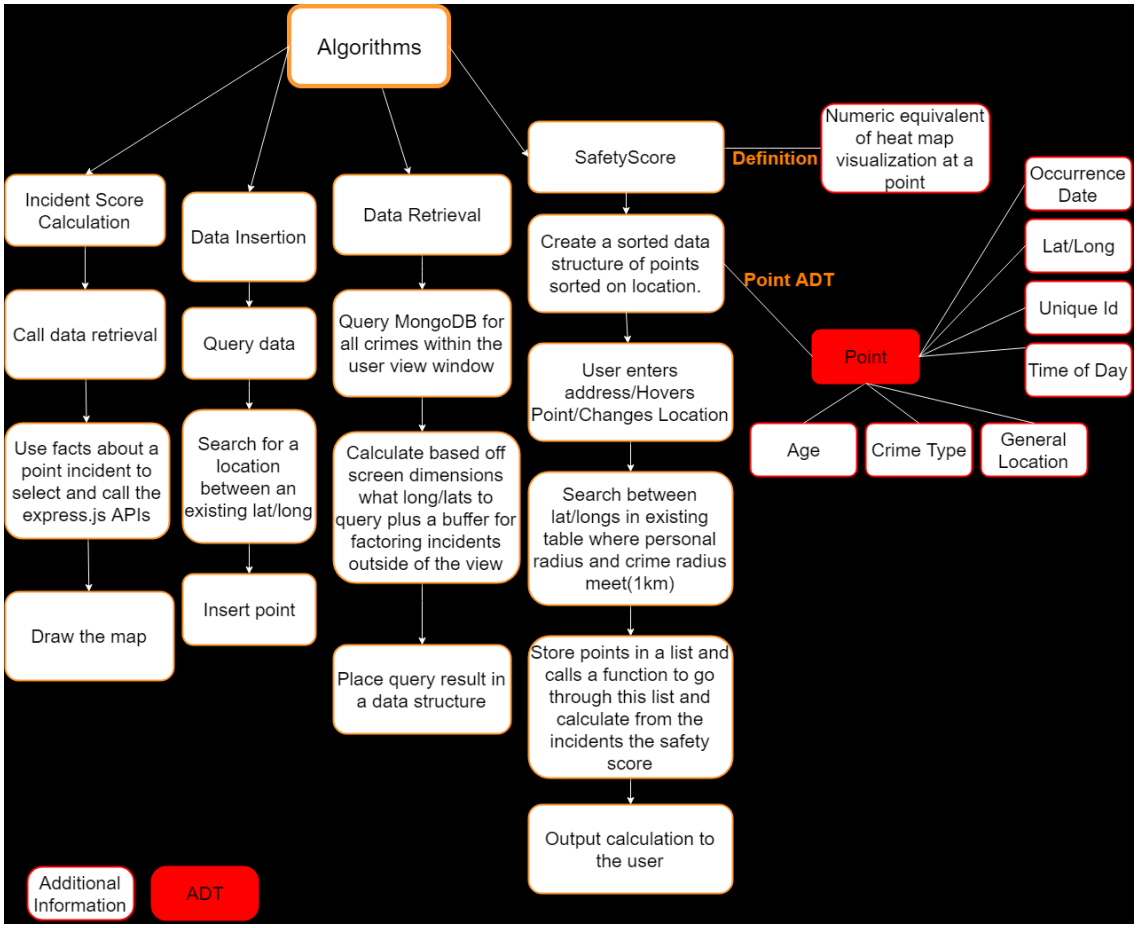

Figure 4. Algorithms Work Breakdown Structure. This diagram presents the algorithmic approaches used in Crime HotSpot. Reprinted from "Presentations" by Crime HotSpot, 2018, Retrieved from https://www.cs.odu.edu/~cpi/old/410/silverf18/presentation

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2.2.1 Crime HotSpot Website

Crime HotSpot will be a web application. The website would thus act as the interface for users wanting to use crime mapping functionality. As mentioned, the heatmap is the primary focus of the application and will provide users with options to filter results based on their preferences. Most of the interactive functionality will be implemented in AngularJS and Google Maps. In addition to interfacing with users, the website will also interface with the dynamic application server. View preference information will be sent to the server as a GET request, along with information about the user's chosen location. Location information would be gathered by either user input or GPS/wireless location. The object sent back to the website is the heatmap rendering provided by Google Maps, but returned by the application server.

2.2.2 Google Maps API

The Google Maps API is Team Silver's middleware of choice for facilitating interactive maps in Crime HotSpot. Google offers access to their developer technology as a service, billing developers based on chosen API functionality and volume of use (Google, 2018). Depending on API used, $200 worth of credit is given out to developers each month as well (Google, 2018). Crime HotSpot would be using the Maps JavaScript API, the main version that offers the most customizability and is platform agnostic (separate SDKs are offered for iOS and Android). The code calls to Google Maps would be made from the application server and the resulting heatmap would be relayed back to the website.

2.2.3 Crimes Database

The MongoDB database will store the crime data in both raw form and a form usable by Google Maps API. Raw data is uploaded from any terminal that can access the database. The raw crime data provided by law enforcement would likely be processed before being stored however. Law enforcement may hand off data in any number of file formats, some of which are not supported by MongoDB for upload. In other instances, raw data may contain fields that are unnecessary for use in the Crime HotSpot application. In both instances, data would need to be parsed before upload. Team Silver has developed Python scripts to do this. Once uploaded, the data is processed a second time. During this period, the raw data is sent to the application server to be converted into Point data. A Point is a container data type that includes information from the raw crime report along with other attributes Google Maps uses to draw the heatmap. These secondary attributes include latitude, longitude, radius of crime, unique ID, and time of day. They are generated in the application server and sent back to the database for storage.

2.2.4 Application Server

The purpose of the application server is to be the main point of intersection between the other components. These components do not speak directly to each other. Instead, they communicate with the application server and the application server serves as a proxy to get the necessary information. This is where most of the logic and processing is done for the application.

3. Identification of Case Study

As of this writing, Crime HotSpot is planned to be a publicly available product and free to use. The application targets the everyday person. Users are likely to be people that are curious, cautious, and who generally want to be aware of their surroundings. The customizable heatmap and clean interface could bring a variety of users to choose Crime HotSpot over others. For example, potential property owners could check on areas surrounding ideal real estate. This idea transitions well over to the business side, where realtors would use the product for much the same reason. A similar example relevant to both businesses and governments would be finding ideal locations for new property. Crime is an important factor to consider when looking for where to start a business and governments might want to also get a feel for whether a certain location is appropriate and safe to house a new school.

4. Product Prototype Description

4.1 Prototype Architecture

4.1.1 Crimes Database

The database will be hosted through MongoDB Atlas. It is a cloud based system of database creation and management provided by the creators of MongoDB. MongoDB works with cloud providers such as Amazon Web Services, Google Cloud Project, and Microsoft Azure to give MongoDB Atlas users computer clusters to store databases on (MongoDB, n.d.). Team Silver chose this option for ease of set up during the prototyping phase. If Team Silver is satisfied with the service, it would likely be used for the real world product. One design decision made during the prototype phase is that certain individual crimes would be grouped together into one entry for the database. Samples of crime data given to Team Silver has shown that law enforcement will often group multiple offenses into a single entry if they are directly related/charged to the same individual. It was decided a similar approach should be taken with Crime HotSpot. The result would be less entries to store in the database. Before crimes are uploaded to the database, they are placed into categories (see section 4.2.1 for more information), with each category being assigned a severity value. The max severity is eight, with other possible values being four, two, and one. For directly related crimes, the two most severe crimes are chosen. The severity value of the second one is divided by four and then added to the severity value of the first. This new sum is then partnered with the category and crime description of the most severe crime. Those three pieces of information are then stored into the database as a single entry.

4.1.2 Web Page

The web server hosting the Crime HotSpot web pages will be hosted on a Ubuntu Linux VM, as part of the ODU CS Department servers. It will use Docker to support development and deployment in a VM environment. Development work for the web pages will consist of HTML, CSS, and JavaScript (by means of AngularJS).

4.1.3 Application Server

The application server will also be hosted on a Ubuntu Linux VM as part of the ODU CS Department servers—the same as the one hosting the product website. Since the physical and virtual machine will be shared between these components, communication will be between separate local processes but not between machines. Docker containers might even play a role in how the processes communicate, as in a shared channel for example.

4.1.4 Google Maps API

Acquiring API keys required for Google Maps API is being coordinated with the ODU CS Department. As with other parts of the prototype, development of the front end of Crime HotSpot will happen iteratively. Team members specializing in front end development will start with easy to reach milestones, such as getting a basic geographical map of ODU loaded up onto the product web site. The map would preferably take up the entire width of the users' display, attempting to balance surface area covered with the rest of the UI layout and website headers.

4.2 Prototype Features and Capabilities

4.2.1 Crime Categories

Team Silver has chosen four distinct categories of crime for the prototype, each in order of decreasing severity. These are: "Severe Crimes Against the Person," "Crimes Against the Person," "Crimes Against Property," and "Crimes Against the Public." Examples of each include aggravated assault, harassment, destruction of property, and disorderly conduct, respectively. Team Silver feels that this covers the majority of common crimes, as supported by sample data received from law enforcement. There is a fifth category for crimes that do not fit into the four previous ones. An example of this would be identity theft. Restricting the number of categories to a reasonable amount was discussed during initial research and refined during prototype design. It was found to be beneficial to the idea of a clean looking interface, as crime categories would be visible to the user in features such as crime filters. As noted above in section 4.1.1, a smaller number of categories also helped make the math simple for averaging severity and processing directly related crimes.

4.2.2 Location

The location functionality for the Crime HotSpot prototype will be limited in scope. There will be no specific search feature for users. The location will be fixed to the area surrounding ODU, limited by the jurisdiction of the ODU police department.

4.2.3 Static Database

Team Silver has limited crime data to work with. Therefore, it is planned to load the database only once by csv, without any updating functionality. In essence, there will only be a single dataset for the entirety of the project.

4.2.4 Crime Heatmap

As a result of having limited real world data to work with, Team Silver is not planning on implementing any date filtering functionality to the heatmap interface. The current data at Team Silver's disposal is limited to 60 days' worth of crime incidents. Artificially creating dummy data is a possibility if time permits but is tedious and will only be created if the current data is not sufficient for drawing a standard heatmap.

4.3 Prototype Development Challenges

4.3.1 JavaScript MEAN Stack

The MEAN stack is nontrivial to learn and master. Team Silver does not plan on becoming MEAN stack experts during the course of the semester, similar to how the team cannot legitimately be called domain experts on crime mapping (though the team has learned quite a bit on the topic). Nevertheless, through the combined patience, perseverance, and efforts of each team member, it should be possible to learn enough of the MEAN stack to put together a workable demonstration of Crime HotSpot. Tutorials and online courses related to MEAN have been disseminated to all team members and that should provide a foundation for everyone to learn from. Lastly, while the team has been split up into subgroups to develop the front end, back end, and infrastructure, team members are encouraged to lend a hand whenever they see an opportunity, regardless of role.

4.3.2 Cross-browser Compatibility

Being able to display the intended design of a website across different browsers can be a challenge, especially if each browser has differing feature sets. Team Silver will start with the most common web browsers, such as Chrome and Firefox. They will use the most recent versions to test front end and other functionality, but time permitting may test old browser versions or other less common browsers. These may even become distinct test cases.

5. Glossary

5.1. Application Programming Interface (API) - a set of functions and procedures allowing the creation of applications that access the features or data of an operating system, application, or other service.

5.2. Crime Map - A map that has crime statistical data overlaid on it to provided information on the criminal activity of an area.

5.3. Heatmap - a representation of data in the form of a map or diagram in which data values are represented as colors.

5.4. JavaScript MEAN Stack - MEAN is a free and open-source JavaScript software stack for building dynamic web sites and web applications. The MEAN stack is MongoDB, Express.js, AngularJS (or Angular), and Node.js.

5.5. JavaScript Object Notation (JSON) - a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language

5.6. SafetyScore - A number, proprietary to Crime HotSpot, that represents the relative safety of an area.

6. References

Bureau of Justice Statistics. (2018, December). *Criminal Victimization.* Retrieved October 5, 2018 from Bureau of Justice Statistics: https://www.bjs.gov/content/pub/pdf/cv16_sum.pdf

Business Insider. (n.d.). *Tourist.* Retrieved October 5, 2018 from Business Insider: amp.businessinsider.com/images/5abbaa40a54f322b2d8b4597-750-563.jpg

Crime HotSpot. (2018, December 15). *Presentations.* From Crime HotSpot: https://www.cs.odu.edu/~cpi/old/410/silverf18/presentation

CrimeMapping.com. (2018, December 5). *Helping You Build a Safer Community* . From TriTech Software Systems: CrimeMapping.com

FBI: UCR. (2017). *Offenses Known to Law Enforcement.* From FBI's Uniform Crime Reporting (UCR) : https://ucr.fbi.gov/crime-in-the-u.s/2017/crime-in-the-u.s.-2017/topic-pages/offenses-known-to-law-enforcement

Google. (2018, December 19). Understanding Billing for Maps, Routes, and Places. Retrieved January 29, 2019, from https://developers.google.com/maps/billing/understanding-cost-of-use

Lexis Nexis. (2018, December 18). *Lexis Nexis Community Crime Map.* From Lexis Nexis: https://communitycrimemap.com/

Microsoft Corporation. (2011, 2). *Heat Map.* Retrieved October 5, 2018 from alastaira.files.wordpress.com/2011/02/image24.png

Minnesota Brown. (2018, July 28). *Campaign Signs.* Retrieved October 5, 2018 from minnesotabrown.com/wp-content/uploads/2018/07/campaign-signs.png

MongoDB. (n.d.). MongoDB Atlas. Retrieved January 30, 2019, from https://docs.atlas.mongodb.com/

Neighborhood Scout. (2018, October 8). *VA Crime Rates and Statistic.* From NeighborhoodScout: https://www.neighborhoodscout.com/va/norfolk/crime

NIJ. (n.d.). *Mapping Crime: Understanding Hotspots.* Retrieved September 5, 2018 from NCJRS: www.ncjrs.gov/pdffiles1/nij/209393.pdf

Old Dominion University. (2017, August 24). *Old Dominion University.* Retrieved September 1, 2018 from Old Dominion University: media.wric.com/nxs-wrictv-media-us-east-1/photo/2017/08/24/odu_37569108_ver1.0_1280_720.jpg

Search Business Analytics. (2011, July). *What is a Heat Map (Heatmap).* Retrieved September 5, 2018 from SearchBusinessAnalytics: searchbusinessanalytics.techtarget.com/definition/heat-map

Wikipedia. (n.d.). *Crime Mapping.* Retrieved October 5, 2018 from Wikipedia: https://en.wikipedia.org/wiki/Crime_mapping