Lab 1: Crime HotSpot Product Description

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Lab 1 - Crime HotSpot Product Description

1 Introduction

Crime mapping is an important tool in the crime analyst's arsenal to determine patterns in criminal behavior. Crime mapping presents crime characteristics for a given area using tags, shading, or other visual features. Once created, crime pattern analysts use maps to determine future geographic crime patterns based on current statistics. Crime mapping and analysis, when done well, can be invaluable in assisting police departments determining where resources should be allocated.

For much of its existence, crime mapping has been the sole domain of law enforcement. Until recently, mapping software was often expensive and resource intensive, making it impractical for use by the general public. For example, according to the ESRI website for the professional mapping software ArcGIS, a standard professional license for the program is $2750.00 per year, per person using the software. While some online mapping tools did exist, most--such as MapQuest--were only useful for getting directions. Now, as internet speeds increase, smart phones become more capable, and the overall cost of online resources decreases, viable, powerful online mapping tools are more accessible to the general public.

While law enforcement uses crime mapping as part of a deep analytical process, seeking to gain valuable insights into individual crime patterns, members of the general public seek out crime information to gain a better understanding of their safety and the safety of areas to which they may travel. With the current publicly available resources, users are typically able to view crime data as either a collection of points, often with an indicator of the type of crime that occurred at that point or as a representation of the concentration of crime in a specific area. These approaches often provide little context, high visual clutter, and rely on untrained users to

make determinations on how to filter and interpret what they see and come to a conclusion about their relative safety. As an example, during political campaign seasons, a commonly reported crime is the theft of signs representing particular candidates, shown in Figure 1, which would represent a low risk to public safety. However, if represented on a map along with other crime data, without indicating the nature of the crime or its severity, these areas could appear unsafe.

Figure 1: Political signs are frequently stolen. While the crime is minor, it can appear as a major crime pattern without the proper context

Crime HotSpot is a crime mapping website seeking to alleviate these problems by providing better context, an easy to interpret heatmap representation, and enough customization to allow users to focus on the area of safety that most concerns them while still providing deeper, fact-based analysis. While the use of heat maps in crime mapping is not unique, most heat maps currently available only represent the raw number of crimes in an area. This approach does not give the user a true sense of the level of crime in an area and does not give them a correct indication of the risks to their safety. As shown in Figure 2, on the following page, users' efforts to gain useful information from currently available crime mapping resources has are likely to end in incomplete, incomprehensible, or inaccurate information.

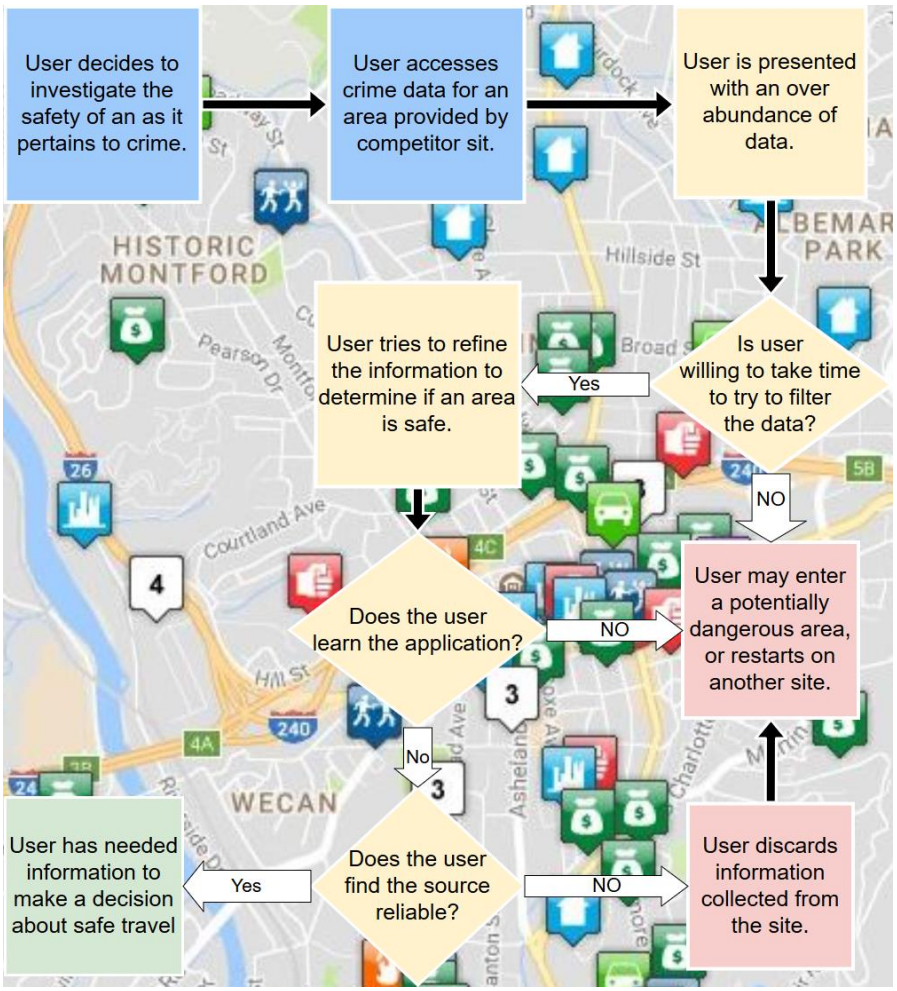

Figure 2: The current process is cluttered, difficult to follow, and may yield inaccurate or misleading information

A better crime mapping solution for the general public presents its information clearly and concisely, with an interface that is easy to navigate for anyone who has a basic knowledge of computers. The crime map should give the user the ability to hone in on certain risk categories without giving so many options as to become overwhelming. The crime map should also provide context to ensure the crime data is presented in a way that does not skew the true picture of safety.

2 Product Description

To solve the problems in the current crime mapping solutions, Crime HotSpot will use a proprietary SafetyScore metric to analyze the available crime data and indicate higher risk areas as brighter parts of the map. The SafetyScore will take take into account the type, date, time, and severity of individual crimes. This number will be modified to account for distance from the user's location and the time since the crime occurred. The data will then go through a final adjustment for population density in the area being represented to ensure the SafetyScore truly represents the user's safety accurately, and within the context of their location and selected timeframe.

This information will be presented on a heat map, shown in Figure 3, which can easily convey the intensity of the safety risk at a quick glance for different areas.

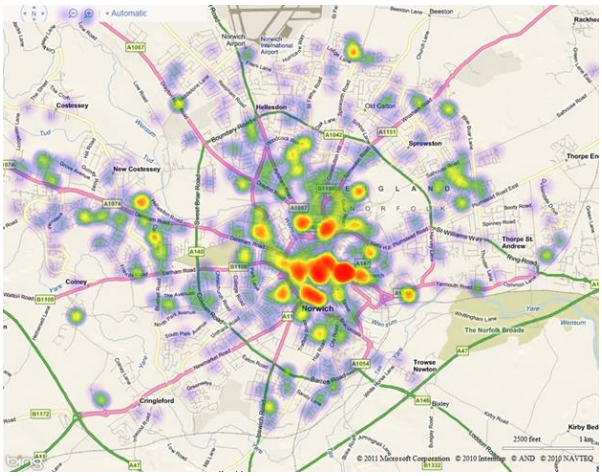

Figure 3: An example of a heat map

On the initial load, the map will display all available crime statistics surrounding the location designated by the user. This page will also feature quick filters to allow the user to highlight certain high-level categories of crime. For those who wish to retrieve more specific information, there will be an analytics page offering additional data representation options and the ability to more finely tune how much they wish to weigh the importance of certain crime categories.

To create additional value from the processing of this data and the SafetyScore model, a mobile application provides the user with information on their current location as they travel. The goal will be to provide warnings to users who may be entering unsafe areas and allow for real-time navigation in unfamiliar areas. This application will use the same back-end as the web site, simply presenting the information in a different way.

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With these improvements, Crime HotSpot will provide the user with a better solution flow, shown in Figure 4, enabling them to see better information in a format that will more readily fulfill their needs.

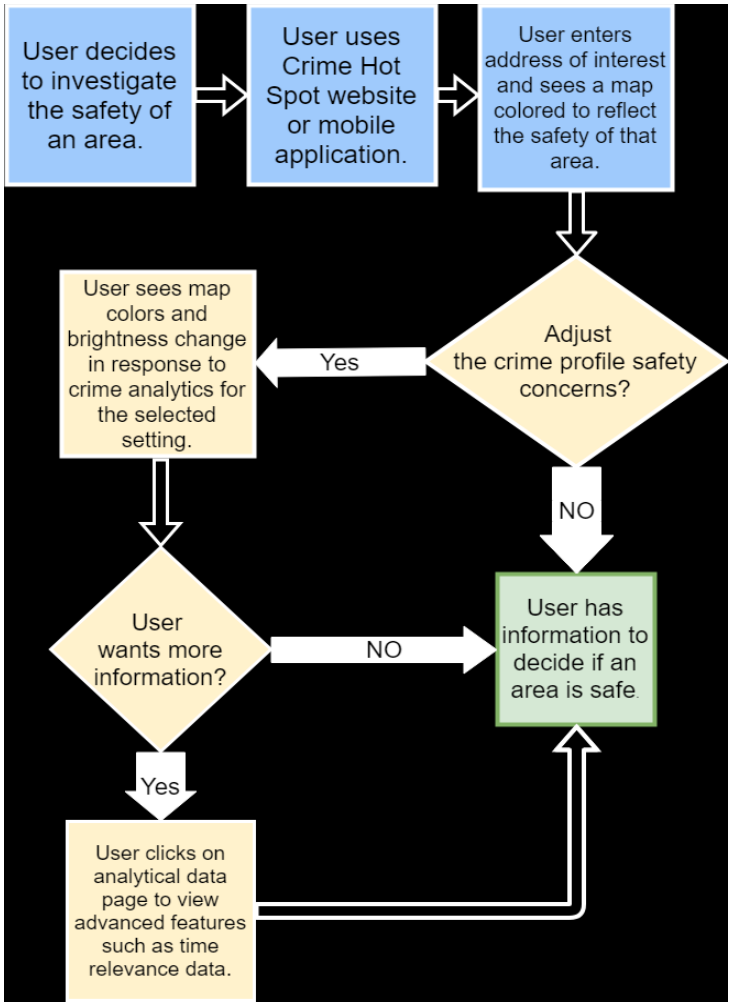

Figure 4: The proposed solution flow

2.1 Key Product Features

Crime HotSpot will use crime data gathered from local, state, and federal agencies--as available--in the SafetyScore calculation. To avoid copyright infringement and ensure information integrity, Crime HotSpot will not perform any web scraping of publicly available

crime statistics. Once received, the data will be cleaned and normalized to be used by Crime HotSpot in its crime database.

A key feature of Crime HotSpot will be the generalization of the geographical crime references. By aggregating the data into general areas, potential bad actors will be unable to use the site to identify possible "soft targets". This feature will also preserve the privacy of the victims to whom the crime data refers. While their names are not included in the crime data, presenting specific locations could allow for cross referencing of other information and violate victims' privacy. This will be done while preserving the integrity of the overall presentation of the data.

When a user enters the page, Crime HotSpot will (with their permission) use their location as a starting point to present an initial heatmap. If the user does not wish to provide their location, they will be asked to provide one. Once the location is set, Crime HotSpot will query the crimes database to gather relevant data and calculate the SafetyScore, which will be represented on the heat map in two ways: with a color gradient to represent the intensity of risk, and, when the user hovers the cursor over a section of map, as a pop-up with more specific SafetyScore information for that section of map.

The initial score will be determined by aggregating the severity of a crime and the general probability that it will occur, factoring for distance and time, and finally factoring for population density. Once the score is calculated, a radius of influence will be determined for the individual crime incidents, with a higher score indicating a larger radius of influence. On the heat map, individual incidents will have a greater color intensity as their safety score increases. Their radius of influence will also be displayed as a color gradient that will "cool" as it moves from the center of the generalized area towards the edge of the radius. As the radius of influence overlaps

from multiple crimes occurring in close proximity, the map will appropriately show those areas of overlap as having an increased risk to safety due to the compounding of risks from the individual crimes. When the user hovers the cursor over a location on the map, a large tool-tip will be displayed showing the specific safety score for that location (generalized to a city block or larger) based on the incidents which have radii of influence covering that location. The categories of the incidents which most strongly influence the score in that location will also be displayed.

2.2 Major Components

The architecture of the problem solution will follow the Model-View-Controller design pattern, as shown in Figure 5:

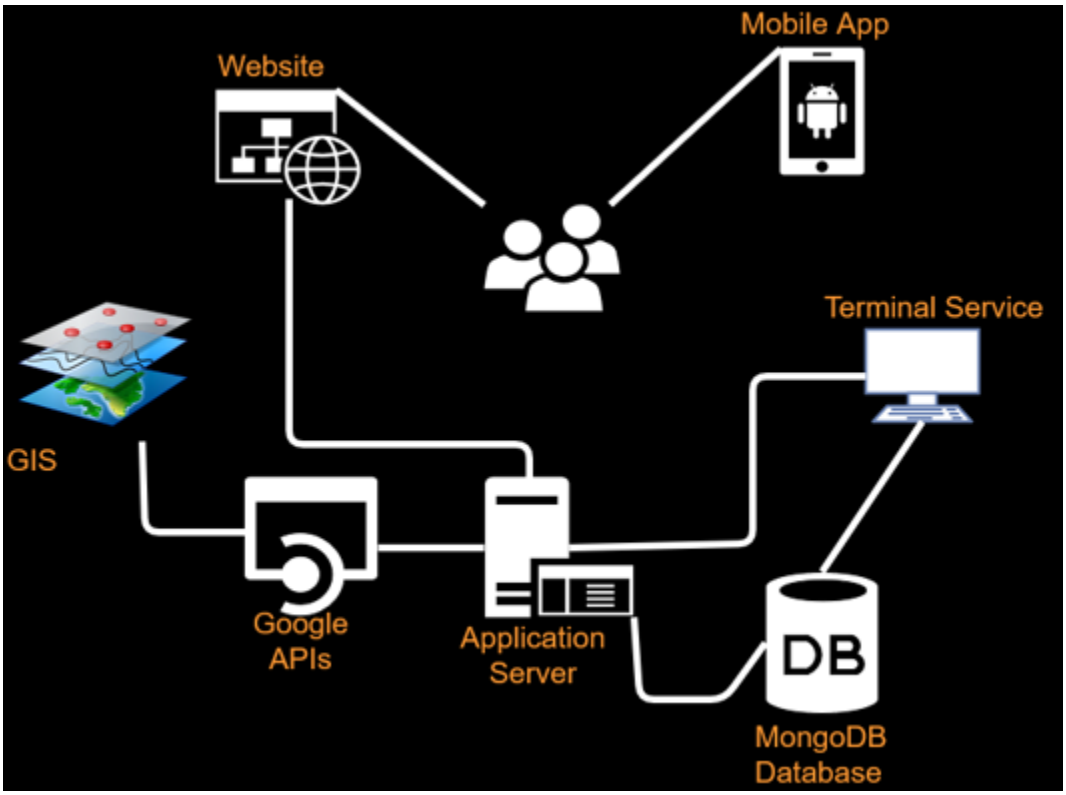

Figure 5: The major functional components of the proposed solution

The primary feature of the front-end view component will be a large map which will display a heatmap layer and give access to the hover tool-tip feature. "Quick-filter" buttons will provide the user the ability to quickly change the crime-categories being represented and a separate analytics page will allow the user view different visual representations of the data. The base map, heat map, and pop-ups will be drawn using the Google Maps API. The model component will be represented by the crimes database, which will store all of the crime incidents loaded from various law enforcement datasets. The application server will control the interaction between the user, the database, and the Google Maps API.

3 Identification of Case Study

The intended audience for Crime HotSpot is the general public, businesses, local governments, and non-profit organizations who wish to learn more about the safety of specific areas. Members of the general public will be the most common users, seeking to gain information about where they currently live, where they may wish to move, or areas to avoid in new cities they want to visit for vacation. Businesses can use the information to research new locations, demonstrate that their area of business is safe when pitching to investors, or looking into potential security measures if they find that their area is high risk. Local governments and non-profit organizations can use the information to determine where to focus resources in initiatives to reduce crime from a non-police perspective. While the prototype will not be designed with this use in mind, law enforcement may find the SafetyScore visual presentation of risk helpful and may wish to incorporate our site functionality into their processes.

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4 Product Prototype Description

The Crime HotSpot prototype architecture will be identical to the original program solution architecture with exclusion of the mobile application. While the goal of the mobile application was to provide an alternate way of viewing the crime data processed by the application server, it was not a key component of the problem solution and was not necessary to demonstrate proof-of-concept. All other components will remain the same.

4.1 Prototype Architecture

The Major Functional Components diagram for the prototype, shown in Figure 6, shows the same overall structure, but with the mobile application removed.

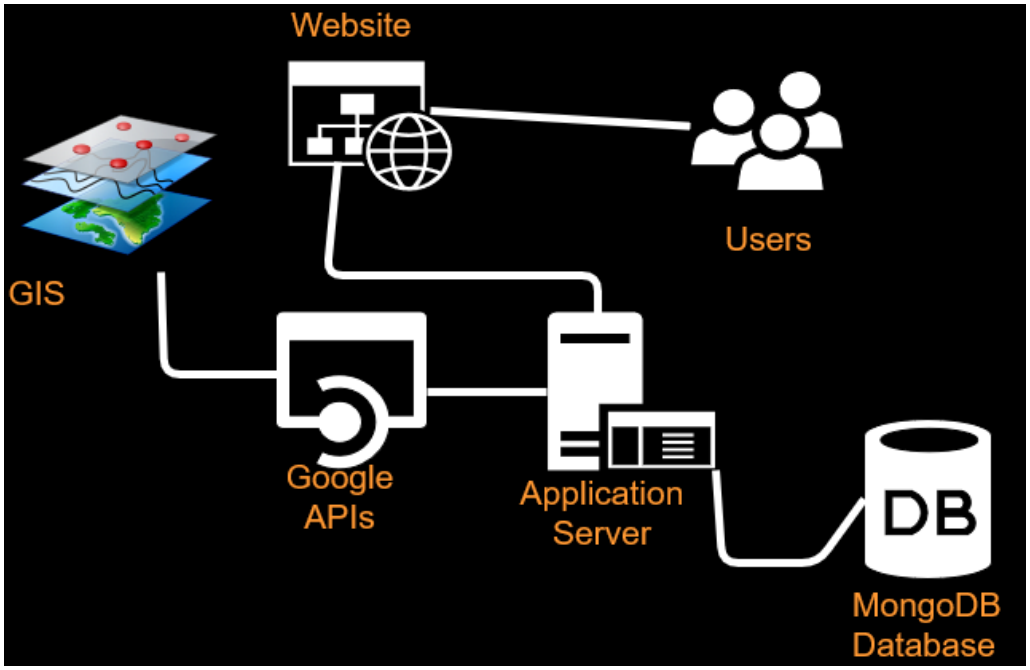

Figure 6: Prototype major functional components.

The crimes database will be built using MongoDB Atlas, a cloud managed document database. Using MongoDB Atlas reduces the back-end infrastructure that must be managed and allows development to focus on adding user functionality. Crime incidents, provided in a comma-delimited file, will be cleaned and normalized to fit into a geolocation schema provided

by the MongoDB API. This will allow for simpler queries relating to specific locations and the ability to easily retrieve results within a given radius of the location of interest.

The application server will act as the hub of our web application and will be implemented using Node.JS as a runtime environment and Express.JS to provide the server framework. When a user location is provided through the front end, the application server will query the MongoDB. The results from the geolocation search will be processed to calculate the SafetyScore, including the initial score and the dynamic factors specific to the user's location. The results will be stored as JSON objects. The application server will select appropriate incidents incidents and create the Google Maps tags necessary to render the base map and heatmap layer on the client system. This will be accomplished by making calls to the Google Maps API, which will render the maps on the client side.

The front-end of the web application will be implemented using Angular.JS, a JavaScript framework for front end development. As the focus is on clean design and a straight forward interface, the map itself will be the main feature of the page, with the menu options limited to navigation to the analytics page and the ability to select from one of several "quick filters" to easily modify the way the risk information is represented in the heat map. The analytics page will provide the ability to look at the data using non-geographical visual representations such as graphs, charts, and tables.

4.1 Prototype Features and Capabilities

To simplify the crime incident analysis, the Crime HotSpot prototype will group the crime incidents into 4 categories: moderate crimes against a person, severe crime against a person, crimes against the public (such as a DUI, which does not have a specific victim but represents a public risk), and crimes against property. Each of these categories will be assigned a

static number reflecting the severity of the crimes involved and the likelihood of their occurring. This number will be used as the primary base factor for calculating the SafetyScore.

While the intention of the real-world product would be to have a dynamic database, able to be loaded from a diverse dataset and update on a regular basis, our prototype will use a representative static database instance as a proof-of-concept for the heatmap. An administrator will use a script to facilitate the cleaning and normalizing of the data and will load the data directly into the MongoDB database. Crime data provided by the ODU police department representing crimes from the recent past year will be used for our prototype.

Given that crime pattern analysis and predictive analytics are a deep and complex field, the real-world product would involve lengthy and significant consultation with a professional crime pattern analyst or analysts to give the SafetyScore true predictive capabilities. The formulas and analytical methods used to calculate the SafetyScore in the prototype are designed to create a roughly representative assessment of risk to create the heatmap and provide proof of concept.

4.2 Prototype Development Challenges

The MEAN stack was selected to ensure quick compatibility between the front-end, back-end, and data store; but is new to a majority of the team. Development will involve a "learning on the go" approach, significant collaboration, and teammate support to ensure success. This risk will be significantly mitigated by the use of agile development techniques, the wide availability of online training for the MEAN stack, and having team members focus on different areas of development to keep the overall amount of information that must be learned by an individual team member to a manageable size.

All web development involves the challenge of browser cross-compatibility. MS Edge, Google Chrome, Mozilla Firefox, and Apple Safari can have significant differences on which functionalities in JavaScript and Angular they support. Coupled with users who may not have the latest version of these browsers, this can be a major problem. These problems are typically more severe for a full-scale, full featured website. Our prototype will not need to use the latest libraries of Angular, which are more likely not to be supported and will not be subjected to a full-scale variety of users.

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Glossary

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

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.

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

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.

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

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

Soft Target: A person or property which presents as having poor defenses against crime.

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