Opencrimemapping.org: An Online Tool for Visualizing Crime

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Abstract. In this paper we present a method for creating geographic visualizations of criminal incidents using open data and open-source software. The motivation for this method is to provide law enforcement agencies (LEAs) and interested citizens an affordable and relatively easy way to start analyzing geospatial data. The National Incident Based Reporting System (NIBRS) is a national standard for LEA incident reporting going into effect for all 18,000 U.S. LEAs in 2021. This project uses the Dallas Police Department's publicly available, NIBRS-style, incident data to develop a geovisual analysis tool called opencrimemapping.org.

Keywords: NIBRS · Visualization · Cartography. · Geovisualization

1 Introduction

Crime maps can be useful for both law enforcement agencies (LEAs) and citizens. The first crime maps depicting the rate of crimes relative to social factors in regions of 1830s France have been attributed to the subsequent creation of the fields of criminology and sociology[1]. In this digital age agencies have moved well beyond mapping with physical illustrations. Crime mapping is used in varying levels of complexity and for various purposes for LEAs. One important use of crime mapping is public transparency. However, the adoption of digital crime mapping for public use has not been a consistent service of LEAs. In the United States (U.S.), the Federal Bureau of Investigation (FBI) has used the Uniform Crime Reporting (UCR) program to promote transparency and generate reliable crime statistics for the U.S. since 1930 . The current UCR standard for law enforcement agencies (LEAs) is to report individual incidents via the National Incident Based Reporting System (NIBRS). As more LEAs conform to NIBRS, there is an increasing body of standardized incident reports available to LEAs and the public. Incident based crime reports are raw in format, not aggregated like the former UCR program reports. This format provides flexibility for exploring crime data.

[1] Crime Mapping, Criminal Justice Research, http://criminal-justice.iresearchnet.com/criminology/research-methods/crime-mapping/2/

The resources available to U.S. LEAs for crime data analysis are wide ranging. There are approximately 18,000 U.S. law enforcement agencies across federal, state, county, and local jurisdictions. These agencies range in department size from 1-30,000 officers with the majority of agencies having 10 or fewer officers[2]. Furthermore, the fragmented nature of U.S. law enforcement as a collection of independent agencies makes the adoption of data handling practices disparate. Given the importance of putting crime data on maps, poor map making is a concern. LEAs and individuals creating crime maps for public consumption are often novice map makers. This paper provides an introductory method for geovisualization that can be affordably adopted by LEAs and engaged citizens interested in exploring geographical trends in police incidents.

Our solution was to detail a geovisual method for displaying criminal incidents using open-source software. We then built a tool called opencrimemapping.org to display our methodology in a workable website. The tool is built with open-source tools. Opencrimemapping.org displays various types of thematic maps using the method we lay out in the paper. We also show maps that don't fit the methodology presented to show how color, basemap, variable and time selection can impact the look of the map.

Infrastructure for the design and use of maps for crime display could lead to increased communication between police and citizens and thus improve quality of service and reputation. Novice map creators have the ability to display crime incidents on maps with a few lines of code and little to no money.

First, the value of geographic visualization is discussed in the context of the birth of computing and modern crime analytics. Second, we explore data analytics in new domains such as public safety. For the novice LEA or citizen data analyst, this paper explains the critical process of exploratory data analysis (EDA). Then we discuss the history of open data and the importance of open data to promoting the use of data analytics in new domains such as public safety.

This paper moves on to describe the open source, NIBRS compliant, incident data of the Dallas Police Department used to build a methodology for geovisualization. The application and application implementation sections break down the major steps that should be taken to generate a reliable police incident map. Beyond the essential components of the map, this paper lends examples of specific open source software and code that can be reused by novice crime analysts.

2 Geographic Visualization

Geovisualization is deeply rooted in traditional cartography which has been around for thousands of years in human history. Geovisualization is the visualization of geospatial information to create human understanding that leads to data exploration and decision making [1]. Traditional maps known as static maps are simply fixed images. These maps can be produced on traditional mediums such as hardcopy, like books, atlases and magazines. They can also appear

[2] National Sources of Law Enforcement Employment Data, https://www.bjs.gov/content/pub/pdf/nsleed.pdf

online as images on websites in file formats such as Portable Network Graphic (PNG), Joint Photographic Experts Group (JPEG), and Portable Document Format (PDF) as seen in figure 1.

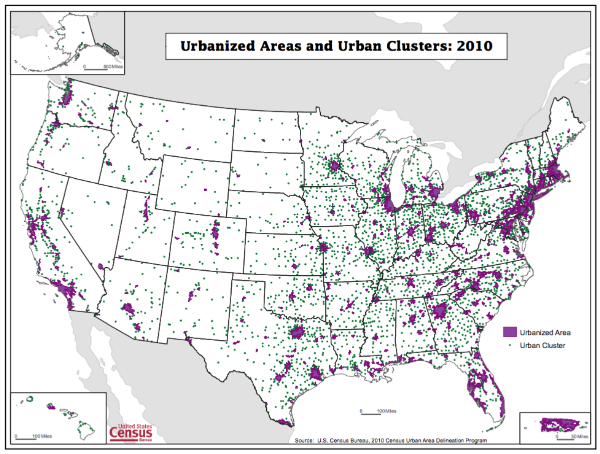

Fig. 1. This map from The U.S. Census Bureau is an example of a geovisualization on a static map. It shows the distribution of urban areas in the U.S. and Puerto Rico.

Interactive maps like the example in figure 2 allow the user to zoom in and out, hover-over popups, and more to engage data and find underlying patterns in greater depth. Interactive maps are produced and viewed on computers.

Some early work in geovisualization can be traced back to the term geographic visualization by the National Science Foundation in 1987. If we go back a decade earlier, we find that Jacque Bertin presented design principals for presenting cartographic and information design to explore data [2]. The International Cartographic Association (ICA) created a Commission on Visualization in 1995 to stimulate geovisualization research and encourage interdisciplinary research to create highly interactive, exploratory methods to initiate knowledge construction. In 2015, the ICA created the Commission on Visual Analytics to support geovisualization. This commission focuses on interactive visualizations that can support knowledge construction and insights from spatial data in forms that are both big and small[3].

Modern information availability has helped lead to an explosion of geovisualization tools. There are numerous private companies using geovisualization as revenue drivers. Perhaps the best known is Google's Maps Platform. Google's Map Platform has over one billion monthly active users and gets 25 million

[3] Robinson, Anthony, "New Directions in Geovisual Analytics: Visualization, Computation, and Evaluation", International Cartographic Association Commission on Visual Analytics, 2/2/2018, https://viz.icaci.org/

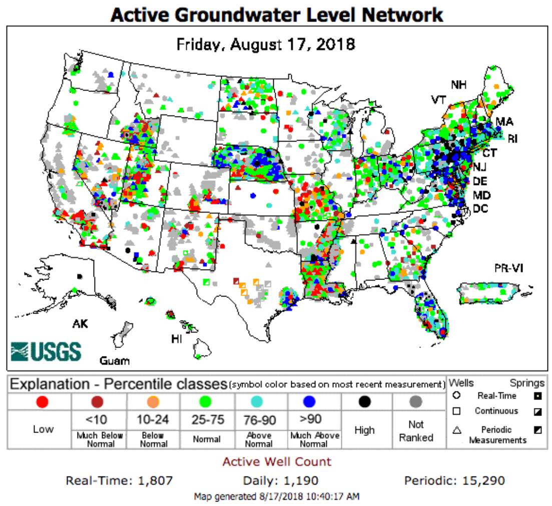

Fig. 2. This map from The U.S. Geoglogical Survey is an example of an interactive geovisualization on the Internet. The interactive map allows the user to look at the Active Groundwater Levels at wells across the U.S.

updates a day[4]. Google sells their platform to companies to display information spatially. Government agencies use geovisualization for military, forestry, fishery, demographic and economic data display for both internal and external communication.

3 Crime Analytics

With modern technology, it would be easy to assume all or most police agencies utilize complex geographic visualization tools. News media coverage of crime data analytics tends to focus on the most ground breaking and intriguing innovations of the moment. A 2016 Science Magazine article detailed the use of advanced predictive software by agencies looking both to predict where crimes will happen and the actual individuals who may commit or become victims of crimes [3]. For example, PredPol is proprietary software that uses algorithms to predict where crimes are likely to happen during a shift [3]. While forecasting crimes is a highly pertinent application of incident data, it is not a cure-all for understanding and effectively using crime data. Furthermore, for the majority of small police agencies, deploying simple data analytics tools can be a huge technical and monetary hurdle.

[4] Google Maps Platform, https://cloud.google.com/maps-platform/maps/

In 2015 President Obama initiated the Task Force on 21st Century Policing to investigate and speak to the rifts between police and the public [5]. The final report outlined six pillars detailing recommendations and action items. The first pillar was the importance of building trust and legitimacy between police and those they serve. Part of the recommendation on building trust and legitimacy was to nurture accountability and transparency. Subsequently, the Police Data Initiative (PDI) was launched per recommendation of the Task Force on 21st Century Policing [6]. The PDI is a collective network of law enforcement agencies, researchers, and technologists already developing and delivering best practices for collecting and publishing public datasets as well as utilizing data and technology for the improvement of policing and community relations. As of March, 2018, there are 130 contributing agencies and over 330 available data sets through the PDI website. The PDI demonstrates and embraces the diversity of law enforcement agencie's needs and resources with both large and small department participants.

4 Data

Data was sourced from the Dallas Open Data website hosted by Socrata in order to provide an illustration of the process of using open source NIBRS compliant incident data[7]. This website is designed to provide transparency to citizens and developers with a variety of data sets that pertain to city governance, services, and culture. The NIBRS based data set of interest on Dallas Open Data is titled Police Incidents. The Police Incidents data set is provided by the Dallas Police Department and is updated daily with incident reports dating back to June 1, 2014.

As of May, 2018 there are approximately 357,000 incident entries and there are 103 incident attributes. Some important features of an individual incident report include the unique identifier, incident number with year, the location details of the incident, the descriptive details of the complainant, the reporting officer details, and the details of the type of incident that occurred.

Classification of crimes are based on preliminary information supplied to the Dallas Police Department by the parties that report. These incidents can be changed at a later date if more investigation is executed. Crimes classified as sexually oriented offenses, offenses where juveniles are the victims or suspects, property that is considered evidence, social service referrals, and vehicle information that could identify suspect or victim are not included in the data set.

The data that was used focused on burglaries in the city of Dallas. For dot and cluster map types we used the following data from the data set in Table 1.

[5] Final Report of The President's Task Force on 21st Century Policing , http://elearning-courses.net/iacp/html/webinarResources/170926/FinalReport21stCenturyPolicing.pdf

[6] The Police Data Initiative, https://www.policedatainitiative.org/

[7] Dallas OpenData, City of Dallas, https://www.dallasopendata.com/

Attribute	Description
location1	Contains address, city, zip code, state, latitude and longitude
mo	Modus Operandi (MO) or short description of the offense
premise	Location type of where incident took place
date1	First date of the date occurrence of the incident
day1	Day of the incident based on date of occurrence (date1)
time1	The first starting time of the time occurrence of the incident
zipcode	Zipcode in which incident occurred
ucr_offense	Uniform Crime Report Offense type

Location1 is used to geocode locations of burglaries defined by the UCR offense. The other attributes are used as pop-ups in the interactive maps. Burglaries at businesses and residences were used. These burglary classes were chosen to simplify the maps.

4.1 Open Data

The open data movement came on the heels of Internet globalization and is still developing rapidly [4]. In 2007 prominent academics and open data champions met to outline the guiding principles of open public data. In 2013, the U.S. government formally recognized open public data as a valuable national resource in a memorandum to the heads of executive departments and agencies titled "M-13-13 Open Data Policy-Managing Information as an Asset" [5]. The motivation behind the memo was to make information resources accessible, discoverable and usable by the public [5]. As one of the key pillars defined in the memo, accessibility suggests that open data must be made available in convenient, modifiable, and open formats. These formats must be machine-readable and should be made available to the widest range of users for the widest range of purposes [5]. The larger goal of open data is to promote transparency in democratic governments, citizen participation, and drive innovation that can ultimately generate economic value. This project focuses on open data generated by the NIBRS set forth by the FBI UCR Program in partnership with the Bureau of Justice Statistics (BJS) in 1989. The NIBRS succeeded the Summary Reporting System (SRS) which provided aggregate statistics from law enforcement agencies with only one crime recorded per-incident regardless of the number of crimes that occurred. NIBRS provides uncombined incident information that is more easily usable by interested parties. However, NIBRS has been slowly adopted by law enforcement agencies on a voluntary basis until now. Recently, the FBI set forth a NIBRS compliancy deadline of 2021 for all law enforcement agencies in the U.S. Former FBI director, James Comey, emphasized the importance of conforming to NIBRS in a 2015 speech to the International Association of Chiefs of Police (IACP):

”NIBRS is a way in which we can collect data that will identify patterns, trends, and help us prevent crime and have thoughtful, informed conversations at the national level.”

5 Opencrimemapping.org Application

Opencrimemapping.org, displayed in figure 3 is an application built with an open-source toolkit. Thematic map examples are presented to the user to help take some of the guesswork out of producing interactive maps. Opencrimemapping.org presents the user with the ability to change parameters of the map in terms of time and base maps.

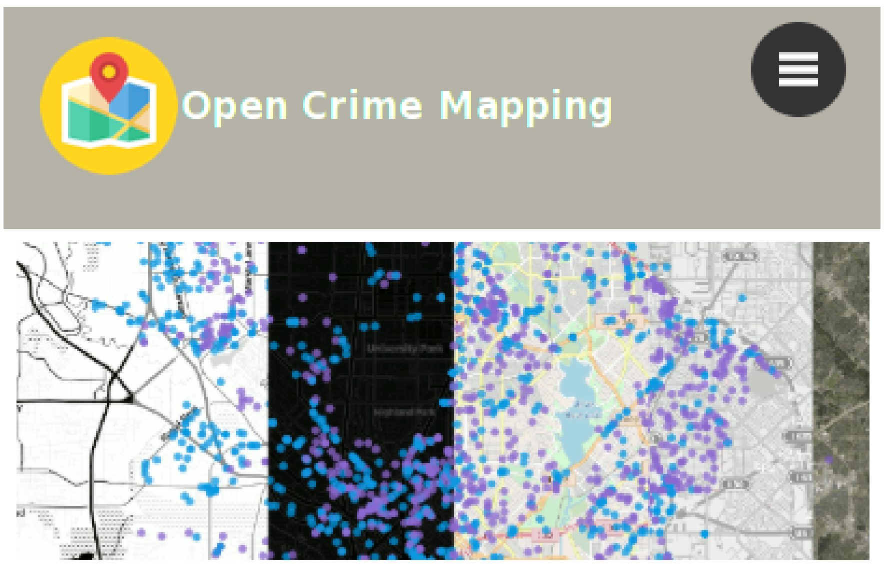

Fig. 3. Opencrimemapping.org takes users through examples of thematic maps to help take guesswork out of producing interactive maps.

The application was developed mainly with the open-source language R. R is an open-source language that is used for statistical computing, R compiles and runs on both Windows, MacOS, and multiple UNIX platforms [8]. R is used in this application to gather, clean, display and deploy Opencrimemapping.org. Maps were built with the combination of R functions and compiled code, or packages put together by developers at Leaflet. Opencrimemapping.org is deployed out to the web with the package called Shiny.

[8] What is R, https://www.r-project.org/about.html

The Leaflet package for R is an open-source JavaScript library for interactive maps[9]. Leaflet gives the R user the ability to create interactive maps. The Leaflet package also connects users with different map providers to so users can have different base maps available to use when creating interactive thematic maps. The developers of Leaflet included functions that worked with Shiny for deployment and user interface (UI).

The Leaflet maps at Opencrimemapping.org are published by the Shiny package in R. Shiny allows R users to use a web framework to build web applications with an open-source R package [10]. The Shiny package enables R users to deploy web applications without prior knowledge of Hypertext Markup Language (HTML), Cascading Style Sheet (CSS), or JavaScript. Shiny is also used to create a user interface on some of the maps in Opencrimemapping.org so that users can toggle between time, or basemaps.

6 Application Implementation

We developed an application to be used by LEAs that outlines a standard process for generating crime maps utilizing NIBRS data as input variables, open-source software, and design strategies that best promote transparency with the public. Law enforcement agencies at the state and local levels are held to criminal and civil law compliance by the U.S. Department of Justice. For example, these include laws that ensure all law enforcement officers do not deny any individual in the U.S. rights set forth by the U.S. constitution[11] . Standards for the delivery of service by LEAs remain mostly self-regulated. In 1979 the Commission on Accreditation for Law Enforcement Agencies (CALEA) was created as an independent credentialing authority that works to create standardized practices "to improve the delivery of public safety services"[12]. In 2017 there were just over 1,000 LEA enrolled in the CALEA accreditation program. With at least 18,000 LEAs servicing the U.S. this leaves many agencies without a standard practice for the delivery of crime incident data to the public.

This application includes practical guidelines and an example website with the goal of being easily replicable and enhancing legitimacy and trust with the public. The application description below is spilt into subsections of Time, Interactivity, Color, Basemap Selection, Map Types, and Variables. The subsections of the application description are put into place to act as a guide for novice mapmakers.

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[9] Leaflet for R, https://rstudio.github.io/leaflet/

[10] Shiny Server: Easy R Web Apps, https://www.rstudio.com/products/shiny/

[11] Addressing Police Misconduct laws enforced by the Department of Justice, U.S. Department of Justice, https://www.justice.gov/crt/addressing-police-misconduct-laws-enforced-department-justice

[12] The Commission, CALEA, http://www.calea.org/content/commission

6.1 Time

Time or temporal analysis in maps has been in use with thematic maps for many years. Like space, time is heterogeneous [6]. We see day differences in terms of activity for weekdays and weekends. The analysis of spatiotemporal data can be complex with many numbers of distinct planes. This can cause in the example of a dot map to display too much information and leaving the user with no knowledge to be gained from the map. To help with this, interactive maps should be time bound. Users of Opencrimemapping.org are able to switch between time periods to obtain knowledge.

In most visualization methods time is considered linear. Most visualizations that incorporate time do so based on a timeline [7]. Actions in time can occur in cycles. With burglaries in Dallas weekdays display higher densities of instances than on weekends.

In crime mapping, victims, offenders, and property managers adjust densities over time around specific places. Using the drop down to select different years on our tool the user can see differences in density as displayed in figure 4. The user can recognize that less burglaries happened in 2017 verse prior year 2016.

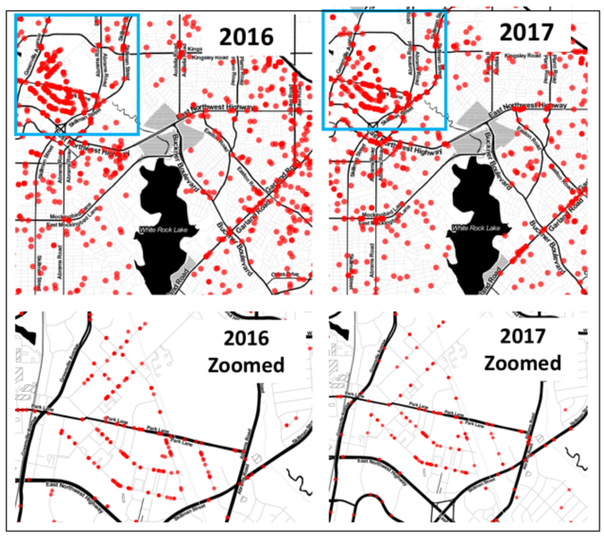

Fig. 4. This dot map has been zoomed in a location in Dallas with a high density of burglaries. Using the drop-down button the user is able to see the difference in density from one year to the other.

6.2 Interactivity

Growth in computer processing speed and Internet technologies have helped lead to the growth of interactive map availability, design and consumption. Cartographic interaction is the use of a digital map by a user facilitated by a computer. This creates a dialog between the user and map.

Maps manifest themselves as knowledge from the mapmaker about the map's variable of interest. The goal of a map whether successful or not is the transfer of geographic insight from the mapmaker to the map user [8]. In User-Centered Design for Interactive Maps: A Case Study in Crime Analysis by Roth et. al. an interactive framework for maps is presented which focuses on the needs of the user when conceptualizing and implementing an interface [9]. This application focuses heavily on ease-of-use. The User-Centered Design (UCD) framework is designed around three U's.

Usability describes the ease of using an interface to complete the user's objective. Opencrimemapping.org's user interface is set up from Shiny. We use a drop-down button so the user can move through periods of time easily. The user also has the ability to pan, zoom-in and zoom-out with the map displayed in figure 5. We also provide the user with the ability to hover-over specific instances. When the user hovers-over they are presented with more detailed information about the incident.

Fig. 5. This heat map uses Shiny to create interactive interfaces so users can select different periods of time by selecting the drop down button on the upper right.

The usefulness of an interface for completing the user's desired task is called utility. *Utility* taxonomy essentially breaks down to identifying one data element. Opencrimemapping.org uses color themes that are well thought out to ensure a user can find data elements on a map. The second taxonomy of utility is being able to search for information through space and time to help answer "when" and "where" questions.

Finally, to complete the UCD loop is the *user*. The targeted user is often not an expert in the field that the tool focuses on. Target user needs will change over time and cause an iterative process in designing a user interface. This application did not use a formal research method to identify user needs. Instead our tool was developed through a qualitative process of trial and error with users that were not part of the tool's development.

6.3 Color

Thematic maps through history have used color to communicate activity within a geography. With early maps the information was imprecise. The imprecise nature of maps led map makers to choose between pictorial or abstract representations of more detailed data[10]. Color in early maps was more vibrant than in early production maps where printed color was limited. By the 19th century printing improved enough to allow expansion in the role of color again [10].

The start of modern color in thematic maps can be traced to Jacques Bertin's 1983 Book "Semiology of Graphics". Bertin presents the goal of giving the reader of a map a clear visual indication of what is happening on the surface of the earth [11]. One way this is accomplished is through using color to show the difference between entities. ColorBrewer developed by Mark Horrower and Cynthia Brewer in 2003 helps the process of choosing appropriate color schemes for mapping needs. The authors point out that choosing color schemes can be very difficult when designing thematic maps. Most GIS software have color schemes, but they don't provide direction on the use of color.

When a thematic is displayed on a laptop LCD it may not print the same way. The ColorBrewer system suggests color schemes for agencies that need to have the maps available through multiple media types. There is a total of 35 color schemes or sets. They are divided into three groups: qualitative, sequential and diverging. Sequential schemes work well when order is needed in data from low to high. Diverging colors are good for the separation of variables. Qualitative color schemes use differences in hue to create a set that does not imply order [12]. In Opencrimemapping.org we use a diverging scheme to show the difference between residential burglaries and business burglaries on a dot map shown in figure 6.

Colors in thematic maps also need to take into consideration users with impaired color-vision. Pastel-like colors were found to be more confusing to color-vision impaired users than darker colors. This is an important consideration because approximately 1 in 25 people are color-vision impaired [13]. Finally, color selection needs to take into account unintended bias. For example, when mapping crime data using a color scheme that may match skin tones there could be a perception that the colors reflect specific ethnicities.

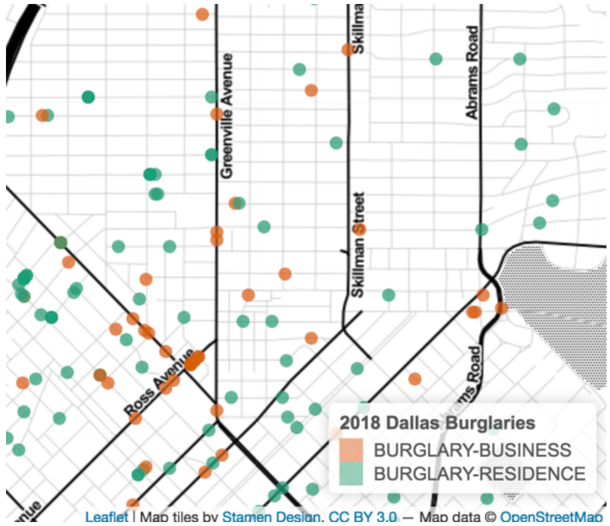

Fig. 6. This dot map uses diverging colors selected from ColorBrewer.org to display different burglary types. The color selection in this map also takes advantage of ColorBrewer's option for managing color blindness.

It's important that the map maker make a careful and well-thought-out choice in the data colors that are displayed on a map. Failure to do so could lead to the user not gaining new information from the map.

6.4 Base Map Selection

A basemap is GIS data that has been planimetrically corrected. A planimetric image has had the effects of tilt and perspective removed and only displays the horizontal surface features of the Earth's surface. The basemap is what we think of when we imagine the boundary lines defining countries and states, it provides the setting. A basemap can be as simple as a few boundary lines. However, with GIS technology base maps can include intricate details about natural and cultural surface features.

Leaflet maps use 'tiles' like most digital maps[13] . Tiles are individual map images that are joined along invisible seams when called. This preserves computational efficiency while enabling zoom. The process of building a map in Leaflet is described as stacking layers. For example, the first layer is generally the base map so markers showing the location of police stations would be layered on top. This layering capability provides flexibility to selecting a basemap because even basemaps can be layered together assuming a level of opacity is used to allow the bottom basemap to show through the top basemap.

[13] Using Basemaps, Leaflet for R, https://rstudio.github.io/leaflet/basemaps.html

With Leaflet one does not need to build their own basemap, but that is still an option. Leaflet provides pre-designed basemaps created by Leaflet as well as third parties that can be printed to a screen in 3 lines of code or less[14]. There are many impressive open source basemap tile designs available. Before choosing a basemap for crime display it is important to ask, "Who are these maps for and how will these maps be used?" and to remember that the quality of these maps also reflects on the LEA as a professional entity. The 1999 U.S. DOJ publication Mapping Crime: Principle and Practice, described the process of using maps as creating abstractions of reality. As the abstraction increases the further from reality we move. However, abstraction allows a complex story to be told simply [14]. The process of selecting a basemap is a balance between abstraction and reality. The goal of police transparency revolves around telling what is true as best as possible. Transparency also depends on the ability of citizen users to understand. Figure 7 below shows a basemap of Dallas, TX that has a watercolor design and a basemap that has a more realistic topographical details. While the watercolor map is appealing, it does not allow a user to easily determine locations of interest in Dallas. On the other end of the spectrum, a basemap could potentially show so many details that when using the zoom feature incident depictions get easily lost in the chaos. For example, a web-based test of basemap usability conducted by Konecny et al. found that all tasks completed with a topographic basemap took longer to complete and suggest that topography can be cognitively challenging [15]. Ultimately, the selection of a basemap should minimize frustration for the user.

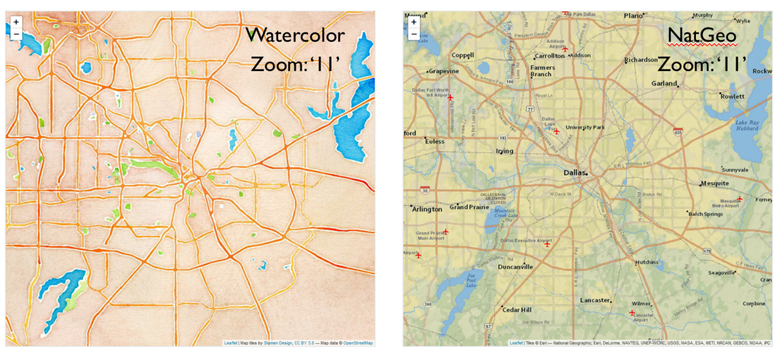

Fig. 7. These basemaps illustrate artistry verses clarity in the selections of basemap options within Leaflet.

[14] Leaflet-providers preview, Leaflet, http://leaflet-extras.github.io/leaflet-providers/preview/index.html

6.5 Map Types

There are a variety of major thematic map types that can be used to display crime incidents. Digital maps can be extended well beyond push pins in a hanging map. In combination, map types can paint both images of individual incidents and overall trends. If not carefully constructed, digital crime maps can also be misleading.

Dot Maps Dot maps are a traditional mapping style where each dot represents a discrete object. Dot maps can be effective at showing where individual crime incidents occur and the distribution of many incidents across space.

Individual dots will be most accurately represented using a coordinate system such as latitude and longitude or state coordinates. When using data from different sources it is essential to use a single coordinate system. State coordinates cannot be accurately placed on a map developed using latitude and longitude because state map coordinates represent physical distances on the ground.

Dot size is also important. Dot sizes too large can oversaturate a map and lead to lots of overlap. Dot sizes too small can be hard to perceive. On the other hand, larger dots may be preferred to obfuscate the exact location of incidents. If a dot overlaps a few residencies rather than pointing to a single residence it will offer some protection of privacy to victims and/or accused. If a formal algorithm for selecting dot size is not used, it is best to compare several dot sizes to determine the most accurate and useful representation of a single incident. With leaflet, dot sizes can increase upon zoom to retain their relative size to the geographical area they represent. This is an important feature to have so that upon closer inspection the location of a single dot still appears to be in the correct coordinate space.

Dot maps can be used to look for trends and patterns. If dots are displayed with opacity, it is possible to see density more clearly for highly populated maps or maps with strong clustering. The patterns in a crime map are both an important investigative tool as well as possible source of misleading information. A cluster of incidents may appear to be a hot spot, but they may also represent a more highly populated area [15]. Dot maps are advantaged because they can display segments of incidents or totally distinct incidents. Crime maps often include an assortment of icons to map many distinct types of incidents. The limitation of mapping many incident types at once is over saturation. The time frame for a map may need to be significantly reduced to fit many types of incidents onto a map. Furthermore, many incident types can be so busy it is difficult to interpret the map or use it as an investigative tool.

Cluster Maps Cluster maps are an extension of dot maps. Cluster maps represent the collection of incidents for defined surrounding areas. Cluster maps are more computationally efficient than dot maps. With Leaflet, a cluster is labeled

[15] Mapping Crime: Principle and Practice https://www.ncjrs.gov/pdffiles1/nij/178919.pdf

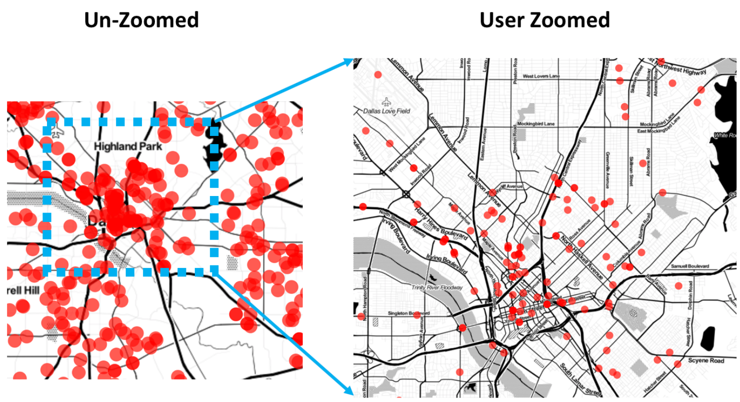

Fig. 8. This dot map shows the challenge of balancing appropriate dot map size in both a zoomed-out and zoomed-in view.

with the number of incidents represented within each single cluster. A mouse over effect allows the user to highlight the area captured by a single cluster. When a cluster is clicked on the map zooms in toward the area captured by the cluster and pulls smaller clusters and individual markers out of the first cluster. Figure 9 shows the mouse over effect and the 'spiderfy' effect of clusters as the zoom increases.

Heat Maps Heat maps in simple terms are fluid density projections placed on top of a basemap to indicate where incidents are most clustered. Heat maps use colors to represent a scale of numbers. Usually, as colors become darker they represent increasing numbers. A heat map is useful for a big picture view of the distribution of a single type of incident. If incidents are combined for a density analysis they should be related or grouped together and defined as a larger category.

Heat maps are considered distinct from hot spot maps. Heat maps do not use statistical significance to distinguish between density. Hot spot maps are projected into polygons that represent statistically different densities. When using a heat map it is important to consider this difference because there is a greater potential for misrepresenting data. If a density projection is too dark it may overemphasize crime incidents and if a projection is too faint it may be difficult to find any patterns.

6.6 Variable Selection

The selection of variables to be represented in crime maps for the public is a business problem. Police departments serve as public safety agents and crime

Fig. 9. The left cluster map shows the mouse over feature in leaflet that highlights the area captured by a cluster. The right cluster map shows a zoom view with smaller clusters and some individual markers representing single incidents

maps are an extension of this service and a peek into the role of the police department. To continue along the theme of trust and legitimacy, departments should consider asking citizens what types of crimes they are interested in. They should also balance sensitivity. Some crimes, such as those related to sexual offenses or offenses involving children need more privacy and careful consideration before being shared with the public. Also, the display of multiple incidents at once may imply to the user that they are related in ways that they may not be. The correlation between incidents of specific types may be legitimate, but if causation or further research into correlations is not well understood the public interpretation could be incorrect.

7 Ethical considerations

Open data in public safety presents some ethical considerations. One such ethical issue is the publishing of the complainant information. Specifically in the Dallas Open Data Public Safety Police Incident data set the user is able to find the complainant name, race, gender, age, and address. The complainant could be the person who reported the crime that took place, or the victim of the incident. The offender or parities interested in protecting the offender could use that information for malicious intent.

Including the complainant's name appears to be a common practice among open data sources. This was highlighted in a Federal Trade Commission memo by their Chief Technologist Lorrie Cranor in 2016 stating that there was a possibility that people who access open police data may able to identify crime victims or reveal their locations[16]Cranor identified several instances where the agencies had fully identified victim information. Another city had names removed but continued to post location information. Even with cities that attempted at victim de-identification other databases might have been used that may contain pieces of the identification once pieced together.

8 Summary

Opencrimemapping.org is an online tool that is designed to help novice map-makers make thematic maps that will lead to increased communication between police and citizens and thus improve quality of service and reputation. Opencrimemapping.org features different types of thematic maps showing the same data set so novice map makers can make choices based on the geovisual methods presented in this paper. Other valuable features include: (1) multiple base-map selection tools to see the effects of different basemaps; (2) The ability to change time frames; (3) Check different coloring methods outside of our methodology and compare them with our methods; (4) See different intensity levels on a heat map to show heatmap ambiguity. Maps that present crime incidents that are communicated to the public are important, and the combination of opencrimemapping.org and the methods presented in this paper help novice map creators improve the quality and reputation of their respected LEA.

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