Chapter 5

Evaluating the Effectiveness of CCTV in Baltimore, Maryland

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Additional information is available at the end of the chapter

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Abstract

This report reviews the results of an investigation into the effectiveness of public surveillance systems in Cherry Hill, Baltimore City, Maryland. Its chief objective is to discern whether closed circuit television (CCTV) cameras are a successful crime control measure and whether their implementation displaced crime or generated a diffusion of benefits to the areas outside a camera's viewshed. Previous research on the efficacy of CCTV leaves much to be desired, and the debate is still inconclusive. Thus, this study attempts to move toward new ways of analyzing crime data gathered pre- and post-implementation of cameras in a given target area. To conduct this research, the investigation utilizes a combination of existing and new geographical information systems (GIS) spatial techniques to visualize and measure crime distribution and uses light detection and ranging (LiDAR) data to produce a precise mapping of a camera's line of sight. Findings from each analytical method are compared, contrasted, and combined to provide rounded results. These findings suggest that the implementation of GIS techniques in crime mapping have huge potential and could provide innovative uses for CCTV within law enforcement crime control programs.

Keywords: GIS, CCTV, crime displacement, crime, LiDAR, spatial, crime distributions, surveillance, WDQ analysis, spatial analysis, hot spot analysis, viewshed analysis, crime mapping

1. Introduction

Crime can be defined as a type of action that is considered wrong and punishable by society [1], although some have argued that the term "crime" does not have any basic or widely accepted definition [2]. Crimes of various types happen every day in the world, and each event occurs at an exact geographical location. Whether it is the victim's physical location, a cybercrime IP address, or a computer where data are stored, all crime has a connection to a place. Thus, with the study of crime, emerges the field of crime mapping. Crime mapping has applications to many fields, including law enforcement and geographic information systems. The technology used to map crime can also be employed to monitor, reduce, and/or displace criminal activities. One such example is the use of closed circuit television (CCTV). There are many different arguments and opinions as to whether CCTV cameras actually help to reduce crime or whether they merely displace crime around the corner.

CCTV cameras are currently used in the United States and in other parts of the world [3] with the intention of reducing criminal activity in large urban centers. The city of Baltimore has a history of high crime rates. Of late, this has been directly addressed by one of the most extensive camera systems in the United States, in the hope of improving the lives of citizens and the economic status of the city [4]. However, systematic studies to assess the validity of this approach have not yet been published [5]. For this reason, Baltimore City's extensive use of CCTVs renders it a suitable candidate to determine whether there is a correlation between the implementation of CCTVs and a decrease in criminal activity. More specifically, this study employs impact analysis, as well as geostatistical methods and theory, to characterize any positive/negative associations of crime pattern alterations in CCTV camera viewshed areas in Baltimore. This investigation has the potential to greatly improve our general understanding of the role that CCTV devices play in crime control. It also provides informed recommendations to justify the investment and systematic use of these devices to improve safety in large urban centers. Moreover, this study will potentially increase community awareness of the reliability of crime cameras and thereby influence other law enforcement agencies to follow in Baltimore's footsteps.

Baltimore has had a well-documented history of widespread criminal activity. In 1978, the Baltimore Police Department (BPD) reported 197 homicides, a number that then almost tripled by 1993 to 353 homicides. As recently as 2013, a total of 235 murders were documented in the city. Baltimore's rate of violent crime is above the nation's average, as national violent crime in 2009 summed to 1,318,398 incidents, an equivalent rate of 0.4 incidents per 100 people [6]. In 2003, Baltimore was ranked seventh in total violent crime in the United States, experiencing a total of 11,183 violent crimes and 48,653 total crimes [7].

In an attempt to control and reduce criminal activity, in September of 1995, the Baltimore Police Department was awarded the $75,000 federal Byrne Memorial Grant to start a video control project [5]. The overall expectations for the project were to decrease violence in the downtown business district and to increase business in downtown centers which had become unpopular due to high criminal activity [5]. Sixteen fixed position cameras were installed for $47,000 to view sidewalks, public parks, and streets, with the ultimate goal of monitoring crime activities [5]. Subsequently, in 2004, the mayor of Baltimore visited London and realized that public surveillance technology may help in crime solution and prevention [4]. In CCTV, he hoped for a new and effective combatant to the city's high crime rates.

Currently, the City of Baltimore has one of the most extensive camera systems in the United States. The City has spent over $16 million in acquisition, installation, and maintenance of the

CCTV system. Most of the funding came from federal homeland security grants. The cameras are composed of both fixed- and hard-wired systems and portable units, or Police Observation Devices (PODS). PODS are camera units that can be easily moved around and set up, but footage must be downloaded directly from each digital recording system for post-incident review and analysis [4]. The fixed hardwired systems, on the other hand, are mounted at certain locations and monitored by police officers from a centralized watch center. Officers at the watch center can zoom, pan, and follow a moving object. One Baltimore citizen stated that "From time to time, thanks to surveillance camera, crooks are caught in the act. It helps put down some of the crime that's going on in the area" [8]. The general consensus among Baltimore citizens who live near one of the camera locations is that the system provides a certain degree of increased comfort [5]. Thus, CCTV cameras, including PODS, are useful tools that allow us to characterize and deter criminal activity, serving the community directly.

2. Materials and methods

The methods used to determine whether CCTV cameras displace crime, decrease its frequency, or leave it unchanged are detailed in the following sections. This methodology involves both descriptive and inferential geographical statistics to evaluate criminal instances in Baltimore city, by using the procedures of data collection, study area identification, spatial analysis tools, map creation, and data analysis. Also examined are descriptive statistics for overall crime, significant changes in crime rates, and if these changes are due to the crime cameras.

3. Data collection

This study uses data collected by the Baltimore City Police Department (BPD). In order to obtain the required data for this study, a request letter was sent to the commissioner of BPD, Mr. Anthony W. Batts. Once the commissioner approved the release of requested data, a subsequent formal request to export the data was sent to the BPD Information Technology Department. The BPD provided camera locations with installation dates for all cameras installed throughout the city from 2005 to 2014. Additionally, BPD provided victim-based incident crime data for the period of January 2009 through January 2015 for the entire city of Baltimore. The crime camera data were given in a spatial events file used in GIS software (shapefile format), which contains the field attributes of camera number, location, project type, date installed, latitude, and longitude. BPD was not able to supply victim-based incident crime data from the year January 2003 to January 2009 due to a fire in the police department. Alternatively, the victim-based incident crime data from January 2003 to January 2009 were obtained from John Hopkins University GIS department's library database. The attributes that came with this data were nearly identical.

The data were collected by BPD using protocol GPS handheld devices to record the exact location of each incident. Additionally, BPD uses satellite imagery to record the latitude and longitude coordinates of the precise location of the crime for the crime camera data. The data are projected to Maryland's NAD83 state plane coordinate system. The crime events are recorded by BPD using CitiStat, which is an extension of the CompStat software used by the entire city of Baltimore. CitiStat was originally a way for the city to handle complaints but has evolved into a program capable of handling many issues within the city, such as policing, homelessness, public works, and waste management. The data in CompStat are collected by the minute and analyzed, then presented in a visual form by BPD [9]. BPD has been working to incorporate the crime cameras into CompStat to make it easier to identify suspects whose criminal activity was recorded by the cameras [4].

Light detection and ranging (LiDAR) data were collected from the US Geological Survey (USGS) website and was captured by USGS for Baltimore City in 2008. LiDAR is a type of remote sensing technology that can measure distance by lighting up a target area with a laser, then computing the reflected light [10]. LiDAR systems collect elevation (z) and positional (x, y) data for the reflected objects scanned by the laser under an aircraft, which can create three-dimensional generations of the landscape with multipoints [11]. This file was downloaded from USGS's website and then converted into multipoint data for this study using Environmental Systems Research Institute (ESRI) ArcMap.

4. Study areas

Following the work of Bowers and Johnson [12], we measured the frequency of crimes that occurred 5 years prior to and 5 years after the installation of cameras in given areas. The cameras used in this study were installed in Baltimore during the month of February in 2008. Camera cluster analysis (CCA) provides additional evaluation of appropriate areas for this study, where cameras have overlapping buffers [13]. It is important that these camera clusters are adequately distanced from individual cameras, to avoid a buffer zone that could conflict with the analysis [13]. A buffer is an area around a map feature that is measured in units of distance or time (ESRI GIS Dictionary, n.d).

Theoretically, there is no reason to examine displacement of crime if crime in the target area has not changed over time [13] because the results would not show any significance. As illustrated in Map 1, downtown Baltimore City is made up of 50 city blocks, which range from Center Street to Camden Street and from Green Street to Cathedral Street with a camera in nearly every intersection [13]. The neighborhood of Cherry Hill was chosen for this study as crime data was available from BPD for 5 years prior to installation in 2008 and 5 years post-installation. Cherry Hill as seen in **Figure 6** is located on the southwest border of Baltimore City and is mostly positioned around an outer edge of the Chesapeake Bay estuary. Cherry Hill's population consisted of 96% African American in 2000 and 94.6% in 2010, compared to 64% in the city. There was a total population of approximately 7772 in 2000 and 8367 in 2010. Cherry Hill's housing consists of low-income public housing, including the largest public housing development in the city. It is a dense urban residential neighborhood. The median rent is $442 in 2000, which is comparatively lower than the city as seen in **Table 1**. Minimal gentrification has taken place during this study's time period, based on the census data. The number of nonfatal shootings per 10,000 residents in Cherry Hill is at a rate of 96.3 compared

Figure 1. WDQ equation.

to Baltimore City at 46 between the years 2005 to 2009 [14]. Baltimore City's level of violent crime is much higher than the national average: violent crimes were reported at a rate of 1,318,398 or 0.4 incidents per 100 people in 2009 (**Figure 1**) [7].

5. WDQ and DiD analysis

This study assesses the hypothesis that the presence of the CCTV crime camera decreases the rate of crime within the visibility of the cameras. An impact analysis test is used to examine the validity of the crime cameras in Baltimore City for crime distribution. In order to perform the weighted displacement quotient (WDQ) and difference-in-differences (DiD) analyses, the following steps were implemented: (1) buffer zones were assigned around the individual selected crime cameras in the study area, (2) displacement was determined using concentric buffer zones, thus allowing for a distinction between a decrease in displacement and the influence of diffusion [12] buffer zones to be implemented to capture the presence of displacement or any change or potential displacement for the crime distribution.

The WDQ was computed using the GIS software ESRI ArcMap (Standard Desktop version 10.2.2) to produce three concentric buffer zones that are placed around each individual CCTV crime camera using the "buffer" tool in the geoprocessing toolbar. The size of each class of buffer is determined by the BPD's internal requirements for crime analysis of CCTV effectiveness for 28 days before and after the camera installation period. Buffer zone "A" represents the project area set at a 0.05 mile radius, buffer zone "B" represents displacement area with a 0.1 mile radius, and buffer zone "C" represents the control area with a 0.2 mile radius. Buffer zone "B" accounts for a proportion of crime committed in buffer zone "C." Displacement of crime is shown by movement of crime sites; area "B" should increase, while crime in buffer zone "A" should decrease. If the results of the buffer WDQ analysis are positive, then there is sufficient evidence for diffusion of benefits; if the results are negative, displacement of crime may be more likely. This analysis is a type of interpretation of the WDQ. Thus, WDQ is used as an indicator of potential diffusion of benefits and displacement of crime prior to and post-camera installation within the target area of the crime camera buffers. WDQ values can be inferior, equal to or greater than 0 and can be used to indicate whether diffusion of benefits of spatial displacement has occurred.

The crime data is separated into six categories: grand theft auto, larceny, robbery, assault, rape, and homicides. Data is then spatially joined to the buffer zones using GIS before being exported into individual feature classes in the project geodatabase. A report generated by ArcMap arranges the crimes within each buffer zone in a tabular format to further visualize the data for pattern analysis. The crime codes are generalized for each crime into one category (e.g., all types of robbery are placed into one category). This is to maintain consistency and to reduce error. The data were linked in ArcGIS using a spatial join to count the number of different crimes for each buffer. A report with charts was subsequently developed to easily visualize these findings. Additionally, a percentage of change was calculated from before and after the comparison. An additional chart was made to visualize the percentage change. Finally, a Difference-in-Differences (DiD) is calculated to quantitatively measure the amount of displacement and diffusion of benefits and to determine how much impact the crime cameras have in the distribution of crime beyond the visibility of the camera and into surrounding areas. In this study, DiD was used to compute the average percentage increase or decrease for displacement within the Baltimore City CCTV crime camera's visibility zone, taking the values for buffer zone "A" and subtracting them from the values from buffer zone "C".

6. Spatial analysis and map creation

Tools used to visually display the patterns of CCTV crime camera distribution in Baltimore City consist of spatial analyses and map generations. Environmental Systems Research Institute's (ESRI) ArcGIS ArcMap Desktop Standard 10.2.2 is used in this study to perform these two functions. Spatial data included in the project are: crime camera locations, crime events, streets where crimes occurred, neighborhood boundaries, digital elevation model, Bing aerial base map, traffic lights, neighborhood boundaries, buildings, county boundaries, and municipality boundaries. GIS software is employed in this study to create maps and to implement spatial analysis tools to evaluate whether the presence of the CCTV crime camera decreases the rate of crime within the visibility of the cameras. All geographic files for the entire study are assembled into an ArcCatalog Geodatabase. To properly map the crime data from the cameras in Baltimore City using crime mapping, hot spots must be identified. The following type of spatial analysis tools and scripts were used to identify hot spots in ESRI ArcMap: fishnet, spatial join, incremental spatial auto-correlation, and optimized hot spot analysis. In order to characterize the occurrence of crime diffusion of benefits and displacement, hot spot analysis maps are created.

The process to create these maps required the determination of a grid size for the aggregated crime data up to 5 years before and 5 years after the installation. The tool in ArcMap to create a grid is Fishnet. In order to determine the appropriate grid size for the crime data, the formula $\left(\frac{A}{N}\right)^{\frac{1}{2}}$ [15] is used, where A represents the study area, the Cherry Hill neighborhood, and N is the number of crime incidents.

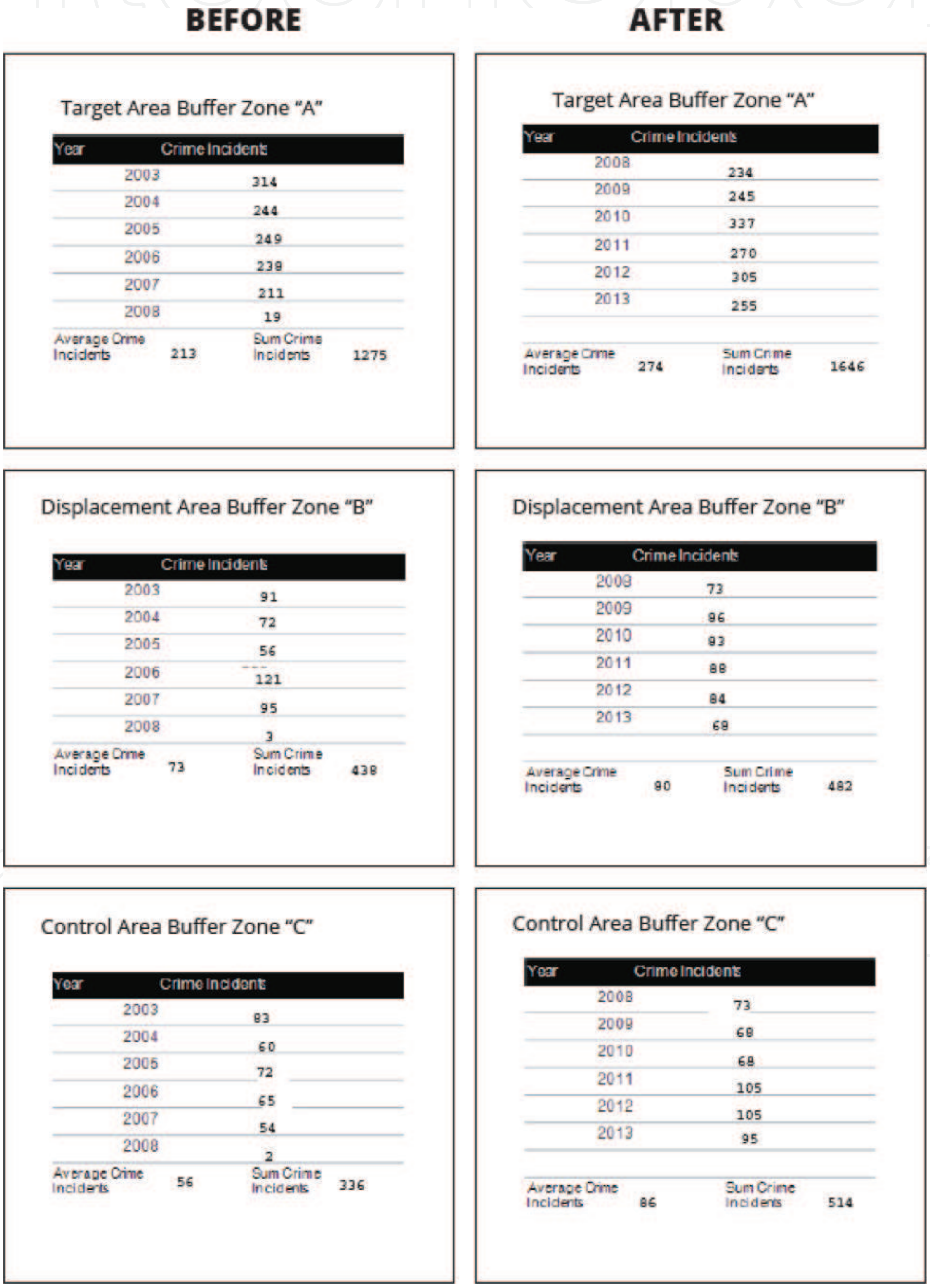
Subsequently, the number of incidents within each grid cell is calculated in ArcMap using the spatial join tool. The incremental spatial auto-correlation tool is then used in ArcMap to determine the fixed distance band, which uses a critical distance to decide what neighbors to use in the grid cells. This ensures that the scale of the analysis will not change and will be consistent across the study area. Every feature within a fixed distance is included, and every feature outside that distance is excluded. The fixed distance band is ideal for point data, as it ensures that all points have a neighbor. The tool performs the Global Moran's I statistic for a series of increasing distances to measure the amount of clustering for each distance. The output of the incremental spatial auto-correlation tool will produce a report and a graph of "*Z-scores*" at each distance. The peak value of the z-score distance is used for the fixed band distance value. Then the optimized hot spot tool will be used to produce the "*Z-scores*" and *p-values* of the crime data. A small *p-value* and high "*Z-score*" will indicate a substantial hotspot. Alternatively, a low "*Z-score*" and small *p-value* will show a significant cold spot. A "*Z-score*" near zero means minimal or no spatial clustering. The optimized hot spot analysis tool uses the hot spot analysis (Getis-Ord Gi*) tool using parameters from the count of the crime incidents in each grid cell from the fishnet tool with the spatial join. The output of this tool creates a "*Z-score*", *p-value* and GI_Bin result for each feature. The GI_Bin identifies hotspots corrected for multiple testing and spatial dependences suing the false discovery rate (FDR) method.

This study also uses the spatial analysis method for calculating the viewshed of the crime cameras, using the viewshed analysis tool in ArcMap. The LiDAR data in the study area is converted into a multipoint using ArcMap. The multipoint is then converted into a raster using ArcMap point to raster tool, which will create a raster elevation model. The parameter used in the analysis for the viewshed of the crime cameras is the crime camera height of 25 feet. This is called the offset, the vertical distance in surface units to be added to the *z-value* of the location of the surface. In this case, it is called OFFSETA, which adds the vertical distance to the *z-value* of the observation point. A viewshed analysis requires two input data sets, usually a point layer of viewpoints and an input of a DEM or TIN, which represents the land surface [16]. In this case, the inputs for the tool are the raster elevation model derived from the LiDAR data and the Cherry Hill crime camera points. The result of the viewshed analysis is a raster that categorizes cells into the visible and nonvisible classes [16].

7. WDQ and DiD analysis results

The WDQ Chart as seen in **Figure 2** displays the amount of each crime incident before the installment of the crime camera and after. These reported crime incident totals for each buffer area are variables to produce the WDQ results.

It is worth noting that in 2008, the "Before" column displays a low crime incidence value, due to crime taking place in the month prior to installation in February. The "After" column



BEFORE

Target Area Buffer Zone "A"

Year	Crime Incidents
2003	314
2004	244
2005	249
2006	238
2007	211
2008	19

Average Crime Incidents 213 | Sum Crime Incidents 1275

Displacement Area Buffer Zone "B"

Year	Crime Incidents
2003	91
2004	72
2005	56
2006	121
2007	95
2008	3

Average Crime Incidents 73 | Sum Crime Incidents 438

Control Area Buffer Zone "C"

Year	Crime Incidents
2003	83
2004	60
2005	72
2006	65
2007	54
2008	2

Average Crime Incidents 56 | Sum Crime Incidents 336

AFTER

Target Area Buffer Zone "A"

Year	Crime Incidents
2008	234
2009	245
2010	337
2011	270
2012	305
2013	255

Average Crime Incidents 274 | Sum Crime Incidents 1646

Displacement Area Buffer Zone "B"

Year	Crime Incidents
2008	73
2009	86
2010	83
2011	88
2012	84
2013	68

Average Crime Incidents 80 | Sum Crime Incidents 482

Control Area Buffer Zone "C"

Year	Crime Incidents
2008	73
2009	68
2010	68
2011	105
2012	105
2013	95

Average Crime Incidents 86 | Sum Crime Incidents 514

Figure 2. WDQ count chart.

indicates crimes committed after installation in 2008. This chart was used to produce a trend graph as seen in **Figure 3**. The intervention line as seen in **Figure 3** displays when the cameras were installed in Cherry Hill at the end of February 2008. This graph shows the crime trend from 2003 to 2014. Overall, the average number of crimes has increased slightly, but not appreciably.

Results from the WDQ seen in **Figure 4** show that post camera installation, the reported crime incidents in the target buffer area (A) increased by 29%. The reported crime incidents in the buffer area (B) increased by 10%. In the control buffer area (C) the reported crime incidents increased by 53%. The success measure for the analysis was at −0.586. This means that the reported crime incidents in the target area were increased, but it performed better than the control area. The buffer displacement measure came in at −0.366 and the weighted displacement quotient (WDQ) at 0.624. Significantly, the buffer displacement and success measure indicate an effective scheme with a diffusion of benefits. It must be remembered that diffusion of benefits only occurs when there is a decrease of crime outside the camera's surveillance area. This means that displacement buffer area (B) suffered proportionally less crime in comparison to the control buffer area (C) after CCTV implementation.

Overall, the WDQ analysis determined that crime in the target area was higher and performed better than the control area. However, total crime in the combined buffer area and target area increased by 25%. The total net effect (TNE) for the Cherry Hill area was the prevention of the possibility of 490 crimes. Conclusively, it can be said that there is a positive benefit to the operation of installing crime cameras in the target area. It should be noted

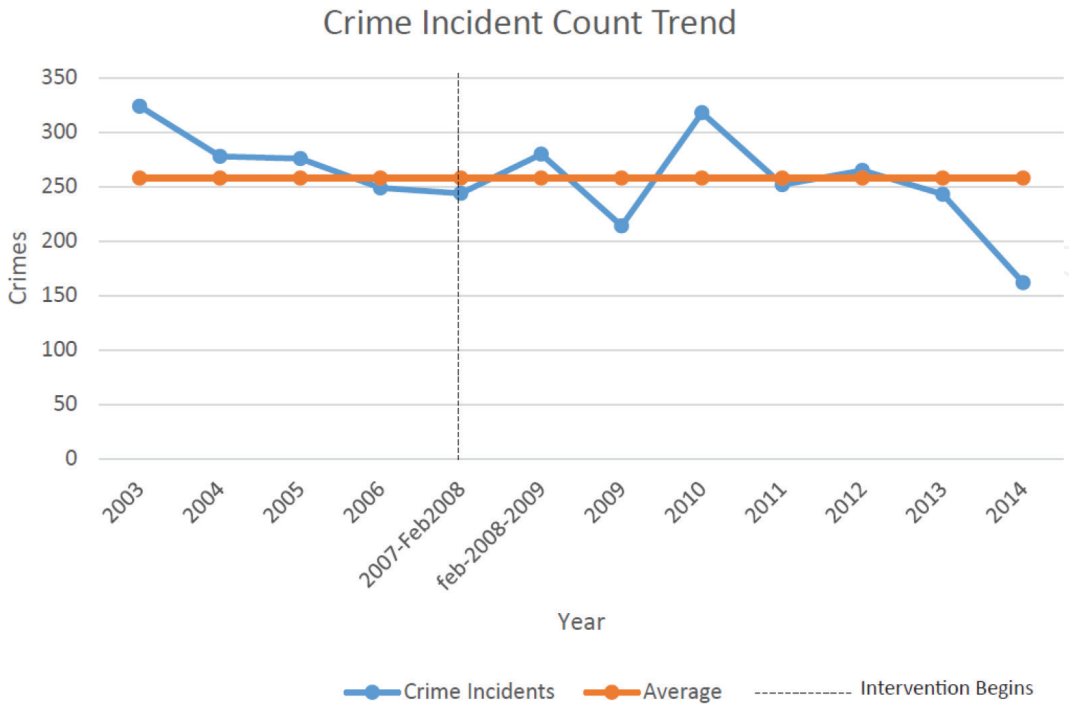


Figure 3. Crime trend in Cherry Hill, Baltimore, MD, 2003–2014.

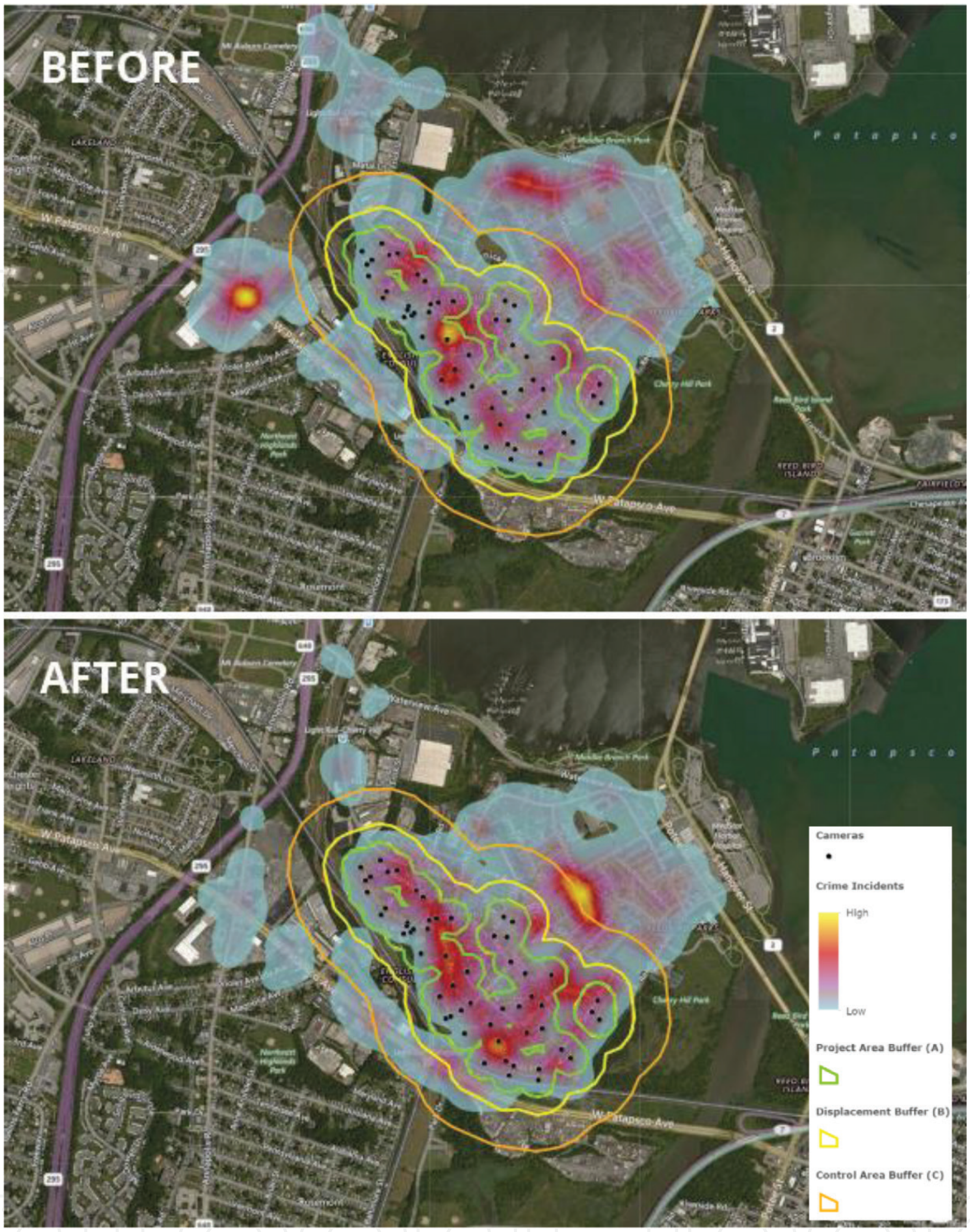


Figure 4. (a) WDQ analysis: before and after; (b) green: buffer A; yellow: buffer B; orange: buffer C.

that although crime incidents after the intervention are higher, this could be due to cameras recording more criminal activity. So, in reality, crime may have been occurring prior to CCTV interpolation but not officially recorded as an incident by police, due to lack of evidence and reportage.

8. Viewshed and hot spot analysis

The viewshed analysis provides a great visual understanding of the visible landscape from the Cherry Hill BPD crime cameras. Seen in **Figure 5** are the results of the viewshed analysis in the study area Cherry Hill, the transparent purple layer representing the area visible by the

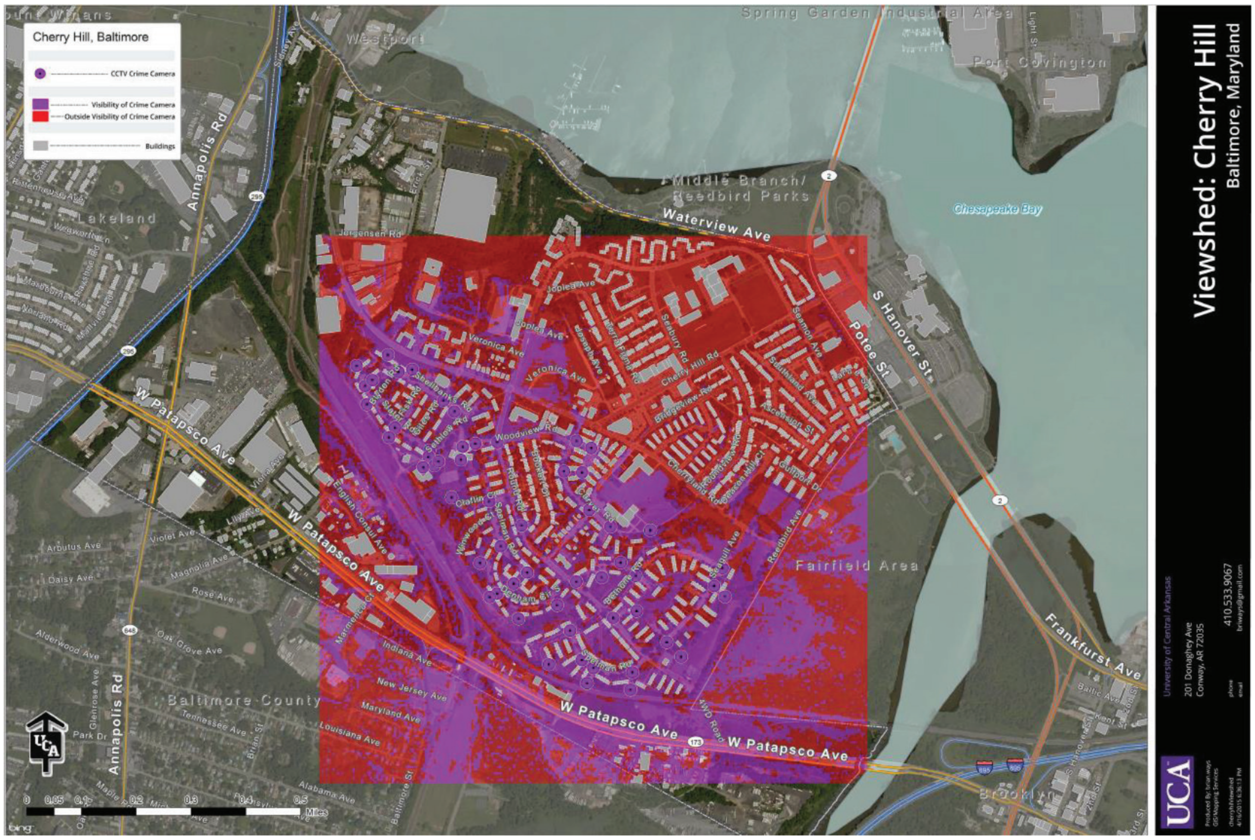
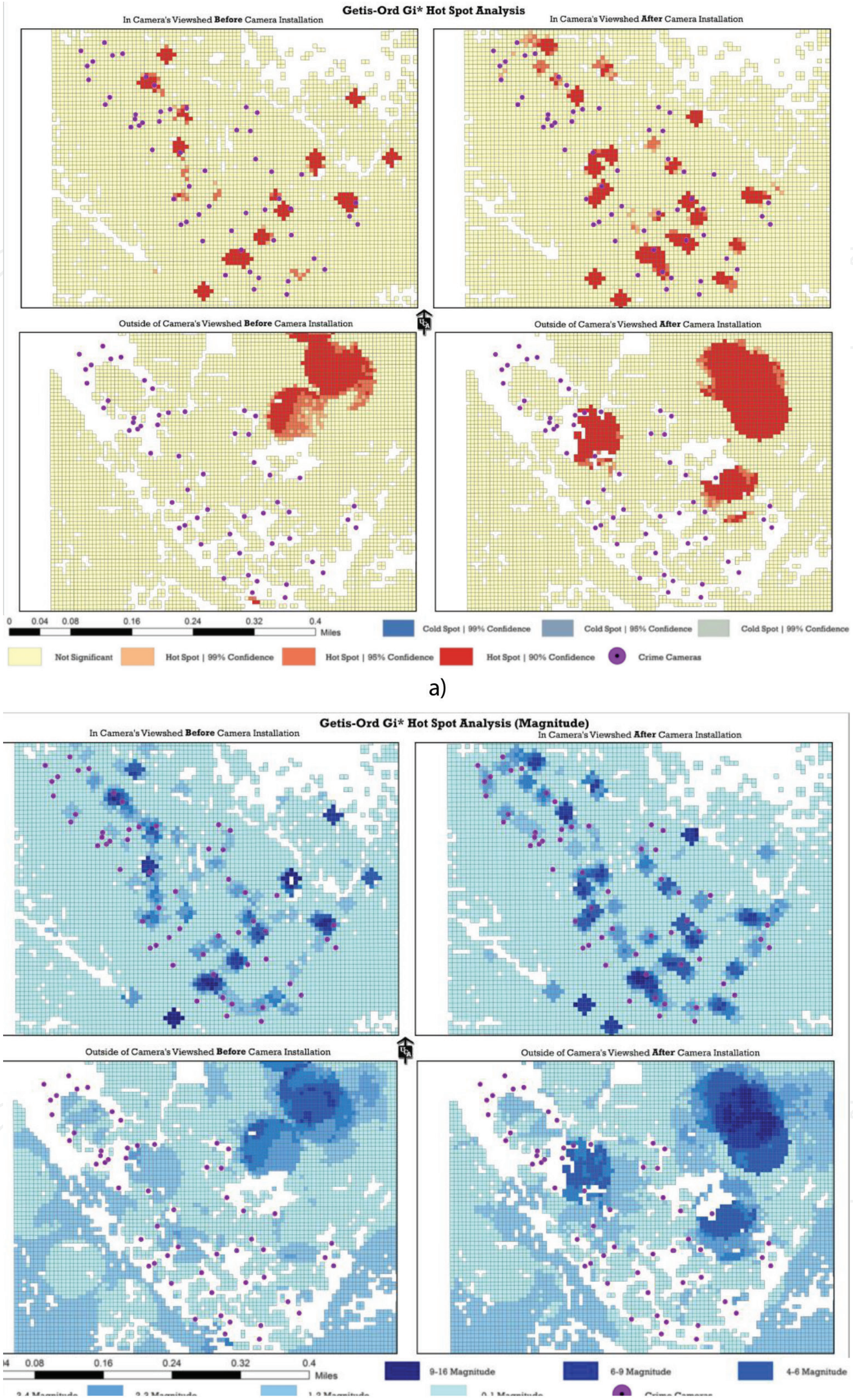


Figure 5. Viewshed analysis.

crime cameras, and a transparent red for the non-visible areas. The identifications of buildings are placed on top of the visible or non-visible viewshed layer to demonstrate what is actually seen by the crime cameras.

The viewshed analysis result layer was then used as a parameter to calculate the Getis-Ord Gi* optimized hot spot analysis. The results of the Getis-Ord Gi* optimized hot spot analysis tool created a new feature class of the crime incident data, for pre- and post-installation of CCTV cameras. It was signified by whether it is part of a statistically significant hot spot, a statistically significant cold spot, or if it is not part of any statistically significant cluster as seen in **Figure 6(a)**. The red areas are hot spots, or areas where a high number of crime incidents have taken place. The cold spots would be the blue areas, but there are none on this map for the data. The beige areas represent a statistically insignificant cluster of crime incidents.

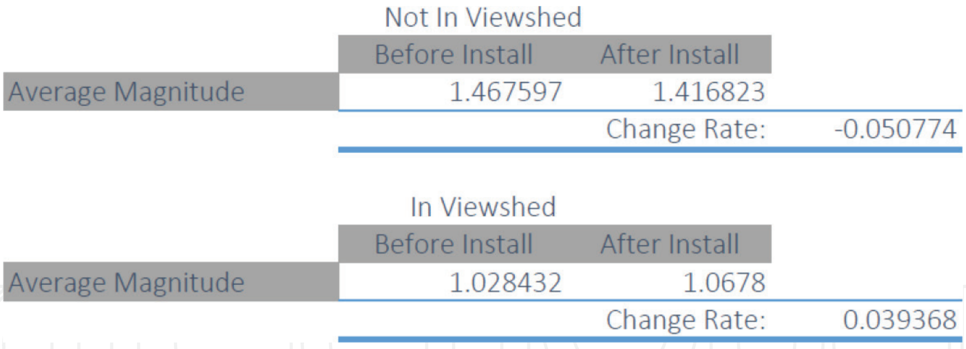
The magnitude results from the hot spot analysis can be visualized as a − 0.50774 change rate in average magnitude (in comparing before and after CCTV implementation), outside of the camera's viewshed as seen in **Table 1**. In the viewshed of the camera, the average rate of crime increased with a value of 0.039368. The degree of crime decreased after intervention outside CCTV view, but the level increased after intervention within the cameras' line of vision. The decrease in magnitude of crime incidences outside the camera's viewshed after the installation is analogous to diffusion of benefits. The increase of magnitude inside the camera's viewshed could be comparable to the WDQ results. In the qualitative thematic map produced as seen in **Figure 4**, the change from densest (darker) crime zones from pre- to post-installation offers a strong visual depiction of the magnitude of the measure of crime. Some of the movement



a)

b)

Figure 6. (a) Getis-Ord Gits* optimized hot spot analysis comparison. (b) Getis-Ord Gits* optimized hot spot analysis magnitude comparison.



Not In Viewshed

	Before Install	After Install	
Average Magnitude	1.467597	1.416823	
		Change Rate:	-0.050774

In Viewshed

	Before Install	After Install	
Average Magnitude	1.028432	1.0678	
		Change Rate:	0.039368

Table 1. Magnitude change rate.

depicted may be due to the awareness of perpetrators of the location of CCTV units, and thus their blind spots, to commit a crime. The results below compare crime rates outside of the viewshed, before and after camera installation. Their findings gesture toward a good method to select new camera sites. These can be obtained by comparing maps of hotspots pre- and post-CCTV fitting, outside of the viewshed, as noticeable, as seen in **Figure 6(a)** and **(b)**.

9. Discussion and conclusion

As opposed to other similar studies, this study differs when displaying the evaluation of crime distribution from CCTV cameras. Its practical and scholarly value is shown through this unique approach, overcoming limitations in previous studies. Other investigations were not able to obtain the exact viewshed for their results, due to limitations like land use and road infrastructures. This work has obtained the exact view of sight of the crime cameras by using LiDAR data to calculate the viewshed. The analysis for a portion of this study is just contained within the boundaries of what is visible to the cameras and what is out of sight: a new practical application that police departments could use to analyze criminal hot spots. The use of LiDAR data to produce a viewshed of exactly what cameras see has not been undertaken prior to this study, and its practical value can be seen in the results. The results from WDQ analysis are exhibited as a decrease of crime in the control area, but an increase of crime in the camera's target area. Along with this tactic, the methods and results of previous studies were also utilized to conclude to a well-rounded result.

The WDQ analysis used buffer sizes based on the BPD procedure measures for camera line of sight. These measurements of the buffer sizes are based on camera vendors, local law enforcement officers, and camera monitor's typical zooming ability. When the hot spot analysis used the exact viewshed to calculate its results, its comparison with the WDQ was similar. This demonstrates that there is a clear benefit to installing crime cameras. It is worth noting that the hot spot analysis calculated the magnitude of the rate of crime. Thus, it can only give an idea of if there is displacement or diffusion of benefits taking place versus the WDQ analysis, as the WDQ results provide an exact measure to demonstrate both displacement and diffusion of benefits. Conversely, it could be argued that the hot spot analysis gives a better idea of criminal incidence patterns due to its recreation of the exact viewshed of the CCTV surveillance. Each method has its strengths and weaknesses, but together, they work in tandem to bolster each other. It should be pointed out that both results of WDQ and the hot spot analysis demonstrate an increase of crime post-installation within the parameters of CCTV surveillance. The analyses of both sets of results also corroborated the decrease of crime outside the camera's surveillance area: for WDQ, surveillance areas mean target area buffer (A) within .05 mile radius, but for the hot spot analysis, this represents its exact viewshed. This could indicate that both results had a diffusion of benefits.

With the use of the weight displacement quotient, it needs to be pointed out that the result measure should not be used as an exact quantification of displacement or diffusion of benefits, but it should be used to indicate the possible existence of these. The only way to obtain this exact measure would be through conducting extensive interviews with large numbers of local criminals. Overall, this type of research approach would be costly and error laden, potentially outweighing its practical benefits. Most research in this vein is with offenders who are incarcerated or on probation.

The crime data used in this research is restricted in interpreting and understanding the 'true' picture of crime. It must be understood that not every crime that occurs is reported then recorded, and that not every crime that is recorded is investigated. This means that caution should always be observed with interpreting and analyzing any crime data. Another issue with the crime data used in this research is that it was not possible to get the exact consistency from BPD for the data from 2003 to 2014. BPD could only supply data from 2009–present, due to a fire in their data facility in 2011. This data could have been extracted, but for an unrealistic cost. The 2003–2008 data were obtained through John Hopkins University's GIS data library: despite claiming that it originated from the BPD, the data differed slightly. With a few adjustments, however, it was successfully reconciled to BPDs'. This provided confidence in using it for this study, but it must be heeded as a limitation. Additionally, policing behavior over time can vary. A change before and after installation of cameras could lead to a change in crime distribution. A further variable to be considered is a possible shift in the demographics in Cherry Hill during this period. One more point of deliberation is over the possibility for human error when dealing with any large data set, such as the crime incident data. The complexity of crime must be re-emphasized, and other uncontrollable variables could play a part in the outcome of the results listed. If these limitations are understood, then they can be better accounted for.

Results from the viewshed and hot spot analysis show a decrease in magnitude outside the area of view of the CCTV. The magnitude of crime increased, however, after the installation of the cameras, in the line of the camera's visibility. This could be accounted for simply by the fact that after camera intervention, more criminal incidents are detectable, versus outside the viewshed where fewer incidents can be recorded. Whether this is directly due to camera footage, more victims coming forth, or police programs actively working in detected hot spots with CCTV is unclear, due to lack of acknowledgement in the crime incident data. Nonetheless, CCTV crime cameras have a small, desirable impact on crime, generally speaking, judging by the presence of diffusion of benefits. It has to be acknowledged that a successful CCCTV operation in a particular area's parameters may not be the same as in another crime fighting location. This is where the opportunity for the use of GIS within policing operation broadens. Research indicates that where people think they are being watched, crime reduces. GIS forecasts based on CCTV could forestall displacement and create a mobile and anticipatory police presence in crime hot spots, thus enhancing the capability of existing CCTV operations.

Baltimore patrons think that the city's public surveillance system prevents crime, and that it helps solve criminal activity that would have not been apprehended otherwise due to lack of identification, failure to recover the weapon, or even the absence of a witness willing to come forward. It has encouraged witnesses to cooperate with the police, where they would not otherwise. This ties in to theses previously proposed in this paper, about the elevated rates of general crime in hot spots post-installation of cameras. Although there are some complications with its usage, it has been observed that key investigations and prosecutions lie in the evidence provided by camera technology. It is important to view the evaluation of the crime surveillance cameras in the context of a larger community policing framework. These devices are not flawless, but just another—albeit useful—crime control and investigative tool. Cameras may make some difference, but this cannot be confidently stated. Ideally, this tool should be used as part of a process with all other law enforcement strategies. This technology is only as effective as the police program running it. GIS techniques merely enhance the CCTV's capabilities.

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