Monitoring Terrorist Operation in Kadhimiya District Center of Baghdad using RS and GIS Applications
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Abstract—Monitoring and handling organized crime in Iraq is still going routinely and with ill-conceived operations. Because of the difficulty of obtaining correct and accurate data, the analysis process and propose successful solutions to prevent or reduce their number has become very difficulty. In this paper, Poisson distribution is used to simulate number and location of the organized crime (i.e. terrorist attacks) in the study area. Remote Sensing (RS) and Geographic Information System (GIS) applications are implemented to specify the geographic coordinates of the utilized images and maps and matching them with the geographic coordinates of the simulated crime event locations. Two possibilities in the implementation of criminal operations are assumed; the first assumption is proposing the launch operations from within the study area, while the second assumption was that the launch of operations from outside the study area. The study suggested that the crimes operations were rushed from point of closest distance from all events sites, and the availability of roads to get to the desired location for the execution of the crime. The results showed good agreement with reality.

Keywords—Crime analysis, Terrorist location prediction, Terrorist monitoring, GIS for crimes analysis, Poisson distribution

I. Introduction

The concept of place is essential to crime pattern theory because the characteristics of place influence the likelihood of a crime. Most crimes are not random events; they are distributed in terms of where they occur. Some areas are more subject to criminal activity than are others. The non-random spatial distribution of people causes motivation to perpetrate a crime, and the spatially non-random distribution of opportunities that increase the odds that a person or property will be victimized. Different intentions may be associated with the execution of the crime; for examples it may be certain personal intentions linked to crime, or may be the characteristics of the place (such as existence of certain financial institution like banks), or may be associated with the environment of the place (e.g. presence of a large parking full of automobiles). Crime literature has abundant references relating crime patterns to specific geographic features. For example, opportunities of burglaries and thefts are related with the presence of commercial areas and parking. There are indications reported that crack houses induce crimes (dealing in illicit drugs) that have a multiplier effect in the neighborhoods where they are located, and raise the volume of burglary and theft in their area and customers raise money to buy drugs. Recognition of the concept of place in the theory of crime allows a new dimension to the implementation of crime prevention [1]. In Iraq, terrorist crimes have taken another dimension, usually based on sectarian religious worldview between coexisted communities in adjacent areas. Therefore, mapping sites linking crime and criminal activities to map urban features provides the ability to enhance understanding of the non-random nature of the crime sites and improve crime prevention measures. In this paper, we will introduce some ways to manipulate the organized terrorist crimes by employing the remote sensing (RS) and Geographic Information Systems (GIS), by linking the linking the statistical concepts with applications of RS and GIS applications; i.e. linking the nature of the terrorist crimes with their geographical locations of occurrences

II. The Study Area

Iraq lies between latitudes 37.38° and 28.5° N, and longitudes 38.70° and 48.75° E. Baghdad is the Iraq capital city, lies between latitudes 33.452° and 33.184° N, and longitudes 44.189° and 44.576° E. The administrative areas of Baghdad are consisting of ten districts and thirty two sub-districts. Population is concentrated in the center of the city and is estimated at 7.457772 millions. As illustrate in Fig-1, the study area Kadhimiya district is located near the center of Baghdad, lies between latitudes 33°39 and 33°33 N, and longitudes 44°29 and 44°37 E. It is an Islamic religious center (including the shrine of two Imams) and attracts a lot of visitors; its population is about 760,065 peoples.

III. Remote Sensing Applications

Remote sensing can be broadly defined as the collection and interpretation of information about an object, area, or events without being in physical contact with the object. Aircraft and satellites are the common platforms for remote sensing of the earth and its natural resources. Aerial photography in the visible portion of the electromagnetic wavelength was the original form of remote sensing but technological developments has enabled the acquisition of information at other
wavelengths including near infrared, thermal infrared and microwave. Collection of information over a large numbers of wavelength bands is referred to as multispectral or hyperspectral data. Remote Sensing data is processed and analyzed with computer software, known as a remote sensing application. A large number of proprietary and open source applications exist to process remote sensing data. In general, these applications can be defined as image processing software packages designed for use with satellite imagery have built-in capabilities that allow it to make use of geocoding information. With these software packages, the visual image is less important than the underlying data values that make up the image. For example, automated land cover classification is one type of processing that requires specialized software [2]. The software uses algorithms to partition the image into different land cover classes based on the pixel values of the individual image bands. The most common used remote sensing software packages include [3-4]:

- **IDRISI**: is a GIS and image processing software lends itself to a large number of wide-scale applications, includes a set of rich and powerful tools to deal with the satellite images.
- **ENVI**: (Environment for Visualizing Images) is ideal software for the visualization, analysis, and presentation of all types of digital imagery.
- **Global Mapper**: is a GIS software package developed to run on Microsoft Windows. It handles vector, raster, and elevation data, and provides viewing, conversion, and other general GIS features.
- **ERDAS IMAGINE**: is a geospatial data authoring system, incorporates geospatial image processing and analysis, remote sensing and GIS capabilities into a powerful, convenient package. It enables to easily create value-added products such as 2D images, orthophoto mosaics, landcover classification, 3D flythrough movies, vectors derived from imagery, and cartographic-quality map compositions from geospatial data.

In this research the Global Mapper and ENVI packages have been utilized to rectify and extract the required images and maps, illustrate in Fig.-2.

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Fig-1: (a) The Iraqi’s administration map showing the locations and the territories of their provinces, (b) Baghdad map showing the district areas, (c) The boundary of the study area (Kadhimiyah)
IV. GIS Applications

Geographic information systems (GIS) (also known as Geospatial information systems) are computer software and hardware systems that enable users to capture, store, analyze and manage spatially referenced data. Nowadays, GIS technologies have been applied to diverse fields to assist experts and professionals in analyzing various types of geospatial data and dealing with complex situations. GIS plays an essential role to help people collect, analyze the related spatial data and display data in different formats. Too many successful cases that benefit from applying GIS as solutions in various fields can be found by browsing the internet websites; for examples; GIS provides a complete solution and modern technologies for raising the value of water and wastewater resources [5]. It represents solutions for agriculture industry use, by applying GIS technology to their operations, agricultural operations are able to manage resources and responsibilities more efficiently, devise data portals that disseminate vast amounts of agricultural data and interactive maps, and support farming communities [6], GIS enables users to select a suitable site to open a chain store. If a chain store is run at a wrong site where there are only a few target customers or there are too many stores providing similar services [7]. It can be used for Education Foundation Property, not only for improving the efficiency of the land management but knowing the usage, location and other relevant information of every property [8]. In relation to our research, the GIS play an important role in mapping and analysis of crime components; e.g. police departments employ GIS and RS technologies in various applications, including criminal intelligence and crime analysis, crime prevention, public information, and community policing, for instance see [9]. In this paper, the term maps of crime analysis will be used to describe the process of using GIS in the analysis of terrorist crimes, not just putting the accidents on a map but also for analysis them, by combining the use of GIS components with crime analysis techniques to focus on the spatial context of the crime activities.

GIS Components

The major components of a GIS that are used to describe the data features, visualization, scale, and querying are; point, line, polygon, and image features [10].

a) Point feature: is a discrete location that is usually depicted by a symbol or label. In GIS point feature is analogous to a pin placed on a paper wall map. Different symbols are used to depict the location of crimes, motor vehicle accidents, traffic signs, buildings, beat stations, and cell phone towers. For example, Fig.-3 shows different types of terrorism events.

![Fig.-3: Example of used point feature representing three types of terrorism events (Explosive devices, suicide operations, and bomb cars)](image-url)
b) **Line feature**: is a geographic feature that can be represented by a line or set of lines. Fig.-4 shows how different types of geographic features such as highways and streets can be represented by a line in a GIS. Additional examples are streams, streets, power lines, bus routes, student pathways, and lines depicting the distance from a stolen to a recovered vehicle.

![Image of study area with delineated main and branch roads](image)

**Fig.-4** shows the study area with delineated main and branch roads.

c) **Polygon feature**: is a multisided figure represented by a closed set of lines. Fig.-5 shows different types of lines; the largest blue polygon represents the city boundary, the green are census tracks, and the black are census block groups.

![Image showing study area partitioned by polygons](image)

**Fig.-5**: The study area partitioned by polygons painted by different colors to represent different classes of population (i.e. hybrid, poor, target, and terrorist)

d) **Image feature**: a satellite or a photomap that is digitized and placed within the GIS coordinate system associated with its x and y coordinates. Fig.-6 represents a high resolution satellite image for the study area. There is a distinction between image shown in Fig.-6(a) and the same image shown in fig.-6(b) which combined with map geometric attributes.

![Examples of high-resolution satellite images](image)

**Fig.-6**: Examples of high-resolution satellite images differs by combines (b) with map geometric attributes.
V. Creating Crime Events by Poisson distribution

Because (as mentioned in the abstract) the difficulty of obtaining correct and accurate data representing the date and locations of the terrorist crime events, we have turn our attention to simulate them statistically, using Poisson distribution. The Poisson distribution is found appropriate for applications that involve counting and predicting the number of times a random event occurs in a given amount of time, distance, area, etc. [10]. Equation (1) represents the probability of the observed events ($y_i$) follows the Poisson distribution for the mean count given in Eq. (1), $\lambda_i$. Thus, the expected distribution of crime counts, and corresponding distribution of regression residuals, depends on the fitted mean count, $\lambda_i$, as illustrated in Fig.-7.

$$
\rho(y_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!} \quad (1)
$$

$$
\ln(\lambda_i) = \sum_{k=0}^{K} \beta_k x_{ik} \quad (2)
$$

Equation (2) represents the regression equation relating the natural logarithm of the mean or expected number of events for case $i$, $\ln(\lambda_i)$, to the sum of the products of each explanatory variable, $x_{ik}$, multiplied by a regression coefficient, $\beta_k$.

Fig.-7 The plot shows the probability of Poisson distribution for different means values $\lambda$.

In fact, the Poisson distribution is a one-parameter discrete distribution that takes nonnegative integer values ($\lambda$) which is both the mean and the variance of the distribution. As illustrated in Fig-5, as $\lambda$ values become large, the Poisson distribution increasingly approximates the normal.

Given space-time crime observations $(x_k; y_k; t_k)$, crime locations maps can be generated for a time interval $[t_{\text{start}}; t]$ by overlaying crime event points onto a city map, [11-12]; i.e.

$$
\lambda(x, y, t) = \sum_{t-T<t_k<t} g(x-x_k, y-y_k, t-t_k) \quad (3)
$$

Where: $g(x; y; t)$ is a space-time kernel reflecting the diffusion of risk following each event.

In this research, the Poisson distribution is used to generate random points (i.e. crime events) distributed over the map of the study area. The generated point coordinates (Y & X in pixels) were transformed into geographic coordinates [i.e. Lat. ($\phi$) phi] & Long. ($\lambda$ Lambda)], using:

$$
\phi = \text{Upper Lat. of study area} - Y \times \text{Nor}_{\text{incr}} \quad \text{and} \quad \lambda = X \times \text{Eas}_{\text{incr}} + \text{Left Long. of the study area} \quad (4)
$$

Where:

$$
\text{Nor}_{\text{incr}} = \frac{\text{Upper Lat. - Lower Lat.}}{\text{Number of Rows}}
$$

and:

$$
\text{Eas}_{\text{incr}} = \frac{\text{Left Long. - Right Long.}}{\text{Number of Columns}}
$$
Number of events distributed over the region of the study area can be changed by using different values of Poisson distribution mean ($\lambda$). As an example, Fig-8 shows different number of events distributed of the map of the study area (Baghdad city), using $\lambda = 53$ and $84$.

![Figure 8](image)

It remains to mention that the number of martyrs and wounded persons per incident is also guessed similarly, using random number generator. Example of simulated events is listed in Table-I, and illustrated in Fig-9.

![Figure 9](image)

**TABEL-I**: show example of simulated x-y and Long.-Lat coordinates and the number of martyrs and wounded persons per each event, simulated by utilizing Poisson random distribution.

<table>
<thead>
<tr>
<th>Event index Number</th>
<th>x-axis (pixels)</th>
<th>y-axis (pixels)</th>
<th>Long. ($\lambda$) Degree</th>
<th>Lat. ($\varphi$) Degree</th>
<th>Martyrs</th>
<th>Wounded</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56</td>
<td>2047</td>
<td>44.54021</td>
<td>33.22218</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>2</td>
<td>78</td>
<td>2112</td>
<td>44.53833</td>
<td>33.21546</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>79</td>
<td>844</td>
<td>44.53824</td>
<td>33.34667</td>
<td>12</td>
<td>18</td>
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<td>……</td>
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<tr>
<td>27</td>
<td>2965</td>
<td>380</td>
<td>44.2914</td>
<td>33.39468</td>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>28</td>
<td>3147</td>
<td>2095</td>
<td>44.27583</td>
<td>33.21722</td>
<td>7</td>
<td>29</td>
</tr>
</tbody>
</table>
VI. Crime Analysis

And, like crime mapping, associating non-emergency service calls and non-criminal incidents on a map, assists managers and supervisors in placing manpower in areas where they are most needed and at the ideal time. GIS enables agencies to carry out predictive modeling of forecasting to manage field assignments and investigative efforts.

a) Methodology and Results

Geography plays an important role in policing and crime analysis. Response capabilities often rely on a variety of data from multiple agencies and multiple sources. The ability to access and process information quickly while displaying it in a spatial and visual medium allows authorities to allocate resources quickly and more effectively. In the “mission-critical” nature of policing, information about the location of a crime, incident, suspect, or victim is often crucial to determine the manner and size of the response. GIS takes the traditional statistical information used in crime analysis and places it on a map, showing specific crime pattern and relationships. GIS analysis of traffic data assists in the identification of selective enforcement locations.

The main goal of this research is to evaluate the terrorist crimes in a selected part of Baghdad province by suggesting two deduction hypotheses: The first is by assuming that the terrorist activities was originated from within the study area, while the second hypothesis assumes that the terrorist operations were exported into the study area from surrounding regions. In both hypotheses, the closest distance to reach the targets and the availability of the highways will be taken into consideration to guess the place of origination of the crime.

The center of figure of the terrorism operations has been calculated by averaging the x-y coordinate values, and then transformed into the corresponding geographic coordinates (using the Eq.-4), illustrated in Fig.-10.

![Fig.-10](image)

**Fig.-10**: The study area (Kadhimiya), the yellow star symbols represent the crime events and their center of figure point presented by red dotted circle.

![Fig.-11](image)

**Fig.-11**: represents the same feature points (as in Fig.-10) projected on the road map of the study area.

In an attempt to deduce the location of the launch terrorist operations from inside the study area, the coordinates of the location that has shortest distance with the residual operational sites is calculated and illustrated in Fig.-12.
The same features (as in Fig. 12) projected on the road map of the study area is shown in Fig. 13.

From the point of shortest distance we can deduce the location from which the terrorists moved. The point should be located somewhere in the neighborhood of a road junction point, as illustrated in Figs. 14 & 15.
The second hypothesis proposed in this research suggested the terrorism operation as to be originated from exterior region. To satisfy this suggestion we will follow the same procedures performed for the interior hypothesis; i.e. firstly looking for a point (on a suggested border from the center of operation events) has minimum distance from the crime events locations. Secondly, looking in the neighborhood of this point for a point or place that is suitable linked with the crime positions (i.e. junction point) through available sub or high ways. The procedures are illustrated well in figures (16 to 19).

Fig. 16: Map of study area shows the location of crime events (green asterisks), central point (red dotted circle), and the searching boarder (red circle).

Fig. 17: Same as fig. 16 with boarder point (black star) representing the shortest distance to the crimes locations.
Fig.-18: Same as in fig.-17 with a hazardous-materials symbol (red) representing the most likely terrorism emerging position.

Fig.-19: The feature points of fig.-18 embedded on the image of the study area.

VII. Conclusion

Terrorism is undeniably horrific and harmful to the mankind. It kills maims and destroys political purposes. Terrorism, in some way or other, is more horrifying than other awful forms of violence, including war, criminal brutality, and psychopathic mayhem. Seldom expect the events, cannot easily understand why violence strikes when and where it does. Although different tools of technical devices are in operation in collecting information, there are several measures that we believe will contribute to prevention and deterrence of catastrophic terrorism. We suggest some measures like certain criteria, determining the event clusters and tracking the main road Entry, therefore, finding prediction areas by apply interpolation tool. This study exhibits that these methods and tools can be useful for users. It demonstrates that using existing dataset of poison randomly distribution, that is assumption the event accident, and spatial analysis and GIS can provide an opportunity to specify the solution to understanding and limitation terrorism risk, and also lay a security foundation to pursue terrorist gangs, further investigation in correlated factors responsible for increased organized crimes risk. The use of such spatial analysis and tools should become an integral component in the Crimelogy and criminal activity risk assessment.

References

