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Analyzing the Terrorist Operations in Baghdad Using the RS and GIS Techniques

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Abstract: ***The city of Baghdad (capital of Iraq) has witnessed at the last nine years a lot of the terrorist criminal operations because of fatwa's of some religious extremist. As a result of these criminal operations too many innocent citizens killed without any sin. In our current research we will try to analyze these crimes depending on their occurrence locations, using the Remote Sensing (RS) and Geographic Information System (GIS) techniques. Because the difficulty of obtaining accurate data for the locations of these criminal operations and the number of victims in each of them, the research adopted Poisson distribution to simulate the locations of these operations and the number of casualties resulting from them. The simulated data has been simulated to match and compare with available data (for Year 2010). Because of the large study area, it has been divided into 16 blocks of equal areas and then focusing our investigation on the hotspot blocks which includes a large number of operations. Identification the sites from which the terrorist operations were launched then made by adoption the proximity between the lunched points and locations of occurring operations.***

Keywords: Terrorist operation, hotspot analysis, Poisson distribution, crime detection, GIS techniques

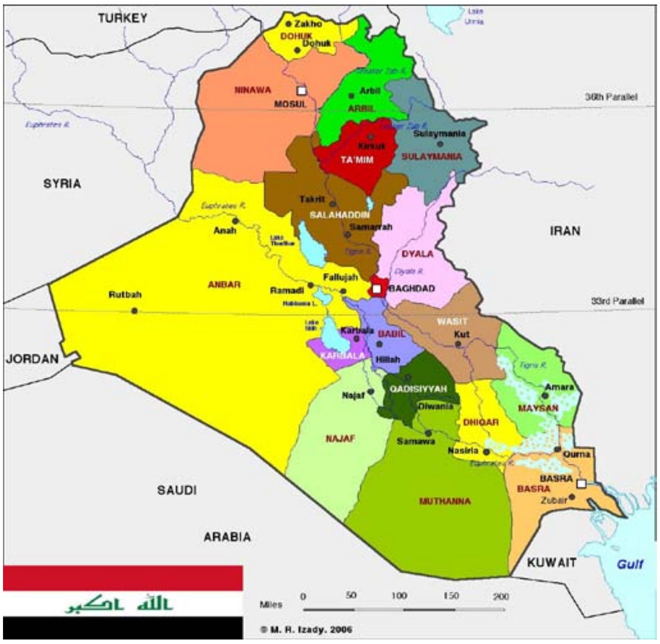
1. Introduction

Referring to our previous study [1] which concerned the analysis of part of the current study area and tried to identify the locations of the launch terrorist operations, assuming firstly; it was launched from within the study area, and secondly from outside the study area. In our current research, we will attempt to expand the previous research to include the whole province of Baghdad, which had been exposed in previous years (2004-2014) to a large number of terrorist crimes of that included car bombings and suicide bombings by explosive belts. As is the case in the previous research, and due to the lack of real data, we have used the random Poisson distribution instead of the real events of the terrorist crimes to create the crimes geographic locations, and number of martyrs and casualties. Number of the adopted crimes was 75 to be quite close to those events of the year 2010. The widespread commercial availability of geographic information systems (GIS) and the available data from the remote sensing (RS) imaging systems which have subsequent embraced by official authorities as an important tool for crime analysis have presented the crucial in laying the groundwork of our present research. In certain similarity between the terrorist phenomena and the disease events, we can guess if the geographical incidence of terrorist and disease events shows any tendency towards clustering in geographical space, and if cases of disease and terrorist tend to occur in proximity to other cases [2]. The problem has become more urgent in recent years in light of the concerns that have been raised about possible links between terrorist incidents and overlaps regional policies, and religious sectarianism, such as, for example sectarian extremism among segments of Iraqi society.

Administrative map of Iraq shows the names and locations of the provinces. The country is sandwiched, respectively, between the following latitude and longitude geographical lines: 37.38°N→ 28.5°N, 38.70°E →48.75°E. The country includes 1,648,000 km^2 of area, and total population of 35,024,191.

2. The Study Area

Figure 1 illustrates the study area beside the Iraqi administrative map, both showing the bounded geographic lines, regional areas, and total population count. Utilizing the ArcMap editor tools, the most significant districts of the study area (i.e. 22 layers) have been delineated and presented as layers, illustrated in fig.2.



Baghdad zonal map shows the major districts of the city, the city lies between the following latitude and longitude lines 33.452°N → 33.184°N and 44.189°E → 44.576°E. The population of Baghdad is approximately 7,216,040, extended over an area of approximately 204.2 km^2

Figure 1: The Iraqi's adminstrative map and the study districs map of Baghdad city

ID	*District Name*	*Area km^2*
1	Al-Taji	271.121
2	That Al-Salasil	178.738
3	Al-Fahama	93.813
4	Al-Monawra	0.138
5	Adhimyia	2.720
6	Al-Kadhimiya	28.922
7	Abna Al-Rafedein	0.365
8	Al-Sader	4.482
9	Al-Furat	0.189
10	Sadeeq-Akbar	0.446
11	Palestine	9.807
12	Al-Risafa	1.406
13	Al-Karkh	2.369
14	Al-Mansour	6.571
15	Abu-Ghraib	241.949
16	Baghdad-Jedeeda	142.348
17	Karrada-Sharqia	72.471
18	Al-Jisr	169.868
19	Al-Mamoon	230.753
20	Al-Yousifya	428.785
21	Al-Mahmudiya	215.602
22	Al-Rasheed	243.677
Total Area		2346.54

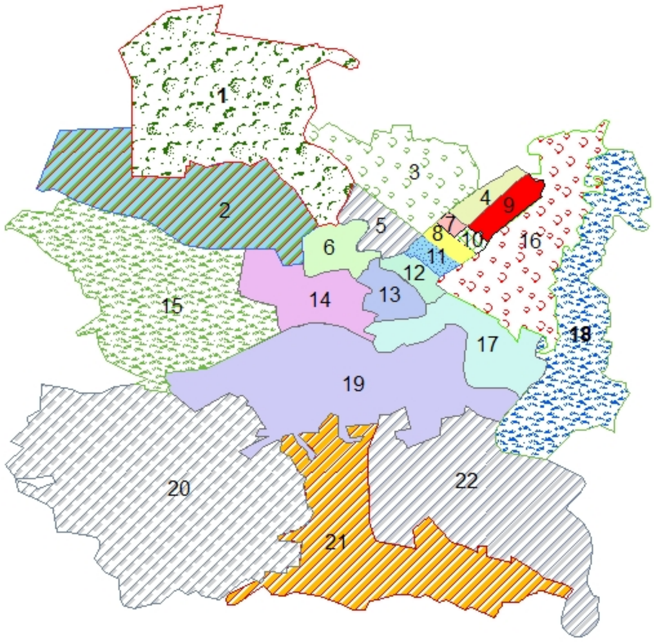


Figure 2: The most significant districts of the study area

3. Point Pattern Analysis (PPA)

It is the study of the spatial arrangements of points in (usually 2-dimensional) space. The simplest formulation is a set X = {x ∈ D} where D is called the 'study region,' is a subset of $\mathbf{R}^n$, an n-dimensional Euclidean space. The easiest way to visualize a 2-D point pattern is a map of the locations, which is simply a scatterplot but with the condition that the axes are equally scaled. If D is not the boundary of the map then it should also be indicated. An empirical definition of D would be the convex region of the points, or at least their bounding box, a matrix of the ranges of the coordinates. Another straightforward way to visualize the points is a 2D-histogram (sometimes called a quadrats) that bins the points into sub-regions of equal size (often squares) regions. A benefit of quadrat analysis is that it forces the analysis to take into account possible scales within which statistically significant inhomogeneity may be occurring [3]. Within each sub-region, as shown in fig.3, the pattern distribution of points may takes one of the three point processes; Random distribution in which any point is equally likely to occur at any location and the position of any point is not affected by the position of any other point, Uniform distribution in which every point is as far from all of its neighbors as possible, and Clustered distribution in which many points are concentrated close together, and large areas that contain very few points [4].

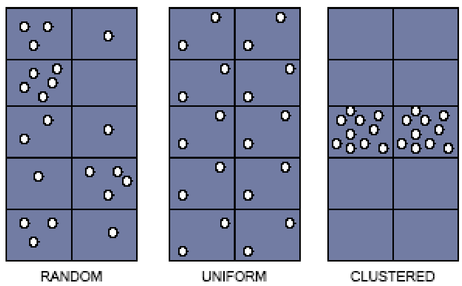


Figure 3: Three types of different pattern point's distributions [4]

4. Poisson Distribution

In probability and statistics theory, the Poisson distribution is a discrete probability distribution that expresses the probability of a given number of events occurring in a fixed interval of time and/or space if these events occur with a known average rate and independently of the time since the last event. This 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, [5]. The probability of Poisson distribution for observed events (y_i) of given means (λ_i.), as given in eq.(1), is illustrated in Fig.-4.

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

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

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

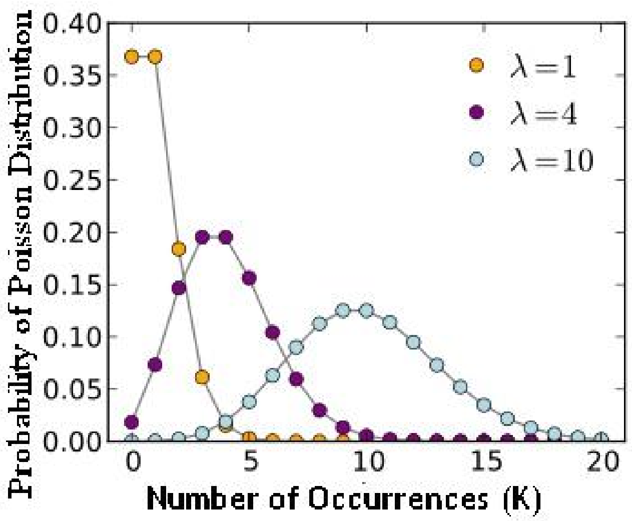


Figure 4: The probability of Poisson distribution for different means values λ.

Given space-time crime observations (x_k; y_k; t_k), crime locations maps can be generated for a time interval [t _ T; t] by overlaying crime event points onto a city map, [6]; i.e.

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

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

As it was done in our previous paper [1], the generated point coordinates (Y & X in pixels) have been transformed into geographic coordinates [i.e. Lat. (φ phi) & Long. (λ Lambda)], using:

$$\varphi = Upper\ Lat.of\ study\ area - Y \times Nor_{incre} \ ; \text{ and}$$
$$\lambda = X \times Eas_{incre} + Left\ Long.\ of\ the\ study\ area \qquad (4)$$

$$Where:\ Nor_{inre} = \frac{Upper\ Lat. - Lower\ Lat.}{Number\ of\ Rows};$$

$$and:\ Eas_{incre} = \frac{Left\ Long. - Right\ Long.}{Number\ of\ Columns}$$

Number of events distributed over the study area can be changed by using different mean values of Poisson distribution (λ). As an example, Fig.5 show random number of 75 events created by Poisson distribution thrown randomly over a high resolution image (QuickBird 0.6m) of Baghdad city.

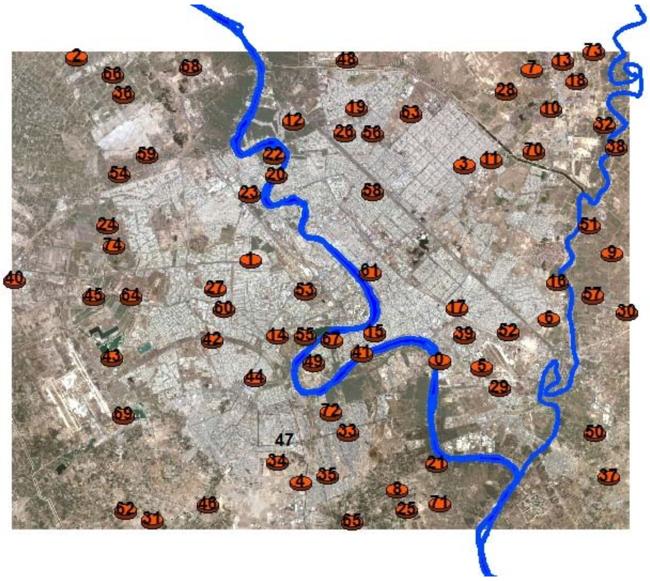


Figure 5: The Poisson distribution with 75 events furnished over high resolution image of Baghdad city (The symbols are labeled by their sequence of occurrence)

5. Hotspot Analysis

Hotspot analysis uses vectors (not raster) to identify the locations of statistically significant trouble points. The Hotspot Analysis tool calculates the Getis-Ord Gi* statistic (pronounced G-i-star) for each feature in a weighted set of features. The G-statistic tells us whether features with high values or features with low values tend to cluster in a study area. This tool works by looking at each feature within the context of neighboring features. If a feature's value is high, and the values for all of its neighboring features are also high, it is a part of a hot spot. The local sum for a feature and its neighbors is compared proportionally to the sum of all features; when the local sum is much different than the expected local sum, and that difference is too large to be the result of random chance, a statistically significant Z score is the results. The Getis-Ord local statistic is given as [7]:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{S \sqrt{\frac{n \sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2}{n-1}}} \quad (5)$$

Where x_j is the attribute value for feature j, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features, and

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2}$$

When G_i^* statistic is a z-score so no further calculations are required (the Z-score is simply standard deviation).

Fig.6 shows the event's locations furnished over the image of Baghdad city, each labeled with G_i^* score value, computed with **fixed distance band** equal to 3500m. In fact the fixed distance band reflects maximum spatial autocorrelation which exhibits maximum clustering, as can be measured by the **Spatial Autocorrelation Tool**.

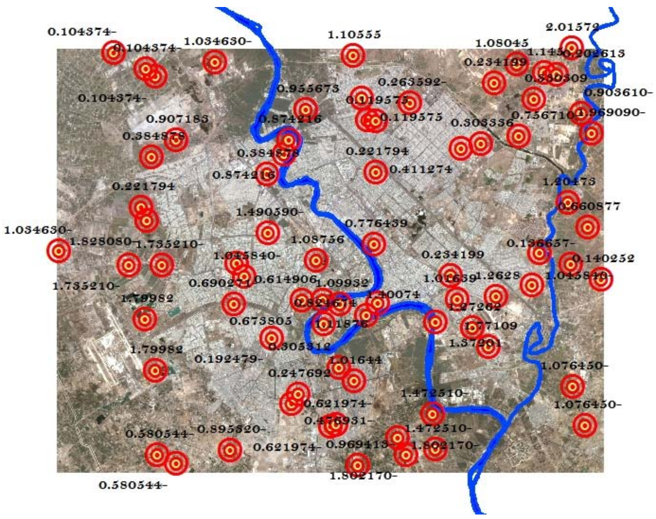


Figure 6: Shows the event's locations furnished over image of Baghdad city image, each location symbol labeled by its G_i^* score value

The standard distance is a useful statistical tool which provides a single summary measure of feature distribution around their center; it measures the dispersal among events around the center [8]. It creates a new feature class containing a circle polygon centered on the mean for each case. The circle polygon is drawn with a radius equal to the standard distance. Those events that occur within the circle vary less among themselves with respect to the standard distance from the mean and those events outside of the circle vary more in their spatial relationships [9]. Fig.7 shows a total of 41 points out of 75 were detected within the standard distance circle area. The geographic coordinates of the mean center of this data set were (Lat/ 444985, Long/ 3687690) meters. The standard distance circle had a radius of 11970 meters. The symbol's labels refer to the number of martyrs in that event.

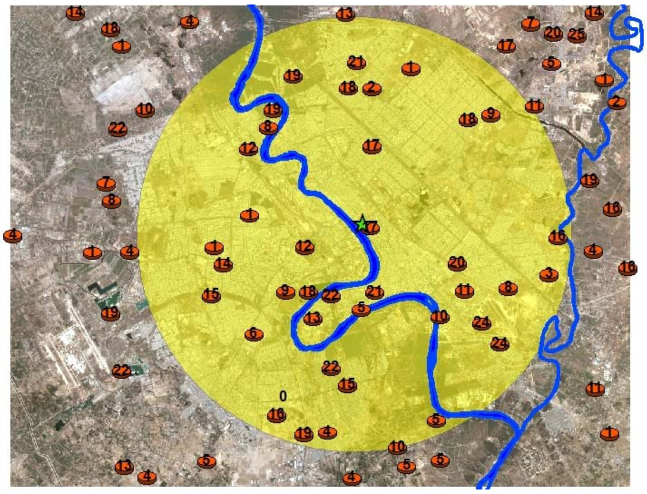


Figure 7: Summary circle for standard distance (enclosed 41 out of 75 points) with one standard deviation and a radius of 11970 meters

The Crime hot spots, in facts, are areas of high crime intensity; they help law enforcement agencies to make better decisions about allocating police resources, they can effectively communicate crime patterns and crime prevention strategies to decision makers and the public. Given a set of weighted data points (e.g. number of crimes per block), and operating under the expectation that data values are randomly distributed across the study area, this tool delineates clusters of blocks with higher than expected crime incidents. The Hot Spot Analysis tool also delineates spatial clusters of lower than expected crime incidents. These clusters reflect crime cold spots and may provide clues about policy or environmental factors that discourage crime [7]. One of the simplest approaches to better understand some factors that support terrorist activities is examining the distribution of terrorist crimes in different quadrats. For example, fig.8 represents quadrats involve hotspots of certain decided number of terrorist events (i.e. at least two points), each quadrat block of area 50547220 m^2.

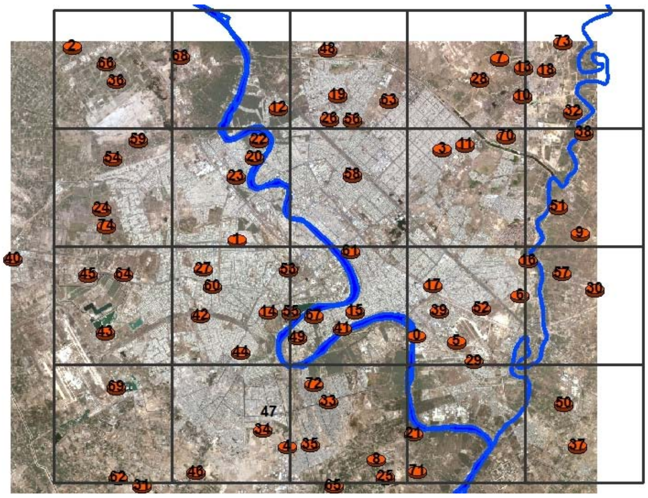


Figure 8: Illustration of hotspot utilization method, the highlighted circle representing more concentrated terrorist events

The quadrat blocks have been classified according to the number of terrorist events involved in each of them (i.e. 2-Yellow, 3-Green, 4-Blue, and 5 or more-Red), as shown in Fig.9. The circle radii were chosen as the twice the standard deviation of the distribution of events within the block. The block with largest number of events has been shaded to recognize it from others.

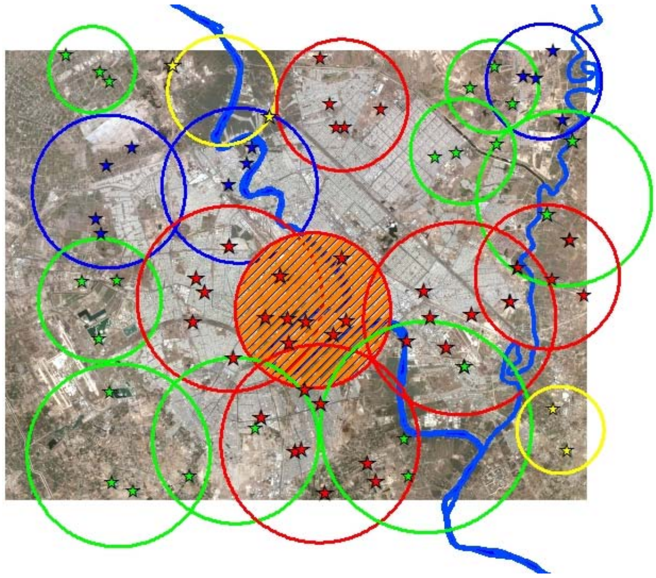


Figure 9: Chromatic classification of the quadrat blocks based on the number of events within each

6. Analysis Methodology and Results

Similarly to what has been done in our previous research [1], we will try to predict the location of access point to the area of criminal operations. The criterion of the shortest distance between the starting point and the operational sites is adopted first to define the location of this point to the hottest quadrat block, shown in Fig. 10.

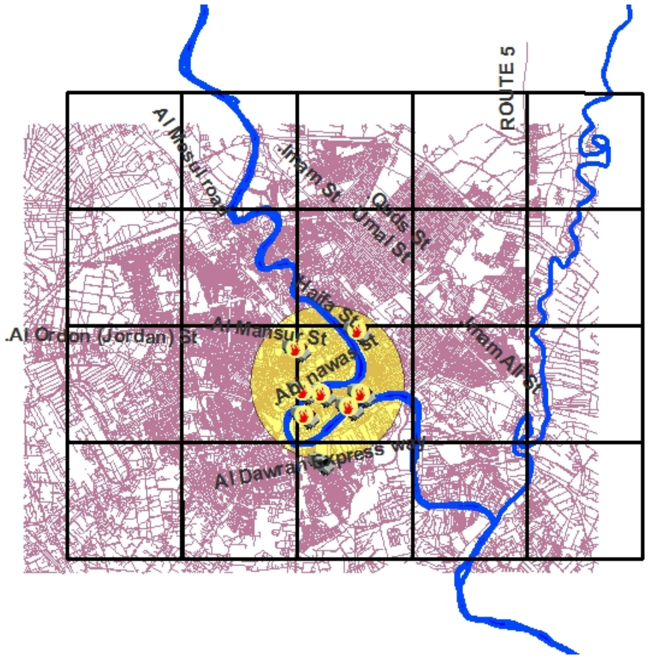


Figure 10: Illustrates the location of the access point (Van car symbol) and the locations of the explosion events (i.e. burned Van car symbol)

To identify the location of the access point to the study area (Baghdad city), we have adopted the locations of the border points (i.e. farthest from the regional center), shown in fig. 11.

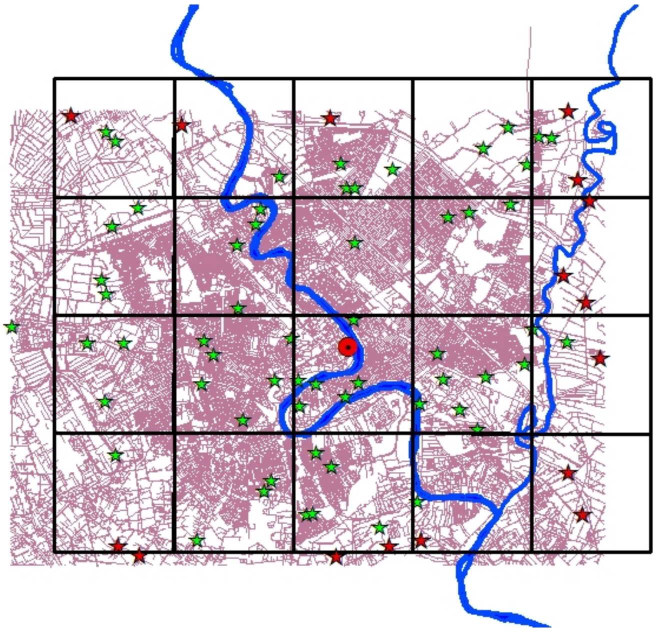


Figure 11: Shows the adopted 16 boarder points (red stars) of the 75 criminal events points (green stars) furnished on the road map of the study area (Baghdad city). The location of the mean distribution is presented by the red dotted circle

In similar way to the identification of the access point to the hottest region (fig 10), the shortest distance between the adopted boarder location points and the rest of the cars explosion events. Figure 12 shows the position of entrance bombing car and the locations of the exploded cars.

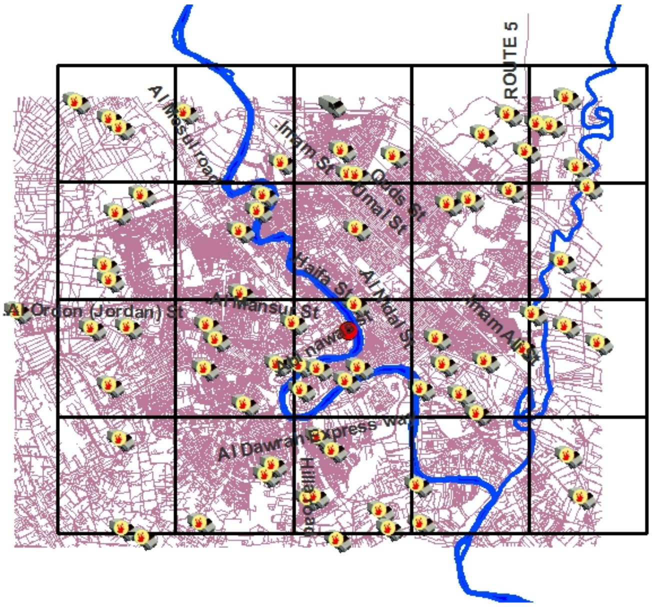


Figure 12: Shows the location of the access point (unexploded Van car symbol) and the rest of the exploded Van positions

7. Conclusions

The large number of terrorist operations in the last ten years in Baghdad has heading us to adopt this type of study and proposed it to our graduate students, with the hope of preventing or minimizing their effects as much as possible. The availability of the efficient computer hardware and software (e.g. ArcGIS and ArcMap tools) beside the remote sensing data (e.g. Maps, and different resolution satellite images), and the efficient expertise necessary to deal with these topics has encouraged us to enter in these subjects in the hope of helping the security forces to deal with these cases optimally. The division of the study area (i.e. equal block's size quadrats), for example, helps to choose the correct patrols and inspection locations between the parts of the study area (i.e. installing barriers to control the movement of terrorists between those areas). Also, identifying the locations of access points from outside into inside the study area help mainly to prevent and reduce the occurrence of those operations and guessing their inception and launching position. However, due to the lack of accurate data about the locations of these crimes and their time of occurrence, we cannot rely on research results, but we hope to support the security officers in their investigation to recognize these terrorist operations by following the modern methods that deal with such cases.

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