The GIS based Criminal Hotspot Analysis using DBSCAN Technique

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Abstract—Spatially Data mining used efficiently to extract any potential patterns and associations to detect hidden information from multiple sources data. In this paper, data mining Density-based spatial clustering of applications with noise DBSCAN algorithm is emphasised. The importance in this work was using a prototype software to process the giving data into an understandable outcome throw clustering technique, it is a powerful method for criminal activities detection and pattern recognition to get useful information that can help police to reduce crimes. Spatial data mining is practical with geographical crimes data set and processing a large amount of crimes data. Police conventional way was manual and time-consuming using a pin on the wall. Therefore, it has to be developed and merged with advanced techniques. In this study, data mining clustering method was used to examine Baltimore, Maryland's crimes information. The processed criminal data from the state of Maryland, Baltimore City was 340,924 cases and 16 attributes to reflect the cases between 2012-2018. DBSCAN algorithm is utilized to cluster crimes incidents focused on certain predefined events and the outcome of these clusters employed to find hotspots. The clustering findings are visualized by the GIS to make crimes distribution on the map at real-time for the law enforcement to understand and interact

Keywords—component; Crime clustering; GIS; Pattern recognition; DBSCAN algorithm; spatial; temporal; Geospatial; Hotspot

I. INTRODUCTION

Crime is a social disorder behaviour. Criminology is a crime research that collects and examines crimes data. Recently, criminal activity has grown and it is the police department's responsibility to manage and reduce illegal activity. Police needed advanced methods to help reduce crime. Clustering technique was applied with criminal activities and pattern recognition to detect useful information on crimes. This paper focuses primarily on using mapping hotspot predicting methods to detect and forecast where crime is quite likely to occur. This way, the police will concentrate their efforts on expected crime hotspots. Crime research is critical to give law enforcement patterns on the probability of crime in the future and related data such as crime area and possible tactics, crime category, etc... pattern recognition could be applied of different types of crime shooting between 2012–2018 is mainly considered in this study. It, therefore, requires methodologies and improvements of certain techniques to help authorities identify crime trends and avoid crime in the future by supporting the relocation of security forces in certain areas that are somewhat dense and reliant on data mining. For this purpose, data mining offers clustering technique while (GIS) can visualise and locate risk district. the crime clustering is used primarily to classify criminal trends and anticipate crime.

clustering is a data processing methodology used to identify and predict future patterns dependent on similarity measures. DBSCAN Clustering has been used to analyses the crimes attribute. Cluster points of a local crime set could be viewed by the map's geospatial plot while using (GIS) gives the crime pattern recognition. It is a set of clusters which determines the cluster relation. This study aims to examine crime in Baltimore county using DBSCAN...
clustering to identify crime trends and to classify criminals behaviour. Over the past ten years, the advent of remote
sensing and survey technologies has dramatically increased the ability to gather millions of bytes of geographic data
regularly bases. Nevertheless, while information becomes difficult to discern, the abundance of spatial data cannot be
fully realised. This addresses GIS to convert geographic data “intelligently and automatically” into information and
synthesize geographic knowledge [5, 6]. The intervals between the sites of the crime are usually not difficult to access
by the police in the unplanned areas, the badly planned areas are better represented by separating them into areas of
clusters then the cluster-based analysis is performed. Therefore, the approaches that promote clustering are ideal for the
badly planned configurations of crime investigation. Spatial crime point patterns are focused on event coordinates such
as incidence locations and may also include the occurrence time. It is possible to chart all or a sample of point pattern
on the map. The purpose of the study of Spatial Crime Points trends is to determine whether the point pattern is
randomly distributed, clustered or frequent. Patterns of spatial crime points are typically interpreted as clustering
analysis. Usually, a dot map is used to represent patterns of spatial crime points. This method efficiently used to
analysis clustering by evaluating crime incidences clustering in the detected hotspots where time and space relation
analysis is required. The methods need the creation of distance matrices regarding the spatial attribute’s relation
between crimes. Crime hotspots are high-intensity regions on a map, they are designed to examine geographic areas in
relation to the crime for researchers and analysts [1]. Developing maps containing hotspots is now a vital and powerful
technique of policing; it helps to build knowledge and awareness of different areas of the city and possibly why crime
occurs there. It is necessary to study crime in both space and time in order to understand it. Nevertheless, the majority
of crime trend analysis and related activities have been studying the spatial nature of crime ignoring the temporal
aspect. Crime pattern analyses in this paper, focus on the predict crime trends and proposes clustering the data of
criminal activity recorded by the police department of Baltimore city.

II. RELATED WORKS

It will be more easily and less costly to reduce crime using machine learning and quantitative analysis. It tests the
assumption of spatial-temporal dissimilarity locations and low crime concentration. Where committed crimes (whether
its time changing due to temporal dimensions, or spatial dimensions) supply a significant explication of the present
direction of violent crimes [2, 3]. Mining information from vast amounts of spatial data is known as “spatial data
mining”. Processing vast amounts of temporal-spatial data become a very pressing field in many applications ranging
from geospatial data to law enforcement information [4, 5]. The amount of spatial data collected increased
exponentially and rapidly, therefore, the human ability to analyse has exceeded its capacity [6]. Aggregation techniques
have been identified as a primary means of extracting data to temporarily discover knowledge in spatial crime datasets.
The development of aggregation algorithms got so much attention in the past ten years and proposed the development
of a new aggregation technique of [7, 8]. DBSCAN is a leading method in density-based spatial clustering with noise
algorithm, in particular, it was noted that the number of crimes in one specific location is not limited only to its
historical records [9]). Thus, two factors were suggested: temporal correlation and area-based spatial correlation, to
measure and predict patterns of the crime dataset [11, 12]. However, it is quite difficult to achieve a large dataset
because the information on the crime is classified [13]. Crime analysis typically addresses information at a macro-level,
like the regularity of crimes occurrence on specific geography, rather than processing data at the incident level. It is
suggested to deduce similar incidents using the aggregation (clustering) technique with mixed equivalent measures
[14]. Crime data is generated at the incident level using many applications. A popular application is a geographic
information system (GIS). Aggregation is a way to cluster data in which each set of properties is identical without
utilizing a recognized structure in identical data [15, 16]. An aggregation is a simple data extraction method which
blends a set of items and topics in an entity manner in the same category than in other classes. Recently, GIS has
become effective and useful in dealing and displaying geographic information and its characteristics to assess patterns
of spatial crime [14]. To determine the activity of criminals and crime hotspots, GIS and data mining techniques have
been employed as a tool for spatial and temporal detection [17]. Investigated crime patterns and related activities took
place in spatial distribution, ignoring time dimension of [18]. Crimes, is classified by time and space [19]. Many
methods can be used to explore patterns by analysing crime patterns and regular activity queries [20]. Using data on
different crimes, it was found that crime hotspots quickly turn in response to the structure of life to understand spatial
and temporal crime patterns [20]. To create effective police strategies and input, both spatial and temporal aspects of
crime incidents are required [21]. This paper investigates a small point in time using pattern-based techniques to help
police and researchers discover new patterns of criminal activity. Thus, the investigation continues in this field. This paper also reviews the growth patterns of recurrent patterns of extraction [22]. Evaluation of spatial group is an essential way of extracting spatial data. It divides objects into groups as per commonalities in both aspects of the site and attributes. It plays a key role in determining density distribution and detecting hotspots. Spatial aggregation algorithms are found in spatial space, while algorithms in network space are less well researched [23]. Use patterns based on strategies has potentially helped crime investigators to find better patterns based on criminal activity.

Research in this area also continues. This paper considers the expansion of recurrent criminal pattern mining patterns. In general, many types of research that explored spatial patterns of crime described separate points for singular crime types. They also studied if hotspots intersect or if crime kinds relate to hotspot sites; provide conclusions from a range of available data (e.g. Hotspots only) [24]. In comparison, a multivariate method uses this information from all regions to model correlation frameworks between types of crime and enables the generation of small-scale threats for each sort of crime from several popular, general and unique variables of crime at the same time [25]. Aggregating facts and visibly displaying them into groups of facts, heterogeneous data, is divided into several homogeneous groups. Prediction discover patterns and information that may lead to sensible assumptions. The future value is estimated based on the record type. It complies with results of constant value. Visualizations-enables researchers to locate critical information quickly and efficiently. This also relates to the presentation of data in a manner that allows users to display complex data patterns. It is used to provide a clear understanding of the trends or interactions that are observed in accordance with other data mining methods. A crime hotspot is referred to as the focus areas of criminal activities that are usually verified by analysing crime data in geographical information system (GIS) [26]. As a result, crime hotspots map analysis assists law enforcement and police department to identify places with high crimes rates, the sorts of crimes undertaken and the best way to react to crime. Hotspot maps are an effective means of high-density visualisation of crime mapping areas. In addition, the use of GIS tools for spatial and temporal analysis has been shown to be successful in identifying the implied relation between events [27]. It provides an idea of how criminals are spatially distributed and can, therefore, help tackle them. GIS is an essential tool to deal with spatial and temporal analysis, display it on a map and fight crime [28]. A vast number of complaints and media about incidents, which are committed almost hourly, have made it harder, if not complicated, to identify these crimes. The need to track and report these crimes is, therefore, growing as a critical way to monitor and identify these signs of crime on the media. Recorded clustering has become progressively an important objective with unsupervised methods of learning to achieve good outcomes [29]. This seeks to use various types of extractions and cluster algorithms to dynamically combine related documentation in one cluster. Continuous work is being done to improve document clustering methods such as extraction and clustering strategies to resolve the complexity of designing a general-purpose document clustering for criminal investigation and the unplaced issue of extraction and clustering [30, 31].

I. METHODOLOGY AND RESULT

DBSCAN Clustering has been used to Analyze feature places of the crimes to reach the hotspots regions on Baltimore city. The crime dataset from Baltimore crime City Police Services, Maryland was collected using the website data.gov. Specifically, in the period between 2012-2018. The set of crime data consisted of 340,924 cases of crime and 16 attributes. Each attribute description consists of 15 distinct types of crime such as Shooting, Aggravated assault, Common assault, Larceny from car, theft from vehicle, auto theft, burglary, Larceny, homicide, assault by threat, Robbery – street, Robbery – residence, Robbery- carjacking, Robbery – commercial, Rape, Arson, see Table.1 for details. The shooting was mainly considered in this study as it was one of the categories. The offences were associated by particular longitude and latitude location. In order to produce average positions from 2012 to 2018, the offences are geo-coded into the map of Baltimore Maryland using GIS. Table.1 shows a section of crime dataset in raw spreadsheet form. The proposed method dissociates the attribute of the criminal's action and configures the mentalism of criminality action depending on the crime records distributed on the map and their analyzed features. Clustering is powerfully to find the relations between crimes components. It facilitates the crimes pattern recognition and potentially hazardous hotspots in the long term at the probable of occurrence time show a high increase in crime cases. Therefore, the method employed in this work focus on three key pieces of crime information, which are the description of the crime (it will divide the types into to categorise), the prevalence time and the location of the crime, (it will focus on the spatial analysis of the data). This method extracts all possible attention-grabbing frequent patterns supported by crime key features (the description of the
crime, the crime and the longitude and latitude location of the crime). Preprocessing the dataset and extracting the feature that does not have a null value so, it does not influence the clustering accuracy method.

Displaying the dataset on (GIS) will not be turned into useful information. Therefore, DBSCAN clustering technique used to detect the crime pattern depending on the attribute of the crime. This will help to extract the most criminal density from the dataset records using (GIS). The purpose of the clustering is to detect the potential crime pattern in a specific location within a particular time within the probability. The analysis aims to give the best precision in identification of crime trends. DBSCAN is capable of discovering clusters with arbitrary shapes using a machine learning algorithm that helps reduce time and effort. DBSCAN is favourable over k mean algorithm due to its characteristic that it does not need the number of clusters, the separated distance between the clusters or the centres of each cluster. This is what made it more dependable in dealing with such cases of data and spatial-temporal attribute to determine the most significant hotspots in crime mapping. DBSCAN resorts two parameters to characterize “density”, namely Eps (a positive real number) and MinPTS (a positive integer). Given a 2d-dimensional data object p, the ball centered at p with the radius of clusters is considered as dense if it covers at least MinPTS Objects. Then the clusters formed by considering all the objects in a dense cluster centered at p should be added to the same cluster as p. Furthermore, two clusters can be merged when the central object of a dense cluster is added to another cluster. The merging will be performed to the effect’s fullest extent until no more clusters can be merged. DBSCAN suffers from time-intensive computations since it needs to perform n “range queries and cluster labelling propagation for all the objects. This searches the datasets to retrieve all satisfactory element sets. The aim of using this method is to identify regular trends of all potential crime depending on the type of criminal activity and to collect the outer point spread over the field which underestimates the significance and risks of these points in the specific area. This method aims to establish a dataset of all crime hotspots along with their regular period correlated with it. Using the places and time attribute in DBSCAN algorithm and omitted the noise points in the result of DBSCAN crimes attribute form analysing the dataset to determine hot spot location. Public safety and crime prediction operations are among both residents and government's most essential worries. Such practices are dedicated to vast amounts of money, human resources, equipment and supplies. Besides, there is a massive concern to validate the allocation of police resources. If the police could anticipate, with an acceptable accuracy, when and where a specific type of criminal activity will take place, a double gain would be achieved. First, it would also be doable to focus the required logistical practises and assets to combat this specific type of criminal activity in the geographic area and the timeframe forecast, and the comparison between the number of resources allocated to police forces and the results they have achieved can lead towards a more sufficient basis for preparing and distributing public security. The result will be shown on the geographical information system every year cluster with a map of Baltimore Maryland showing in, at last, the pattern of all the years. The DBSCAN algorithm evolves regions with adequately high cluster density and sees arbitrary shape clusters with noise in spatial data sets. This identifies a cluster as a total series of points correlated with distance.

Table 1: Shows the section of crime dataset in raw spreadsheet form

| No | CrimeDate | Crime Time | Crime Code | Location | Post   | District          | Neighborhood | Longitude | Latitude | Premise          |
|----|-----------|------------|------------|----------|--------|-------------------|--------------|-----------|----------|------------------|
| 1  | 12/8/2018 | 23:20:00   | 4E         | 100 S EUTAW ST | 113 | CENTRAL          | Downtown West | -76.62083 | 39.28724 | HOTEL/MOTE       |
| 2  | 12/8/2018 | 23:00:00   | 6D         | 900 S CATON AVE | 832 | SOUTHWESTERN     | Violetville   | -76.67137 | 39.27355 | PARKING LO       |
| 3  | 12/8/2018 | 23:00:00   | 6D         | 2600 HUDSON ST  | 232 | SOUTHEASTERN     | Canton        | -76.57891 | 39.28211 | STREET           |
| 4  | 12/8/2018 | 22:50:00   | 7A         | 3800 MARY AVE   | 425 | NORTHEASTERN     | Glenham-Belhar| -76.54639 | 39.34841 | STREET           |
| 5  | 12/8/2018 | 22:49:00   | 4E         | 500 S CATHERINE ST | 842 | SOUTHWESTERN     | Shipley Hill  | -76.65599 | 39.28388 | ROW/TOWNHO       |
| 6  | 12/8/2018 | 22:15:00   | 3AF        | NORTH AV & N MOUNT ST | 733 | WESTERN         | Sandtown-Winchester | -76.64499 | 39.30995 | STREET           |
| 7  | 12/8/2018 | 22:00:00   | 4E         | 2900 ROCKROSE AVE | 612 | NORTHEASTERN     | Park Circle   | -76.66197 | 39.32895 | ROW/TOWNHO       |
| 8  | 12/8/2018 | 22:00:00   | 4E         | 2900 ROCKROSE AVE | 612 | NORTHEASTERN     | Park Circle   | -76.66197 | 39.32895 | ROW/TOWNHO       |
| 9  | 12/8/2018 | 21:48:00   | 4B         | 1400 KUPER ST    | 935 | SOUTHERN         | New Southwest/Mount Clare | -76.63975 | 39.28505 | STREET           |
| 10 | 12/8/2018 | 21:30:00   | 3AF        | 0 ALBEMARLE ST   | 211 | SOUTHEASTERN     | Jonestown     | -76.60422 | 39.28909 | STREET           |
| 11 | 12/8/2018 | 21:13:00   | 4E         | 2700 W           | 721 | WESTERN          | Rosemont      | -76.66158 | 39.29327 | ROW/TOWNHO       |
The procedure is:

**A. Algorithm: DBSCAN**

This algorithm is given the crime dataset as an input. Crime date, time of the crime. The DBSCAN clustering is performed result, the Crime pattern recognition of type shooting in Baltimore during 2012–2018.

Input: N attributes to be clustered as well as Eps, MinPts global variables.

Output: Clusters of Crime
Method:
1. Select a point P arbitrarily.
2. From P, recover all density-accessible points from P wrt Eps and MinPts.
3. If P is a core point, there will be a cluster.
4. When P is a boundary point, no points can be reached from P and the next point of the list is visited by DBSCAN.

**B. Clustering Hotspot**

Process all the other points in the same way Figure 2 until Figure 7 represents the crime patterns detected after DBSCAN clustering. While Figure 8 shows the hotspots visualized by GIS.

**II. CONCLUSION AN EVALUATION**

Crime detecting is a complex and evolving field of research in the world. Data Mining plays a big role in studying criminal pattern recognition, crime detection and crime prevention by governmental agencies for public safety. This research introduces the process of identifying crime trends and predicting crimes hotspot in Baltimore city. The highly populated areas are labelled (density location) based on the attribute of crimes depend on the data of the Baltimore population map. Clustering methods are used to detect crime patterns to anticipate crimes based on the quest of similarities. The DBSCAN clustering is incorporated and assessed on the basis of precision. The results of DBSCAN clustering is highly accurate and effective compared with other methods. This system, therefore, assists government bodies to improve and analyze crimes accurately. The efficiency of the DBSCAN clustering algorithms is assessed with precision using silhouette measures. It provides mapping with uniform and efficient high density crime hotspots. The use of GIS / Clustering methods in Spatial-temporal analysis, confirmed as an efficient means to understand the underlying correlation between incidents. This work can be extended in the future to enhance clustering by applying certain algorithms and statistical techniques algorithms to get more efficient and effective crime classification. It can also enhance privacy to protect the crime dataset and criminal record that are provided by police stations using a Wearhouse protected with security measures. Finally, it is recommended that Artificial intelligent and GIS should be combined to help in making a fast and accurate decision for public safety. This work aimed to support and help law enforcement authorities to reliably predict and identify crime pattern recognition in Baltimore. Hence, the high density crime locations will be
reduced, and the distribution of the police patrols will be relocated depending on the spatial-temporal data analysis concentrating on high density crime places.

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