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Comparison of Algorithms for Crime Analysis

Dhananjay Raghav[1], Rashi Gupta[2], Sakshi Kaushik[3], Ashish Kumar[4]
[1, 2, 3, 4]*Computer Science Department, AKTU University*

Abstract: ***There are nearly thousands of crimes that happen every day. There are many algorithms for calculating an area's crime rate but there is no best algorithm for calculating an area's crime rate, depending on the algorithm's accuracy and time complexity. So, we've taken four unsupervised clustering algorithms K means clustering, agglomerative clustering, gaussian clustering, density-based spatial clustering algorithms to compare them based on the accuracy of the algorithms on a given collection of data to figure out the best algorithm to figure out the crime rate of a given region. This paper essentially presents a comparative study of all four clustering algorithms, and it is found that k means clustering algorithm is the best clustering algorithm for calculating an area's crime rate on the given data set.***

Keywords: Crime Clustering, Crime rate, K-Mean Clustering algorithm, Agglomerative Clustering algorithm, Gaussian Clustering algorithm, Density based algorithm.

I. INTRODUCTION

Crime is an illegal act to society. It affects society, as well as the individual suffering from the crime. Different security forces are trying to monitor the crime but their process takes too long. So, we are seeking to solve these problems as part of society by studying crime using various algorithms. Criminology describes empirical study of crime and criminal behaviour, and prosecution is a law enforcement practice. A move towards this is the use of clustering algorithms which is an important data mining tool.

Data mining techniques are very useful when identifying trends, differences and correlations between large data sets. It involves grouping, clustering, rules of association, estimation, regression, etc. Cluster analysis analyses the cluster which has the same properties. Unsupervised clustering algorithms are employed in this paper. Unsupervised algorithms are divided into four groups based on partioning, distance, hierarchy and mixture. The paper contains four means k algorithms, gaussian mixture model, hierarchical agglomeration and spatial clustering of application with noise dependent on density. These algorithms are implemented with a crime data collection on the python editor and then compared based on the precision measured with the aid of the silhouette index. The purpose of this study is to assist police enforcement agencies so that they can continue with less time for police data reports and also, with the aid of these algorithms, identify crime-prone areas.

We may distinguish two major areas in the field of machine learning: supervised learning and unsupervised learning. The key difference between both learning is the data form and the methods used to manage the data. Clustering is an unsupervised problem of learning with the goal of finding clusters of points in the dataset that share certain common features.

Supervised learning is a machine learning method learning some particular function or task that transforms an input into output based on input-output pairs or specified datasets. Supervised learning algorithm analyses and executes the training data collection accordingly. Additionally, supervised learning algorithm is known as classification and regression. Classification is a concept of learning which classifies data into a given category. Regression is an approach to finding relations among the variables. Such algorithms are: linear regression, random classification of forests and supporting classification vector machines. Supervised learning algorithm is so called because the data set requires supervision to learn and train. Study of the clusters is also known as clustering. Clustering is a process of grouping different objects into a category that have similar properties. Some unsupervised algorithms are so-called k-means clustering, apriori algorithms, hierarchical clustering, fuzzy clustering, and so many, Unsupervised learning because it needs no training and supervision. Unsupervised learning finds undetected trends in non-pre-existing labels with fewer human control in data sets. It allows probability densities to be modelled over inputs. This can be further defined as the key variable and analysis of the cluster. Given the set of points in two or more dimensions, the best fitting line can be defined as one that minimizes the average point to line square distance. Repeating the method provides an orthogonal basis where different data dimensions are unrelated. These simple vectors are known as principal components and procedure is known as principal component analysis. Crime is nowadays a common word that we can here in our day-to-day life almost every day, but how many of us are really talking about it, i.e. talking about the pace at which the crimes happen nearby. Crime rate is a main factor which can help:

1) The government officials to take appropriate steps to stop the crime.
2) Persons living in an area shall ensure their own protection, depending on the rate at which the crime occurs in their neighbourhood..

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Crime rate is characterized as the rate at which the crime occurs in a region, essentially by measuring the crime that occurs in that region, the crime rate of an area can be calculated / examined.

Analysis of the crime is necessary to calculate / examine the crime rate, since

a) Analysis of the crime tells us the time when the crime most occurs.

b) It will help the officials of the government take the appropriate measures to stop the crime in that region.

II. LITERATURE REVIEW

The field of crime analysis is very growing, and each and every researcher has a very broad scope to explore the field and come up with some findings in their work. However, Adel Ali Alkhaibari and Ping-Tsai chung introduce K-means clustering and agglomeration on New York Police Department's crime data collection to determine and reduce crime rates. In the context of knowledge discovery, data analyses play an important role in finding interesting trends or details for understanding particular phenomena or large applications. Visual Data Mining often uses visualization techniques to display tacit yet valuable information from large data sets to generate visual images that help to explain complex, often massive data representations. As the amount of data handled in a database increases, so also does the need to simplify the overwhelming amount of data. Cluster analysis is the process of categorizing a large group of data items into smaller groups which share the same or similar properties [1]. Sunil Yadav, Meet Timbadia, Ajit Yadav, Rohit Vishwakarma and Nikhilesh Yadav have proposed a method for forecasting and analysing crime by applying data progression and then using data mining methods such as WEKA and R on the data progress. The program is trained by feeding past years record of crimes taken from India's official online database listing various crimes such as murder, kidnapping and abduction, dacoits, theft, burglary, rape and other crimes of this nature. They also used supervised, semi-supervised and unsupervised learning technique for information discovery on crime records and to help improve the predictive accuracy of the crime. This job would be of assistance to the prevention of crime by the local police stations [2]. Dr S. Sivaranjani. Sivakumari and Aasha M introduce K-means clustering, agglomerative clustering and noise-based spatial clustering (DBSCAN) for clustering on predefined data and then comparing the results of this clustering algorithm with the best suitable crime detection algorithm in Tamil Nadu. K-Means Clustering, Agglomerative Clustering and Density Based Spatial Clustering with Noise (DBSCAN) algorithms are used to cluster crime activities based on some predefined cases and the effects of these clustering are compared to finding the best suitable crime detection clustering algorithm. The result of K-Means clustering algorithm is visualized for interactive and easy understanding using Google Map. Classification K-Nearest Neighbor (KNN) is used for estimation of violence. The performance of each clustering algorithm is evaluated and metrics such as precision, recall and Fmeasure are used to compare the results. This research assists law enforcement agencies with greater precise forecasting and crime identification in Tamil Nadu and thus decreases the crime rate. [3]. Anant Joshi, A.sai Sabitha and Tanupriya Choudhury analyses different types of crimes by qualitative and quantative method by using k-means clustering on the given crime data collection from New south Wales area of Australia. The main aim of this paper is to examine by using qualitative and quantitative method the crime that includes burglary, murder and various drug crimes that often include suspicious activity, noise complaints and burglar alarm. Using the K-means clustering data mining method on a crime dataset from Australia's New South Wales region, crime rates for all types of crime and high-crime cities were established [4]. Shiju Sathyadevan ; Devan M. S ; Surya Gangadharan S. presented a paper using data mining to extract previously unknown, useful data from unstructured data. Crime detection and prevention is a structured method for the identification and study of crime patterns and trends. The program can identify regions that are highly likely to occur in crime, and can imagine areas vulnerable to crime. Crime data analysts will help law enforcement officers speed up the process of crime resolution with the advent of computerized systems [5]. Romika Yadav and Savita Kumari Sheron proposed a model to work on past crime patterns in order to predict future crimes using R. A crime is an illegal act which can be prosecuted by state or other authorities. It is through by leaps and bounds, and it is not just the government's duty, but we should also seek to take action against it. This paper proposes a model that will assist in assessing the characteristics that lead to a higher degree of illegal activity. The model is designed to solve issues such as:- identify regions based on different activities, identify variables with high likelihood of crime, provide suggestions for suggestions on protection. We will use regression analysis to create a relationship between dependent and independent variables for this reason. The dependent variable is the number of crime and other attributes such as location or place of crime are independent variables. Additional structural vectors are performed and then standard deviation is applied, then clustering technique is applied and finally, using the 'R' method, it is plotted and analysed in order to obtain areas vulnerable to crime. We may use more sophisticated statistical methods and techniques in future to identify the crime on different datasets [6]. Jyoti Agarwal, Renuka Nagpal and Rajni Sehgal took the crime dataset and then conducted pre-processing and applied the operator of normalization to the data collection.

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Then, clustering was done on it and identifying the crime prone areas by displaying the clusters. This project focuses on crime analysis using a rapid miner method that uses clustering algorithms such as K-Means, Random Forest etc. Security is a big concern for the people in today's scenario and a model is proposed in this paper that will help police monitor crime rate. As data mining is very useful for any dataset study. In this paper we will use rapid miner tool like WEKA explorer to pre-process, normalize and classify data. First take the crime dataset and then perform pre-processing and apply the operator of normalization to data collection. Then conduct clustering on it and evaluate the crime-prone areas by displaying the clusters.

This project focuses on crime analysis using a fast miner method that uses clustering algorithms such as K-Means, Random Forest etc. We may assume that clustering techniques have a promising future that will be very useful in analysing the deprivation dataset, the dataset of education in the future [7].

Vineet Jain, Yogesh Sharma, Ayush Bhatia and Vaibhav Arora spoke about experimental set-up for crime prediction and analysis. A repository is to be created on the web hosting site in which two databases are created one for the storage of user-related information and another for the storing of crime reports that occur in different regions. You can extract the details and add it using SQL Queries. The user which is marked on google map adds the location.

Crime data is passed to k-means algorithms which in turn form clusters by repeatedly calculating the data distance from the centroid. From the results one can easily determine the crime prone areas and take preventive measures. Crime analysis is very important to prevent the crime in the society.

Our method predicts the crime prone areas based on clusters that have been created. This system uses an unsupervised algorithm named K-means algorithm. We discussed in this paper the experimental framework for crime prediction and analysis. A repository is to be created on the web hosting site in which two databases are created one for the storage of user-related information and another for the storing of crime reports that occur in various regions.

Using SQL queries the information can be extracted and added. The user which is marked on google map adds the location. Crime data is passed to k-means algorithms which in turn form clusters by repeatedly calculating the data distance from the centroid. From the findings one can quickly classify the areas vulnerable to crime and take preventive action [8]. Omkar Vaidya, Sayak Mitra, Raj Kumbhar, Suraj Chavan, Mrs Rohini Patil Proposed a method using two algorithms k-means and fuzzy-c to evaluate crime. This program will predict the areas with high crime rate.

The system allows the user to select the details of the crime and select the clustering algorithm as needed, and the system will show the data graph and geospatial view of the areas [9]. R. Babu Bulli, Snehal G., and P. Aditya Satya Kiran presented a paper on the importance of data mining in terms of its techniques, and how we can easily solve the crime. Crime records will be stored in police database.

To analyse the data quickly they have clustering data mining technique. Clustering is a method of grouping identical characteristics which maximizes or minimizes the similarity. They have used the algorithm k-means and the algorithm of expectation-maximization.

They use these techniques since these two techniques come under the algorithm of partitioning. Partition algorithm is one of the best ways to solve crimes, to identify and group related data. The algorithm K-means is used to partition the grouped object according to its means. Expectation-maximization algorithm is the extension of the k-means algorithm, in which the data is partitioned on certain parameters [10]. Rasoul Kiani, Siamak Mahdavi and Amin Keshavarzi use data mining technique and use the genetic algorithm to optimize the parameters of the outlier detection operator with the RapidMiner tool [11]. K Lakshmi, N Karthikeyani Visalakshi And S Shanthi optimized the K means as problem occurs during centroid initialization. They combined Crow Search Algorithm with k means to obtain optimal solution. The performance is compared to other algorithms such as the K-Means+ Genetic Algorithm [12]. H. Benjamin and David Fredrick A. Suruliandi performed a study of supervised and unsupervised algorithms used in previous years to evaluate crime and forecast crime [13]. Anukampa Behera, Sujata Chakravarty, uses clustering techniques to apply three approaches to gene expression data analysis and represents a comparative study between Hierarchical, K-Means and Fuzzy C-Means clusters [14]. Devendra Kumar Tayal, Arti Jain, Surbhi Arora, Surbhi Agarwal, Tushar Gupta and Nikhil Tyagi used the techniques of data mining to detect crimes and identify offenders. Their approach is divided into six modules and implemented on WEKA platform. Crime testing is also carried out on WEKA. They used their approach to improve society [15]. ShyamvaranNath has introduced K-means clustering algorithm to identify crime patterns and speed up the crime resolution process by generating a geo-spatial crime plot [16]. Krishnendu S.G, Lakshmi P.P, Nitha L proposed an automated K-means algorithm to minimize time complexity and increase the performance of crime and crime pattern analysis [17].

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III.DATA CAPTURED AND PREPROCESSING

The data collection in this paper is done from the government website "data.gov.in" which includes a dataset of crime against women such as rape, dowry deaths, insult to women's modesty etc. The data is composed of 15 columns and 457 rows. Pre-processing of data is a method by which raw data is converted into an accessible type of data. Pre-processing of the data is possible as follows:-

1) *Step 1:* The states and crimes are written in numerical form to make it easily available.
2) *Step 2:* Using normalization, the data is converted into an acceptable type to process.
3) *Step 3:* In order to improve performance and reduce data and costs, the data is then reduced.
4) *Step 4:* Data is scaled using the scaling algorithm in python based on various algorithms.
5) *Step 5:* Data is also fitted using optimized python algorithm.

Pre-processing of the data is done to prepare the raw data for further processing.

IV.PROPOSED ARCHITECTURE

This section provides us with the method or architecture for analysing the crime using different (four) algorithms using Python language on the Python editor based on the given data sets. The procedure is as follows:

A. Take one single algorithm for clustering at a time.
B. Run the python editor clustering algorithm to test for any errors on the algorithms.
C. Sort the data collection according to the criminality research criterion.
D. For the given clustering algorithm, take an excel file (data set) as an input.
E. To obtain clusters run the clustering algorithm with the specified data sets.
F. Compare the algorithms as to cluster accuracy.

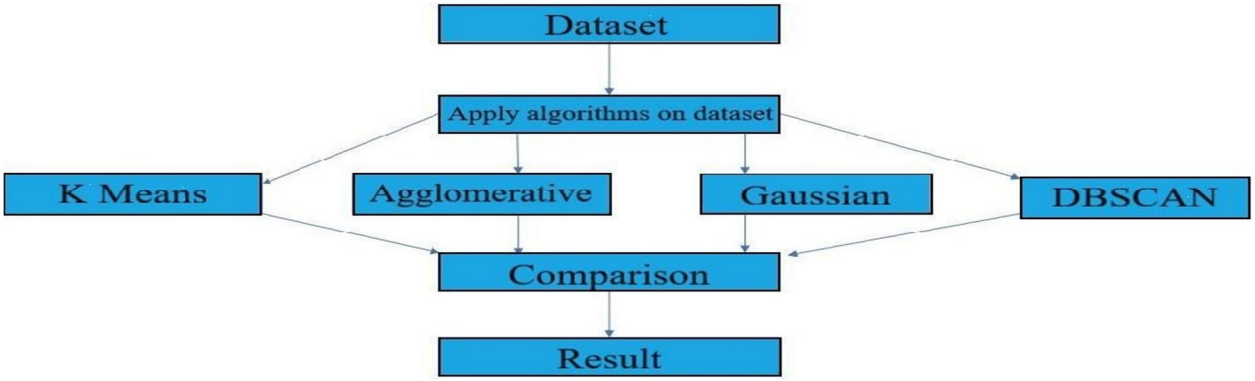

Fig. 1 Flowchart of System

V. IMPLEMENTATION AND METHODOLOGY

In this part we have briefly described the working of four clustering algorithms that we have taken for crime comparison. The algorithms are given below

A. K-Means clustering Algorithm

K-means clustering is a method of creating clusters on the specified set of data in which each set of data belongs to a cluster based on its Euclidean distance from the cluster assumed.

Process

1) Make two clusters from the first two data sets values, initially.
2) The initial data sets being taken are known as the cluster's centroid.
3) After that the distance between the Euclidean and both clusters are taken out
4) The least Euclidean distance is taken, and a new cluster is created by measuring the centroid from both values.
5) That process is being iterated.

K mean algorithm's time complexity is O (NKD), where N is the number of data sets to be clustered in. K is cluster's number, and D is dimension of data.

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B. Agglomerative Clustering Algorithm

Agglomerative clustering is a type of hierarchical clustering that clusters each individual element into its own cluster. All these clusters are iteratively merged until all the elements form one cluster.

Process

1) Calculate the proximity of each data point and view each data point as a single cluster.
2) Clusters of the same similarity are considered identical and are combined to form one cluster.
3) Calculate the proximity of new clusters further, and combine clusters that are similar to forming new clusters.
4) The above step is continued until there is one cluster left.

Agglomerative algorithm's time complexity is O (KN2) where N is the number of elements to be clustered, and K is the number of clusters.

C. Gaussian Clustering Algorithm

The Gaussian clustering algorithm or Gaussian mixture models are probabilistic models that use the soft clustering technique to allocate the points in different clusters. This implies that each data point with a corresponding probability may have been generated by either of the distributions.

Expectation and Maximization is used for determining latent variables.

It basically includes two steps:

1) E-step (Expectation)
2) M-step (Maximization)

Process

a) E-step: - In this step the available data is used to estimate the values of missing variables.
b) M-step: - based on estimated values in the previous step the complete data is used to update the parameters.
c) We calculate the values of each data point based on the previous step, and update the values iteratively.

Gaussian clustering algorithm's time complexity is O(NKD3), where N is the number of data points K is the number of Gaussian components and D is the problem dimension.

D. Density Based Spatial Clustering of Applications with Noise

Density-based spatial clustering of noise or DBSCAN applications is an algorithm that points together groupings that are similar to each other based on measuring distance (Euclidean distance) to produce a minimum number of points. DBSCAN also labels outliers as the points in regions with low densities.

Process

1) It necessitates two parameters, i.e. Eps & Minpts.
2) Eps is defined around a data point as the neighbourhood.
3) Minpts is defined as the minimum number of neighbour (data points) within eps radius.
4) Find all the neighbouring points in eps and figure out which key points you have visited with more than Minpts neighbours.
5) Assign or create a new core-point cluster.
6) Recursively find connected points with all its density and assign them to the same cluster as the centre. For the remaining unvisited points in the dataset continue the above measure. Noise is the points which do not belong to any class.

DBSCAN algorithm's time complexity is O (K2), in which K is the number of clusters.

VI. RESULT ANALYSIS

A. Cluster Validity

For cluster validation we have used silhouette index.

B. Clustering RESULT

The comparison of all the four algorithms is done on the basis of accuracy which is calculated by silhouette index for the given data set. The Fig-2 shows a graphical representation of accuracy for all the for algorithm.

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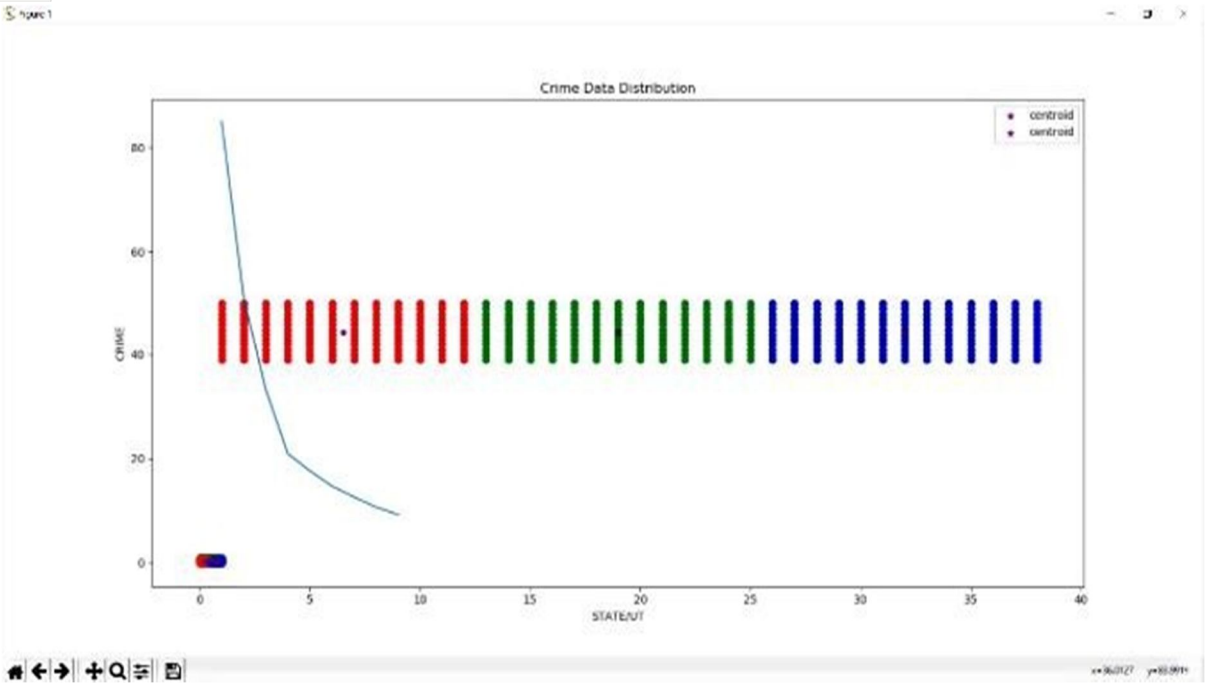

Fig. 2 Output of K-Means Clustering

By implementing K-means the output algorithm as shown in figure 2. Thru K-means we have obtained centre-based clusters. Cluster is collection of objects so that a cluster object is closest to a cluster's centre. We obtain three clusters in that production. Centroid is measured using the distance from the Euclidean. Red cluster is the first cluster with lowest centroid value, green cluster with minimum centroid value and blue cluster with highest centroid value.

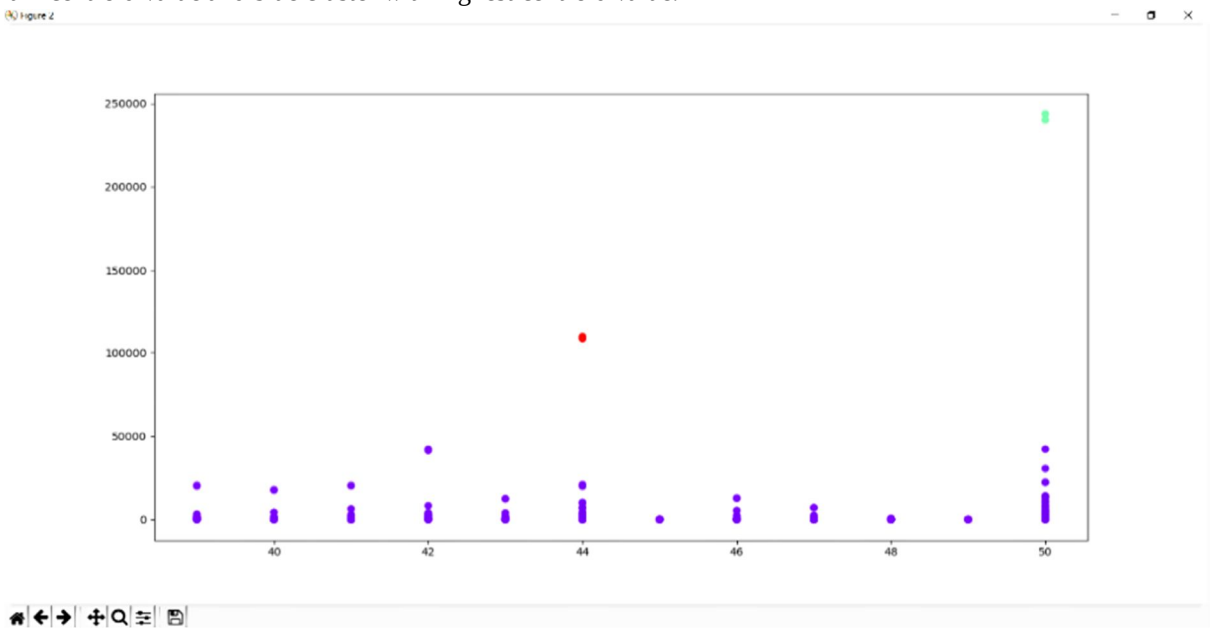

Fig. 3 Agglomerative Clustering

We obtain the performance on implementing agglomerative clustering in python, as shown in fig 3. Through agglomerative clustering we obtain cluster dependent on density. Density-based cluster is a cluster that has small points regions, unlike other high-density regions. This clustering starts with an individual cluster called as leaf. A node is formed by two leaves that have the shortest distance between them. The node is often referred to as cluster. The process is repeated until all of the set of data is processed. From this algorithm we obtain three sets of clusters, represented in three different colours: blue, red and cyan.

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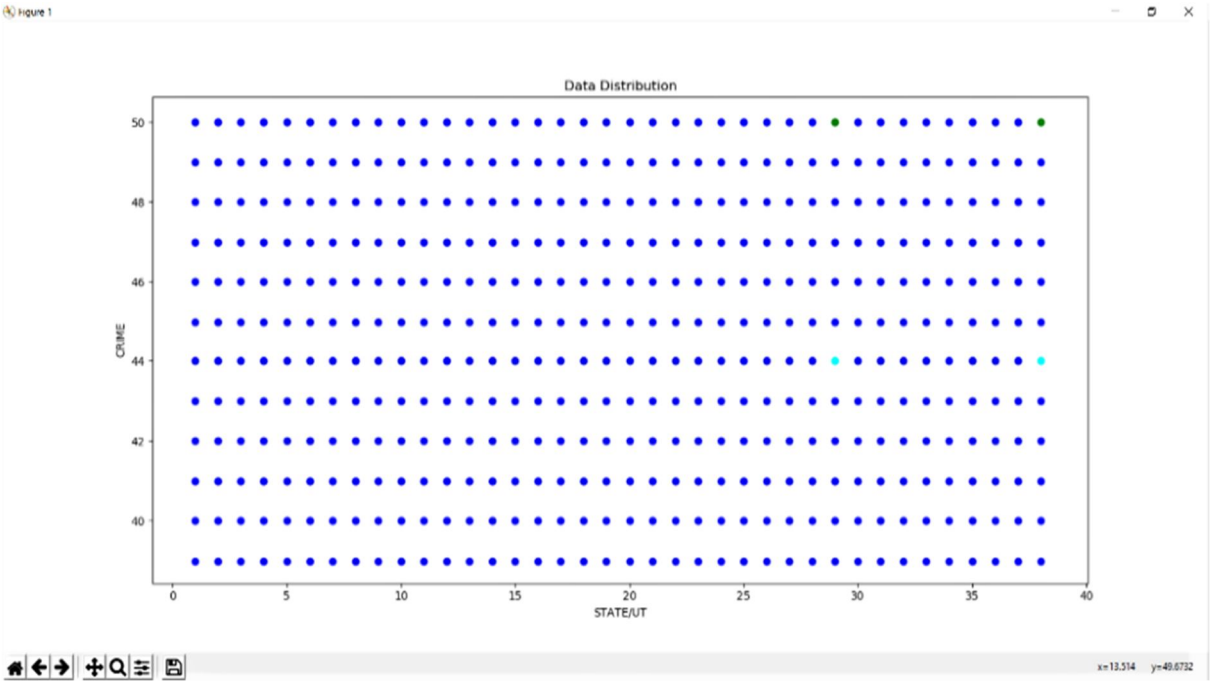

Fig. 4 Gaussian Clustering

The output is obtained by implementing Gaussian clustering as shown in fig 4. We obtained well-separated clusters from that algorithm. A well-separated cluster is a set of points, so that any point in the cluster is closer to any other point in the cluster than to any other point in the cluster. This clustering algorithm enhances centroids calculated by the algorithm k-means. In this we obtained clusters that are blue and cyan in two different colours.

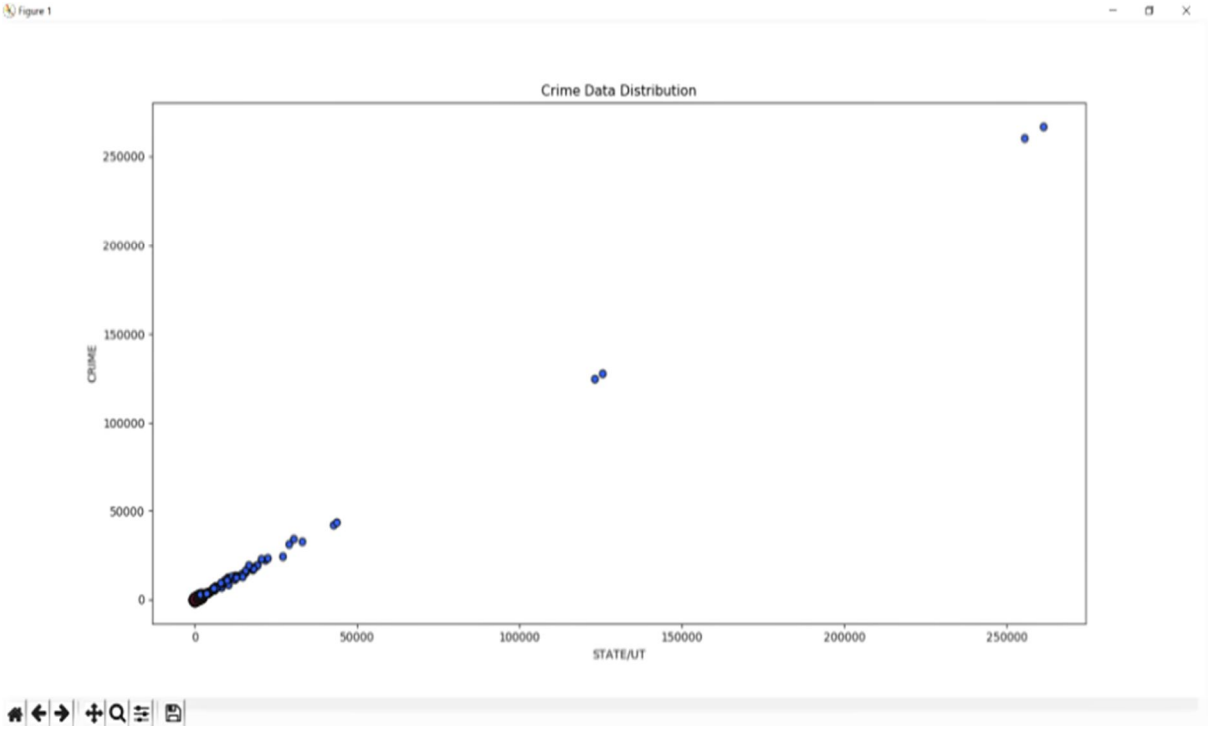

Fig. 5 DBSCAN Clustering

By implementing DBSCAN clustering we obtained the output as shown in fig 5. We have obtained contiguous cluster from this algorithm. Contiguous cluster is set of points such that a point in cluster is closer to one or more points mentioned in the cluster. We have obtained two coloured cluster from this that is dark blue and light blue coloured cluster.

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C. Silhouette Index

1) It refers to a method of interpretation and validation of consistency within clusters of data.

2) The silhouette value determines that how similar to its own clusters compared to other clusters.

3) The silhouette Coefficient is defined as:-

$$S(i) = (y(i) - x(i)) / (\max\{(x(i), y(i))\}$$

Where y(i) is the average inter cluster values of data points and x(i) is the average intra cluster values of data points.

4) The value of silhouette index lies in range [-1,1].

If the value is 1, then it means data points are assigned to right clusters.

If the value is 0, then it means data points can be assigned to another cluster closest to it.

If the value is -1, then it means data points are wrongly clustered and misclassified.

ALGORITHM	ACCURACY
HIERARCHICAL	0.690
DBSCAN	0.733
KMEANS	0.782
GAUSSIAN MIXTURE MODEL	0.358

Table. 1 Comparison based on Accuracy

VII. CONCLUSION

Due to factors such as increasing poverty, migration, unemployment, discontent and corruption, crimes are rising at an alarming rate. Departments of crime enforcement search different criminal record databases manually or with computer programs which is a time-consuming operation. In this paper, we use four different algorithms to determine which algorithm works best in assessing the recording of crime data. We have implemented our proposed method and will evaluate the outcome based on the precision of the algorithm. From the graphical representation given above in Table 1, it is easy to see that the K-means algorithm is more accurate from all the other algorithms.

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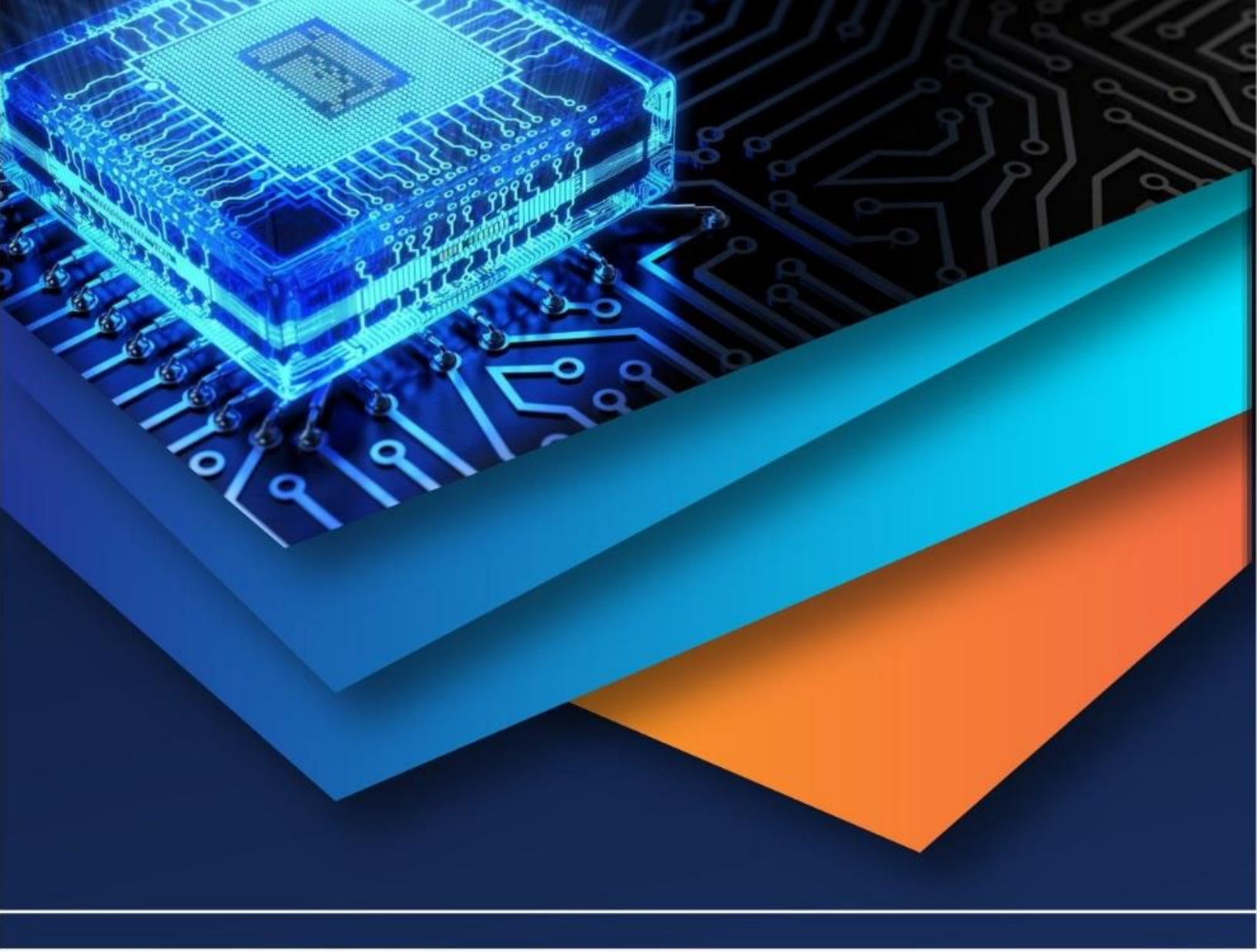

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