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Counter-Terrorism and Crime Detection Using Hybrid Approach of Data Mining, NLP and GEO-Spatial Social Media Analytics

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Abstract— Crime, an unlawful act, causes terror and threat to our society and is a major concern for national security as well as international security. However, very negligible work has been done to develop models and methods to hold an active collaboration between counter terrorism and criminal investigation systems. The need is felt to develop a system that collects as well as categorise the data on crimes along with an analysis of crime affected areas identification. In this study, an efficient crime investigation system is proposed in which fuzzy rules and k mean clustering algorithm is employed to identify and detect crime affected region along with showing it on the map. The study of Data Mining and NLP is incorporated for crime detection and prevention with an aim to provide a safer society to live.

Keywords— Counter terrorism; Crime detection; Social Media; Data mining; Geo-Spatial; NLP.

I. INTRODUCTION

Crime intelligence investigation is indispensable part for the resolution of crimes at any time and any region of a country. Crime is as old as mankind itself Schafer stated that Crime has been present from the very start of humanity and still continued. Furthermore, crime has become a common societal phenomenon which means it is contemplate now as part of an organization's functional element. The concept of decision making in some formal, structured way is nothing new by collecting and utilizing information. In order to obtain advantage over opponents, it is necessary to maintain the most up-to-date, accurate information regarding amongst other things, their intentions and capabilities. This rule employs in every field, be it politics, business, military strategy, or criminal intelligence. In addition, it is a process that has always been, and still is, constantly developing and evolving, in response to changes in technology, organizational needs, and new/ higher levels of analytical skill. Today, criminal intelligence is actualizing with law enforcement organisations and through technologies such as databases, data mining techniques. Forensic science has provided a lot in crime resolution during investigation. Crime analysis proceeds through daily interpretation of crime data coming from new cases within intelligence units. The activities of criminals, their plans about a new crime can be accessed from information collected in dedicated databases separately. The basic intelligence system subsists of very general process: planning, collecting, collation, dissemination and feedback [1]. Visualisation of information supports analysis of information by disintegrates information into simpler perspectives. It helps to gather and summarise data. Link charts can be used to aggregate all information. It can be merged with other techniques such as databases to memorise and data mining. Investigative problems can be analysed through spatial, temporal and relational dimensions.

Table 1 Crime Information system

Tools	Functions	Technique
Crime analysis	Analysis of data for prediction	Crime data and k-means clustering technique
Crime hotspot detection	Visualisation of crime for crime hotspot detection	k-means clustering, location recognition
Crime map	Risk assessment	Geographical information, location recognition
Information offering	Text, picture, video, map	GPS based technique, location recognition
Guarding	Alarming	GPS based, SMS
User participation	Map	Geographical information

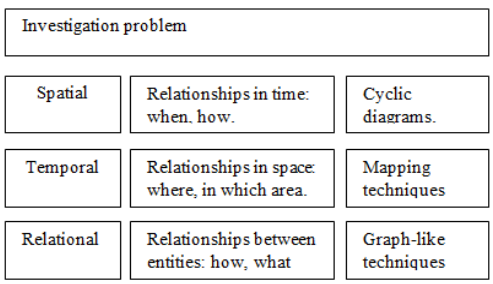

Fig. 1 Analysis of investigation problem [1].

Crimes are categorised into soft crimes and hard crimes. Huge Forensic data is estimated, processed, and stored within the cloud [3]. Then, with the use of data mining techniques, this stored data is extracted out in four major steps as Classification, Clustering, Regression and Association rule mining [4, 5]. Various data mining techniques are gettable to mine crime data like K-means, Hierarchical and Fuzzy clustering based techniques. Then NLP paradigm in which smart objects are interconnected through the internet is used for the aspiration of crime prevention. Crime information system is shown in Table 1. The aims of proposed system are:

1. To find suspect through social media comments and posts using NLP.
2. To find the area and location of suspect.
3. To plot the crime affected region with the help of geographical maps e.g. Google, yahoo, etc.
4. Keeping track of all the criminals released on bail.
5. To secure confidential information related to crime and criminals.
6. Risk assessment for public safety using NLP concept.

In proposed system, first of all, fuzzy based inference system is used. Then k-means clustering technique is used to detect the regions of crime and is shown with the help of the map. K-means technique is used over any supervised technique since crimes vary in nature widely and crime database often contains several crimes. Thus, for detecting newer and unknown patterns in future, clustering techniques work better. This help in a careful investigation of crime and guarding safety to citizens. As crime data is huge so the cloud-based storage is used.

The rest of paper is organised as follows. Section 2 gives information about related work about crime, data mining, cloud computing and NLP. In Section 3, the proposed system is presented. Before concluding the paper in Sect. 5, experimental results are presented in Sect. 4.

II. LITERATURE SURVEY

2.1 Crime

In 2002, E. R. Groff et al. [6] described what is required to use crime mapping methods, and assesses how accurate they are in predicting future crime concentrations, or "hot spots." Factors such as data requirements and applicability for law enforcement have also been used. In 2003, W. Gorr et al. discussed that the crime forecasting can control crime. They used The GIS (Geographical Information System) to detect the location wherein crime happened instead of a single specific location. In 2012, Sylvain Ioset et al. [2] revealed that there can be a common database foranalysis of high volume crimes. Systematic procedures have been analysed by them to integrate links mainly through DNA profiles, shoemarks patterns and images. In 2013, Quentin Rosy et al. [1] discussed that forensic science and criminal investigation is essential for resolution of crimes. There is need to bridge the gap between intelligence process, analyses of investigation problem and visualisation method. In 2013, S. Ismail et al. [7] carried out a research in which a particular location of Malaysia was considered. The crime location and mindset of the criminal was also considered in this case. In practice, usually the police target persons with their criminality and study their strategy of implementing crime. The police also monitor the current crime situation and will take necessary action when the crime index increases. Their finding showed that economic crisis was obvious in increase of crime rate. In 2016, Valerie Spicer et.al. [21]presented a crime mapping technique for identification of crime patterns along street segments.[1]In the current paper, we propose an approach for the design and implementation of crime detection and criminal identification for Indian cities using data mining techniques. Our approach is divided into six modules, namely--data extraction (DE), data preprocessing (DP), clustering, Google map representation, classification and WEKA® implementation. First module, DE extracts the unstructured crime dataset from various crime Web sources, during the period of 2000---2012. Second module, DP cleans, integrates and reduces the extracted crime data into structured 5,038 crime instances. We represent these instances using 35 predefined crime attributes. Safeguard measures are taken for the crime database accessibility. Rest four modules are useful for crime detection, criminal identification and prediction, and crime verification, respectively. Crime detection is analyzed using *k*-means clustering, which iteratively generates two crime clusters that are based on similar crime attributes. Google map improves visualization to *k*-means. Criminal identification and prediction is analyzed using KNN classification. Crime verification of our results is done using WEKA®. WEKA® verifies an accuracy of 93.62 and 93.99 % in the formation of two crime clusters using selected crime attributes. Our approach contributes in the betterment of the society by helping the investigating agencies in crime detection and criminals' identification, and thus reducing the crime rates.

2.2 Data mining in crime analysis

In 2003, Giles C. Oatley et al. [8] developed OVER Project primarily to assist the Police with the high volume crime, burglary from dwelling houses. The final predictions on the likelihood of burglary are calculated by combining all of the varying sources of evidence into a Bayesian belief network. In 2006, Jiawei Han et al. discussed [4] the data mining concepts and techniques. In 2006, Tony H. Grubesic [9] described that one of the fundamental challenges in crime mapping and analysis is pattern recognition. He explored the use of a comprehensive partitioning technique known as fuzzy clustering for hot-spot detection. Functional and visual comparisons of fuzzy clustering and two hard-clustering approaches that are k-medoid and k-means, across a range of cluster values are analyzed. In 2006, ShyamVaranNath et al.

[10] discussed that k-means clustering is used in the identification of crime patterns. In 2012, KilianStoffel et al. [11] demonstrated a methodology and an automatic procedure, based on fuzzy set theory and designed to infer precise and intuitive expert-system-like rules from original forensic data. In 2014, ApurvaJyal et al. [12] discussed that Clustering is a process of Combiningset of objects in a manner that objects in same group share the same similarity. In 2014, Tae-Heon Moon et al. studied [13] that crime has damaged citizens' lives and properties, establishing a safe urban environment has been a crucial social issue. This study reports results of big data analyses, which includes not only real crime data, but also urban attributes such as pedestrian flows, etc. They have given various factors related to crime prevention.

From the proposed system we have researched the crime across regions. The fuzzy based system is used in order to determine the type of crime. Risk assessment is also conducted so that people can be warned about the crime location and suggests appropriate actions. The proposed system introduces accuracy within the location detection process. Also speed with which information is transferred will increase. This is accomplishes by compressing the information being transferred. The unnecessary information is removed by the use of registration process. Hence abstraction is also provided by the use of proposed system.

2.3 Cloud computing

In 2010, Qi Zhang et al. [3] clearly demonstrated cloud computing, highlighting its key concepts, architectural principles, state-of-the-art implementation as well as research challenges to provide a better understanding of the design challenges of cloud computing. In 2014, Sandeep K. Sood et al. [14] discussed that aim of cloud computing is to provide bigger data center that will cater the needs of the user. . He proposed a new approach in which cloud customer (CC) establishes the session to access the resources.

2.4 NLP

In 2011, CASAGRAS defines the NLP as [15]a big frame work for data exploitation and communication capabilities.It connects physical and virtual objects and provides proper recognition of objects. This network is also described by a high of degree of capturing a large data.It provides a model in relation to RFID. In 2013, JayavardhanaGubbi et al. [16] presented a cloud centric vision for implementation of NLP. They have explained the concept of public and private clouds. In 2014, Eleonora Borgia described [17] that IOT is a new concept that combines technologies and aspects from different approaches. Internet protocol, sensing technologies, RFID concepts, communication technologies, embedded devices are merged together to form a system. When intelligence is embedded in objects, they become intelligent objects and gather information from the environment and alsoconnect with the physical objects through Internet to transfer data and information. The physical-cyber world interaction takes place with these three different phases: (i) collection phase, (ii) transmission phase and (iii) process, management and utilization phase. In 2014, Jeong-Yong Byun et al. [18] has presented the idea that NLP can be used in smart crime detection. The proposed system can detect the crime in real time by analysing human emotions. In 2014, NomusaDlodlo et al. discussed that NLP can be used in crime prevention [19]and community safety. They had taken advantage of information and communication technologies. The information can be fetched on the go and user does not have to physically visit the police station. In 2015, Sheeraz A. Alvi et al. [20] discussed that NLP can also be used for multimedia devices. They have introduced a paradigm in which smart multimedia things can interact with each other and with other things connected to internet. NLP communication stack consists of link layer, network layer, transport layer and application layer. It is used in enhancing public safety and security.al. [8].

III. PROPOSED SYSTEM

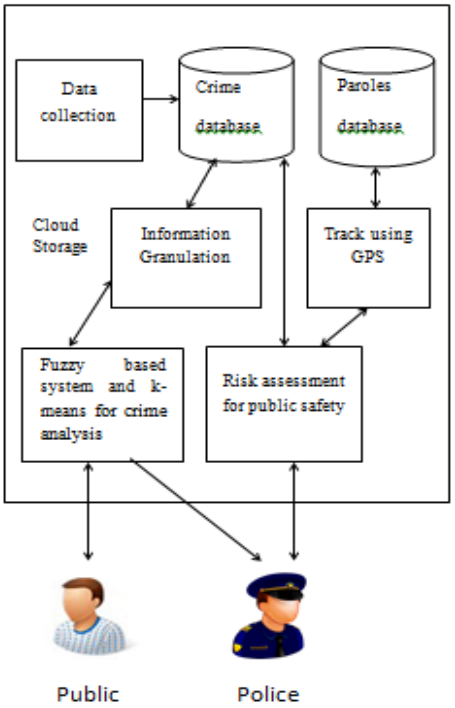

Figure 2 shows the proposed system related to crime prevention and for the safety of public.

It consists of data collection, Fuzzy inference system for prediction and k-means clustering for hotspot detection, risk assessment for public safety and security of confidential information. The data-collection component is responsible for collecting the information related to criminals and crime from police. Then fuzzy inference system is used for making rules. For purpose of crime analysis, k-means clustering over classification is preferred as crime rates changes rapidly.

Personal information about users is truncated, and a unique case number is provided for further usage of the system. All compiled information and results generated are stored in a cloud storage repository termed as crime database. This database provides easy, flexible, and secure way to share information among public and police.

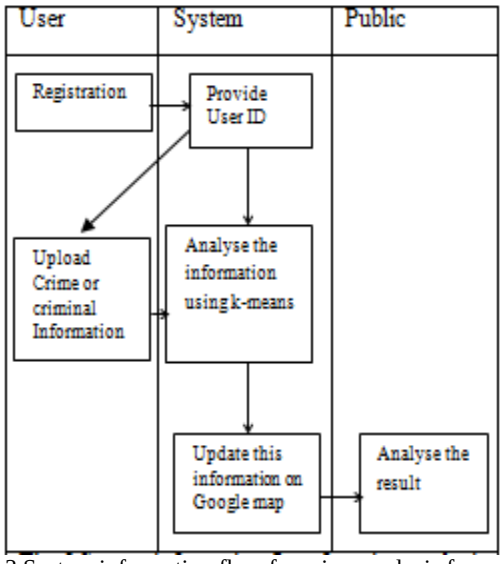

Fig. 3 System information flow for crime analysis for public.

3.1 Data collection – Data related to crimes can be taken from police records, from various websites from internet. Attributes related to crime can be divided into two types.This research is applicable for the static as well as live running data. For conducting this research, a dataset has been gathered from Kaggle website. This dataset is related to the tweets for a terrorist attack in U.S. These tweets of the social media users are used to identify the suspects and extent of risk to the national or international security because of these suspects out of the commentators.

a. Criminal related private data- This information is private and cannot be displayed on maps.

Table 2 Attributes of criminal related data.

S.no.	Attributes	Description
2.	Name	Name of criminal
3.	Address	Permanent address of criminal
4.	Age	Age of criminal
5.	Gender	Male or female

a. Crime related Public attribute

Table 3 Attributes of crimerelated data

S.no.	Attributes	Description
1.	Date	Crime date
2.	Crime location	Location of crime
3.	Type of crime	Burglary
4.	Number of particular crime	Numerical

c. Parole attributes

Table 4 Parole attribute table

S.no.	Attributes	Description
1.	Date	Crime date
2.	Crime location	Location of crime
3.	Type of crime	Burglary
4.	Number of particular crime	Numerical

d. Crime code table

Table 5 Crime code table

S.no.	Crime	Code given
1.	Attempt to murder	1
2.	Burglary	2
3.	House theft	3
4.	Kidnapping for ransom	4
5.	Murder	5
6.	Motor vehicle theft	6
7.	Rape	7
8.	Robbery	8
9.	Other kidnapping	9

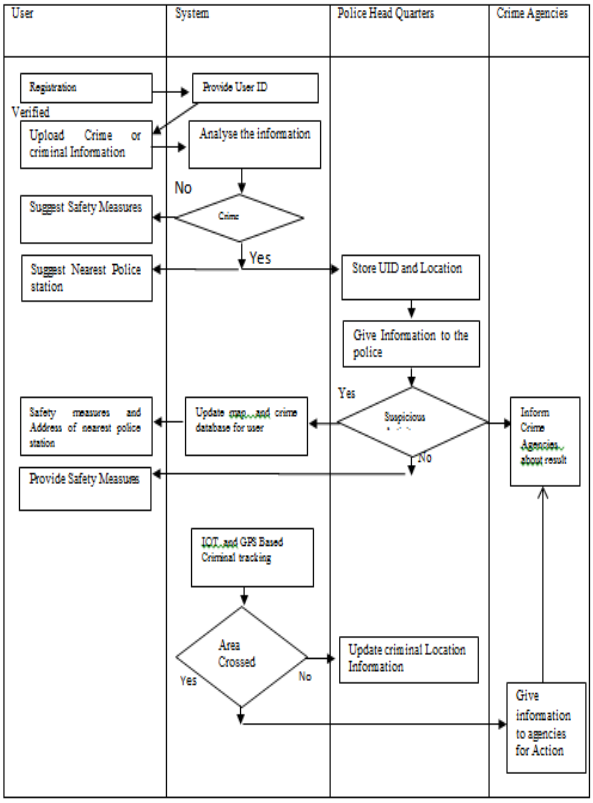

Fig. 4: System information flow for crime prevention for police.

3.3 Fuzzy based inference system for detecting types of crime and k-means clustering in crime analysis to predict the crime-

To detect the type of crime fuzzy techniques will be utilized and in order to predict the crime k-means clustering will be used. The main things used in fuzzy system are fuzzy logic,

fuzzy inference system. Fuzzy logic detects the degree of statement in a fuzzy way.

In Fuzzy inference system, sets have associated a membership function (denoted μ(x)) which maps an input value to its appropriate membership value [11]. A membership function may be any arbitrary function with values in [0, 1]. Fuzzy rules are used in inference system [11]. Fuzzy rules have formed like if x is A then Y is B [11].

In the proposed system the fuzzy rules are used to determine whether the crime is soft or intense. The dataset will be sued for this purpose. The count of crimes and percentage can vary according to crime incidents reported to police. As we have various types of crimes in the database, this database can be updated after every week.

1. **Sensitive crimes-** These crimes are also known as expressive crimes. The risk associated with these crimes is high. These crimes are listed in following table.

Table 6sensitive crimes

Crime type	Code given	Total count of crimes
Att. to murder	1	22
Murder	5	31
Rape	7	0

2. Materialistic crimes- Materialistic crimes are known as instrumental crimes. An instrumental crime, are motivated to achieve a tangible goal, such as obtaining a physical good through theft. The risk associated with these crimes is low.

Table 7 Materialistic crime

Crime type	Code given	Total count of crimes
Kidnap. for Ransom	4	22
Other Kidnap.	9	31

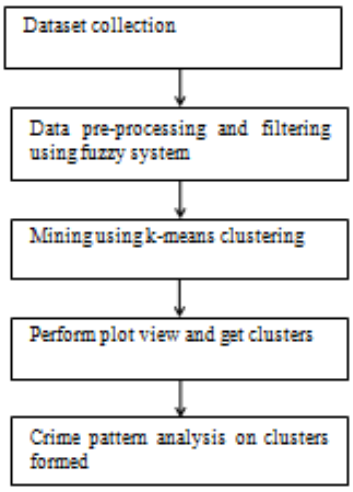

Fig. 6Proposed system for crime analysis

2. Miscellaneous crimes – Miscellaneous crimes are very soft crimes. These are related to social issues of a city.

Table 8 Miscellaneous crimes

Crime type	Code given	Total count of crimes
Burglary	2	22
House Theft	3	31
Motor vehicle theft	6	0
Robbery	8	0

The rules to determine the type of crime are as follows. These rules are formed through fuzzy based inference system.

IF CRIME1 IS BURGLARY, THEN CRIME IS MATERIALISTIC
IF CRIME1 IS ROBBERY, THEN CRIME IS MATERIALISTIC
IF CRIME1 IS THEFT, THEN CRIME IS MATERIALISTIC
IF CRIME1 IS MOTOR VEHICLE THEFT, THEN CRIME IS MATERIALISTIC
IF CRIME2 IS KIDNAPPING FOR RANSOM, THEN CRIME IS MISCELLANEOUS
IF CRIME2 IS OTHER KIDNAPPING, THEN CRIME IS MISCELLANEOUS
IF CRIME3 IS ATTEMPT TO MURDER THEN CRIME IS SENSITIVE
IF CRIME3 IS MURDER THEN CRIME IS SENSITIVE
IF CRIME3 IS RAPE THEN CRIME IS SENSITIVE

We can also make rules to identify risk associated with these crimes. Rules which are formed for these can be expressed as follows:
IF CRIME1 IS BURGLARY THEN IDENTIFY RISK IS MEDIUM
IF CRIME1 IS ROBBERY THEN IDENTIFY RISK IS MEDIUM IF CRIME1 IS THEFT THEN IDENTIFY RISK IS MEDIUM
IF CRIME1 IS MOTOR VEHICLE THEFT THEN IDENTIFY RISK IS MEDIUM
IF CRIME2 IS KIDNAPPING FOR RANSOM THEN IDENTIFY RISK IS LOW
IF CRIME2 IS OTHER KIDNAPPING THEN IDENTIFY RISK IS LOW
IF CRIME3 IS ATTEMPT TO MURDER THEN IDENTIFY RISK IS HIGH

IF CRIME3 IS MURDER THEN IDENTIFY RISK IS HIGH
IF CRIME3 IS RAPE THEN IDENTIFY RISK IS HIGH

3.3 Crime Analysis

Selecting k-means technique - We choose k-means clustering method for crime analysis. The K-means clustering algorithm will be step by step execution of series

of instructions. These instructions if followed successfully then desired result will be obtained. In our proposed system we have to load the crime dataset into the proposed model and then the dataset will be evaluated using the techniques of clustering. The clustering technique will partition the same types of crime into the different clusters of groups. The crime is sensitive or not then will be determined. The crime analysis is the important aspect of the proposed system. If this system is successful, then the crime location and crime itself can be forecasted and hence may result in the reduction in the crime. The proposed system to detect and plot the crime locations on the map is described through the following procedure.

The basic k-means clustering algorithm consists of following steps [5]
Input
K: the number of clusters.
D: a dataset containing n objects
Output: A set of k clusters
Method
(1) Arbitrary choose k objects from D as initial centroids
(2) Repeat
(3) (re)assign each object to cluster to which the object is most similar, based on mean value of objects in cluster;
(4) Update the cluster means, i.e. , calculate the mean value of objects for each cluster;
(5) Until no change

K means algorithm complexity is O (tkn), where n is instances, c is clusters, and t is iterations and relatively efficient.

3.4 Crime prevention and risk assessment–

3.4.1 Crime prevention by tagging criminals-When a criminal in major case is released on parole, all his details are captured. For unique identification of criminals, their biometric details like fingerprints and face image is added in crime database. Fingerprints can be taken using a fingerprint scanner, face image can be taken using face scanner[19]. As in crime database, we have the biometric information of major criminals involved in different crimes and total crime related information of city. This all concept is explained with the help of following figure:

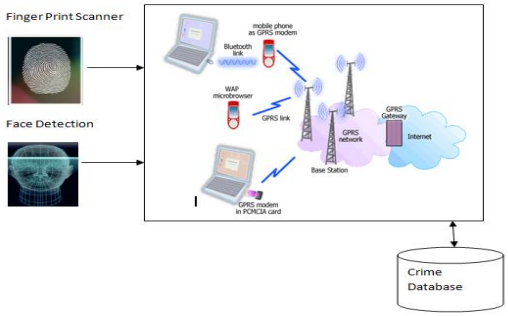

Fig. 7Criminal identification system

In CIS the scanners are used in order to take the finger prints and face detection of the person to be tested. The information so obtained is verified against the criminal database. The tested result if found positive the relevant information is transferred to the concerned officials.

3.4.2 Criminal monitoring system

Parole is tagged with a tracking device like a sensor in the form of the bracelet. We assume that tag is not detachable. The sensor has GPS or GSM sim card in that so that location of that person can be known at any time. The database is connected to correctional services department. The database containing parole conditions is also linked to this correctional services department [19]. So when criminal released on bail violates any conditions like when
•The parole moves out to area in which he is not allowed.
•Meeting some another criminal.
•The parole again commits some crime. Then alarm is triggered on a system in department. The crime database release details of monitoring officer for further action.

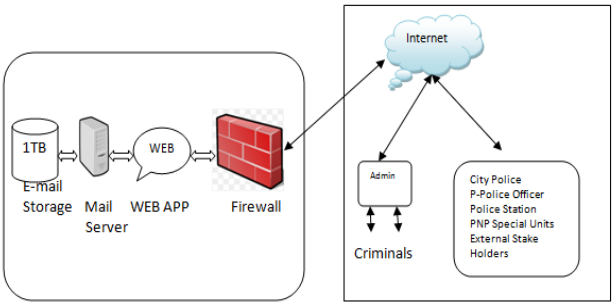

Fig. 8Criminal monitoring system

CMS will use the Email service in order to monitor the entire system. The information about the criminals are transferred to the officials with the help of this system. This information should not be accessed by unauthorized users so firewall is used.

3.4.3 Risk assessment for safety of public

Risk assessment is used is to guarding safety to citizens. As we have used k-means clustering for detecting hotspots of crime and to group similar types of crimes into group. If proper up to date information is available, then citizens can be alerted in time. Crimes are shown on pie chart according to percentage of crime. The major crime areas are plotted on Google map.

Dark blue = $D > 50\%$
Dark purple = $40\% < D \leq 50\%$
Green = $30\% < D \leq 40\%$
Red = $20\% < D \leq 30\%$
Light red = $10\% < D \leq 20\%$
Yellow = $D \leq 10\%$

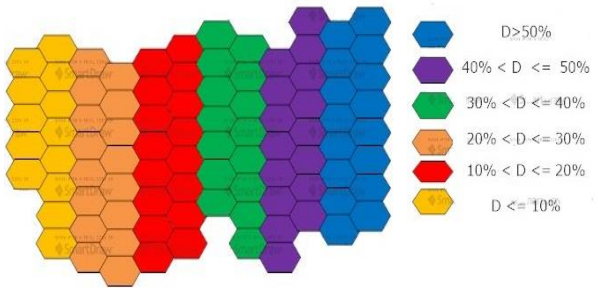

Fig. 9To show particular crimes according to crime density.

3.4.4 NLP in updating crime information in database – The NLP is the network of physical objects, vehicles etc. which are embedded within electronics, software, sensors etc. which enables these to collect and exchange the data. The rapid growth in the technology also resulted in the increase in the crime. The technology can be used to timely detect the crime and taking appropriate measure to avoid such situation. The emotion of the human beings are scanned and matched against the stored information[18]. Police officers are primarily focused to reduce the crime in the region.

The IOT will help in crime detection which will be described through the following steps.
1) Emotion Sensing- The sensor is required to be fitted within the cloth which is most often is with the user. The sensor attached will check the emotion by analyzing the heart beat, inner temperature of the user etc.
2) Emotion Recording- In order to improve the crime detection, emotions are recorded using CCTV camera.
3) Crime Detection-The real time crime detection will be based upon the emotion sensing and emotion recording. The information is sent to the relevant agencies for investigation
4) Crime database updation- All this information will be updated in database.

Algorithm 1: Mapping crime areas
Step I: Identify types of crime and crime areas
Step II: Use fuzzy based system for dividing crime into types and K-means clustering for mapping.
Step III: Use Google maps to plot that crime area.
Step IV: When crimes increase
Step IV.1 Increase particular crime percentage.
Step V: Exit

Algorithm 2: Crime detection using NLP
Step I: Use sensor to sense emotions of user.
Step II: Record all the emotions in CCTV camera.
Step III: If emotions of user not good.
Step III.1: Send that information to police for investigation.
Step IV: If after investigation result is true.
Step V: Update that information in crime database.

Algorithm 3: Tracking criminals released on bail
Step I: Store information of criminals released on bail in database.
Step II: Use sensor that has GPS to track criminal.
Step III: Use bail condition database and crime database.
Step IV: If bail condition violated then alarm is triggered in concerned police department.

3.5 Security of confidential information – Information regarding crime areas and major criminals is stored in crime database. This information can be used by concerned people and crime agencies, police using SSL and secure shell (SSH) technologies. SSL is a security protocol, which encrypts the data flowing from server to user, and vice versa. SSL certificate will be provided for each website that uses specified technology to send or receive data. However, SSH provides a secure remote connection with the system.

IV. PERFORMANCE ANALYSIS

The existing system is improved by the use of proposed system along with IoT. The user will get the information about the crime and criminal on the go. The users will get the precautionary measures also with the proposed system. The particular case of trafficking is considered and is shown through the graph as follows

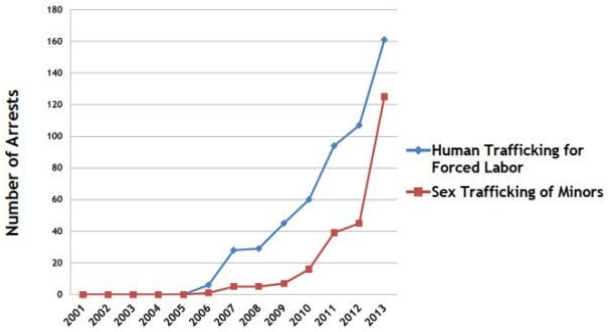

Fig 10: Showing the Data plot up to year 2013 for Trafficking

The graph associated with various algorithm classifications are as described below

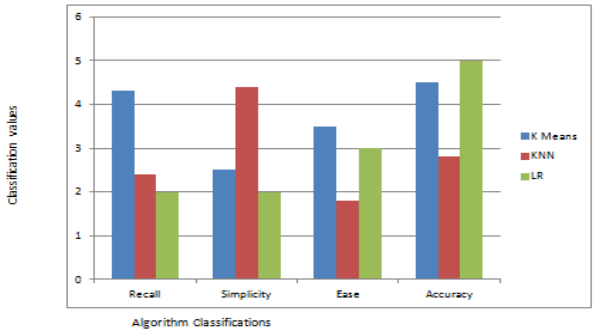

Fig 11: Showing Classification Values

The difference in time consumed is also plotted. The performance charts are generated and are listed as follows

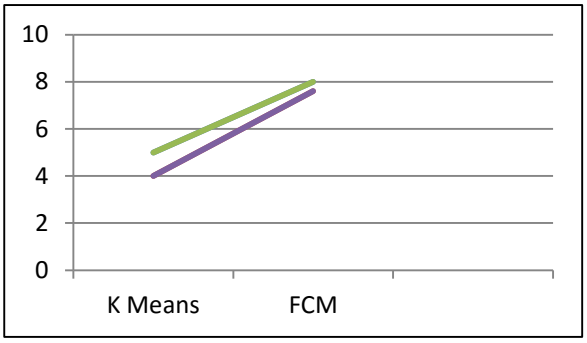

Fig 12: Showing performance of K-Means and other algorithms

The performance analysis indicates that the performance if K Means is better as compared to the FCM technique. Red line indicates the Kmeans and Blue line indicates the FCM technique.

V. CONCLUSION

Crime detection and prevention is one of the major concerns for the national and international security professionals. With improvement in technologies, these technologies are used in the order to detect the regions in which crime takes place. In this paper, a cloud based crime investigation system is prospective for crime prevention. This will be useful in utilizing safety of public. This paper contributes a major support in the crime analysis through the usage of fuzzy rules and k-mean algorithm by grouping of identified data. The key point of this paper is to plot crime locations on google map which can alert the citizens in time and it is utilized by police for doing proper security arrangements. In this clustering algorithms crime analysis can be done and NLP is helpful for reducing and preventing criminal activities. The Iot helps in determining the location of the crime and making user aware of the situation also. User will get the information on the go. The mobility will help the user to identify the situation and let the user take corrective steps. The information about the situation also will be passed to the user's relatives. So safety of the user will also be ensured. The information will be given only to the registered users so user verification is also a part of proposed system.

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