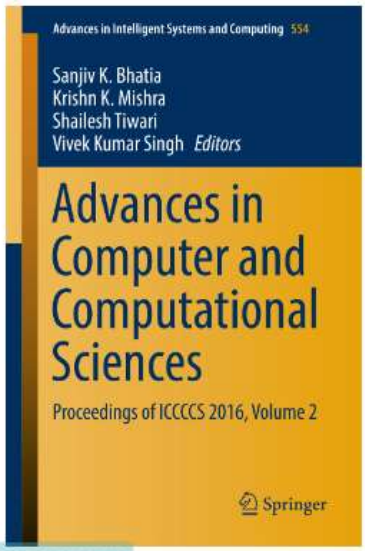

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Lisää ostoskoriin

E-kirja, PDF, Adobe DRM-suojattu
ISBN: 9789811037733
DRM-rajoitukset

Bhatia, Sanjiv K.

Advances in Computer and Computational Sciences

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Role of Clustering in Crime Detection: Application of Fuzzy K-means

Nidhi Tomar and Amit Kumar Manjhvar

Abstract The rising rate of crime has devastated everything seriously. The reason of working on crime dataset is to make a better system, which can make people more aware about the increasing type of crime and crime rate in various fields. The proposed paper works on the detection of crime count and the factors that decide the increasing nature of crime in a better way. Utilization of fuzzy k-means has lead to a better technology that detects the crime rate in a better and effective way. The termination measure is an important factor to define the clusters that are formed over the years. They help in easy detection whether the crime is increasing over the years or not. The dataset from the Indian government's website is taken and been processed so that the results that are calculated can be as correct and near to reality as possible.

Keywords Data mining · Crime detection · Fuzzy · K-means · Clustering · Termination measure

1 Introduction

Crime is a very serious problem in the world. Malefaction is a crime against the society that is often prosecuted and realizable by the law [1]. Criminals commit crime at the place anywhere in type. Traditionally solving crime has been the privilege of the crime equity and law enforcement specialists. With the incrementing utilization of the computerized system to track crime, computer data analysis has commented availing the law enforcement [2]. Many challenges are increasing encountered by decision-makers in the law enforcement department in detecting, identifying the public crime or and tracing or tracking the social crime or

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S.K. Bhatia et al. (eds.), *Advances in Computer and Computational Sciences*,
Advances in Intelligent Systems and Computing 554,
https://doi.org/10.1007/978-981-10-3773-3_57

actions according to their timeline is becoming a tedious task [3]. The Process of information divided into similar object groups known as clusters. Object consist that are similar to one another and exceptional to objects of other collection is called clustering in this implementing work we differentiate a cluster through a c-means clustering methods using the concept of fuzzy [4].

1.1 Fuzzy K-means Approach

It is the type of clustering algorithms, it is the procedure of partitioning the points of data into the clusters like k and S1 (l = 1, 2,…, k) and clusters Sl are related to representatives (cluster center) Cl. The relationship between a cluster and data points belong to a fuzzy [5]. That is, a membership is $u_{i,j} \in [0, 1]$ is used to show the degree is belong to data point Xi and cluster center C_j. Denote data points set as S = {Xi}. Fuzzy K-means method is based on minimizing following distortion:

Clustering methods Fuzzy k-means is used for division of points of records into the k clusters S_l ($l = 1, 2,\ldots,k$) and clusters S_l are related with a representative (cluster center) C_l. The correlation between a data point and cluster representative is fuzzy [6]. That is a membership $u_{ij} \in [0,1]$ is used to show the degree which is belongings of data point X_i and cluster center C_j—Denote the set of data points as $S = \{X_i\}$. This algorithm of Fuzzy k-means is based on the minimizing the following distortion:

$$J = \sum_{j=1}^{k} \sum_{i=1}^{N} u_{i,j}^{m} d_{ij} \tag{1}$$

With respect to the memberships u_{ij} and cluster representatives C_j, where N is various data points; m is the fuzzifier parameter; k is numerous clusters; and d_{ij} is squared Euclidean distance between data points X_i and also representative of cluster C_j. It is noted that u_{ij} should satisfy the following constraint:

$$\sum_{j=1}^{k} u_{i,j} = 1, \; for \; i = 1 \; to \; N. \tag{2}$$

1.2 Working Steps of Fuzzy K-Means

(1) Input is a set of initial cluster centers $SC_0 = \{C_j(0)\}$ and the value of is set P = 1.
(2) Set of cluster centers SC_p, are given compute d_{ij} for i = 1 to N and j = 1 to K. Update memberships value $u_{i,j}$ by the following equation:

$$u_{i,j} = \left(\left(d_{ij}\right)^{\frac{1}{m}-1} \sum_{l=1}^{k} \left(\frac{1}{d_{il}}\right)^{\frac{1}{m}-1} \right)^{-1} \tag{3}$$

If $d_{ij} > \eta$, set $u_{ij} = 1$, where n is a small positive number.

(3) Calculate center of all clusters applying Eq. (4). To find a new cluster set representatives $SC_{p+1.}$

$$Cj(P) = \frac{\sum_{i=1}^{N} u_{ij}^{m} X_i}{\sum_{i=1}^{N} u_{ij}^{m}} \tag{4}$$

(4) If $\| C_j\ (p) - C_j(p-1) \| >$ and for j = 1 to K, stop, where $\varepsilon > 0$ is a very small positive number. Otherwise, set P + 1 → P and go to step 2.

The computational complexity of FKM in the form of phase 2 and 3. Though, the computational complexity of phase 3 is much less than that of phase 2. For that cause, this complexity, in various distance calculations terms, of FKM is O (Nkt), where t is the amount of iterations [7].

2 Literature Survey

Wang Shunye et al. [8] Stimulated with the random determination problem of initial centroid and similarity measures, the researcher presented a make novel k-means methods of clustering dissimilarity based. The algorithm which proposed gives enhanced accuracy rates and results. Pallavi Purohit and Ritesh Joshi et al. [9] proposed an enhanced approach designed for original K-means algorithm due to its certain limitations. The main reason of this method is poor performance in the initial centroid random selection. The proposed algorithm deals with this problem and improves the performance and cluster quality of original k-means methods. It first finds out the closest data point by calculating Euclidian distance between each data point and then these points are deleted from population. Juntao Wang and Xiao log [10] discussed about an improved version of k-means clustering algorithm to deal with the problem of outlier detection of existing k-means algorithm. The proposed algorithm usages noise information filter to the deal with this issue [11]. Density based outlier detection method is applied to the data to be clustered so as to remove the outliers [12]. The motive of this method is that the outliers may not be engaged in computation of initial cluster centers.

3 Proposed Work

The proposed work show that the number of clusters formed in the graph displays the crime count yearwise in all the cities. The proposed algorithm is applied fuzzy k-means of the crime data which leads to cluster formation in a better way. The crime detection being an important aspect needs to be taken seriously. The main motive of providing this proposed is to highlight the use of clustering technique on real-world based dataset which is based on crime. The database contains crime type, location, city, crime id and few more columns. The database seems like this: (Fig. 1).

A flowchart representation has been shown below here for the proposed work (Fig. 2).

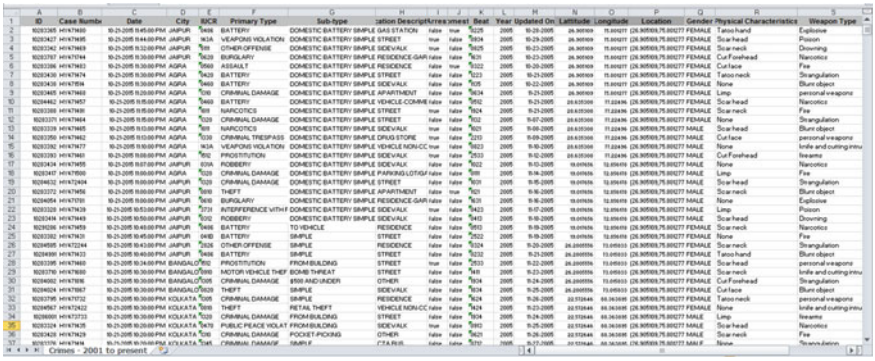

Fig. 1 Crime dataset

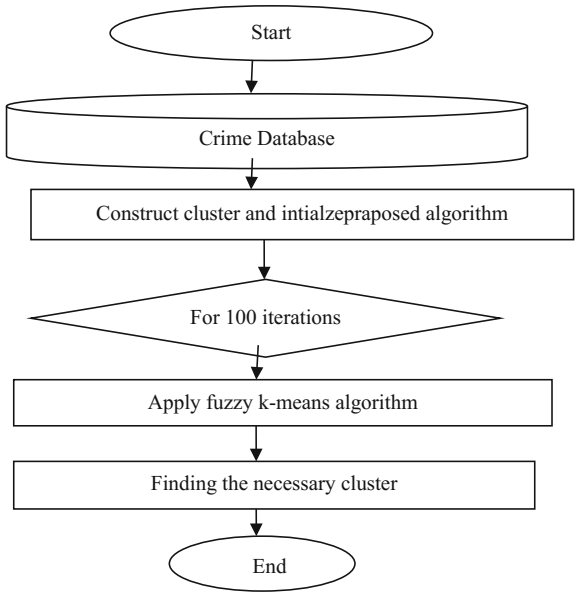

Fig. 2 Flowchart of proposed algorithm

Proposed Algorithm Pseudocode:
Pseudo_ Yf_FKMC1 (X, c, options, init_V)

1. Define maximum iterations max_it = 100;
   termination threshold = 1.0e+03*;
   initial_velocity = 0.
2. Define n: Number of feature vectors
   p: Length of each feature vector
3. if use_init_V,
   V = init_V;
   else
   V = Yf_FKMC1_InitV (c, p); % Initial cluster centers
   end
4. for i = 1:max_iter,
   [V, U, E(i)] = Yf_FKMC1_Step (X, V, c, m);
   Show iteration count & termination measure value. End.

Pseudo_ Yf_FKMC1_InitV(c, p)
Generate initial cluster centers for FKM clustering using formula:
V = rand(c, p)
Pseudo_Yf_FKMC1_Step(X, V, c, m)

1. Initialize n = size (X, 1)
   p = size (X, 2), where, X is the input data of the crime
2. Distance calculation using Euclidean distance formula
   dist = Yf_EuDistArrayOfVectors1 (V, X)
3. Now calculating the new membership degrees using a variable temp.
   tmp = dist.^(−2/(m−1))
   U = tmp./(ones(c, 1)*sum(tmp))
4. Check constraint by checking
   tmp = ((sum (U)−ones (1, n)) > 0.0001)
5. Update V, mf, and E
   mf = U.^m % MF matrix after exponential modification
   V = mf * X./((ones(p, 1) * sum(mf′))′) % new center
   E = norm (V−V_old, 1)
6. End.

4 Result Analysis

The results show various factors and results:

1. Cluster formation in the base: these are the crime counts on an overall basis. The x-axis shows the year and y-axis shows the total number of crimes (Fig. 3).
2. Termination measure: this can be defined as the value of the termination measure that goes along with the number of iterations. The value denotes the

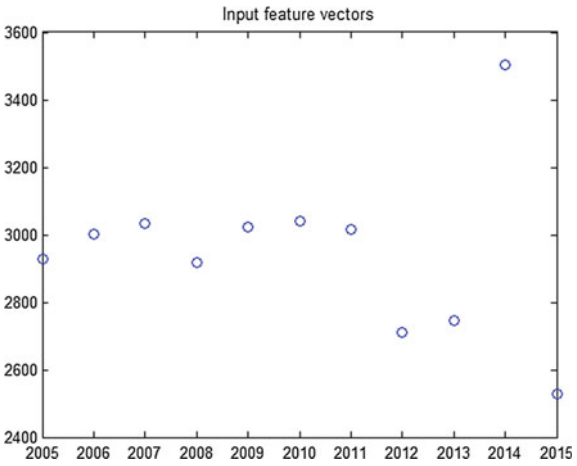

Fig. 3 Crime count yearwise

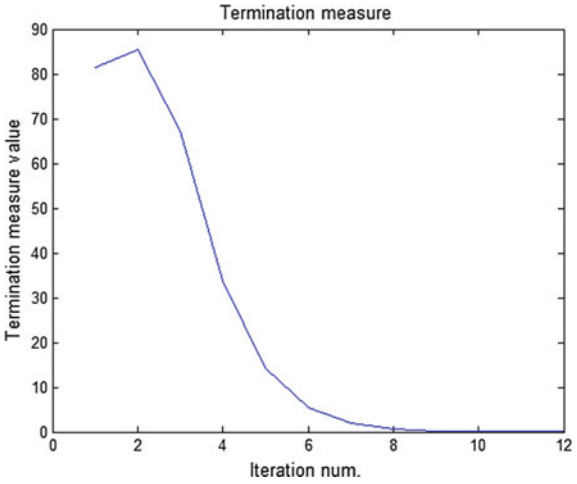

Fig. 4 Termination measure

termination of the proposed algorithm. The termination value is set initially and the algorithm is terminated when its value reaches a very less point. The termination value taken in proposed algorithm is 1.0e + 03* (Figs. 3 and 4).

3. Membership function: membership function is used in fuzzy as the degree of truth and evaluation of extension of the outcomes. The figure shows the membership values for both base and proposed respectively. From the figure it can be derived as the fact that membership value for proposed is better than previous values (Fig. 5).
4. Cluster formation: Number of clusters defined = 2. The clusters formed are shown in the Fig. 6.

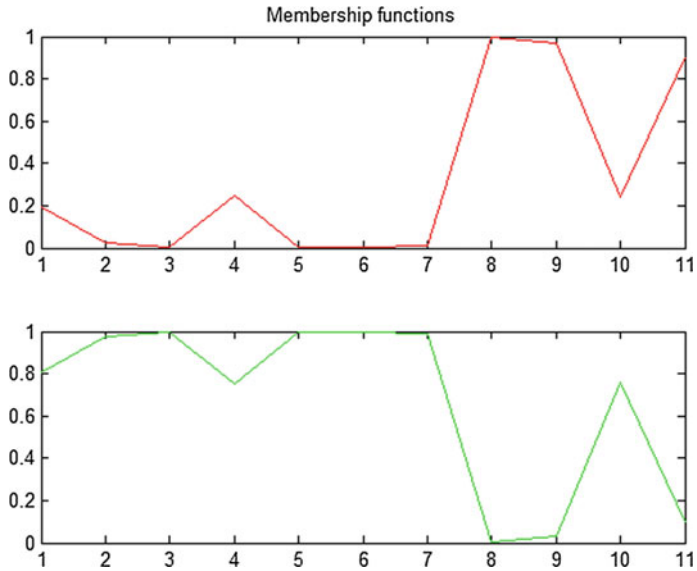

Fig. 5 Membership function

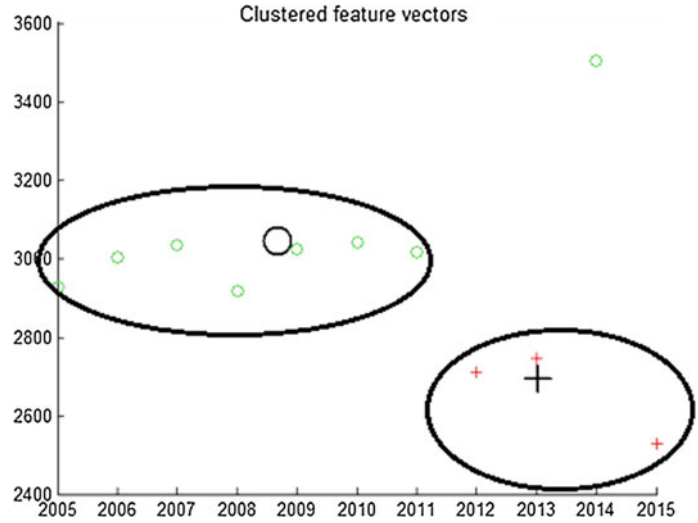

Fig. 6 Clustered feature vectors

4.1 Results of FKMC

The results are generated in iterative manner which are shown below in tabular form:

Iteration	Termination measure value
1	81.444251
2	85.274352
3	67.243550
4	33.692983
5	14.442164
6	5.292763
7	1.842184
8	0.629867

4.2 Comparison Results

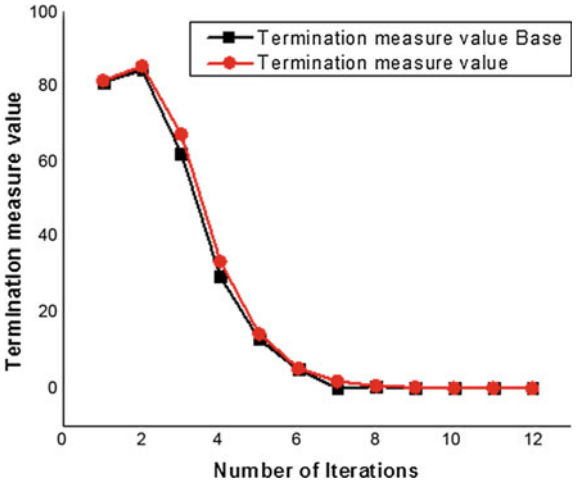

Fig. 7 Termination measure value graph

5 Conclusion

Crime detection plays a vital role in our lives for the reason that of the increasing rate of the crime happening in every area of the country. The crime is also of various types which has made it complex further. The government is not able to find a proper way out towards the removal of the crime and have better control over it. The proposed works above is a step ahead in this field. A further work needs also to be done so as to detect the category of crime, crime count, citywise distribution, increasing rate, etc. The various factors which affect crime rate are discussed.

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