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A Study on the Application of Fuzzy Clustering Analysis in Juvenile Delinquency Prevention

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Abstract: In recent years, the application of data mining technology in juvenile delinquency prevention has been receiving growing attention. The clustering algorithm of machine learning can divide data into many clusters according to grouping targets and its main purpose is to find several similar clusters among the data. The fuzzy clustering analysis method has excellent performance in clustering distribution rate. This study applies the Fuzzy C-means (FCM) analysis to group the data and determine appropriate major characteristics to enhance the fuzzy clustering analysis method in terms of juvenile delinquency discriminant rules and prevention.

Key words: Fuzzy clustering analysis, fuzzy c-means, juvenile delinquency

INTRODUCTION

In recent years, due to the development of economy, the urbanization of the population, the change in family and social structures and value system conflict, juvenile delinquency tends to become increasingly serious. In addition to increasing numbers of crimes, the means and nature of the crimes also become increasingly worse, giving rise to deep concerns of governments and the public of various countries. Today's juvenile delinquents may be adult criminals in the future. On one hand, who cannot bear the new generation falling into the abyss of crime, as they are not mentally mature. Without timely preventive measures, it may pose an even greater risk to society. According to the official crime statistics in Taiwan, in the recent 10 years, juvenile delinquency has been marked with the following trends and phenomena, increase in number, more violent, more generalized, increase in female juvenile delinquents and juvenile delinquents charged with theft are most in number. The research data of this study were collected from the juvenile delinquency database of Taiping District, Taichung City. In recent years, the industry and commerce of Taiping District has been growing rapidly and industrial employees account for 43% of the total employees of the district. The establishment of the

Taiping Industrial District has attracted many small and large factories, making it an important area of Taichung City for its flourishing manufacturing industry. The population of the district has been growing since 1996. The population has grown from 172,965 in 2010 to 174,284 in 2011, with the population growth rate around 0.76%. The criminal cases dropped from the 1426 in 2010 to 1130 in 2011, suggesting a state of stabilized security in the district. According to the 2011 data, the population under 19 years old in the district is 40745, accounting for about 23.38% of the total population. The population aged under 49 is 127,875, accounting for about 73.37% of the total population. And the population with educational levels below high school and vocational school is about 97,357, accounting for 55.86% of the total population. This suggests that the demographic structure of the district tends to become younger while the average education level is relatively lower. On the other hand, the number of juvenile delinquency cases in 2010 was only 10 which sharply grew to 35 cases in 2011 with the growth rate being about 55.6%. This study applies a lustering algorithm for data mining to explore the qualitative variables of the victims of such cases, including "gender", "residence", "age" and "educational level" to analyze and summarize the trends and tendencies of juvenile delinquency of the area, according to different clustering

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results, to provide a reference to police and other relevant authorities in the prevention of such crimes and effectively reduce the occurrence of such cases.

At present, due to the rapid development of information technology, information reception is fast and in large amounts. When using computer technology for automatic analysis of data, much useful information is hidden within the large amount of data. How to effectively extract such information is a topic worth exploring. In recent years, due to the progress in data mining technology, it can find hidden useful information in a database through computer analysis and thereby, determine meaningful relationships and rules. There are numerous clustering analysis technologies for data mining, such as the commonly used K-means (Delibasic *et al.*, 2012) and Fuzzy C-means.

This study uses the fuzzy clustering analysis method in the prevention of juvenile delinquency. The fuzzy clustering analysis method (Fuzzy C-means) clusters data according to qualitative relevance in order to enhance the discriminate rate of different qualitative data by crime clusters (Krinidis and Krinidis, 2012). The adjustment of the number of clusters can have an extremely important impact on the clustering analysis results. The main purpose of this study is to select the major crime qualitative attributes and apply cluster analysis to compare the clustering effects of juvenile delinquencies between different variables and provide a basis for reference in juvenile delinquency prevention (Montgomery *et al.*, 2011; Bosse *et al.*, 2009).

LITERATURE REVIEW

The major research method of this study is to apply clustering analysis to understand the distribution of juvenile delinquency data. Clustering is conducted according to the similarity level of characteristics. Data of higher degrees of homogeneity are clustered, where the greater the inter-cluster heterogeneity, the better. The major field of application is the clustering of the data of similar quality for excessive data amounts, or under certain targets, before analysis of clustering results. Moreover, as samples of the cluster are highly similar, it is more appropriate for use as the basis of judgment.

JUVENILE DELINQUENCY

Many scholars, including Sander *et al.* (2012), have studied the impact of juvenile delinquency on academics using the meta-analysis method. After reviewing more than 250 reports and based on various settings of independent samples, including schools, communities and juvenile jurisdiction, with samples of heterogeneity and generally weak research designs, under the control

conditions of many collected reports, the active impact of academic juvenile delinquency preventive measures is quite limited. The lack of a driving theory or experience to support academic intervention is significant.

School is an important place for the socialization of teenagers. Healthy schooling can make up for, or correct, the impact of bad family influences. However, deficiencies and lack of education may also have an adverse impact on the socialization of teenagers and the formation of the criminal mind. Some schools emphasize intellectual development while neglecting moral and ethnic cultivation and such culture is often simple, outdated, lacking in real content, divorced from reality or unattractive. Some schools excessively emphasize the importance of academic achievements and classify their students according to their academic performance which may greatly dampen their self-esteem and hinder their initiative and confidence. Therefore, some students may feel exhausted regarding education and choose to drop out to join bad social groups and engage in criminal activities (Peiying, 2011). In addition, during the course of their intellectual development, they have not received sufficient ethical guidance and training and cannot assume a correct attitude towards life and society, resulting in committing crimes.

Regarding the analysis of youth and children data from 2004 to 2008; Kong and Lim (2012) suggested that the number of cyber juvenile delinquencies have rapidly increased and tend to rise in level with the peak occurring in the second year in junior high school students (15 years old). In addition, analysis of the changes in interception and proportion has confirmed the differences in the impact of individual experience of cyber crimes.

CLUSTERING ANALYSIS

The general methods can be divided into hierarchical and non-hierarchical clustering analysis. The common clustering algorithms include K-means, Fuzzy C-means, Global Fuzzy C-means (G-FCM) and the fuzzy subtractive clustering method (Heo and Gader, 2010). The K-means of non-hierarchical clustering analysis is the most commonly used in application and teaching. This clustering method is a type of hard clustering; however, in applications of actual cases, the problem of overlapping results may occur. Hence, this study introduces the concept of the fuzzy theory for fuzzy clustering to overcome the overlapping problem.

The major usage of the method is to divide a large amount of data into a few major categories using the concept of dual logic, such as general cluster methods. Regarding the fuzzy principles, Professor L.A. Zadeh of UC Berkeley was to the first to propose the fuzzy theory which accepts fuzziness by avoiding the traditional logic

of 0 and 1. Through the extension of the fuzzy set theory, the membership function is not restricted by 0 or 1, but the value is in the range of 0 to 1 in order to obtain the membership degree of the characteristics of the data under assessment while determining the assessment results by the fuzzy multi-criteria decision-making method (Sahu *et al.*, 2012).

The given initial clustering center of the FCM algorithm has great impact on the number of iterations. By identifying the major axis, the data can achieve the maximum variance along the axis and obtain a few points on the axis at equivalent intervals to acquire the various initial cluster centers of lowest correlation to improve clustering quality and calculation speed.

RESEARCH METHOD

According to the "Taiwan Criminal Cases Statistics", as published by the Bureau of Criminal Police, the Ministry of Internal Affairs of Taiwan, the term juvenile delinquents refer to criminals under the age of 18; the concept of youth crime is defined in the "Crime Statues and Analysis", as published by the Ministry of Justice and the relevant definitions relating to the violation of criminal law by youths is summarized, as shown in Table 1.

This study first introduces Fuzzy C-means (FCM) by explaining the formula structure and functions.

FUZZY C-MEANS CLUSTERING METHOD

Fuzzy C-means is a clustering method derived from the K-means algorithm, as proposal by Bezdek in 1973, to enhance the clustering results through the fuzzy logic concept (Wu, 2012). It is mainly to minimize the target equation in order to obtain the clustering results. The target equation is as shown in Eq. 1:

$$Cm = \sum_{i=1}^{c} \sum_{j=1}^{k} a_{ij}^{m} \left\| x_i - v_j \right\|^2 \tag{1}$$

where, Cm is the target function, c is the number of clusters, k is the total characteristics, a_{ij} is the membership value of the No. i cluster of No. j pixel, m is fuzzy degree which is set as 2 in most cases, x_{ij} is No. j Eigen value, v_i is the cluster central value of No. i cluster and $\|\bullet\|$ is Euclidean distance computation.

In addition, the restraint equation (Wang *et al.*, 2012) is as shown in Eq. 2:

$$\begin{cases} 0 \le a_{ij} \le 1, \forall i,j \\ \sum_{i=1}^{c} a_{ij} = 1, \forall i \\ 0 \le \sum_{j=1}^{k} a_{ij} = k, \forall j \end{cases} \tag{2}$$

Cluster center v_i is obtained by the a_{ij}:

$$a_{ij} = \left[\sum_{t=1}^{c} \left(\frac{\left\| x_j - v_i \right\|}{\left\| x_j - v_t \right\|} \right)^{\frac{2}{m-1}} \right]^{-1}, 1 \le i \le c, 1 \le j \le k \tag{3}$$

$$v_i = \frac{\sum_{j=1}^{k} a_{ij}^{m} x_j}{\sum_{j=1}^{k} a_{ij}^{m}}, 1 \le i \le c \tag{4}$$

EMPIRICAL DISCUSSION AND ANALYSIS

Data set: Case study section, first introduced the research object Taichung City Government Police Department Pacific Branch 100 annual juvenile delinquency; followed by the experimental results of this study, to discuss the proposed experimental procedure.

During the empirical study, the data were collected from the juvenile delinquency database of the Taiping Branch of Taichung Police Bureau. After the elimination of omission values, there were a total of 62 samples, with 10 characteristic variables, including (gender, age, vocation, case date, residence, educational level, economic conditions, crime type, crime tool and criminal history), with the basic data summarized, as shown in Table 2.

This study uses MATLAB software to set the parameters of Fuzzy C-means (FCM) and nine characteristic variables (gender, age, vocation, case date, residence, educational level, economic conditions and crime type) for the clustering of 2,3,4 clusters for comparative research, as shown in Table 3.

Table 1: Definitions of youth and juvenile by age

South	Definition of Youth and Juvenile
Taiwan criminal cases statistics	Criminals under the age of 18
Juvenile case handling act	Minors aged between 12 and 18
Junior welfare law	Minors aged between 12 and 18
Crime status and analysis	Adults aged between 18 and 24

Table 2: Juvenile delinquency database attributes

Data set characteristics	Multivariate
Attribute characteristics	Crime, integer, real
Associated tasks	Clustering
Area	Police
No. of instances	62
No. of attributes	10

Table 3: Clustering analysis parameters

No. of clusters	2, 3, 4, 5
No. of variables	9
Learning function	Fcm (database, cluster numbers)
Clustering analysis (type)	Fuzzy C-means

A CASE STUDY

This study collected the juvenile delinquency data from the Taiping Branch of the Taichung Police Bureau for clustering analysis by age vs. educational level, gender VS educational level and gender vs. residence. The results are summarized, as below:

Clustering by age and educational level: The clustering results of three clusters (k = 3) are as shown in Table 4 and Fig. 1:

- There are eleven people aged 48 years old and above, including 7 females and 4 males, With the exception of three people aged below 59, the remaining are aged above 60 years old. By vocation, 8 people are housekeepers or jobless. By educational level, 6 people are below junior high (including incompletion). This cluster is characterized by older in age, lower educational level, weak in physical strength and most of the members are jobless or involved in housekeeping activities with few opportunities of social interaction. By crime type of juvenile delinquency, theft (4 cases) and fraud (5 cases) are the most. When using the K-MEANS for clustering (Fig. 2, Table 5), the only difference is that a female aged 41 years old is assigned to the same cluster and the victim style is theft and lower educational level which clearly shows that this cluster is mainly characterized by older age

- There are sixteen people, aged between 13 to 14 years old, including 7 females and 9 males; 5 are aged under 19 and one is age 41, the remaining are aged in the range of 20 to 40 years old. By identity, it includes 5 students, 4 in the service industry and three laborers. By educational level, there are 10 people with high school (including vocational school, students in study and students of incompletion). Most members of the group are youth in employment with physical strength and frequent social interactions, as well as growing mentality mature. The crime types of juvenile delinquency include theft (7 cases), fraud (4 cases) and injury (2 cases). A 41-year-old female who is originally in the second cluster in FCM is assigned to the first cluster due to the K-MEANS clustering, but theft is still taken as the main crime type in the second cluster

- There are thirteen people aged between 11 to 25 years old, including 6 females and 7 males. By identity, it includes 10 students. By educational level, all 13 people have high school (including vocational school, students in study and students of incompletion). Most of the members of this group
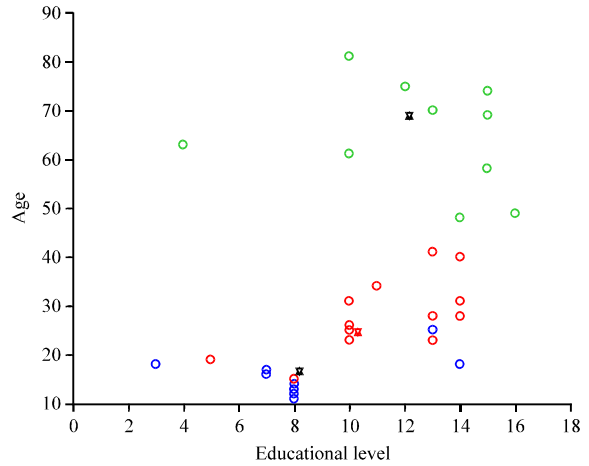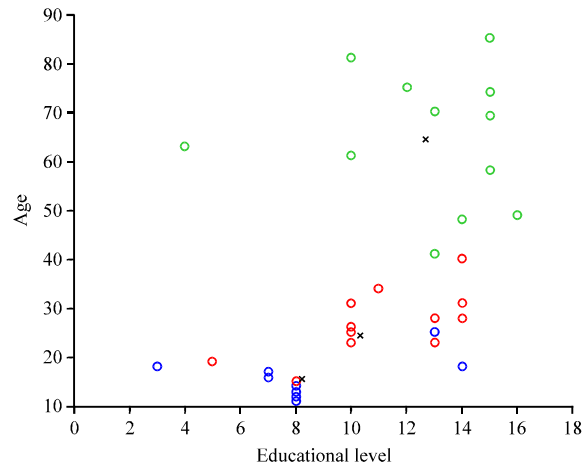

Fig. 1: Clustering results by educational level vs. age

Fig. 2: Clustering results by educational level vs. age

Table 4: FCM clustering results by educational level and age

| | No. of clusters | | |
Characteristics	1	2	3
Age	68.8093	24.7186	16.4804
Educational level	12.1802	10.3269	8.2032
No. of samples	11.0000	16.0000	13.0000

Table 5: K-MEANS clustering results by educational level and age

| | No. of clusters | | |
Characteristics	1	2	3
Age	64.5000	24.3333	15.5385
Educational level	12.6667	10.3333	8.2308
No. of samples	12.000	15.0000	13.0000

continue to study in school and have more and frequent opportunities to interact with peers. The crime types of juvenile delinquency include intimidation (3 cases) and theft (9 cases). The judgment of K-MEANS in the third cluster is not different from that in FCM

Clustering by gender and educational level: The clustering results of four clusters are as shown in Table 6 and Fig. 3 (k = 4):

- There are ten people, aged between 49 years old and 81 years old, including 7 females and 3 males, with the average age of the three males at 69 years old and above while the females are aged between 49 to 75 years old. With the exception of three aged below 59, the remaining are aged above 60 years old. By vocation, 8 people are housekeepers or jobless, including 5 females and 3 males. By educational level, with the exception of one male and two females which have education above college, the remaining people are below senior high (including incompletion). In this group, the male members are relatively older and the female members are mainly engaged in housekeeping or jobless. By educational level, one male member is above the college level and two are above the senior high school level. Two female members are above the college level while five are below senior high and vocational school level. By educational level, there is no significant difference. The crime types are "fraud" and "theft" for both male and female members. In K-MEANS (Fig. 4, Table 7), a male with the educational level of senior high school is assigned into the first cluster which increases the complexity within the cluster and also the proportion of theft

- There are nine people, including 5 females and 4 males, aged between 17 and 48; by identity, there are two females and males in the service industry, two females and one male engaged in business and one male and female student; by educational level, there are two females and male members above the college level (including members in the study), three female members and two male members with educational levels above senior high and vocational high school (including members in the study). The

crime types of the female and male members are concentrated in "fraud" and "theft" cases. In the second cluster, the misjudgment degree of K-MEANS is much higher than that of FCM. Expect that those with lower educational level are in the same cluster, the crime type and gender ratio are not concentrated and the clustering result is confusing

- There are ten people aged between 13 years old and 40 years old, including three female members aged 20 years old and above and four male members aged below 20 years old. By identity, there are four male students and three male workers; by educational level, three female members are above senior high and vocational high levels, three of the male members are above the senior high and vocational high school level (including members in the study) and three male members are at the junior high level (including
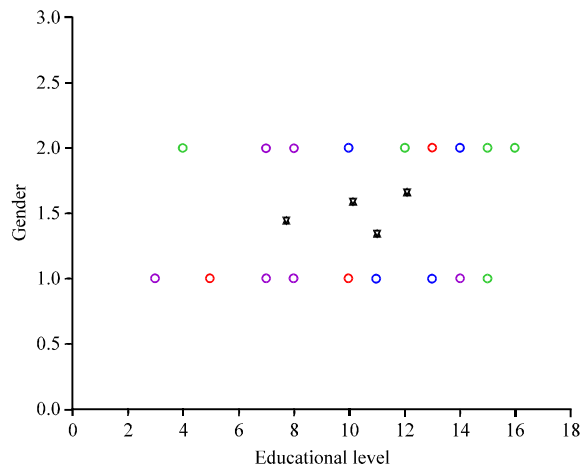

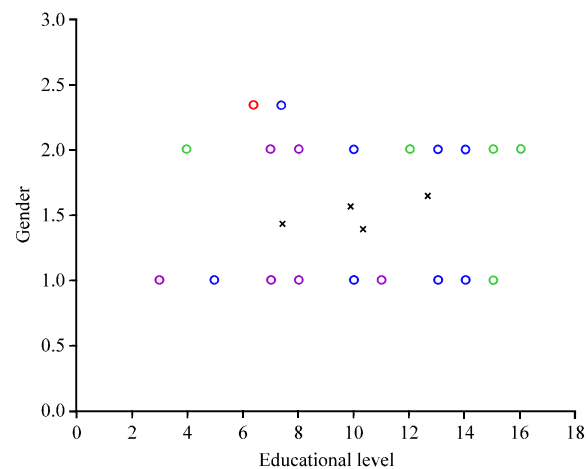Fig. 3: Clustering educational level vs. gender

Fig. 4: Clustering educational level vs. gender

Table 6: FCM clustering results by educational level vs. gender

Characteristics	No. of clusters			
	1	2	3	4
Gender	1.6554	1.5821	1.3346	1.4300
Educational level	12.0903	10.1700	11.0255	7.7517
No. of samples	10.0000	9.0000	10.0000	11.0000

Table 7: K-MEANS clustering results by educational level vs. gender

Characteristics	No. of clusters			
	1	2	3	4
Gender	1.6364	1.5556	1.3846	1.4286
Educational level	12.6364	9.8889	10.3077	7.4286
No. of samples	11	9.0000	13.0000	7.0000

Table 8: FCM clustering results of residence vs. gender

Characteristics	No. of clusters	
	1	2
Gender	1.6649	1.4281
Residence	23.9149	15.3071
No. of samples	12.0000	28.0000

Table 9: K-MEANS clustering results of residence vs. gender

Characteristics	No. of clusters	
	1	2
Gender	1.6364	1.4483
Residence	24.1818	15.7931
Number of samples	11.0000	29.0000

members in the study). The age and educational level of male members are relatively lower. The crime types of the male and female workers are concentrated in "theft" cases. The third cluster allows the gender ratio to become more average and increases the situation of three female victims, so that, K-MEANS is divided into four clusters with poor effect

- There are eleven people aged between 11 to 18 years old, including 5 female members and 6 male members. The average age of the members is below 18; by identity, there are nine students, including 5 male and 4 female students; by educational level, the five female members are all involved in study, including one in senior high school (vocational school) and four in senior high school. Two male members are in senior high school (including vocational school, students in study and students of incompletion) and four students are in junior high (including students in study and students of incompletion). The age of this group is apparently lower, with educational levels concentrated in senior high school. The female crime type is "theft" while for male members, in addition to "theft" cases, the number of "intimidation" cases increased significantly. Similar to the first two clusters, the gender ratio and average do not achieve the desired clustering effect and the educational level is more decentralized, allowing the center point to be lower which is not ideal

Clustering by gender and residence: The clustering results of two clusters (k = 2) are as shown in Table 8 and Fig. 5:

- There are twelve people, aged between 11 to 85 years old, including 8 females and four males. The youngest male member is 48 years old and the oldest male member is 85 years old, the youngest female member is 49 years old and the oldest female member is 75 years old; by identity, 8 members are housekeepers or jobless, including five female
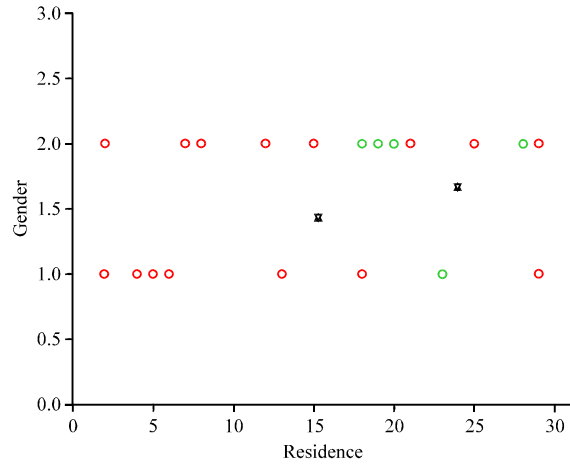

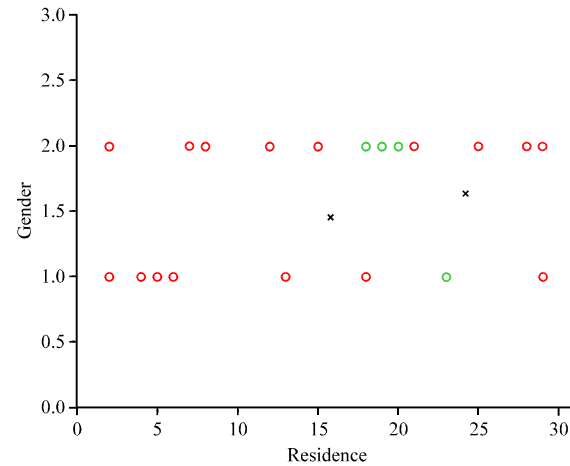Fig. 5: Clustering results of residence vs. gender

Fig. 6: Clustering results of residence vs. gender

members and three male members. By economic conditions, with the exception of one male and one female of "exemption", the remaining are "well-off"; by residence, with the exception of two female members living in the "Yicang Li" area of Taiping District, three females and two males live outside the Taiping District. The crime types of the male and female members are "fraud" and "theft" cases. In the K-MEANS clustering (Fig. 6, Table 9), the 34th female victim with the crime type of theft is assigned into the second cluster. According to this clustering method, the majority of crime types of female members are "fraud"

- There are twenty eight people aged between 11 to 40 years old, including 12 females and 16 males. The youngest male member is aged 13 while the oldest male member is 34. The youngest female is aged 13 and the oldest is aged 40 years old. By identity, there

are 15 students, including 5 of the 9 male students and 4 of the 6 female students, studying in junior high school. By economic conditions, with the exception of two male members of "exemption" and one male member of "poor", the remaining are "well-off";By residence, eight people, including four males and four females do not live in the Taiping Area, the remaining male members live in the "Yongcheng Li", "Toubian Li" and "Xingping Li" areas of the Taiping area; while most of the female members live in "Taiping Li", in the Taiping area. The majority of crime types of the male and female members are "fraud" and "theft" cases while the cases of "intimidation" by male members apparently increased. In the K-MEANS clustering, the cases in the "Yichang Li" area are misjudged in the two clusters, so that the effect is not obvious

Clustering by age and residence: The clustering results of three clusters (k = 3) are as shown in Table 10 and Fig. 7:

- There are eleven people aged 49 years old and above, including 7 females and 4 males. With the exception of three female and two male members living in the Taiping area, aged between 61 to 85 years old. The crime types of members living outside the Taiping area are concentrated on fraud" cases. Similar to the first clustering, the older members are judged as the same cluster which is more accurate than the third clustering that correctly judges the members living in the same area as the same cluster. (Fig. 8, Table 11)
- There are sixteen people aged between 13 to 41, including 7 female and 9 male members. With the exception of three female and two male members living outside the Taiping area, the average age is 23 years old and above for the female members and the average age of the male members is between 19 to 26 years old; most of the male members live in "Hsingping Li" of the Taiping area; most the crimes are "theft" cases for male members living in the Taiping area. The crime type of members living outside the Taiping area is "fraud". In K-MEANS, older members are assigned into the first cluster which is a more accurate method
- There are thirteen people aged between 11 to 25 years old, including 6 female and 7 male members. One female and two male members live in the Taiping area, aged between 17 to 25 years old. For female and male members living in the Taiping area, the crime
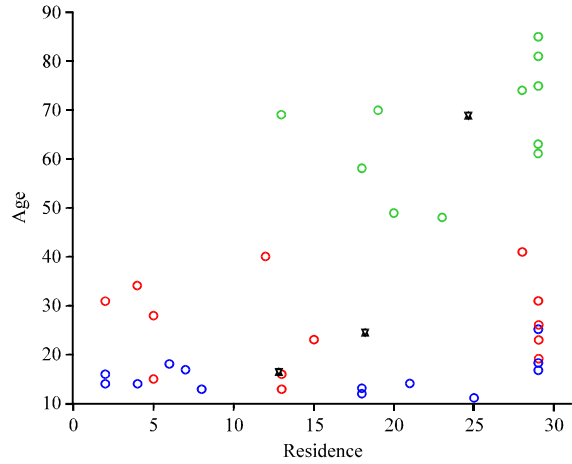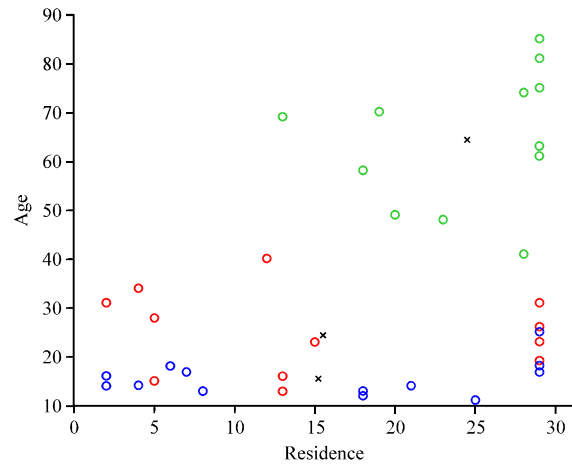

Fig. 7: Clustering results of residence vs. age

Fig. 8: Clustering results of residence vs. age

Table 10: FCM clustering results of residence vs. age

Characteristics	No. of clusters		
	1	2	3
Age	68.8093	24.7186	16.4804
Residence	24.6289	18.1953	12.8623
No. of samples	11.0000	16.0000	13.0000

Table 11: K-MEANS clustering results of residence vs. age

Characteristics	No. of clusters		
	1	2	3
Age	64.5000	24.3333	15.5385
Residence	24.5000	15.4667	15.2308
No. of samples	12.0000	15.0000	13.000

type is mainly of "intimidation" in "Changyi Li" (2 male members) and "theft" in "Taiping Li" (1 male and 1 female member). In the third cluster, K-MEANS clustering is not different from FCM clustering

CONCLUSION

According to the experimental clustering comparison results, the major crime types of juvenile delinquency in the Taiping area are mainly "theft" and "fraud". However, "intimidation" cases against males tend to increase, posing a topic of concern to local police authorities. Moreover, whether it is related to local characteristics, including the continuous growth in the population of people aged below 39, accounting for 57.4% of the total population, more males than females, people with the educational levels below senior high (vocational high), accounting for 51.91% of the total, should be carefully considered by police authorities. Hence, by taking comprehensive crime victim protection measures, the policy can effectively ensure the life, liberty and property of the people living in the area.

The overall comparison of K-MEANS and FCM showed that according to the data of juvenile delinquency, the effect of clustering into two clusters and that into three clusters is slightly different, but when clustering into four clusters, K-MEANS has significantly increased ratio of misjudgment. In the third clustering, three out of four clusters have the problem of feature misjudgment, so that, the features that are originally expected to be more prominent become more average because of K-MEANS, resulting in problems within the cluster. Another feature is that the clusters are more decentralized by K-MEANS, as compared with FCM and it is unreasonable to cluster into four clusters. As a result, this study is more suitable to achieve better clustering results with FCM as the analysis for juvenile delinquency. This study uses FCM to identify the clustering results in order to improve accuracy in determining crimes. Moreover, from the juvenile delinquency database experiment, we can find the causes of juvenile delinquency in order to enhance prevention operational effectiveness (Zhu *et al.*, 2012). In the future, it will become more easy to evaluate accuracy and facilitate adjustments for the prevention of juvenile delinquency.

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