An Integrated Framework Of Decision Support System In Crime Prevention

Noor Maizura Mohamad Noor [a,1], Astari Retnowardhani[b]
[a,b]*School of Informatics and Applied Mathematics*
Universiti Malaysia Terengganu (UMT)
Terengganu, Malaysia

Abstract. Crime prevention is the initiation and attempting to reduce, deter or remove crime and criminals. It includes the anticipation, recognition, and appraisal of making the right decision in crime risk. The decision support system (DSS) framework for decision making process has been developed to assist the decision makers. This research work is one of the efforts in crime prevention. The proposed framework contains of the decision making process based on crime forecasting interval range results. The Fuzzy alpha cut (FAC) and fuzzy inference system (FIS) are used in our proposed DSS framework. The use of expert system in the framework becomes a major discussion in this study. The aims are to enhance the interval range of crime forecasting and to improve the capabilities of DSS in terms of improving the decision making process and selecting the right action for crime prevention.

Keywords. DSS framework, expert system, decision making, fuzzy inference system, and crime prevention

Introduction

The pace of urbanization is rapidly increasing all over the world in recent decades. Crime, in truth, is one of the biggest problems in many countries around the world. Crime prevention is one of the important component of an overall strategy to reduce crime and to streghten public security. There is a wide range of studies on the efforts to improve the effectiveness of crime prevention, covering from developmental prevention, situational prevention and community preventions [1; 2; 3; 4; 5]. Crime prevention is now one of the most important global issues, along with the great concern of strengthening public security. Government and community officials are making an all-out effort to improve the effectiveness of crime prevention. Numerous investigations addressing this problem have generally employed disciplines of behavior science, statistics and computer science.

Discussion of crime forecasting for crime prevention has been done by several researchers [1; 2; 3; 4; 5]. Crime forecasting useful for supporting the tactical deployment of police resources [6]. The tactical decision making by police such as police duty deployment in the right situation and area. For example, in making the right decision in order to create a schedule and determine the number of police for duty, therefore the right crime forecasting value and right decision method are needed.

[1] Corresponding Author: Noor Maizura Mohamad Noor is currently a researcher and an associate professor in the School of Informatics and Applied Mathematics, Universiti Malaysia Terengganu.

However, the crime forecasting results usually used for crime mapping.

Currently, lack of researches done in the used of forecasting results in the selection decision process for crime prevention. In this article we discuss the decision support system (DSS) framework for decision making process used crime forecasting results. Integrating expert system (ES) with a DSS framework can improve the DSS capabilities.

In addition, the integrated techniques of fuzzy alpha cut (FAC) and fuzzy inference system (FIS) have been employed in the proposed DSS framework.

The rest of the paper is organized as follows: Section 1 and section 2 give the overview of the DSS and ES. Section 3, briefly discusses FIS. Section 4, illustrates the framework and Section 5, highlights several discussions and conclusions.

1. Decision Support System

The objective of decision support system (DSS) is to support the human being who makes decisions. The DSS must be designed to communicate its information to its user in a manner that is readily understood and useful within the context of the decision situation [7]. The computer technology assists to improve the DSS process. A DSS is defined as they used by the computer to :[8]

(a) Assist managers with their decision process in semi structured tasks;
(b) To support, rather than replace managerial judgment; and
(c) To improve the effectiveness of decision making rather than its efficiency.

The definition of framework by Sprague [9] is helpful in organizing a complex subject, identifying the relationship between the parts, and revealing the areas in which further developments will be required.

Several of DSS framework have been proposed in many areas, such as in agriculture by [10] which is involved social-economical, geographic information system (GIS), and expert system, human resource (HR) management by [11]. Those applications embedded HR Intelligent DSS framework using hybrid between knowledge-based system and machine learning approaches, hazardous materials risk management decisions by [12] which is included a number mathematical models and empirical rules in conjunction with the capabilities provided by database systems and GIS technologies. The application of e-government by [13] which proposes the integration between e-government framework with DSS framework, and crime prevention by [14] which is used fuzzy logic in their DSS framework. Integration of expert systems (ES) into DSS become trending research in this decade, the ultimate aims are to enhance the decision making process. This integration could improve the DSS capabilities.

2. Expert System in Decision Support System

The integration of the DSS with Expert System (ES) framework could improve the DSS capabilities. Turban explained in [15]. Four basic components of the DSS are: a database, a model base, an interface and a user. Addition of ES can be performed on each component. The used of ES in DSS as like Artificial Neural Network (ANN) for weather forecasting by [16] and fuzzy logic for human resource appraisal and selection by [17]. One of DSS framework with ES for crime prevention has been presented by

Li, et.al. [14]. Fuzzy logic is included in their framework, more details they used fuzzy self organizing map network (FSOM) to detect and analyze crime trend patterns to uncover hidden causal effect knowledge and reveal the shift around effect.

In this study, we get the information about crime detail, as like series data on 10 years of amount crime index for each crime type, the knowledge about kinds of crime prevention are made for each crime type, from experts in the police department.

We suggest adding the ES in our proposed DSS framework for crime prevention like the use of fuzzy alpha cut (FAC) integrate with an ARIMA model for crime forecasting process, and the user of fuzzy inference system (FIS) in the decision making process for selecting the right decision based on crime forecasting data. The integration of selection decision techniques in FIS, FSOM and rule extraction is to discover the crime patterns and visualization, which will provide the information for the police management to determine the accuracy of decisions taken. Then, it will directly support the crime prevention. Meanwhile, the discussion of the integration FAC with ARIMA model we have written in [18]. The detail information from the expert is included in the decision process, to get the appropriate crime prevention in every level of crime incident. It will provide the information for the police management to determine the accuracy of decisions taken. Then, it will directly support the crime prevention. The results can support police in assessing more appropriate law enforcement strategies, increasing the accuracy of selection decision, as well as improving the use of police duty deployment for crime prevention.

3. **Fuzzy Inference System (FIS)**

The fuzzy IF-THEN rules are expressions in the form of If A Then B, where A and B are labels of fuzzy set characterized by appropriate membership functions [19]. Fuzzy IF-THEN rules form a core part of the fuzzy inference system (FIS) [20].

Fuzzy rule-based system or FIS is a system that is used to manage the relationship between the input and output variables of a system [21]. In general, there are 3 types of FIS, there are Mamdani FIS [22], Sugeno fuzzy model, and Tsukamoto fuzzy model. In this research, FIS is integrated with fuzzy Mamdani, where this model is widely used since due to it is easier to interpret and analyze compared to compared with the others [23]. Basically, a FIS is composed of four functional blocks, as follow [21]:

- A knowledge base, containing a number of fuzzy IF-THEN rules, and the membership functions of the fuzzy sets used in the fuzzy rules (fuzzy set database);
- A decision-making unit that transforms the inference operations on the rules;
- A fuzzification interface, which transforms the crisp inputs into degrees of match with linguistic values;
- A defuzzification interface, which transforms the fuzzy results of the inference into a crisp output.

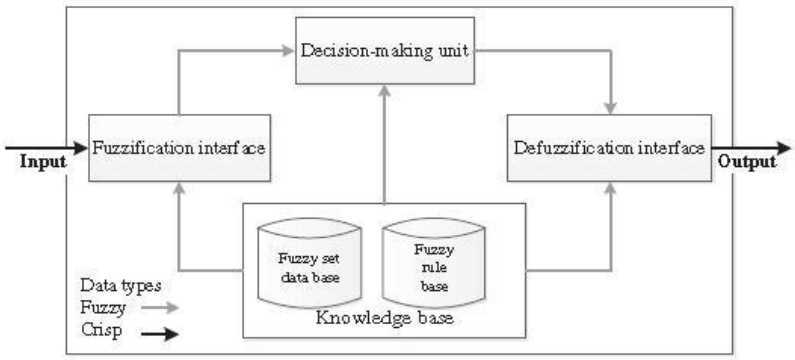

Figure 1 A general scheme of a fuzzy inference system

The Fig. 1 explains that a knowledge base refers to the rule base and fuzzy set database together. The main purpose of the knowledge base is to provide the fuzzy rule base that is needed for the fuzzy processor. The fuzzy rule base contains a set of IF-THEN rules, which is developed by the experiences and knowledge of the experts. The fuzzification interface involves measuring the values of input variables. The decision-making unit (fuzzy inference engine) simulates human decision-making in inferring fuzzy control actions based on the rules of inference in fuzzy logic. The defuzzification interface produces a fuzzy number for output, otherwise decision makers need a crisp number. Therefore, it will be converted the fuzzy output into a crisp output.

The Mamdani method is a type of fuzzy relational model where each rule is represented by an IF-THEN relationship. It is also called a linguistic model because both the antecedent and the consequent are fuzzy propositions [24]. An example of a Mamdani model :

a) Single-input single-output

$$\begin{cases} If\ X\ is\ small\ then\ Y\ is\ small \\ If\ X\ is\ medium\ then\ Y\ is\ medium \\ If\ X\ is\ large\ then\ Y\ is\ large \end{cases}$$

b) Two-input single-output

$$\begin{cases} If\ X\ is\ small\ and\ Y\ is\ small\ then\ Z\ is\ negative\ large \\ If\ X\ is\ small\ and\ Y\ is\ large\ then\ Z\ is\ negative\ small \\ If\ X\ is\ large\ and\ Y\ is\ small\ then\ Z\ is\ positive\ small \\ If\ X\ is\ large\ and\ Y\ is\ large\ then\ Z\ is\ positive\ large \end{cases}$$

4. Integrated Framework of the Crime Prevention Decision Support System

The proposed integrated framework employs the traditional DSS components such as model base, user interface and database. However a typical integrated DSS consists of

five main components which are database, model base, knowledge base, user interface and inference engine. In this study, we used Mamdani FIS technique as an inference component to assist decision making in crime prevention. On the other hand, this framework embedded expert system technique with other DSS component.

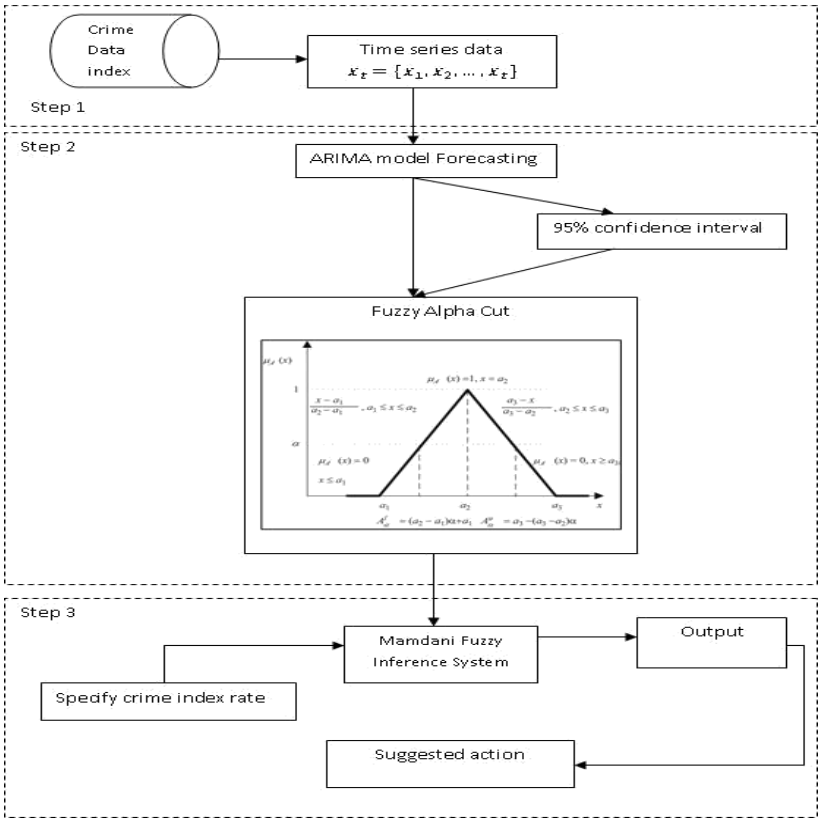

Figure 2 The integrated framework of DSS for decision making for crime prevention

The proposed DSS framework contains three steps as illustrated in Fig. 2:

- The first step is collecting the time series data into crime data index database. We sorted the data by monthly basis based on the type and area of crimes.
- The second step is forecasting process, which is the integration model, ARIMA model with Fuzzy Alpha Cut. It has been discussed in our previous research paper [18]. This process used crime data index from crime index database. The advantages gained from this integration is better crime forecasting interval range. The results are stored in the index crime database.
- The third step is clarifying the decision making process used Mamdani FIS, which is the input for decision derived from previous step. In this step we determined the crime rate index. This determination is purposely to formulate the crime rate limits. Subsequently, with IF-THEN rules of Mamdani FIS, it will then, established whether the crime forecasting interval range data are within the specified crime rate limits. The results obtained will determine the choice of crime prevention decision to be taken by authorities.

5. Discussions and Conclusions

In this research, we proposed DSS framework developed on purpose to assist and enhance the decision making process in crime prevention. In order to improve DSS framework we added the ES in step 2 and step 3. In step 2, the forecasting process, we integrate FAC with ARIMA model to improve the interval range results of crime forecasting. The used of Mamdani FIS in step 3 intends to help decision makers select the right action for crime prevention based on crime rate limits. As an example the value of crime forecasting interval range in the boundary limits, afterward the system will be make a selection decision by IF-THEN rules by Mamdani FIS. The integration FIS techniques are applied to improve decision making performance in attaining optimal results. Mamdani-type inference, as defined for the Fuzzy Logic Toolbox, expects the output membership functions to be fuzzy sets.

As the IF-THEN rules coding example below :

1. Create a range limit

```
Range 1 :

        limit1=min;

        limit11=(min+interval)-1;

Range 2 :

        limit2=limit11+1;

        limit21=limit11+interval;

Range 3 :

        limit3=limit21+1;

        limit31=limit21+interval;
```

2. Using range limit for choosing decision

```
if (forecast>=limit1 AND forecast<=limit11 )
THEN
        Read into database
        Select query
        Print  "Decision based on Forecast : Low level $dec1 "
endif
```

The results and model can support police in assessing more appropriate law enforcement strategies, increasing the accuracy of selection decision, as well as improving the use of police duty deployment for crime prevention. This research in-line with one of the Malaysian government agenda as stated in National Key Result Area (NKRA), which is to reduce crime. The proposed framework is expected to provide an improvement for the police in terms of choosing decisions by using crime forecasting data. Further study is needed to amplify this proposed framework by detecting and analyzing crime trend patterns and visualization of temporal crime activity data.

Acknowledgement

This research work was supported by a Fundamental Research Grant Scheme (FRGS) and Exploratary Research Grant Scheme (ERGS) under the Ministry of Higher Education (MOHE), Malaysia and it is gratefully appreciated.

References

[1] P. Chen, H. Yuan, X. Shu, Forecasting Crime Using the ARIMA Model, in, Fifth International Conference on Fuzzy Systems and Knowledge Discovery, 2008, pp. 627-630.

[2] D. Deadman, Forecasting residential burglary. International Journal of Forecasting 19 (2003) 567-578.

[3] J. Cohen, W.L. Gorr, Development of Crime Forecasting and Mapping Systems for Use by Police, in, H. John Heinz III School of Public Policy and Management , Carnegie Mellon University, 2005.

[4] W. Gorr, A. Olligschlaegerb, Y. Thompson, Short-term forecasting of crime. International Journal of Forecasting 19 (2003) 579–594.

[5] E.R. Groff, N.G.L. Vigne, Forecasting The Future of Predictive Crime Mapping, in: N. Tilley, (Ed.), Analysis for Crime Prevention, Lynne Rienner, 2002, pp. 29-57.

[6] W. Gorr, A. Olligschlaeger, Y. Thompson, Assessment of Crime Forecasting Accuracy for Deployment of Police, in, H. John Heinz III School of Public Policy and Management , Carnegie Mellon University, 2000.

[7] G.M. Marakas, Decision Support System : in the 21st century, Prentice Hall, 1999. [8]R.L. Hayen, Investigating decision support system frameworks. Issues in Information Systems Journal 7 (2006) 9-13.

[9] J.R.H. Sprague, A Framework for the Development of Decision Support System. Management Information Systems Quarterly 4 (1980) 1-26.

[10] A. Agrahari, D.S. Tripathi, A Theoretical Framework for Development of Decision Support System for Agriculture. International Journal of Engineering and Science 1 (2012) 50-55.

[11] H. Jantan, A.R. Hamdan, Z.A. Othman, Intelligent Techniques for Decision Support System in Human Resource Management, in: G. Devlin, (Ed.), Decision Support Systems Advances in, 2010,March, pp. 342.

[12] K.G. Zografos, G.M. Vasilakis, I.M. Giannouli, Methodological framework for developing decision support systems (DSS) for hazardous materials emergency response operations. Journal of Hazardous Materials 71 (2000) 503–521.

[13] A.M. Riad, H.M. El-Bakry, G.H. El-Adl, A Novel DSS Framework for E-government. International Journal of Computer Science Issues 7 (2010) 33-37.

[14] S.-T. Li, S.-C. Kuo, F.-C. Tsai, An intelligent decision-support model using FSOM and rule extraction for crime prevention. Expert Systems with Applications 37 (2010) 7108–7119.

[15] E. Turban, P.R. Watkins, Integrating Expert Systems and Decision Support Systems. MIS Quarterly 10 (1986) 121-136.

[16] S. Viademonte, F. Burstein, An Intelligent Decision Support Model for Aviation Weather Forcasting, in: F. Hoffmann, D. Hand, N. Adams, D. Fisher, G. Guimaraes, (Eds.), Advances in Intelligent Data Analysis, Springer Berlin Heidelberg, 2001, pp. 278-288.

[17] N.A. Ruskova, Decision support system for human resources appraisal and selection, in, Intelligent Systems, 2002. Proceedings. 2002 First International IEEE Symposium, 2002, pp. 354-357 vol.351.

[18] N.M.M. Noor, A. Retnowardhani, M.L. Abd, M.Y.M. Saman, Crime Forecasting using ARIMA Model

and Fuzzy Alpha-cut. Journal of Applied Sciences 13 (2013) 167-172.
[19] L.A. Zadeh, Fuzzy Sets, Information and Control. Vol. 8 (1965) 338-353.
[20] M. Tavana, F. Azizi, F. Azizi, M. Behzadian, A fuzzy inference system with application to player selection and team formation in multi-player sports. Sport Management Review 16 (2013) 97-110.
[21] J. Rezaei, R. Ortt, Supplier segmentation using fuzzy logic. Industrial Marketing Management 42 (2013) 507-517.
[22] E.H. Mamdani, S. Assilian, An Experiment in Linguistic Synthesis with a Fuzzy Logic Controller. International Journal Man-Machine Studies 7 (1975) 1-13.
[23] M. Iphar, R.M. Goktan, An application of fuzzy sets to the Diggability Index Rating Method for surface mine equipment selection. International Journal of Rock Mechanics and Mining Sciences 43 (2006) 253-266.
[24] D.R. Keshwani, D.D. Jones, G.E. Meyer, R.M. Brand, Rule-based Mamdani-type fuzzy modeling of skin permeability. Applied Soft Computing 8 (2008) 285-294.