A Fuzzy Multicriteria Decision-Making Approach to Crime Linkage

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ABSTRACT

This article describes how serial crimes are very interesting for study in the absence of proper and solid evidence. From a high volume of criminal cases of similar types, it is difficult to detect the crimes that were committed by the same offender or not. The process of linking of crimes which were committed by the same offender or offenders is called Crime Linkage Analysis. In this article, a new hesitant fuzzy distance measure has been introduced and a fuzzy multicriteria decision-making approach has been proposed to help Crime Linkage Analysis, which enables us to find to what extent a pair of crime shares a common offender or offenders.

KEYWORDS

Crime Linkage, Fuzzy MCDM, Hesitant Fuzzy Distance Measure, Hesitant Fuzzy Set

1. INTRODUCTION

The objective of crime linkage analysis is to analyze a group of crimes and to find the crimes linked to each other by a common offender or co-offenders. In the presence of sufficient evidence like forensic evidence, DNA or fingerprints or proper digital evidence, the task of linking of crimes becomes nearly certain. But in the absence of such kind of information, the process of linkage analysis becomes a difficult task.

Every person is different from the other in psychological level. During a crime, an offender makes decision consistently for target selection, site selection, time selection etc. The actions of the offender are influenced by his behavior, psychological view, and past experience. For this reason, each and every action of an offender is a reflection of his or her personality. Whatever is the situation there should be some similarities between two crimes committed by the same offender due to the behavior of the offender, called behavioral linkage. An offender may commit two crimes differently if they are presented similar situation, although some basic similarities will be there. There are three basic assumptions for crime linkage analysis (Bennell et al. 2005; Goodwill 2006; Grubin et al. 2001; Woodhams et al. 2007):

1. Although criminal acts differently in different situations, some basic behavioral variables remain consistent in all crimes.
2. As every person is different from each other by personality, there is some distinctiveness of behavior of different criminals.
3. The behavior of criminal can be observed, measured, recorded, and coded.

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The process for crime linkage analysis has the steps of collection and processing of data which includes collection of data from the crime scenes and coding of the physical description of the scene and behavior of the offender (Woodhams, Bull, & Hollin, 2007). For example, location of the scene, timing, used technique, and victim’s characteristics have to be coded in an appropriate way to interpret logically. After coding the crimes, they are compared depending on the behavioral or situational variable.

In practical two crimes were never found to be identical. That is why the terms similarity or distinctiveness between two crimes are itself uncertain. Sometimes proper information is not found at the crime scenes. Therefore, the mathematical interpretation of such kind of information is not certain most of the time and hence fuzzy in nature. In this paper, a fuzzy MCDM approach has been introduced to help crime linkage analysis by linking crimes pairwise from a collection of crimes. The crimes have been represented by hesitant fuzzy set in terms of evidence, as it has the efficiency to cope with the uncertainty that comes into play due to missing information and different pieces of evidence’s different level of interpretation.

Basically there are two approaches in multi-criteria decision making problems (a) multiple attribute decision making (MADM), in which decision has to be taken in discrete space and focused on how to select different alternatives from existing alternatives and (b) multiple objective decision making (MODM) in which decision has to be taken in continuous apace and several objective functions are to be achieved simultaneously. The concept of the fuzzy set theory was first introduced by Zadeh (1965). Then Bellman and Zadeh (1970) and Zimmermann (1978) gave an approach to multi-criteria decision making using fuzzy sets. Yager (1978) illustrated that in fuzzy multi-criteria decision making (FMCDM), the best alternatives have the highest membership grades. Saaty (1980) developed Analytical Hierarchy Process (AHP). Later Saaty (1996) developed Analytical Network Process (ANP). Fan et al. (2002) proposed a new approach to solve the MADM problems. Hawang and Yoon (1981) developed TOPSIS, the technique where similarity is measured to ideal solutions. Liang (1992) presented FMCDM on the basis of an ideal solution and anti-ideal solution. Then Yoong and Hawang (1995) proposed the advance fuzzy TOPSIS procedure. Later due to the flexibility and reliability of the TOPSIS procedure it is developed and used gradually. These are some MADM approaches used for decision making under fuzzy environment most of the time. Similarly, Fuzzy Linear programming, Goal Programming, mixed integer programming are some example of MODM approaches.

Many Researchers discussed crime prevention, prediction in serial crime and linkage analysis from the background of Fuzzy Mathematics. Queck et al. (2001) introduced a pseudo outer product based fuzzy neural network (POPFNN), which detects similarity between two fingerprints and decide whether they belong to the same person or not. Grubestic (2006) used fuzzy clustering to detect crime hot-spot in a city. Sheng et al. (2010) gave an intelligent decision support system to uncover the crime pattern and relationship between the pattern with police duty deployment using fuzzy time series analysis and fuzzy self-arranging map network. Nurul et al. (2012) gave an analysis to detect most crime potential area using AHP approach, combining with the geographical information system. Stofel et al. (2012) introduced a fuzzy clustering based approach to detect a pattern of crime data from original forensic data. Shrivastav et al. (2012) used fuzzy time series to make a prediction of crime. Albertetti et al. (2013) used Multi-attribute utility theory (MADM) approach to crime linkage analysis in high volume crimes. Adeyiga et al. (2016) proposed a fuzzy clustering technique for criminal profiling to provide investigator an intelligent system to detect and prevent crime. The fuzzy system is used to identify the trait of an individual. Gupta et al. (2015) took five different characteristics like economic status, family background, educational level, alcoholic or drug addict and criminal history for mapping of crime potential areas with the help of fuzzification and after defuzzification, the value helps in detecting crimes.
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