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Detecting serial residential burglaries using clustering

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ABSTRACT

According to the Swedish National Council for Crime Prevention, law enforcement agencies solved approximately three to five percent of the reported residential burglaries in 2012. Internationally, studies suggest that a large proportion of crimes are committed by a minority of offenders. Law enforcement agencies, consequently, are required to detect series of crimes, or linked crimes. Comparison of crime reports today is difficult as no systematic or structured way of reporting crimes exists, and no ability to search multiple crime reports exist.

This study presents a systematic data collection method for residential burglaries. A decision support system for comparing and analysing residential burglaries is also presented. The decision support system consists of an advanced search tool and a plugin-based analytical framework. In order to find similar crimes, law enforcement officers have to review a large amount of crimes. The potential use of the cut-clustering algorithm to group crimes to reduce the amount of crimes to review for residential burglary analysis based on characteristics is investigated. The characteristics used are modus operandi, residential characteristics, stolen goods, spatial similarity, or temporal similarity.

Clustering quality is measured using the modularity index and accuracy is measured using the rand index. The clustering solution with the best quality performance score were residential characteristics, spatial proximity, and modus operandi, suggesting that the choice of which characteristic to use when grouping crimes can positively affect the end result. The results suggest that a high quality clustering solution performs significantly better than a random guesser. In terms of practical significance, the presented clustering approach is capable of reduce the amounts of cases to review while keeping most connected cases. While the approach might miss some connections, it is also capable of suggesting new connections. The results also suggest that while crime series clustering is feasible, further investigation is needed.

1. Introduction

Studies suggest that a large proportion of crimes are committed by a minority of offenders, e.g. in the USA, researchers suggest that 5% of offenders are involved in 30% of the convictions (Tonkin, Woodhams, Bull, Bond, & Palmer, 2011). Law enforcement agencies, consequently, are required to detect series of crime, or linked crimes. A series can be defined as multiple offences committed by a serial offender. A serial offender can be defined as someone who has committed two or more crimes of the same type (Woodhams, Hollin, & Bull, 2010). It is suggested by law enforcement in Sweden that, similarly to the international findings, a large proportion of the residential burglaries are committed by professional criminals that travel across large areas of Sweden. Simultaneously, according to the Swedish National Council for Crime Prevention, law enforcement agencies solved approximately three to five percent of the 21,300 reported residential burglaries in 2012.

The detection of linked crimes is helpful to law enforcement for several reasons. Firstly, the aggregation of information from crime scenes increases the amount of available evidence. Secondly, the joint investigation of multiple crimes enables a more efficient use of law enforcement resources (Woodhams et al., 2010).

Law enforcement needs to handle a large amount of reported crimes, and the detection of series of crimes are often carried out manually. A decision support system that enables law enforcement to decrease the amount of cases when reviewing crimes would increase resource efficiency.

Forensic evidence, e.g. DNA, and fingerprints, has been used to detect linked crimes (Bennell & Canter, 2002; Tonkin et al., 2011). The availability of forensic evidence is, however, limited

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(Tonkin et al., 2011). In the absence of forensic evidence, behavioural information can be used as an alternative data source (Bennell & Canter, 2002). A criminal committing a series of crimes has been found to have a high intra-crime behavioural similarity (Woodhams et al., 2010). Similarly, behavioural consistency tends to be lower between criminals in similar situations (Woodhams et al., 2010).

This article presents a new decision support system (DSS) that can be used to systematically collect burglary data and to perform visualisations, analyses, and interpretations of the collected data. The article evaluates a key component of the DSS: the use of clustering techniques to group burglaries based on different definitions of similarity between burglaries, described in Fig. 1. Clustering has been used to group data according to similarity between data points, or to find communities in the data. Clustering residential burglaries based on different similarity aspects would potentially allow law enforcement to find series whilst reviewing a smaller amount of residential burglaries, i.e. used as a case selection DSS. Consequently, the use of this DSS would allow law enforcement agencies to save resources, whilst providing individual investigators with increased support. The clustering is performed using the cut clustering algorithm (Flake, Tarjan, & Tsioutsiouliklis, 2004).

1.1. Purpose statement

The purpose of this study is twofold. First, a DSS for collecting, managing and analysing residential burglary information is presented. Secondly, the potential of minimum cut based graph clustering of crimes is investigated to reduce the amount of crimes to review to detect series of residential burglaries. The impact of different edge representations and edge removal criteria on cluster quality and accuracy is investigated. Clustering quality is measured using the modularity index and accuracy is evaluated by applying the rand index.

The data comprises residential burglary reports gathered from southern Sweden and the Stockholm area.

1.2. Outline

The remainder of this work is organized as follows: Section 2 presents a DSS for residential burglary analysis. In Section 3, the related work is reviewed. Section 4 then describes the minimum cut clustering algorithm. In Sections 5 and 6, the methodology and experimental procedure is described. The results of the experiments are presented in Section 7 and analysed in Section 8. Conclusions and future work is presented in Section 9.

2. Decision support system for residential burglary analysis

Since 2011, researchers from Blekinge Institute of Technology collaborate with law enforcement officers and analysts from the Blekinge county police as well as four additional county police authorities from southern Sweden. The aim is to develop Information and Communication Technology (ICT) solutions for law enforcement. The scope is currently limited to solutions that target residential burglaries. The strategies, tactics, and overall organisational structure of the police vary between countries but the main issues are shared between many countries.

In Sweden, the police is organised into 21 county police authorities, or regional units, where each correspond to a particular county. The National Police Board (NPB) is the central administrative and supervisory authority of the police service. The NPB comprises The National Bureau of Investigation and the Swedish Security Service. In addition, the Swedish police includes the Swedish National Laboratory of Forensic Science. In 2015, the Swedish police will be re-organised into one national authority.

The collaboration between Blekinge Institute of Technology and the Swedish police was formed to improve the capability to solve residential burglary cases. In particular, the police are interested in ICT software, and organisational changes, that improve the data exchange and collaborative efforts of multiple county police authorities when addressing serial crime. Engineers and researchers at Blekinge Institute of Technology developed a prototype DSS for this purpose in 2012. Since then, the collaboration between

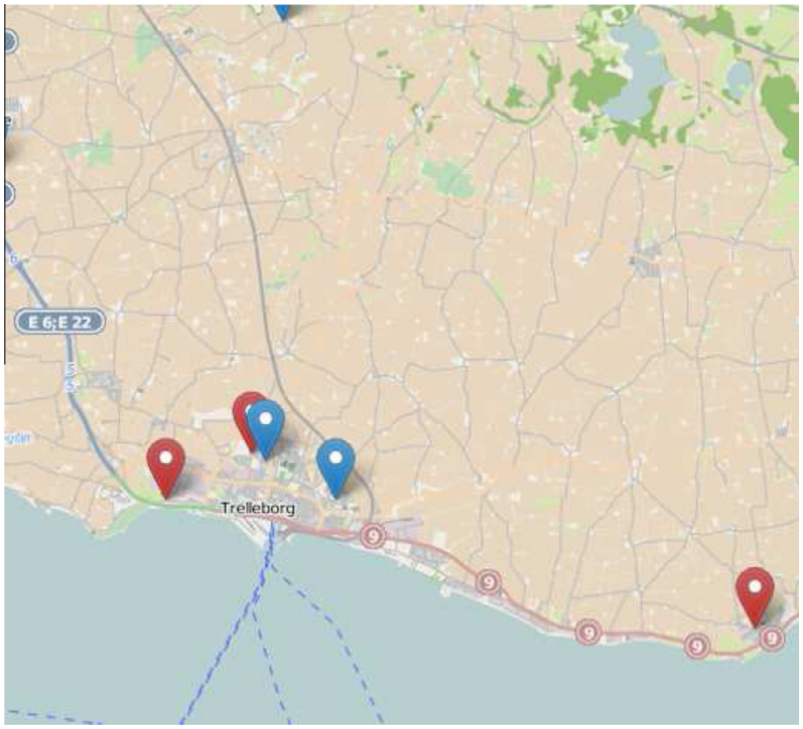

Fig. 1. A view of local crimes with red markers denoting similar crimes in the suggested DSS.