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IDENTIFYING POTENTIAL ZONES OF CRIME COMMITMENT AGAINST TOURISTS IN A PARK: CONCEPTUAL AND LOGICAL SPATIAL DATA MODELING

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ABSTRACT

Location is considered as an important element in studying tourism security. Therefore, mapping crime hotspots has recently been an interesting research topic in tourism development. In order to identify crime patterns and hotspots, it is essential to create a database containing the required spatial data. It should also be integrated with additional qualitative/quantitative attributes affecting criminal actions. Designing a geographic information system (GIS) can be considered as the most efficient way to deal with this problem considering the complex nature of tourism security. This paper presents the theoretical scheme of spatial data modeling with the purpose of indentifying potential crime zones within a developed park. From the spatial point of view, the factors and the constraints, which make a location vulnerable, are defined. The entities are identified by their attributes and characterized by their relationships. Finally, the conceptual and the logical models to create the crime suitability maps are generated. The models provided in this paper are designed in an explicit way; therefore, they can be easily modified or generalized for any specific case study. The presented data modeling procedure can be applied to generate essential databases for crime mapping via any GIS software.

Keywords: GIS, Logical model, Conceptual model, Mapping, Tourism, Crime.

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Contribution/ Originality

This study is one of few studies which have investigated spatial data modeling from theoretical point of view for the reduced case of managing the security of a park.

1. INTRODUCTION

Tourism safety is a topic considered by various researches in recent decades (Crotts, 1996; Boakye, 2010). Studies have shown that, frequently, there is a spatial and temporal pattern in tourist victimization. People are more likely to experience victimization as tourists in specific zones of space and time, than they experience at home (Brunt *et al.*, 2000).

Pizam and Mansfield (2006) identified location as an important element in studying tourism security. There are spatial factors, related to location, that play key roles in understanding this phenomenon, such as the range of impact, distribution of affected areas, and physical characteristics of the environment. Accordingly, designing a geographic information system (GIS) can be considered as the most efficient way for mapping crime hotspots, identifying geo-criminal patterns, integrating various attributes with spatial variables, and developing management services for increasing social security. Ratcliffe and Chainey (2005) provided a comprehensive review of theoretical and technical aspects of crime mapping in GIS. They demonstrated the efficiency of GIS via various global case studies and examples.

Al-Barmalgy *et al.* (2014) studied the possibility of integrating qualitative and quantitative data into GIS to find out a model for monitoring the phenomenon of vandalism in urban open spaces. They collected the essential data to represent the variables of crime motivation from different sources, such as photographic documentation, monitoring lists, qualitative observations, and interviews with users and designers. Then, the relationship between space and vandalism and influence of additional attributes on this phenomenon were analyzed in a GIS environment.

Chakrabarty (2011) identified potential ecotourism zones in forest villages of India via integrating spatial data and non-spatial attributes in GIS and performing overlay analysis. The databases related to criminal actions and terrorist attacks were added to the system to recognize the spatial pattern of hotspots. The developed system could eventually be applied to manage police posts and security teams for controlling any kind of social disorder.

The application of GIS for crime mapping in an urban area of Victoria Islands, Nigeria, was covered by Fajemirokun *et al.* (2006). They fused the maps of the buildings with their relevant information, such as type and usage, in a geographic information system. Using the road-network maps, they built an application for guiding police forces to reach a crime scene as fast as possible. They also analyzed the criminal history of different zones to suggest security management plans.

Focusing on urban tourism, Michalko (2004) studied the relationship between the vulnerability of tourists in Budapest with spatial, temporal and social variables provoking crime commitment. It was concluded that tourism safety could be increased by providing and orientating assistance for tourists at vulnerable locations and informing them of the risks. However, detailed geo-spatial analysis is required at finer urban scales to detect risky areas and to determine the necessities to reach a higher level of security.

Ferreira and Harmse (2000) used GIS environment to integrate crime and tourism statistics with geo-spatial data in South Africa. As a result, they detected general crime patterns, which could be used to identify risky places and situations for international tourists.

This paper is focused on spatial data modeling, which is the preliminary phase of developing a geographic information system. The purpose of the data-modeling trend, proposed in this study, is to determine the potential of different locations within a park for forming crime spots.

Parks, national parks, sub-national parks, country parks and even urban parks are the main sources of attraction in any country. According to the expectations of tourists from the safety point of view and the potential of parks in forming criminal hotspots regarding their vast environment, predicting risky zones should be among the primary development stages of a park. In the current study, we only consider developed parks; i.e. the park is not completely natural, since it provides the visitors with facilities and recreational activities, the protected sites are defined, the pathways among the destinations are determined, and the security of the park is under management.

In order to be informative and efficient, the problem should be reduced. Small-scale studies may lack comprehensive consideration of sub-issues. In this paper, the general problem of identifying crime potentiality is reduced to a lower level and a larger scale by introducing several constraints. The constraints or factors, affecting the security level of a location in a park, are discussed. By overlaying factors with proper weights, one can predict the crime potential of a location and create a crime-suitability map. The conceptual model is developed to describe the attributes and the relationships among the entities. The logical model, required for spatial modeling in a GIS environment, is presented.

The models provided in this paper are designed in an explicit manner and can be easily modified or generalized for specific case studies. The proposed modeling procedure can be used to generate crime-prediction maps via any GIS software. Such maps are useful to allocate security/police posts, local participatory groups, and intelligent monitoring systems for fast information transfer and reaction against any kind of criminal behavior. They can also be integrated to mobile GIS apps (Saravanan *et al.*, 2013) or web-based systems (Fajuyigbe *et al.*, 2007) to be directly available to tourists and managers. An attribute-oriented base for further analysis is provided in e.g. application of classification techniques, to predict crime hotspots (Zhang *et al.*, 2010; Kalaikumaran and Karthik, 2012).

2. CONCEPTUAL MODELING

The main purpose of conceptual modeling is representation of real-world objects and interactions in the most realistic way possible. The scheme of a conceptual model is composed of graphical representation and textual description of its elements. The main rule for designing a reliable model is to make sure that all the essential data is included in the model and that all the data in the model is actually necessary (Simsion and Graham, 2005).

The first conceptual step to build a model is to state the problem and the goals explicitly. Any problem is composed of series of phenomena and objects. Thus, it shall be decomposed to the sub-elements that are required to create the necessary input datasets. These sub-elements are represented as organized entity classes (e.g. layers or tables).

2.1. Requirement Analysis

The main problem, studied in this paper, is to identify the areas within a park where tourists might encounter a criminal action. According to previous studies, crimes in such areas may include property theft, shooting and physical assault and verbal assault, assuming that tourists are educated enough to not be exposed to fraud (Jones *et al.*, 2012). The problem scheme is illustrated in Fig. 1. The main output that one may eventually seek by solving this problem is a crime-suitability map, which shows how potential each place is as a crime spot. Although creating a mathematical objective function is out of the scope of this study, by further analyses of the proposed models, it would be possible to estimate the potential of an area quantitatively (Section 4).

2.2. Defining the Entities of Interest

As depicted in Fig. 1, initially, we should consider the external model of the problem. The safety situation of a park can be affected by various elements (entities). Each entity has several attributes, which are explained as follows. The relation diagram of these entities is presented in Fig. 2.

Geo-rectified ortho-photo: Considered as the geographic map of the area. All the other entities (their centers and/or affected zones) are located by one or more pixels. In return, each pixel may locate one or several entities.

Pathways: Pathways are constructed from path segments, and are the biking and/or walking medians to reach one place from another one. They might be open to authorized vehicles as well.

Path segments: A path segment is part of at least one pathway. The origin and the destination of a path segment are important attributes. The pavement status of a segment is also important, affecting time required to reach a help-needed destination. The path accessibility by bicycles or motorcycles is another significant attribute.

Lighting: Each lamp in the park has a coordinate showing its position. It is turned on and off at specific times every day. Depending on its installation situation and wattage, each lamp is able to illuminate an area, called the illumination field. Other entities of the model are either under the illumination of zero, one or several lights.

Security station: Security stations are central stations from which other security sub-systems are monitored and managed. Each station has at least one staff that stays there most of the time. A staff is responsible to check the data of zero or many cameras and relay information with zero or more security officers and park guardians. The station monitors one or several recreation sites.

Security officer: Officers keep in contact with each other and with security staff. They monitor a specific zone from their check spots. Moreover, they work during a particular range of working hours.

Park guardian: Guardian's role is to protect the environment, not the visitors. He preserves the environment from being manipulated or polluted by the visitors. However, his presence as a person who has connection with a central station is a considerable factor in reducing the risk of crime commitment. Each guardian is responsible of a particular zone during a period of the day.

Intelligent monitoring: In its simplest form, is composed of day/night cameras. The data of a camera is sent to a security station. The area visible by each camera, known as the camera field of view, can be identified regarding its installation coordinates and field of view.

Tourist center: An information center may have several employees and leaders, and provides lifeguards where needed. It supports at least one recreation site and has connection with a security station.

Tourist leader: Tourist leaders are located at pre-determined stations, mostly near recreation sites. Their duty is to direct and guide tourists, to explain the necessary instructions, and to distribute the plans, maps and brochures. Although a leader is not responsible for social security at the park, his existence as a person having connection with a superior control station is an effective factor in reducing the crime rate.

Lifeguard: They are located near dangerous areas where might be the risk of falling, getting injured, being attacked by animals and drowning in water.

Recreation site: Recreation sites are planned to attract tourists for special recreational activities. The statistics of a site demonstrate the frequency of its visits. Thus, the average visit density, visit peak time and off-period are among the main attributes of any recreation site. As a site gets more crowded, the risk of property theft increases; and, as it becomes emptier, it is more vulnerable regarding other physical crimes.

Protected area: A protected area is not accessible by tourists. Therefore, as the main side of the crime (victim) does not exist, no crime takes place within a protected area.

Vegetation class: The study area is classified based on the vegetation cover. Each class is characterized by the plant type, the average canopy height and sparseness of the species. The denser and the higher the coverage of a class, the more difficult the monitoring task; i.e. crime potential is higher.

3. LOGICAL MODELING

There are some transformations which are required to convert a conceptual data model to a logical one (Chmura and Heumann, 2005; Teorey *et al.*, 2011). Those which are needed in this study are explained briefly as follows.

Modifying the initial entity list: The entities which are not required to solve the problem are excluded from the design.

Specifying the attributes: The derivable attributes are removed; i.e. the attributes which can be concluded from other attributes of the model should be excluded.

Primary keys: The primary key is the attribute or a set of ones, by which each instance of the entity is identifiable. In the logical model diagram, the primary keys are underlined.

Foreign keys: Whenever there is a one-to-many relation, the entity of the one side is called the parent and the other side is called the child. A child (many-side) is connected to its parent (one-side) by the parent's primary key; i.e. the parent's primary key is copied to the child entity as a foreign key.

For instance, in our data model, each ortho-photo contains many pixels, but each pixel is contained by one image. Thus, at this one-to-many relation, the ortho-photo is the parent entity and the pixel is the child one. To define the "contain" relationship, the primary key of the ortho-photo should be copied into the attribute list of the pixel as a foreign key, which is denoted by

"<FK>" on the diagram. It means that to access all the pixels of a specific instance of the ortho-photo, we look for all the occurrences of the pixel whose attribute values at the foreign key are equal to the primary key value of the ortho-photo instance.

Modifying the associations: Derivable many-to-many relationships should be removed. For example, the relation "locate" between the pixel entity and the pathway entity should be omitted, since it is derivable from the "locate" relation between the pixel and the path segment entities and the "construct" relation between the pathway and the path segment entities.

Defining intersecting entities: Many-to-many relations are practically the source of confusion in a data model, which should be treated at the logical level. The conventional way to handle this kind of association is to create a new artificial entity called an intersecting entity. This entity is mostly titled after the association and is an entity which cross-references the two sides of a many-to-many relationship.

For example, the association "protect" is a many-to-many relation between the park guardian and the protected area entities; it means that each park guardian protects zero or more protected areas, while each area is protected by one or more park guardians. Thus, we should create a new linking entity called "protect", each instance of which is uniquely identified by a protected area ID and a guardian's ID. By the new definition, each instance of the "protect" is in relation with only one instance of the protected area and each instance of the protected area is in relation with at least one instance of the "protect". On the other side, each instance of the "protect" is in relation with only one instance of the guardian and each instance of the guardian is in relation with zero or more instances of the "protect" entity.

According to the transformations explained above, the conceptual model of Fig. 2 is converted to the logical data model of Fig. 3.

4. CRIME SUITABILITY FUNCTION

Given entities, attributes and their relationships, it is possible to describe the indices which affect the crime commitment potential/suitability at any location. One allocates weights to these elements and averages them to define a crime potential measure. These elements can be summarized as follows.

- *Spatial index*: The distance of a location from and its topological relation with station zones, officer zones, guard zones, cameras fields of view, rescue zones, recreation zones, protected zones, vegetation zones with dens and high plants, illumination fields, pathways and leaders' posts are important factors. For example, the occluded areas and the blind spots, which are not visible by the cameras and are also out of the security officers' sight, can be detected by spatial analysis; if a location is determined as a blind spot, then it is defined as a high crime potential spot.

- *Temporal index*: The accessibility of a location by tourists is limited to a period of time. The temporal relation of this period with the working hours of the officers, the cameras and the guardians, and accessibility hours to the surrounding locations are important. Another temporal factor is the time needed to reach a crime scene; i.e. given a suspicious condition observed by a camera or reported remotely, how long it takes for the nearest security officer to reach that place.

The required time can be modeled as a function of the distance and the accessibility of the paths ending in the location.

- *Behavioral index*: The density of tourists at a site and their behavior are also important criteria. These indices can be partially modeled by the statistics of the sites or by further data collection.

5. CONCLUSION

Geographic information systems play an important role in managing tourism safety regarding its spatial-based nature. However, when the problems are presented in relatively small scales from the first point of the study, the factors and the constraints cannot be determined comprehensively. Therefore, the gathered data does not satisfy the requirements and the models under-estimate the phenomena.

As a solution, each problem can be divided into several sub-issues at lower levels and larger scales. The larger the scale, the more details visible. Once all the sub-problems are solved, it will be possible to integrate and generalize them to address another problem from a higher level of complexity.

In this short study, the problem of identifying potential zones of crime commitment against tourists was reduced to the case of a developed park with constrained facilities. The crime causes were also reduced to those related to the space and its physical characteristics. Regarding these constraints, the factors, which make a location potential to turn into a hotspot, were considered. The entities were characterized by their attributes and their relationships within a conceptual model. The logical data model was then developed by converting the conceptual one based on the transformation rules. The data modeling procedure presented in this study can be used to generate crime forecasting maps through any GIS software.

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Fig-1. Problem scheme and manager vision.

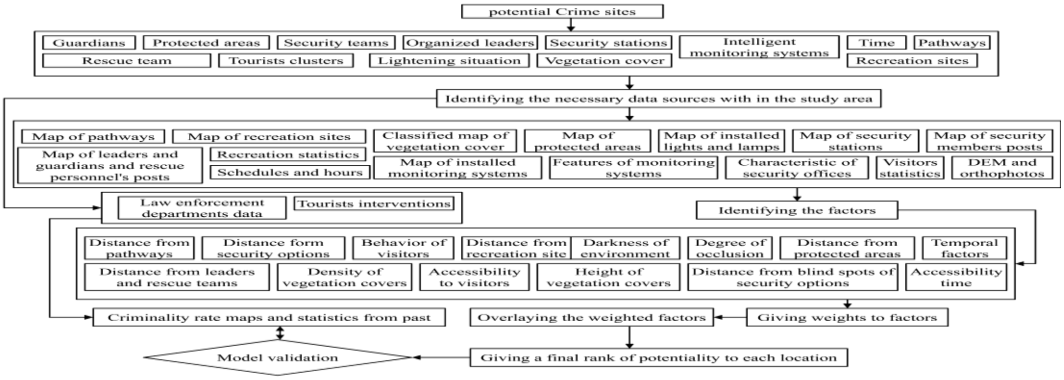

Fig-2. Conceptual model: entities, attributes, associations, cardinalities.

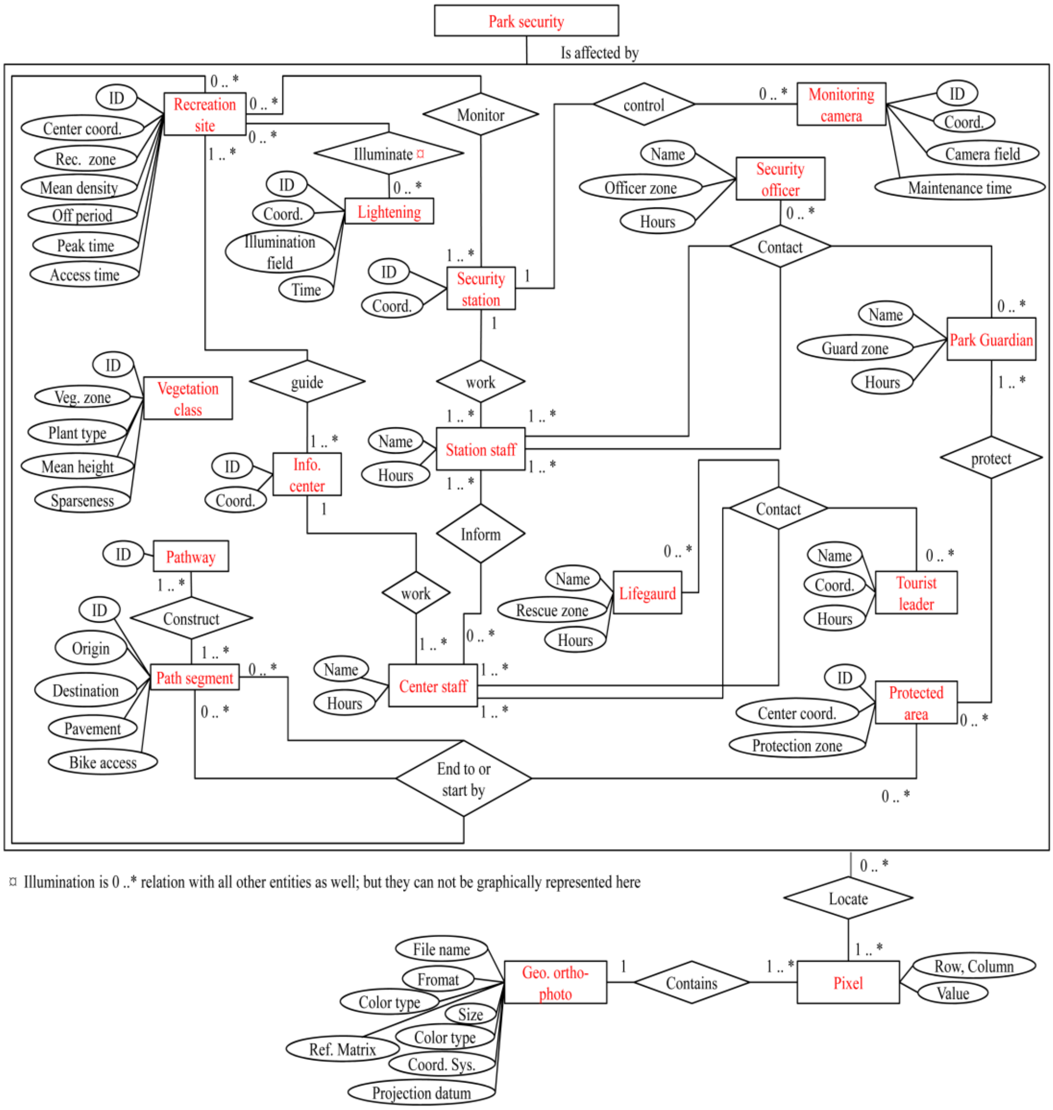

Fig-3. Logical data model.