A VISUALIZATION FRAMEWORK FOR A CRIME MAPPING SYSTEM: A CASE STUDY OF POLICE FORENSIC SCIENCE CENTER 4

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Abstract

The objective of this research is to design and develop a display framework of a criminal mapping system that is effective and applicable for all areas. The researchers have emphasized the design areas of data management for any desired area. The users can access each data display and define the size and center point of the primary map that is needed to deal with the criminal mapping. There are 2 types of criminal mapping that can be displayed, the point mapping and choropleth mapping, and the system also can show the details of each crime area including important surrounding areas in both regular and satellite maps. For a crime mapping test, the investigators took crime data from the Police Forensic Science Center 4 as a case study. In the design and development of the display framework for the crime mapping system the researchers found that the developed crime mapping system can work effectively and can be used in other areas without further development. In their evaluation of the system, the users' overall satisfaction was at the highest level ($\bar{x}$ = 4.64, S.D. = 0.54).

Keywords: Visualization framework, crime mapping, crime mapping system, Police Forensic Science Center 4

Introduction

Crime is a problem that results from the actions of individuals in society. It is a critical problem as people in society may be anxious or terrified because crime might bring about the loss of life or property, which would an enormous loss to people and society. Additionally, crime might be a vital obstacle to the development of all aspects in the country. Thus, the agencies dealing with crime need to have effective methods to store, analyze, and interpret the results of data relating to crime quickly and effectively to support the Crime Prevention and Suppression Division.

Technology has now been developed dramatically, and many people have worked to develop systems in support of the operation of the Crime Prevention and Suppression Division. For example, Worapot and Pongsak (2014) developed a system for storing criminal data by utilizing location-based services via mobile phones instead of GPS in order to indicate the coordinates of a venue and to store pictures and details. Likewise, Boonyarin (2014) designed

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and developed the ontology to suggest how to fill n the data to be applied to the application for inspection of a venue by the Police Forensic Science Center 4. This was done in order to help officials to exercise their duties, and increasingly to standardize the data (Boonyarin *et at*., 2014a; 2014b). The stored data would be analyzed with different techniques to support the officials' further operations.

In general, the technique for analyzing criminal data that is globally accepted by the police is crime mapping (Eck *et at*., 2005). It makes use of geographical data to design a map for analyzing details relevant to crime (Harries, 1999; Chainey and Ratcliffe, 2005; Chainey *et at*., 2008; Santos, 2012; Paynich and Hill, 2013) such as the venues, dates and times, frequency, continuity, and possible trends of the causes of crime in the future. However, the existing crime mapping still needs an individual who is an official to generate it. This has many problems. For example, creating crime mapping and transmitting data takes a lot time because of the complicated process. Note-taking and collecting data regarding a period of time and types of cases by the individual runs the risk of mistakes and the loss of information. Additionally, data stored in the form of documents or papers are very inconvenient to rectify, retrieve, and process. It is also difficult to make decisions. Previously, some people developed systems to help display crime mapping data. For example, Prasong (2004) developed a geographic information system for making a report and recording the crime statistics of the Chiang Mai Provincial Police. This system helped facilitate and reduce an official's operation in the management of case data and crime mapping. The system was connected to Autodesk MapGuide, a geographic information program, in order to display the data on a map. Jessada (2011) developed crime mapping and crime watch for the Tao Pun Metropolitan Police by utilizing Microsoft Visual Basic Version 6 to connect with the users and to process data. Moreover, MapObject Version 2.4 was utilized to handle the maps. The developed system could indicate the position and period of time of the incident, and help to analyze the data more conveniently. Nevertheless, all the above-mentioned systems were only utilized within the police's own agencies and could not be generalized and implemented by other agencies.

In view of the above problems, the researchers have designed and developed a visualization framework for a crime mapping system in order to support the Crime Prevention and Suppression Division effectively and enable it to be applied to any areas without developing a new system. In this study, Google Map was used for displaying the data because it can process mapping data all over the world. Furthermore, it provides an opportunity for the users to make use of Google Map API to further develop their own programs without installing them on a computer. As for this study, the researchers used the data from the Police Forensic Science Center 4 for the case study.

Methods

This study was to design and develop a visualization framework for a crime mapping system. The research procedures were carried out as follows.

1. Exploring and analyzing the users' needs

From the study, it was found that the current crime mapping of the Police Forensic Science Center 4 needed an official to handle it, which took time to output the data. Due to the amount of data, it was not possible for the data to be timely analyzed for planning crime prevention. As a matter of the fact, Police Forensic Science Center 4 needed a system that could resolve the problem of the length of time for crime mapping, and that could display details of the venue of each case as well as important surrounding places in order to support the official's decisions. Additionally, the officials of the Police Forensic Science Center 4 also needed a system that could manage and display the area's data, and that could be implemented in all 12 provinces for which the Police Forensic Science Center 4 was responsible. In this study, the users' needs could be categorized into 3 facets, as follows: 1) they needed a system that could manage and output the crime mapping quickly; 2) they needed to

cut down the expense of the system's development; and 3) they needed to apply the developed system to other areas without developing a new system.

2. Designing the visualization framework for the crime mapping

The researchers decided to design and develop the system as a web application which could manage and output the data quickly via the open source in order to cut down the expense. To meet the need of applying the system to other areas, the researchers designed the area data management so that the users could input the area data, control the area display, and stipulate the display of the main map with the proper size and position.

At this stage of the development of the system, it was divided into 2 parts: 1) data management was utilized to handle the data details in the system consisting of case management, area management, and location management; and 2) crime mapping would display 2 types of mapping; point mapping and choropleth mapping. Moreover, the system could display the details of the venue and other important places.

3. Developing and testifying the system

The visualization framework for the crime mapping system was developed in the form of a web application. The languages used for developing the system were HTML5 PHP and Java Script with MySQL as the system for managing the database. The area management and the display of the crime mapping were developed on the basis of Google Map API.

During the development of the system, it was examined by the experts and related officials and later revised according to their constructive suggestions so that the system was complete and met their needs.

4. Implementing and evaluating the system

1) The development and implementation of the system were carried out simultaneously. Having developed the system, it was practically implemented by the users to test all of the functions to see if the system met the users' needs and could function quickly and accurately. Later, the results of the implementation and suggestions were taken into account in order to adjust the system until it could completely function accurately.

2) The evaluation was carried out by evaluating the users' satisfaction. After implementing the system, the officials of the Police Forensic Science Center 4 in Khon Kaen province were asked to evaluate their satisfaction with the system concerning 4 areas comprising the capability of the system's operation, the functional operation of the system, simplicity of the system, and efficiency of the system.

Results and Discussion

The design and development of the visualization framework for a crime mapping system for the Police Forensic Science Center 4 resulted in a crime mapping system consisting of 2 main parts, as shown in Figure 1.

1. The data management consisted of

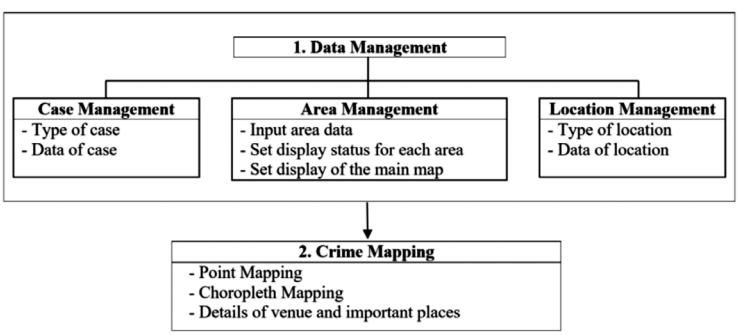

Figure 1. The structure of the crime mapping system

3 elements as follows:

1) The case management could detail the types of cases comprising the case titles, symbols on the map, frequency, and colors representing each frequency. The users could select both the customized and automatic frequency. Additionally, the details of the case data could be added, deleted, and revised if needed.

2) The area management could input the area data, set the default for opening or closing the display for each area, and stipulate the display of the main map with the accurate size and position as the set default.

3) The location management could handle the details of the types of location consisting of

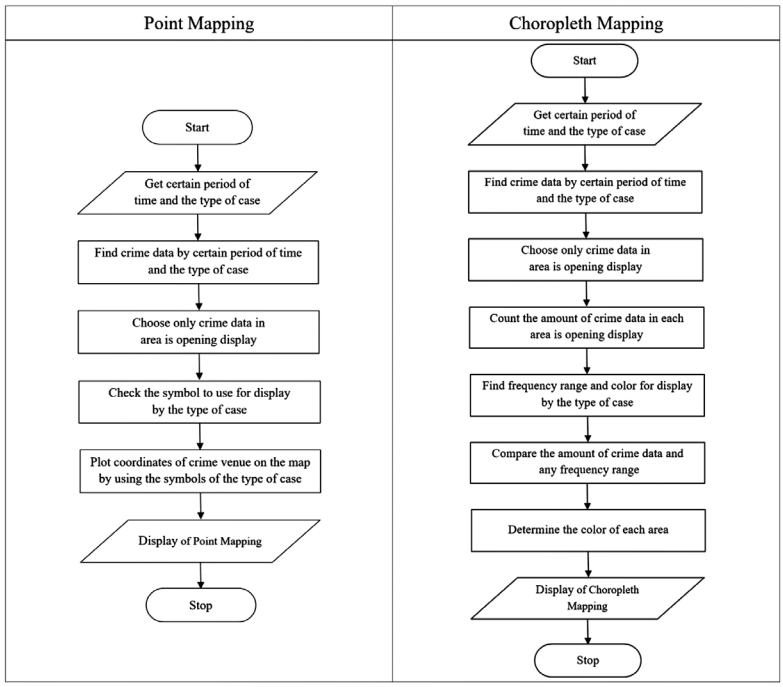

Figure 2. The algorithm of crime mapping

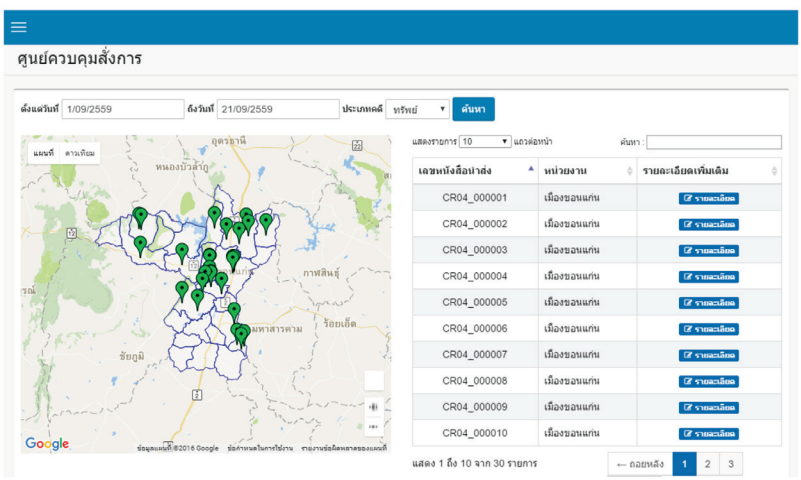

Figure 3. The display of point mapping

titles of the location types and symbols on the map. The location data could be added, deleted, and revised if needed.

2. The crime mapping could display 2 models; point mapping and choropleth mapping. For the 2 models, the users needed to select the certain period of time and the type of the case, and then the system would search for the data. The obtained data would be processed before being displayed as the crime mapping. The algorithm of the crime mapping is shown in Figure 2.

For the display of point mapping, the coordinates of the crime venue would be input to be displayed on the map by using the symbols set for each type of case, as shown in Figure 3; whereas for choropleth mapping, the display of the colors for each area represents the amount of crime occurring in that area. The colors and frequency were different regarding the types of cases, as shown in Figure 4.

Both models of the crime mapping could be looked at for the details of the venue and other surrounding places, and could be displayed on the general and satellite maps. Moreover, the users could select to display the data of all the places or only the interesting places, as shown in Figure 5.

After implementing the developed system at the Police Forensic Science Center 4, the satisfaction survey was carried out. The results are shown in Table 1.

According to the results shown in Table 1, it was found that the users were satisfied with the

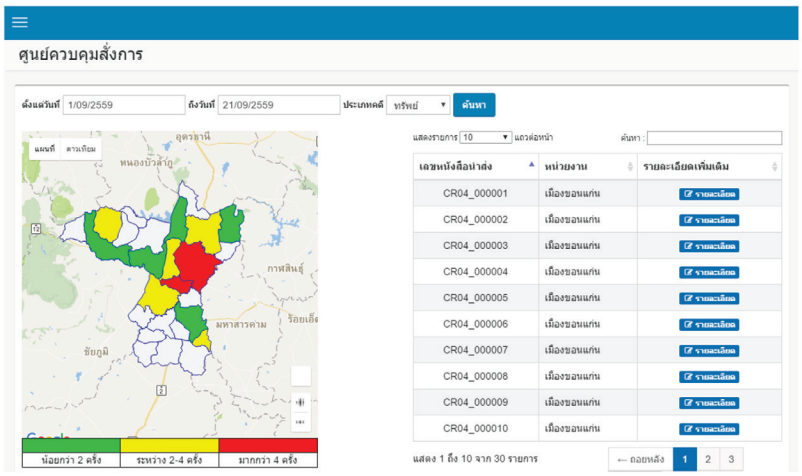

Figure 4. The display of choropleth mapping

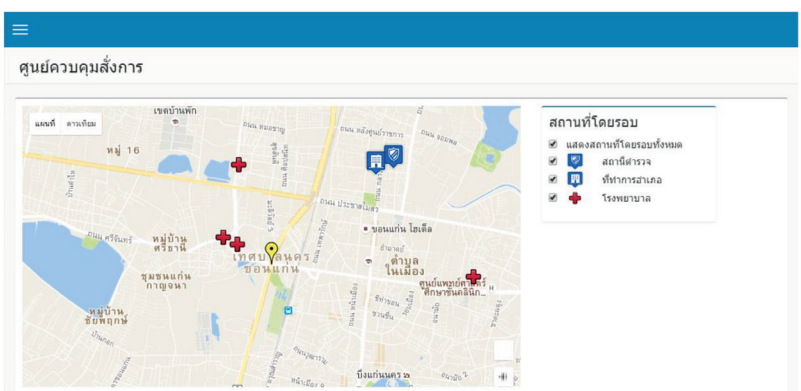

Figure 5. The display of venue details

implementation of the developed crime mapping system at a very high overall level ($\bar{x}$ = 4.64). On consideration of each item, it revealed that the users were most satisfied with the capability of the system operation ($\bar{x}$ = 4.69) followed by the functional operation of the system ($\bar{x}$ = 4.64), simplicity of the system ($\bar{x}$ = 4.63), and efficiency of the system ($\bar{x}$ = 4.60), respectively. Moreover, the users ensured that the developed crime mapping system could exactly support the Crime Prevention and Suppression Division. In addition, it was anticipated that the developed system would be extensively implemented in the future because of its simplicity and convenience.

Conclusions

The purpose of this study was to design and develop a visualization framework for a crime mapping system for the Police Forensic Science Center 4. The results of the study revealed that the developed crime mapping system could operate effectively; that it was easy to implement; and that it met the users' demands. This result was because the procedures in designing and developing the crime mapping system were systemically carried out. Additionally, it was tested and suggestions by the experts at the Police Forensic Science Center 4 during the system's development were implemented by the related officials at every phase. Furthermore, the researchers adjusted any mistakes so that it became an effective and practical system. The developed framework can be practically applied to other areas without the development of a new system.

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Table 1. The results of the users' satisfaction with the crime mapping system

Items	$\bar{x}$	S.D.	Level
1. Capability of the system operation	4.69	0.42	Very high
2. Functional operation of the system	4.64	0.68	Very high
3. Simplicity of the system	4.63	0.51	Very high
4. Efficiency of the system	4.60	0.55	Very high
Overall	4.64	0.54	Very high

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