SMART CITY SECURITY: PREDICTING THE NEXT LOCATION OF CRIME USING GEOGRAPHICAL INFORMATION SYSTEM WITH MACHINE LEARNING

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ABSTRACT

Delivering experience, Smart City development is an orchestration of a system scaling from home to community, precinct, city and nation. Smart City method of Crime Busting has been introduced in the Malaysian context timely when the attention given towards crime has been taking center stage. Through National Key Result Area Safe City Program, crimes are mapped into a centralized Geographical Information System database hence enabling the visualization of crime hot spots. The concept from this study presents possibly a major capability upgrade to the existing Safe City Program by introducing the ability to predict the next location crimes will be committed. Crime profiling is done based on geographical attributes with machine learning to produce reliable prediction of the next crime location. It is hoped the ability to predict the next crime location can lead to another form of proactive crime busting.

Keywords: Predict, Geographical Information System, Machine Learning, Hot Spots.
INTRODUCTION

The author is in the opinion that Smart City development is not about implementing intricately expensive systems but rather piecing together different types of probably cheaper technologies to deliver an experience meant to increase the quality of life. Hence, Smart City development as the author believes is about the delivery of experience to achieve certain aspirations with the purpose to increase the value of living.

Looking at the construction of Smart City platform, systems have to be interconnected. For a home experience, for example, the orchestration amongst Home Automation, Home Energy Management, Home Security and Home Tele-Medicine may deliver a ‘Living Tomorrow’ aspiration. As for a government service experience being another example, the cooperation of at least two government agencies may probably orchestrate the delivery government services of unprecedented aspiration.

In the context of Smart City Security in Malaysia, the Ministry of Local Government & Housing together with the Ministry of Home Affairs are cooperating through their agencies, Federal Town & Country Planning Department (FTCPD) and Royal Malaysian Police (RMP), through a collaboration which sees a unique interconnectivity of systems which delivers a Smart City method of crime busting.

This study will present the application and development of a coupling model consisting of Geographical Information System (GIS) with Machine Learning in predicting crime locations. Of particular concern is in the ability to predict the next location the crime of particular interest will take place. The caveat to this is that the crimes are being committed by at least a serial offender and crimes are not random. GIS is used to determine the location of the crime and the spatial attributes of the location. The spatial information is then translated into a database meaningful for interrogation by Machine Learning. Knowledge gained from database will enable Machine Learning to predict the next crime location for proactive crime deterrence and apprehending the suspect.

NATIONAL KEY RESULT AREA (NKRA) SAFE CITY PROGRAM

For the bigger picture of up keeping our nation’s security, the Government has introduced Safe City Program. Launched in 2010, the Safe City Program aims at the following (FTCPD 2010):

(a) Cities free from destruction to properties and lives, like crime, theft and robbery.
(b) Cities free from destruction and vandalism.
(c) Cities free from social and moral problems.
(d) Cities free from accidents inside and outside of building.
Safe City Monitoring System (SCMS) is conceived under the Safe City Program. Utilizing the mapping of crime on a GIS platform, the Minister of Housing and Local Government has launched Safe City Monitoring System in April 2011. Deploying an ingenious way to quickly visualize the hot spots of crimes, the Safe City Monitoring System makes good use of GIS in collaboration with the existing Police Reporting System through collaboration with the Royal Malaysia Police (RMP).

A very essential collaboration, FTCPD takes custodianship of the GIS infrastructure, spatial data and application while the RMP takes custodian to the crime data. When a police report is made by the public, the attending officer plots the location of crime as well as keying in the necessary information into the PRS (Peter Valentine, 2012). Table 1 below lists the types of crime covered by the SCMS.

<table>
<thead>
<tr>
<th>Category</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violent Crime</td>
<td>Murder</td>
</tr>
<tr>
<td></td>
<td>Attempted Murder</td>
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<tr>
<td></td>
<td>Gang robbery with firearm</td>
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<td></td>
<td>Gang robbery without firearm</td>
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<tr>
<td></td>
<td>Robbery with firearm</td>
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<tr>
<td></td>
<td>Robbery without firearm</td>
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<tr>
<td></td>
<td>Rape</td>
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<td></td>
<td>Inflicting injury</td>
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<tr>
<td>Property Crime</td>
<td>House break-in and theft (day)</td>
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<tr>
<td></td>
<td>House break-in and theft (night)</td>
</tr>
<tr>
<td></td>
<td>Lorry / van theft</td>
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<tr>
<td></td>
<td>Car theft</td>
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<td></td>
<td>Motorcycle theft</td>
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<tr>
<td></td>
<td>Snatch theft</td>
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<tr>
<td></td>
<td>Other thefts</td>
</tr>
</tbody>
</table>

Source: Dept. Of Town and Country Planning Peninsular Malaysia 2008

With the collaboration of RMP and the use of GIS, the PRS is revolutionized by the way of how crimes are recorded and later visualized for the purpose of busting crime. The effective execution of SCMS is reliant on GIS Crime Mapping as the key measure (Mohd Fadzil Mohd Khir, 2007).

Figure 1 on next page shows the crime mapping process. As an incident has happened, a police report is made by the victim. Scene and incident information are recorded and the location of the incident is plotted. The location of the incident is then verified by the investigating officer (FTCPD, 2011).
An existing geo-spatial database then gets updated with the crime incident and its location as per reported into the PRS system. This integration between FTCPD’s GIS facility and RMP’s PRS puts ease and automation to the crime maps and hot spots visualization hence becoming an important enabler to the Crime Mapping database.

As a proof of concept, screen shots from a handout made available by the FTCPD Safe City Program Workshop is excerpted (FTCPD, 2010). Do take note that these screen shots are proof of concept only which are made public and by no means are meant to disclose the capability or inability of the Crime Mapping facility. Above, Figure 2 shows the selection of Kajang, Subang Jaya, Klang, Petaling Jaya, Selayang, Ampang Jaya and Shah Alam municipalities and the Federal Territory Kuala Lumpur illustrating the focus of a selected crime type. On next page, Figure 3 visualizes crime hot spot analysis. Electronic maps easily allows a multitude of capabilities such as adding or removing desired crime types, changing the scale of the map, customizing the details on the map and cross referencing with other types of incidents. The enhanced capabilities to visualize and analyze the spread and
movement of crimes over a multitude of domains make the benefits of the Crime Mapping facility undeniable to the SCP and law enforcement.

Figure 3 Analysis of Hot Spots
Source: Federal Town and Country Planning Department Peninsular Malaysia 2010

CAPABILITY IMPROVEMENT USING MACHINE LEARNING

On top of its existing capabilities, the Crime Mapping facility can be boosted with the capability to learn crime patterns and subsequently able to anticipate or predict the movement of crime. Of particular interest in this study is the ability to predict the movement of serial criminals.

To spare a potential victim from the agony of being a victim, the serial criminal of interest – or the subject – has to be stopped in his or her tracks and apprehended to stop the crime from happening. Hence, police actions such as low or high profile policing or other law enforcement measures can be taken.

It is the noble intent and purpose of this proposed research to boost the capabilities of NKRA Safe City Crime Mapping facility by suggesting the development of anticipative capability to predict with a certain degree of comfort the next location a serial criminal with surface.

THE CONCEPTUAL FRAMEWORK

The collaboration between the Federal Town & Country Planning Department Peninsular Malaysia and the Royal Malaysian Police is the key success factor to the Safe City Monitoring System. When the need to predict arises, machine learning is invoked. Sets of database containing Mapping Information as well as Temporal Crime Information as interrogated.
Mapping Information is the database where spatial attributes pertaining to the previous locations of crime is stored while Temporal Crime Information is the database which stores information on crime. The relationship between temporal crime and spatial attributes is then figured out by machine learning which in turn predicts the next location and probably the time which the serial criminal in question is expected to pop out. Law enforcement actions can then be taken by FTCPD or RMP at the predicted location and time. Figure 4 below visualizes the conceptual framework as articulated.

![Figure 4 Conceptual Framework](image)

**RESEARCH METHOD**

Geographical Information System with Artificial Neural Network (ANN) will be used in this study. At the time this article is written, the selection of spatial attributes and data representation for the ANN are still being studied as well as the learning method and network architectural of the ANN.

**OBJECTIVE**

The following objectives are the main purpose of this research:
(a) To explore the association of serial criminals in relation to crime locations using features from spatial domain.
(b) To derive an appropriate Multiple Spatial Ordering Tactic.
(c) To propose and develop a GIS Time Series Neural Network coupling model capable of predicting the next crime location of a known serial criminal.

**CURRENT SUCCESS OF NKRA SCP**

Overall to date, the GTP NKRA Crime Reduction program is not short of successes and has done the following (Performance Management & Delivery Unit 2012):
(a) Installation of 500+ CCTVs.
(b) Mobilization of 14,222 police personnel into 50 hot spots.
(c) Deployment of 4,000 RELA & JPAM members into hotspots.
(d) Ranked & awarded 753 Balai Police.
(e) Redeployment of police 6,751 police officers.
(f) Activation of 358,811 Rakan Cop Members.
(g) Reduction of 11% overall Index Crime from 2009.
(h) Reduction of 40.6% overall Street Crime from 2009 baseline.
(i) Reduction of 3.1% 'fear of becoming a victim of crime': TNS Survey "Fear of Crime" Index: 48.9% (March to May, 2011 survey).
(j) Accession of arrest cases brought to trial: 23.6% of Investigation Papers (IPs) opened are brought to trial.
(k) Accession of public satisfaction with PDRM: Survey done in May 2011 shows 55% of respondents are satisfied with PDRM service from 35.8% in Dec 2009.
(l) MyDistress Service launched in Selangor with 61,441 registered users as of Feb 2012.

Malaysia is validated as the 4th Safest in the Asia Pacific Region by Global Peace Index (GPI) for the first time ever after New Zealand, Japan and Australia on top of being the most peaceful country in Southeast Asia (Performance Management & Delivery Unit, 2012). To top this up, Malaysia is ranked 19th safest nation among the upper middle income countries by the World Justice Project’s Rule of Law Index.

Having won the ESRI International Special Achievement in Geography Award 2012 (Figure 5 below), the following business cases are solved (ESRI, 2012):
(a) Real-time mapping and updating of crimes at all police stations through the integration with PRS.
(b) Real-time geo-processing analysis.
(c) Real-time Hot-Spot and Timeline analysis.

Figure 5 FTCPD Receiving ESRI’s Special Achievement In geography Award 2012

SIGNIFICANCE OF STUDY

Taking the center stage at the ESRI Special Achievement Award 2012, the success of the SCMS Crime Mapping facility is acknowledged at the global theatre. By building
and incorporating the capability to learn and predict into the SCMS, it is hoped to score another win for Malaysia.

CONCLUSION

With the capability to envisage the movement of serial criminal in question, the purpose and function of the SCMS can be further upgraded and enriched. When law enforcement is in the pursuit of serial criminal, low profile and high profile policing as well as other array of law enforcement initiatives can be deployed to deter a crime from happening, possibly apprehend the criminal in his or her tracks and hence stopping a crime from being committed.

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BIODATA

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