Mathematical Model on Spatio-Temporal Variation of Criminal Activities

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Abstract:

Spatial and temporal analysis is an essential component of crime related events. Such analysis plays a vital role in a lot of security- related applications. This helps to provide information to lead the activities aimed at stopping, detecting and responding to security problems. Crime prone area is identified based on the spatial location. But some crime occurs in the urban residential area based on the temporal factors also. This study carried out to evaluate the spatio-temporal variation of criminal activity in two specific area of North-East India.

Keywards: *Spatio-temporal, Variation, Correlation Coefficient.*

Introduction

The problem of crime is a major issue faced by all mankind. In India, research in criminology is very much neglected among social sciences despite rapid increase of crime and violence which pose a great threat to our nations.
The large variance of crime rates across space due to social interactions is a remarkable confusion in social sciences. These spatial variations of crime behaviour are higher in urban area than rural area of world.
The spatio-temporal variation of crime analysis is a key task that extracts information and knowledge from location and time referenced data and creates knowledge for crime pattern analysis.
The main goal of spatial-temporal crime pattern analysis is to find the spatial and temporal crime pattern and then use the patterns to help tracing the main cause of crimes.
If a large number of crimes occurred in a geographical area, Crime modeler would be interested to study the geographical settings at or near to this geographical location and then the settings could provide clues to the modeler to investigate whether or not crime occurred more often in other areas with similar geographical setting.

Related Works

Criminal activity is not a static event. It is dynamic over spatial and temporal. Many literatures have developed for analyzing spatio-temporal data of criminal activity. The most common methods for analyzing spatio-temporal crime data is ***Geographic Information System(GIS)*** technique which provide important tool for mapping crime over space and time[6].
Environmental criminology has developed for analyzing spatial crime in which crime would correlate with environmental settings [5]. The spatial crime pattern analysis is also supported by the broken windows theory [3]. Many empirical studies support that crimes would correlate with environmental settings. For examples, ***Reneck and Bell***, 1981[4] indicated that more use of drugs seemed to contribute to increased levels of violence.
Routine activity theory [2] and rational choice theory [7] plays important role for spatio-temporal crime analysis.
Routine activity theory consists of three minimal elements for most crime. These are- ***motivated offenders***, ***suitable targets*** and the absence of ***capable guardians*** to prevent crime. These three elements move about in space and time. ***Rational choice theory*** believes that reasoning actor who weighs means and ends, costs and benefits and makes rational a rational choice to commit crimes.

Spatio-temporal variation of criminal activities

Let us consider crime data based on the criminal activity spread over the year 2014 (up to the month November, 2014) in the two places in North-East India.

Let us consider the crime data for ***Guwahati City***, which is very dense populated, crowded and congested area. Another crime data is considered from the Meghalaya area which is thinly populated and non-congested area. The two areas are adjacent to each other. Total population of ***Meghalaya*** are 32, 11,474 living

within total area 22,429 square km. So the density of population is 143(appr.) per square km. Whereas the total populations of ***Guwahati city*** are 9, 57,352 living within the area 216 square km and its population density is 4432(appr.) per square km.

Month-wise crime data of ***Guwahati city*** and ***Meghalaya*** state during 2014 (up to Nov.) are given in Table 2.5

Table- 2.5: Crime data of Guwahati city and Meghalaya state, 2014

Month	*Jan 2014*	*Feb 2014*	*Mar 2014*	*Apr 2014*	*May 2014*	*Jun 2014*	*Jul 2014*	*Aug 2014*	*Sep 2014*	*Oct 2014*	*Nov 2014*
Crime in Meghalaya	257	252	316	352	339	258	328	281	321	320	356
Crime in Guwahati city	930	945	1114	1064	1150	1177	1082	1066	1116	1065	1128

Source: 1.Crime Branch,Crime Unit, 2nd floor Assam Police Central Hospital, Panbazar, Guwahati (Assam) & Police Commissioner Office,Ananda Ram Baruah Road,Panbazar, Guwahati, Assam.2.Meghalaya Police, Shillong "Month wise distribution of congnizable IPC crimes reported in Meghalaya during the year 2014".

2.6: Calculation of correlation coefficient

Sl. No.	*Crimes in Meghalaya*			*Crimes in Guwahati City*			
	Numbers of Crimes in Meghalaya	*Deviations of crimes from assumed mean*	*(Deviation)²*	*Numbers of Crimes in Guwahati City*	*Deviations of crimes from assumed mean*	*(Deviation)²*	*Product of Deviation*
		258 (= $\bar{x}$)			**1177(= $\bar{y}$)**		
	x	u	u^2	y	v	v^2	uv
1	257	-1	1	930	-247	61009	247
2	252	-6	36	945	-232	53824	1392
3	316	58	3364	1114	-63	3969	-3654
4	352	94	8836	1064	-113	12769	-10622
5	339	81	6561	1150	-27	729	-2187
6	258	0	0	1177	0	0	0
7	328	70	4900	1082	-95	9025	-6650
8	281	23	529	1066	-111	12321	-2553
9	321	63	3969	1116	-61	3721	-3843
10	320	62	3844	1065	-112	12544	-6944
11	356	98	9604	1128	-49	2401	-4802
		$\sum u = 542$	$\sum u^2 = 41644$		$\sum v = -1110$	$\sum v^2 = 172312$	$\sum uv = -39616$

Correlation coefficient,

$$r = \frac{\sum uv - \frac{\sum u \sum v}{n}}{\sqrt{\sum u^2 - \frac{(\sum u)^2}{n}}\sqrt{\sum v^2 - \frac{(\sum v)^2}{n}}} \cong 0.25$$

and Regression coefficient of y on x

$$= b_{yx} = r\frac{\sigma_y}{\sigma_x} = r\frac{\sigma_v}{\sigma_u} = \frac{\sum uv - \frac{(\sum u)(\sum v)}{n}}{\sum u^2 - \frac{(\sum u)^2}{n}} \cong 1.01$$

$\therefore$ The equation to the line of regression of x over $y \Rightarrow x - \bar{x} = 0.25(y - \bar{y})$

Arithmetic average of crime

$$\bar{x} = \text{Assumed average} + \frac{\sum u}{n} = 258 + \frac{542}{11} = 307.27$$

and Arithmetic average of crime

$$\bar{y} = \text{assumed average} + \frac{\sum v}{n} \cong 1076.09$$

Hence the equation (2.8) takes the form

$$x - 307.27 = 0.25(y - 1076.09)$$

$$\Rightarrow x = 38.25 + 0.25y$$

The equation to the line of Regression or y over x is

$$y - \bar{y} = r\frac{\sigma_y}{\sigma_x}(x - \bar{x})$$

$$\Rightarrow y = -310.34 + 1076.09 + 1.01x$$

$$\Rightarrow y = 765.75 + 1.01x$$

Above estimation shows that criminal activities are spatial and temporal.

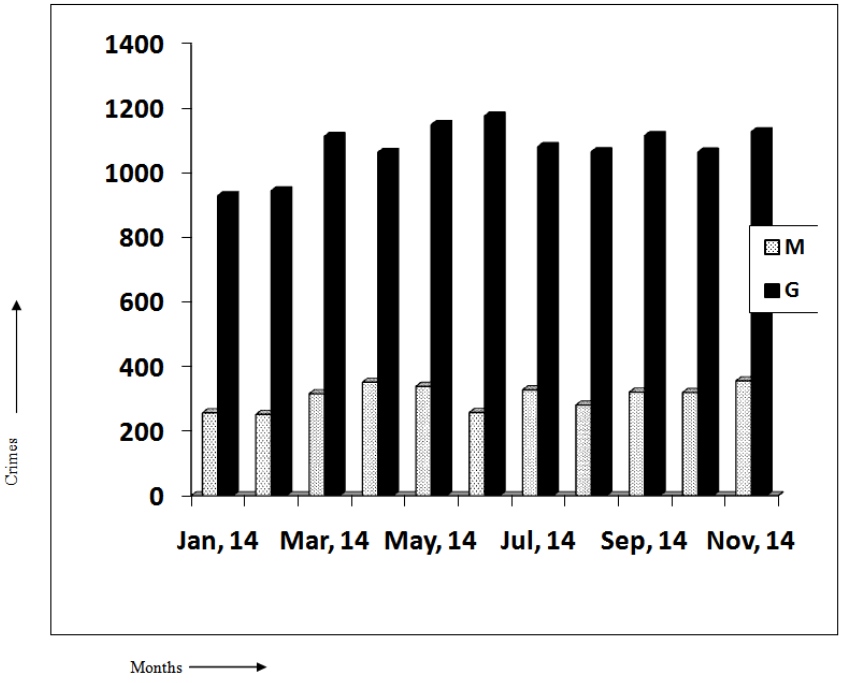

Figure-1

Conclusion

From the Fig.1 it is observed that criminal activity peaks in the month of May and June, moderate in the month of March, September and November at Guwahati, but increasing rate of criminal activity occur in the month of September, October and November at Meghalaya during the year, 2014 and it dips in the other months. Hence spatio- temporal variation of criminal activity can be analyzed from the above data plotting.

More over crime rates are higher at Guwahati than Meghalaya due to the more urban clustered population at Guwahati.

References

[1] Brantingham, P.L. and Brantingham, P.J. (2008) Crime pattern theory. In wortley, R. and Mazerolle, L., editors, Environmental criminology and Crime Analysis. Routledge
[2] Cohen, L.E. and Felson, M. (1979): "Social Change and Crime Rate Trends- A Routine Activity Approach". American Sociological Review, Vol. 44, pp. 588-608.
[3] Wilson, J. Q. & Kelling, G. L. (1982) Broken windows and police and neighbourhood safety. Atlantic Monthly 249, pp. 29-32.
[4] D.Renock and R. Bell, Bars, blocks and Crime, J. Environ. Sys.11(1981) 35-47.
[5] P.J. Brantingham and P.L. Brantingham, Environmental Criminology, 2nd edn. (Waveland Press,1991) pp. 27-54.
[6] J. H. Ratecliffe, Crime mapping and the training needs of law enforcement, Eur. J. Criminal Policy Res. 10 (2004) 65-83.
[7] Cournish(et al,1986) the Reasoning Criminal: Rational choice Perspectives on offending hague :Springer Verlag.