

#### Determining Hotspots of Road Accidents Using Spatial Analysis: Along North-South Expressway

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#### Background of Study





Road traffic accident occurs when a vehicle that is moving along a roadway collides with another vehicle or objects.



- Road accidents may happen in a second but the consequences may last for the day, months and years for the rest of life.

- According to the World Health Organization, worldwide, the number of people killed in road accidents each year is estimated almost 1.25 million while the number of injured could be as high as 50 million.
- Road accidents affected people not only the emotional and physiological but it gives impacts to a country's economic as well.



- Currently according to global status report on road safety 2015, road traffic injuries are estimated to be the ninth leading cause of death across all age groups globally.
- Malaysia has taken a number of initiatives in order to reduce the problem and create public awareness. For example, the road safety plans 2014-2020.



According to Malaysian Institute of Road Safety Research (MIROS), in 2014 the total number of road accidents 476,196 was with the number of road deaths is 6,676 cases seriously injured is 4,432 cases

Malaysia has been ranked the 8<sup>th</sup> in fatalities of road crashes in the Mortality from Road Crashes in 193 Countries Report. According to Malaysia Road Transports Department (RTD) in 2014

Malay a lost RM nine billion due to road deaths.





In 1996, after Malaysian Government had established and implemented a 5year national road safety target to reduce the accident deaths by 30% by the year 2000. In 2000, the reported

Malaysia has taken a number of initiatives in order to curb this problem and create public awareness. The road safety plans 2014-2020 was designed with five desired outcomes of safer vehicles. safer road users, post- ash management, road safety management and safer mobility and

# BUCKLE

Some of the interventions have been implemented, but it failed to give an awareness among road users such as seat belt law and motorcycle helmet initiatives.

#### Highway in Malaysia

- PLUS Malaysia Berhad was incorporated in Malaysia as a public company on 2010.
- Business primarily consists of the operation and maintenance of the Expressways.

- Acts as the support of a country's transportation system.
- One of the ways to overcome the demand for efficient road transportation.



North-South Expressways (NSE), The New Klang Valley Expressways (NKVE) and a Section of the Federal Highway Route 2 (FHR2), Seremban-Port Dickson Highway, North-South Central link, Malaysian-Singapore Second Link, Lebuhraya Butterworth-Kulim and Donang Bridge

- NSE: A 772 km of toll expressways was acting as the backbone of the west coast of the peninsular Malaysia.
- The NSE running the length from Malaysian-Thai border in the North to the border with our neighboring countries, Singapore in the south.

- The highway is good in terms of its condition and connection to every state but some locations need urgent attention.
- Hence, it is important to Identify the hot spots zones along the NSE so that it could minimizes the risks of accident.

#### Problem Statement

- World Health Organization (WHO, 2015), one of the major problem in the world, as well as in Malaysia, has been traffic accidents, which results in approximately 1.245 million of deaths and tens of millions injuries and disables every year.
- Moreover, 80% of all traffic accidents in the world have happened in developing countries.

- Recently 2016, 3 men were killed and 2 others passengers were injured in the separate accidents on the North South Expressway in Simpang Pulai and Slim River after their cars skidded and hit the road barriers.
- Similarly, in Ipoh another separate accidents was reported and 1 man died while another 2 were injured.

- Associated with the growing technology and increasing population in Malaysia, number of vehicles in road traffic is increasing day by day.
- As a result, traffic exposure, and thus, the number of road accident, is increasing.

- Concerns on road traffic accidents within a North-South Expressway (NSE) which running from Sungai Petani to Bukit Lanjan.
- This research can provide a method to target hot spot areas of road traffic accidents along NSE

#### **Research** Objectives

SPATIAL PATTERN
To examine the spatial pattern of road accidents along North-South Expressway (NSE).

HOT SPOTS
To identify hot spots area across North-South Expressway (NSE) using Nearest Neighbor Hierarchical Clustering and Spatial Temporal Analysis.

To compare the methods in identifying hot spot between Nearest Neighbor Hierarchical Clustering and Spatial Temporal Analysis.





Authors/Year	Year	Findings		
1. Road Accident with Casualties in Developing and Developed Countries				
Hoque	2001	<ul> <li>Total 1.2 million deaths, over 80 percent of road fatalities occur in the developing and emerging countries, even though these countries account only about one-third of the total vehicles fleet.</li> </ul>		
Nantulya & Reich	2006	<ul> <li>Poor people in developing countries have the highest burden of injuries and fatalities because of road accidents.</li> <li>Developing countries accounted about 85 percent of all deaths due to road accidents and 96 percent of children killed due to the incidents globally.</li> </ul>		
Korter, Olubusoye, & Salisu	2014	<ul> <li>Road accidents become a global concern because of the frequencies of death, injuries and materials losses caused a burden as well as threat to the country accidents.</li> <li>Study shows that 46.73% of death are caused by road accidents compared to other notifiable diseases.</li> </ul>		
World Health Organization (WHO)	2015	<ul> <li>In 2015, those in 15-44 years old age group account 48% of global traffic deaths.</li> <li>For a young age males are more likely to be involved in road accident compared to females. In addition, it also stated that about three-quarters or 73% of all road traffic deaths are occur among men.</li> </ul>		
Gargett, Connelly, L., & Nghiem,	2011	<ul> <li>Study on road traffic crash fatalities in Australia stated that in 2001, 495,300 Australians reported on long-term effects due to road crashes event.</li> </ul>		

Authors/Year	Year	Findings			
2. Method Approach	2. Method Approach				
Levine	2010	<ul> <li>CrimeStat is free downloadable statistical package software which mainly used to analyse on point data.</li> <li>It offers methods in detecting hot spot locations.</li> <li>This includes fuzzy mode, nearest neighbor hierarchical clustering, moran statistic, and spatial and temporal analysis of crime (STAC).</li> </ul>			
Moreira, Gonçalves, & Shrusbsall,	2012	<ul> <li>Using CrimeStat to identify the hazardous road location using kernel density estimation (KDE), mode, fuzzy mode and NNH clustering methods.</li> </ul>			
Erdogan, Yilmaz, Baybura, & Gullu	2008	<ul> <li>According to Geographical Information System (GIS) based accident information system is useful in identifying the relationship between spatial phenomena that are almost impossible to determine using a non-spatial database.</li> </ul>			
Truong & Somenahalli	2011	• Used GIS approach based for pedestrian-vehicle crash data in Adelaide City, Australia. The study performed spatial autocorrelation analysis in order to determine the pattern of the crashes.			
3. Comparison of Hot Spot Techniques					
Chainey , Tompson, & Uhling	2008	<ul> <li>Compare different hot spot techniques and measure the accuracy of them. I</li> <li>In their study they used Predictive Accuracy Index (PAI) to compare different methods by crime types.</li> </ul>			
Tompson & Towsley	2009	<ul> <li>Used Predictive Accuracy Index (PAI) in their study to identify the crime hotspot in United Kingdom.</li> </ul>			

#### Methodology



#### Study Area



Section	Location	Distance (km)	
N3	Sungai Petani to Jawi	54.90	
N4	Jawi to Cangkat Jering	56.80	
N5	Cangkat Jering to Ipoh	55.40	
C1	Ipoh to Bidor	64.40	
C2	Bidor to Tanjung Malim	59.70	
C3	Tanjung Malim to Bukit Lanjan	60.30	

#### Data Analysis Techniques



#### Nearest Neighbor Analysis (NNA)

- It is performed in order to know the pattern of incident
- Produces the nearest neighbor index (NNI)

H<sub>0</sub>: The pattern of incident are randomly distributed H<sub>1</sub>: The pattern of incident are not randomly distributed (clustering)



Expected Average Nearest Neighbor

Nearest Neighbor Index > 1	The spatial pattern is random.
Nearest Neighbor Index < 1	The spatial pattern is cluster.

### Nearest Neighbor Hierarchical Clustering (NNH)

 Identifies group of incidents that are spatially close.

Criteria 1: Threshold Distance (Fixed Distance)

- \* search radius can be specified exactly.
- \* 1km for highways.
- Criteria 2: Minimum number of Points Criteria 3: Visualizing the output (Convex or Ellipse Hull)
- \* Ellipse : Looks better on map and users seems to understand it better compared to the convex hull.

Advantages:

- 1. It can identify small geographical environments where there are large number of incidents.
- 2. Can be applied to both small and large entire area.

## Spatial Temporal Analysis Clustering (STAC)

- Identifies the densest clusters of incident based on the scatter point on the map.
- 1. STAC lays out a 20x20 grid structure. (Define the triangular or rectangular scan type).
- Place a circle on every node on the grid. (1.414xSpecified Radius)
- 3. Counts the number of incident falling within each circle and ranks in the descending order.
- 4. If a point belongs to 2 different circles, the point within the circles are combined. This process is repeated until there are no overlapping circles.
- 5. The clusters can be displayed using convex or ellipse hull.

- 1. Requires primary file.
- 2. Define search radius (Start with a larger search radius to smaller search radius).
- 3. Select the minimum number of incident for each clusters.

#### Prediction Accuracy Index(PAI)

- To determine the differences between each method in capturing or predicting hot spots location.
- Has been used in hot spot mapping for both comparing the different techniques and prediction

Hit Rate (HR) = 
$$\left(\frac{n}{N}\right)$$

n= total number of accidents found in that particular cluster N= total number of accidents in the study area



• The higher the PAI the more accurate the prediction, hence shows the better method in predicting the hot spots.

# RESULTS AND DISCUSSIONS

#### **Time Series of Road Accident**

Year	Percentage	
2011	21.8%	
2012	27.5%	
2013	24.5%	
2014	26.4%	



#### **Road Accident by Sections**



#### Road Accident by Severity

Severity	Percentage
No Injury	34.1%
Minor Injury	34.8%
Serious Injury	26.5%
Fatal	4.6%



#### **Nearest Neighbor Analysis**

Objective 1: To examine the spatial pattern of road accidents across North-South Expressway (NSE).

Test Statistic (Z) : - 237.6788				
P Value One Tail : 0.0001				
Mean Nearest Expected Nearest Nearest				
Neighbor Distance	Neighbor Distance	Neighbor		
(m)	(m)	Index		
3.8432	758.807	0.00506		

It can be concluded that the road accident cases along North South Expressway (NSE) are having a clustered distribution. This is due to the Nearest Neighbor Index (NNI) is 0.00506 which is less than 1 and p-value is 0.0001 <  $\alpha$  =0.05. Thus, we reject the null hypothesis and conclude that the road accidents exhibits a clustering pattern.

# DETERMINING THE HOTSPOTS

#### Determining the hotspots -1

Objective 2: To identify hot spots area across North-South Expressway (NSE) using Nearest Neighbor Hierarchical Clustering Analysis (NNH)

Cluster	Mean X	Mean Y	Frequency
1	100.9703	4.69366	349
2	101.57	3.2301	349
3	100.6718	4.92755	328
4	101.023	4.69206	298
5	101.5579	3.37062	298
6	101.545	3.43102	295
7	101.5202	3.66175	241
8	101.5841	3.193	234
9	101.2082	4.40789	223
10	101.5468	3.30654	222
11	100.8173	4.77865	213
12	101.4904	3.69159	210

Section	Number of Hot Spot
N3 (Sungai Petani to Jawi)	0
N4 (Jawi to Cangkat Jering)	1
N5 (Cangkat Jering to Ipoh)	3
C1 (Ipoh to Bidor)	1
C2 (Bidor to Tanjung Malim)	1
C3 (Tanjung Malim to Bukit Lanjan)	6











101 524 2 221 Decimal Degree

#### Determining the hotspots - 2

Objective 2: To identify hot spots area across North-South Expressway (NSE) using Spatial Temporal Analysis (STAC)

Cluster	Moon V	MoonV	Frequen
Cluster			су
1	100.672	4.9269	220
2	101.5668	3.23364	218
3	100.4891	5.19155	161
4	101.542	3.43634	148
5	100.983	4.68848	133
6	101.5603	3.37508	130
7	101.5549	3.36426	129
8	101.1708	4.45563	127
9	101.5557	3.38886	114
10	101.5766	3.22311	112
11	101.0037	4.68782	104
12	101.553	3.35176	102
13	101.026	4.68611	101
14	101.5657	3.24579	101

Section	Number of Hot Spot
N3 (Sungai Petani to Jawi)	1
N4 (Jawi to Cangkat Jering)	1
N5 (Cangkat Jering to Ipoh)	3
C1 (Ipoh to Bidor)	1
C2 (Bidor to Tanjung Malim)	0
C3 (Tanjung Malim to Bukit Lanjan)	8











#### Predictive Accuracy Index

Objective 3: To compare the methods in identifying hot spot between Nearest Neighbor Hierarchical Clustering (NNH) and Spatial Temporal Analysis (STAC).

		Area (sq metre)	Frequency	Hit Rate	PAI
All Injury Type	Nearest Neighbor Hierarchical	1.38857	3260	22.29517	163.6884
	Spatial Temporal	0.287	1900	12.99412	461.5725
Fatalities	Nearest Neighbor Hierarchical	0.79899	198	1.35412	17.2779
	Spatial Temporal	0.50907	77	0.52660	1054.5847

#### CONCLUSIONS



A good limit for Nearest Neighbor Hierarchical Clustering to study the hot spots in NSE requires much smaller threshold value which is 1 km.



A good limit for Spatial Temporal Clustering to study the hot spots in NSE requires much smaller threshold value compared to NNH which is 0.5 kilometer.



Comparison of two methods using PAI, shows that STAC outperformed NNH.



Based on the results, most of the hot spot located at Section C3 which is from Tanjung Malim to Bukit Lanjan.



Based on the results obtained, it is important for the concerned bodies to take a remedial action at selected hot spots. This includes adding more caution signage or implements specific interventions to prevent road accident.

## RECOMMENDATION FOR FUTURE RESEARCH

- Add more of hot spot technique methods such as Kernel Density Estimation (KDE), K-Means Clustering, Getis-Ord Statistics and Moran's Index.
- The analysis can include collision types, vehicles involved and severity of the accidents.



## Thank You!

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