Recent Trends in Civil Engineering and Built Environment Vol. 2 No. 1 (2021) 122–131

RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

The Development of GIS Database for Blackspot Accident Area Affected by Day and Nighttime

Fatin Zawani Hamid[1], Saifullizan M. B[2, *]

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn, Parit Raja, Johor,86400, MALAYSIA

[2]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn, Parit Raja, Johor,86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/ rtcebe.2021.02.01.014
Received 30 January 2021; Accepted 28 April 2021; Available online 30 June 2021

Abstract: Road accidents are one of the largest contributors to human deaths in Malaysia and are caused by a combination of factors which include the weather, road engineering, vehicle characteristics, as well as driver performance and actions. This paper aimed to (i) to identify factors causing of blackspot traffic accident area of the route during daytime and nighttime (ii) to analyze road accident data using Geographic Information System (GIS) for the black spot area. Besides, with the advanced aid of technology nowadays, a Geographic Information System (GIS) was being recognized as an excellent system that can be used as an advanced tool in the field of transportation. The determination of the blackspot area needs to be traced and the factor causing need to be identified before all the data being carried out by using the GIS system. The result found the black spot accident area spotted has 737 totals WSI at the F50 route area which is at Jalan Kluang to Jalan Batu Pahat F50 where the time of the accident is from 2 pm to 6 pm during the day. Thus, by the end of this research, hopefully, this study can identify and prioritize the accurate accident-prone points (blackspots) area. Then, the factor causing an accident can to be detected with spatial information using GIS, and the quantity of road accident hope can be reduced when the prediction of safety can be measured and monitored with the help of a GIS database.

Keywords: Blackspot, Factor, GIS

1. Introduction

In Malaysia, an unprecedented number of road traffic accidents (RTA) has occurred and according to a report conducted by [1] in 2018, they have the highest fatality rates (per 100,000 population) amongst the ASEAN countries. Moreover, a road accident can cause a loss to a person such as a fatality, serious injury, and minor injury. All these losses will be sorted according to a period zone. This collection of the road accident data and information will be obtained with the help of the

Corresponding author: saifulz@uthm.edu.my

police station. According to [2] the most critical factor of crash case studies is to locate the prone location which is the reference point. So, the implementation of the Geographic Information system (GIS) will be used to represent the blackspot area graphically to integrate and display the source of information. The functionality of GIS will attribute data for event and future planning in the form of clear and attractive spatial maps so it will be saved time and energy in gathering data processing. The goal of this case study is to develop a methodology for optimizing searching where data can be tied up to determine the blackspot area with the implementation of GIS technology. The prone location area will show up and be determined in the form of spatial maps based on the day and night mode condition. This strategy consists of the actual collection data process and inserting variable accident data that happen at the Batu Pahat, Johor in the GIS software.

1.1 Problem statement

Since Malaysia is experiencing growth in industrial, population, tourism, economy, and motorization, the growth of vehicle registration was also increased. This may be one of the reasons leading to road traffic accidents. But the detection of the blackspot area cannot be well detecting since it goes manually. It will give inaccurate value, or some part of data missed a place somewhere. A proper and effective method should be introduced to ensure gratification among the residents in the Batu Pahat district. How the data of the blackspot area was being recognized and identified? With the help of technology techniques, the prone blackspot area can be effectively better by using GIS software. The development of GIS aims to minimize the problem in finding the exact location of the blackspot area, especially in daytime and nighttime mode condition. The geodatabase will be created to hold all data sets where it will store database tables and map information.

2. Literature Review

GIS database functions as a theoretical framework that supports data models for location search for accident blackspot prone area and how the previous researcher determines a blackspot or prone accident area in some location. Hence, instead of study about the condition of the blackspot area, this chapter also studies the implementation of using GIS.

2.1 Factor causes of blackspot accident

There were several aspects of causes to be investigated before the solution can be determined to prevent the number of road accidents in Malaysia for a better future such as human error, vehicular condition, time of day, and road and environment factor. According to Road safety Factsheet [3], 93% of the causes of traffic accidents was from human errors that can because whether the driver is doing it intentionally or unaware while driving. The documents from accidental police reports can be important evidence that can help show the accident caused. According to [4], a major accident may cause if the vehicle failed in the driving assistance system (DAS) and information system (IVIS). The factor of an accident that listed under vehicle conditions such as engine failure, steering mechanism, braking system failure, improper maintenance, and defective tires.

Hence the comparison between daytime and nighttime period of road traffic accident was made to identify which period had prone traffic accident along the area. The early hours of the morning and the middle of the afternoon are the periods of the day where fatigue injuries and lengthy road journeys occur. Based on the research from [4], the crash can happen because of a lack of highway light and human factors such as driver's tiredness and fatigue especially when people were just feeling exhausted after going back from their shift works. The involvement due to the road and environmental condition accident factor from [3] contribute by 3% while 34% due to roadway related factor and other reason road factor was stated by Highway Safety Manual published by American Association of State highway and Transportation (AASHTO).

2.2 Accident rates according to cluster

According to a previous study from [5] to arrive at the top rates of an accident, the method of weighted severity index is used. The condition of road users is classifying in a range of fatality, serious injury, and minor injury. As stated from [6], If a person dies because of injuries received in a traffic crash within thirty days of the date of the crash, that victim is a traffic fatality. Serious Injuries are injuries other than death resulting in exposure of underlying tissues, muscle, organs or resulting in significant loss of blood, broken, suspected skull, chest, or abdominal injury other than bruises or minor lacerations, or paralysis. A minor injury may be no visible injuries, and the patient complains of pain. This is an injury that can be treated by first-aid application whether at the scene or in medical facilities. Moreover, according to a previous study from [5] to arrive at the top rates of the accident is stated in Eq1. Each level of seriousness of an accident has its weight given based on the Malaysian Institute of Road Safety Research (MIROS) as stated by the researcher from [7].

$$\text{Weighted Severity Index (WSI)} = X1(6.0) + X2(3.0) + X3(0.8) + X4(0.2) \quad \text{Eq. 1}$$

Where,

X1= Number of persons killed, X2 =Number of grievous or major injuries, X3 = Number of minor injuries, X4= Damages Only.

2.3 Geographic Information System (GIS)

The studies from [8] show that in the new technologies GIS is used to collect, preserve and handle data that is spatially referenced to the planet. Besides, by using GIS, a single map could include partial site location data such as streets, buildings, and vegetation. The input of location can be uttered in many ways which are address number, ZIP code, or latitude and longitude. As a result, a research analysis from [5] concludes that it is possible to classify the discovered prone locations using GIS by analyzing spatial characteristics of the discovered locations, as well as assessing the fundamental reasons from which the prone locations are made. GIS analysis is performed using GIS software namely GeoDa. By using this software application, it can analyze and serve the wide range of planning the exploratory spatial data analysis (ESDA) information using advanced technology infrastructure, GIS tools, and database. GeoDa is similar to other kinds of spatial software but may have different user-friendliness with a variety of mergers. In anyhow, GeoDa is still an interactive way to explore the visualization of spatial global information that combines maps with graphic technology in a linked window. Meanwhile, the accident data represent the number of crashes and injury happen during the incident. The relation between several accidents and severity also useful in making a comparative study of the blackspot area. The spatial data give an important role in terms of fixed location in coordinates which can give out the spatial arrangement, and topology.

After that, by using GeoDa analyzing tools, the sources information and data can be carried out in the form of statistical analysis as either in the parallel coordinate plot, three-dimensional plot, and four conditional plots. The conditional was one of the ways to analyze the spatial data. The main principle behind this plot is the use of two-term variables to group the data into different categories which is fall into a specific range in conditioning variables. The conditioning plot in GeoDa support to view in a conditional in the map, box plot, and histogram. According to [9] the conditional map requires a strict assumption in data sources information such as data population, matrices, and the relationship between variables. The data has been described based on the predictive model and gives more explanation on kind of site activities.

2.4 Benefit of GIS

In an overall view, it can be seen clearly that the implementation of GIS has highlighted the definition, factor, importance, and observation for detecting the blackspot accident area. Moreover, the GIS tools itself give the effective way as it has been used as a solver to many of problem. Other than that, using the technology of GIS can reduce time and energy to find solutions especially in

detecting blackspot accident areas. As a result, many previous researchers choosing the implementation of this GIS technology to further their scope of studies.

3 Methodology

The flow and methodology as shown in Figure 1 used in guiding to ensure the development of a workflow system to determine the blackspot of an accident by day and nighttime condition. Moreover, it is very helpful in solving a problem by presenting the data collection in a simple digitizing which is a visual observation by using a technology GIS (GeoDa) method. This begins as the objectives of this study to the spatial geodatabase developed for future use in a system with the form of geospatial result.

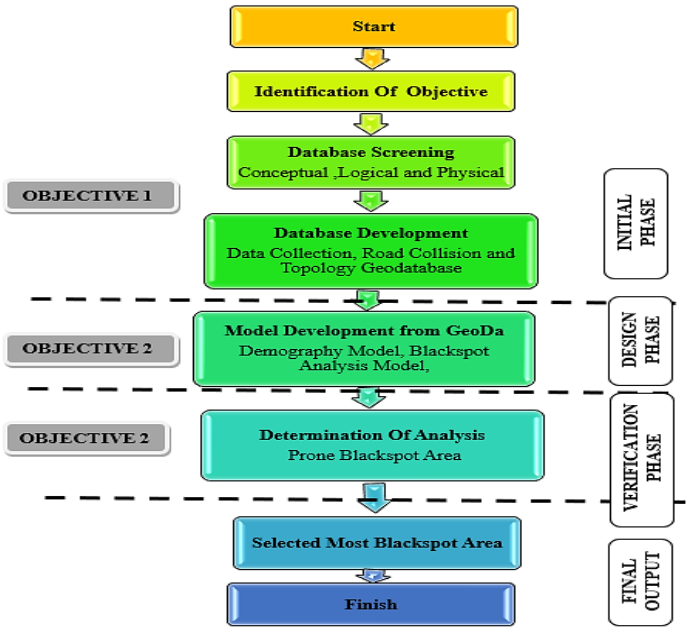

Figure 1: Determination of blackspot accident using a flowchart

3.1 Initial phase

In this phase, after identified the objectives and the problem statement was determined, the data are being collected from 2017,2018, 2019and 2020. The data collection take count of two method sources namely primary and secondary data sources along varies of Batu Pahat road area. In this phase, the secondary data were current files that are used to gather police data. This data includes a list of the outlets for identifying blackspot regions. All the data includes traffic injury information for the different roads along the Batu Pahat area and Road Traffic Department, geographical Photos, topographical and street guide maps of Batu Pahat which is by using Google Maps. This statistics data will be used for the analysis of the weighted severity index (WSI) in which the highest score will be calculated by the degree of severity. The primary data is a direct collection of information on the case study area. It is the experimental investigation or survey. This primary data includes the determination of parameters that causing the accident on road areas such as human behavior, traffic volume, road inventory survey, vehicle condition, environmental condition, weather condition, and all information that can be used for the investigation.

3.2 Analysis of database

The top-ranking to detect blackspot accident area is by using WSI. The analysis of calculation is performed by a collection of secondary sources of data. The data screened based on the night and mode condition and the seriousness of the injury. After all the information have been screened and developed, the detail of the database was being inserted in the WSI formula to know manually which

place got the highest blackspot area. The blackspot detail includes all types of vehicles such as motorcycle, car, lorry, and van.

3.3 Design phase

In the design phase, the data will be inserted according to several supported formats and the model development be constructed based on the conditional plot.

3.3 Verification phase

The verification phase is the determination of blackspot analysis data. The ranking of the blackspot area is displayed as the highlighted area. The displayed results ranged from top to bottom of the blackspot area. Then, the most critical accident area at the top ranking which is the blackspot area determines in the form of spatial maps to be verified for the next final output.

3.3 Final output

This phase will evaluate and shows the prone detection area after the analysis of the database from the initial phase to the verification phase. The most critical blackspot area is made after the software detects the prone area by coloring the spatial maps of the study area. The color of the blackspot area was given based on the ranking. Each of the rankings got their color to represent the detection of blackspot data.

4 Results and Discussion

This chapter elaborates the implementation of the methodology by using the collected data from various sources by the blackspot accident data in the Johor area. After that, it will be followed by the process and geoprocessing technique for selecting the site location for the prone accident blackspot area. At the end of the result, the location of the prone area showed up from the top until the least accident.

4.1 Result of database screening according to the location with injury cluster

The total of accidents in each of the locations described as mentioned in Table 1. The data presented was for about 4 years of accident from the years 2017, 2018, 2019, and 2020. The data screened the conceptual and logical from the original data and has been selected which one has the higher value.

Table 1: Database screening according to the location with injury cluster

Location With Code Number	Fatal				Serious Injury				Minor Injury				No Injury/Damage				Total accident
	2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020	
E001 - L/R Pagoh-Y/P-A/Hitam-Y/P-A/Hitam-Macap	27	24	21	10	4	5	5	1	20	13	10	0	6	25	48	0	219
F001 - Jln Jb-Sbn A/Hitam-Y/P-Labis-Y/P	13	8	9	7	2	1	1	0	16	11	5	0	2	2	1	0	78
F005 - Jln Jb-Mka-Tg Laboh-B.Condong-Peserai	15	20	29	15	2	2	1	3	14	7	1	4	4	3	1	0	121
F024 - Jln Y/Peng-Muar-Y/Peng-Pt Sulong	12	12	7	4	3	0	2	0	13	5	3	0	4	0	1	0	66
F050 - Jln Kluang-Jln A/Hitam-B/Pahat	27	28	34	14	11	4	4	1	23	31	12	0	10	8	6	0	213
J013 - Jln Bkt Pasir-Tongkang Pechah	7	6	3	6	2	0	1	0	6	9	3	0	2	0	0	0	45
J019 - Jln Spg Lima-Pt Sulong	6	5	5	0	0	0	0	0	1	5	0	0	0	0	1	0	23
L001 - Lain-Lain Jalan	24	28	22	25	4	3	4	1	17	23	8	5	3	1	2	1	171
Total Injury	131	131	130	81	28	15	18	6	110	104	42	9	31	39	60	1	936

4.2 Database according to the location with injury cluster chart development

Based on Figures 2, 3, 4, and 5, the bar graph was stated of the location versus Injury in 2017 to 2020. This data shows accident conditions by years. The location was selected for code number road E001, F001, F005, F024, F050, J013, J019, and L001. The condition of the blackspot value can be observed based on the bar graph by years. This figure shows, the highest number of accidents is at Jalan FT50 which is in between Jalan Kluang, Jalan Ayer Hitam, and Jalan Batu Pahat. The road on FT50 got 71 in 2017 and 2018, higher than second top E001 got 57 and 67 in total. From here, even the data shows F50 was the highest-ranking, but it still cannot be considered that will be the top because the data showing are not consistent until it been further investigated through a formula and confirmed in WSI formula and geoprocessing from GIS data.

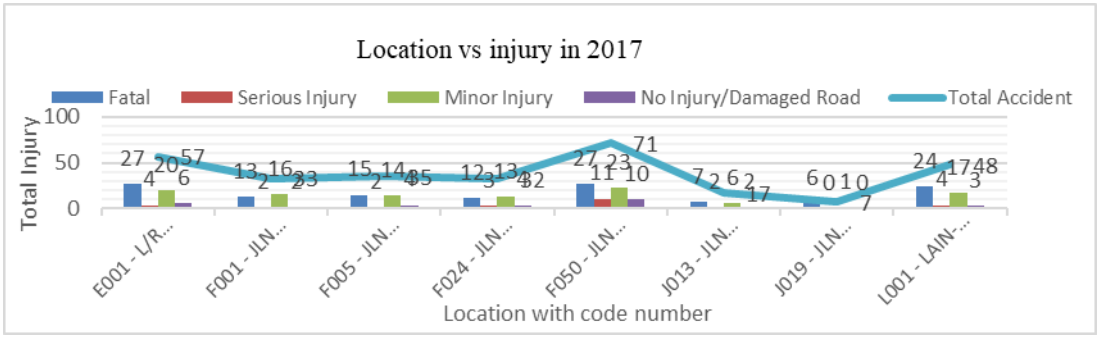

Figure 2: Location vs injury in 2017

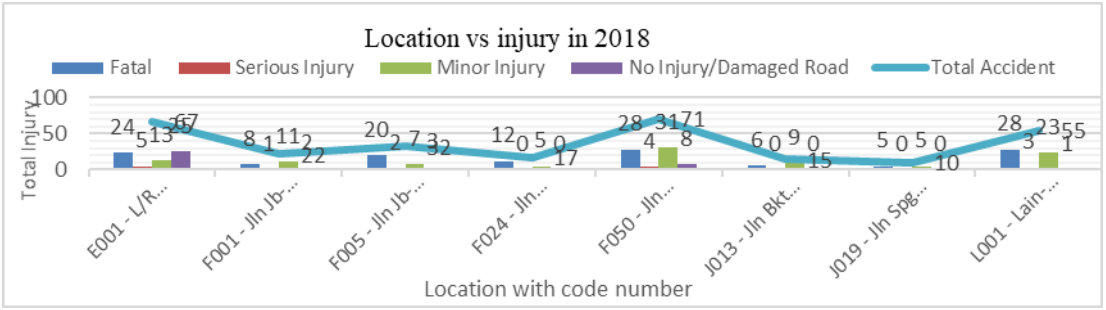

Figure 3: Location vs injury in 2018

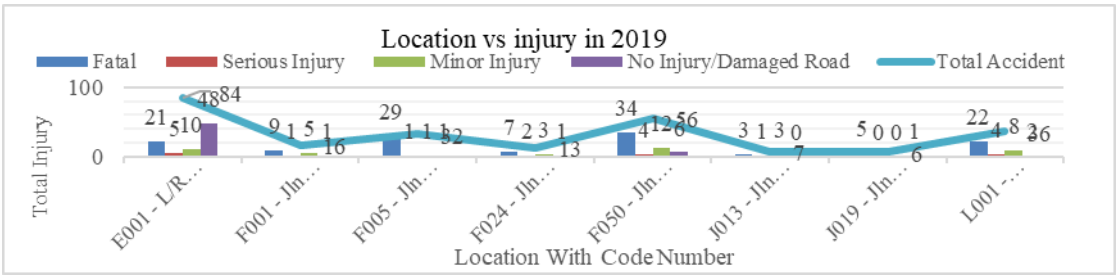

Figure 4: Location vs injury in 2019

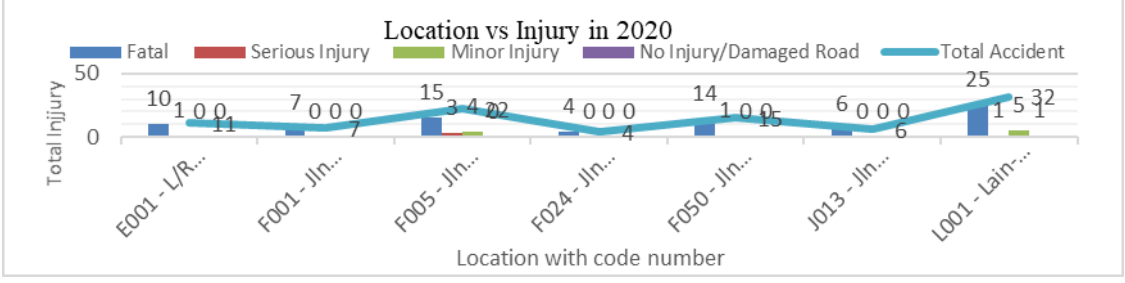

Figure 5: Location vs injury in 2020

4.3 weightage severity index (WSI) and blackspot ranking result

The weightage as shown in Table 2 was calculated based on a total of every location every year. Based on the table shows, the highest total of WSI was at F050 which was from Kluang-Ayer Hitam-Batu Pahat road. Then, the total of WSI is sorted according to the range from top to bottom as shown in table 3.

No	Location with Code Number	WSI				Total
		2017	2018	2019	2020	
1	E001 - Pagoh-YongPeng-Ayer Hitam-YongPeng -Ayer Hitam	192	175	159	63	589
2	F001 -Ayer Hitam-YongPeng -Labis-YongPeng	98	61	62	43	264
3	F005 - Jln Jb-Mka-Tg Laboh-B. Condong-Peserai	108	133	178	103	522
4	F024 - YongPeng -Muar- YongPeng -Pt Sulong	94	77	51	24	246
5	F050 -Kluang-Ayer Hitam-Batu Pahat	216	207	227	87	737
6	J013 - Jln Bkt Pasir-Tongkang Pechah	54	45	24	36	159
7	J019 - Jln Spg Lima-Pt Sulong	37	35	30	0	102
8	L001 - Lain-Lain Jalan	171	196	151	158	676

Table 2: WSI result by years

Table 3: Ranking of the accident spot

Location with Code Number	WSI	Rank
F050 - Kluang-Ayer Hitam-Batu Pahat	737	1
L001 - Lain-Lain Jalan	676	2
E001 - Pagoh-YongPeng-Ayer Hitam- YongPeng -Ayer Hitam	589	3
F005 - Jln Jb-Mka-Tg Laboh-B. Condong-Peserai	522	4
F001 - Ayer Hitam-YongPeng -Labis- YongPeng	264	5
F024 - YongPeng -Muar- YongPeng -Pt Sulong	246	6
J013 - Jln Bkt Pasir-Tongkang Pechah	159	7
J019 - Jln Spg Lima-Pt Sulong	102	8

4.4 Result of database screening according to time parameter with injury cluster

To researching which places with the largest amount of injuries and the potential for incidents, this research has also been undertaken to examine the periods of accidents that exist after the maximum number of accidents were identified. The details available in this figure 6 are in the conditions of the day and nighttime zone. For the study, the time zone being analyzed and split into six separate time zones. Daytime conditions have three time zones, including 6 am. to 10 am., 10 am. to 2 pm. and 2 pm. to 6 pm. Hence, the night condition is also split into 3 time zones, from 6 pm to 10 pm, 10 pm to 1 am and 1 am to 6 am. However, the entire spectrum indicates that the time zone at 2 p.m. to 6 p.m. is the maximum in the three years after that, including 2018, 2019, and even 2020.

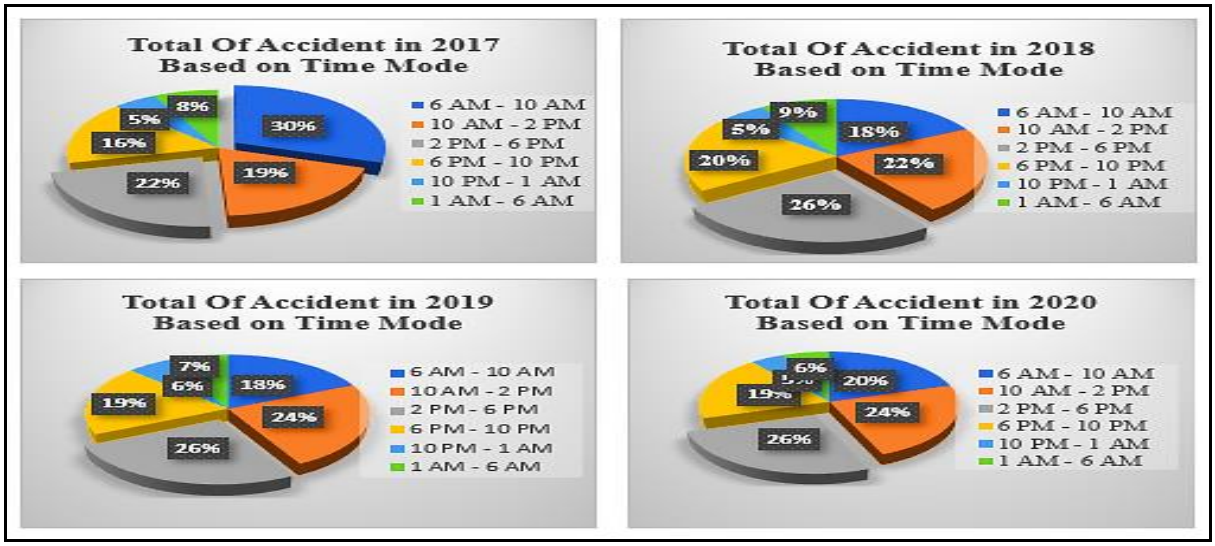

Figure 6: Total of the accident based on time mode

4.5 Database Development from GeoDa

The findings for the blackspot area of an accident would be extracted from this data. A spatial map was added to the location route by adding layer by layer as shown in figure 7. This study is concerned to get data for major road routes in the Batu Pahat area. After added the major road layer, the minor road, and Batu Pahat area was added to form the geospatial map before it been analyzed which route location has the most accident occur. The number of accident blackspot shown in the legend on the left in Figure 8 can also be seen in Table 1. The result shows the value from the least result to highest which 23 are for J019, 45 for J013, 66 for F024, 78 for F001, 121 for F005, 213 for F050, and 219 for E001 code location. So, the most blackspot accident will be chosen.

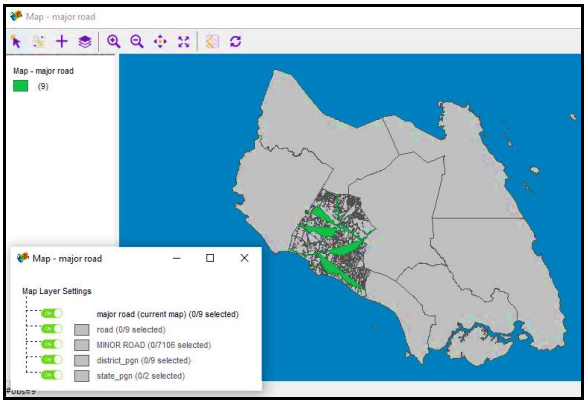

Figure 7: Batu Pahat focussed area on GeoDa map

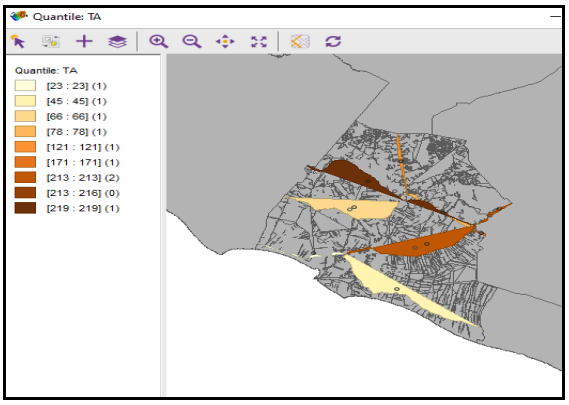

Figure 8: Total of the accident in 4 years

The data displays in the form conditional histogram, which shows the maximum region of blackspot. The codes E001, L001, F001, F50, J013, F005, J019, and F024 represent the hotspot code location. Besides, these data were also obtained based on Geoda's calculations. The conditional histogram assumes the same idea which displays the distribution of its target variable for the data subsets as determined by the intervals for the conditional variables. The histogram sorts the values of the vector in ascending order and attributes them to the bins corresponding to the histogram bars. GeoDa uses a standard histogram and a connectivity histogram to indicate the location of the blackspot.

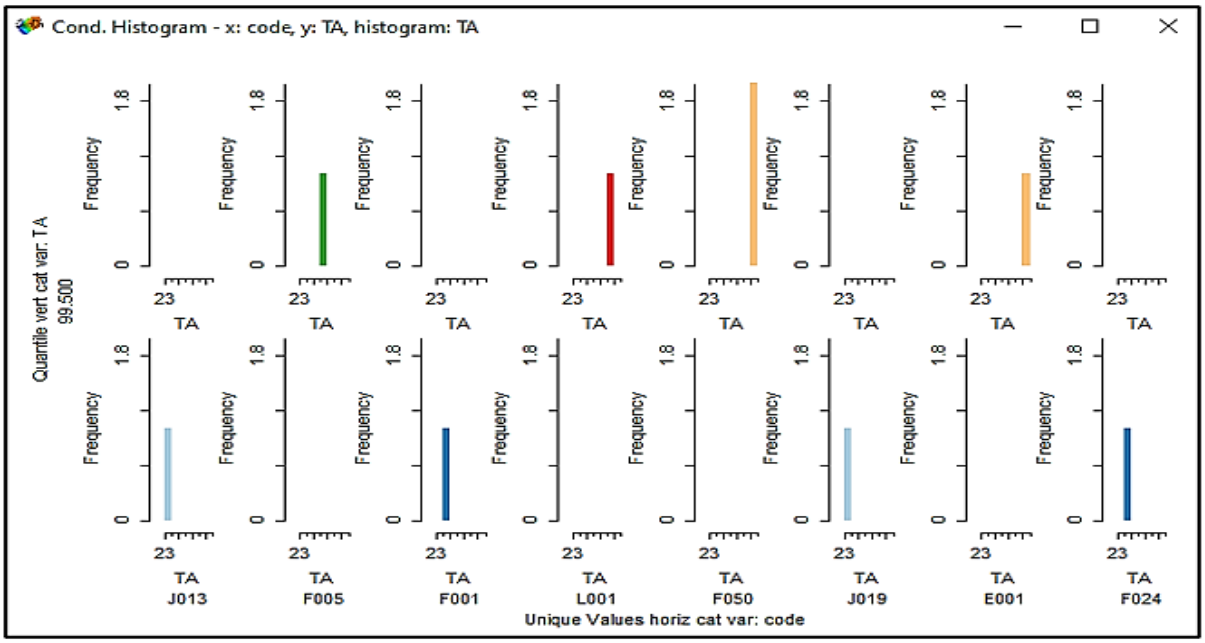

Figure 9: Top ranking of location frequency

As a result, figure 10 is the same value for the top ranking as shown in figure 9. Figure 10 generated the ranking based on the WSI value that has been manually calculated in the previous step to prove it get the same amount with the auto generated from GeoDa total ranking of frequency at figure 9. The location was sorted from least value to high value as shown in the legend in figure 10. It also contains different colors for different route locations. So, the blackspot accident area spotted in figure 10 has 737 totals WSI at the F50 route area which is at Jalan Kluang to Jalan Batu Pahat.

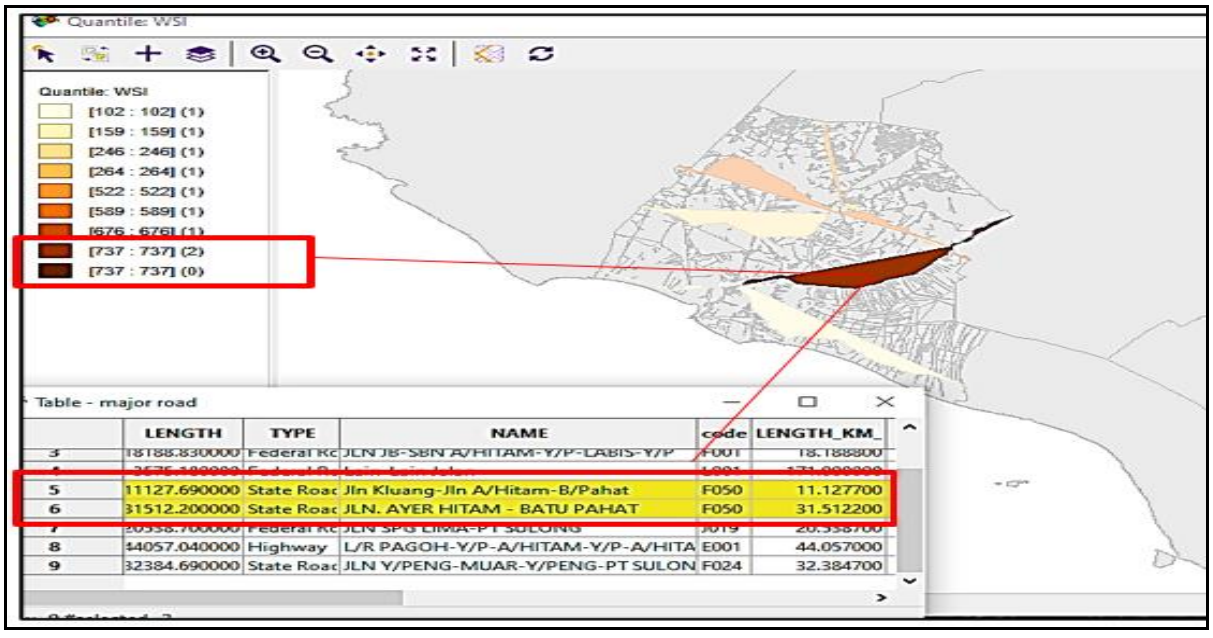

Figure 10: The top location of blackspot area at F50

5 Conclusion and Recommendation

Referring to the discussion and analysis that has been conducted, it can be concluded that the goals and objectives of this study as outlined have been achieved. From the analysis that has been made on accident data and accident time that has been studied in result and discussion, the blackspot area happened is in the area of Kluang to Batu Pahat road in area code F50 where the time of the

accident is from 2 pm to 6 pm during the day. The result was obtained manually calculate using the WSI method and by using GIS through GeoDa Software. The demographic model and implementation built in this analysis can be used repeatedly to examine the process of identifying the location of the black spot accident area. Hence, there is a limitation aspect in the use of tools in the analysis, which makes the outcomes produced to be only the basis for the use. This database should be able to manipulate and display the information involved more efficiently and interestingly. This GeoDa does not accept anything in the form of a polyline, but rather in the form of a polygon. So, the shape of the blackspot route location at the spatial maps was not properly due to polygon shape instead of polyline shape. Therefore, a recommendation that can be made is to make lectures and courses more readily accessible to every higher learning institution, since data collection is convenient and good. In terms of blackspot cases, the recommendation to reduce the accident cases is by installing speed cameras on highway road to monitor and driver more concerned about their car speed. Not just that, since the blackspot area was at F50 and occurred in the time from 2 PM to 6 PM, board indicating the speed limit also need to be installed as a warning because for sure there is congested traffic happen during that hour.

Acknowledgment

The authors would also like to thank the Faculty of Civil Engineering and Build Environment, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] Norziha Che-Him et al. (2018). Journal of Physic. “Factors Affecting Road Traffic Accident in Batu Pahat, Johor, Malaysia” Conf. Ser.995 012033.

[2] Masron, Tarmiji, Wan Muhammad, Taufik Wan Hussin, Mohd Norarshad Nordin, Nur Faziera Yaakub, and Mohd Azizul Hafiz Jamian (2019). “Applying GIS in Analysing Black Spot Areas in Penang, Malaysia.” Indonesian Journal of Geography 50(2):113–14.

[3] Islam, Md Hasibul, Law Teik Hua, H. Hamid, and Arash Azarkerdar (2019). “Relationship of Accident Rates and Road Geometric Design.” IOP Conference Series: Earth and Environmental Science 357(1).

[4] Sandhyavitri, Ari, Zamri, Sugeng Wiyono, and Subiantoro. (2017). “Three Strategies Reducing Accident Rates at Black Spots and Black Sites Road in Riau Province, Indonesia.” Transportation Research Procedia 25:2153–66.

[5] Stephen, Prof Leni, Gladwin G. Kelakom, Jency Maria Sojan, K. S. Sreelakshmi, and N. B. Vishnu. (2018). “Identification and Analysis of Accident Blackspots Using GIS.” International Research Journal of Engineering and Technology 05(03):3455–59.

[6] David A. Noyce, (2018). “KABCO Injury Classification Scale and Definitions.” Federal Highway Administration.

[7] Omar, Noorliyana, Joewono Prasetijo, Basil David Daniel, and Mohd Asrul Effendi Abdullah. (2017). “Accident Analysis and Highway Safety.” MATEC Web of Conferences 103:1–7.

[8] Hunter, Assoc Prof G., and Assoc Prof I. Bishop. n.d. (1997). “Introduction to GIS Definition.” National Centre of Geographic Information and Analysis 1–13.

[9] Whitley, Thomas G., and Gwendolyn Burns. (2007). “Conditional GIS Surfaces and their Potential for Archaeological Predictive Modelling” Brockington and Associates, Inc. United States of America, 292–98.