Geospatial Analysis on the Impact of Road Defects on Motorcycle Accidents

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Abstract. Road accident rate in Malaysia keep increasing over the year. Since then a lot of precaution step, research, life and cost taking apart. However, most of road accident cases are from the group of motorcyclists. To overcome and controlled this trend, the Malaysia society should be aware as a group, because this problem cannot be solved in a single entity. In the identification of the cause of road accidents, decision-makers often need as much information as possible before attempting to make decisions about appropriate measures. Accurate statistical prediction and visualization of information graphically are important for the study of road accidents. Geographic Information System (GIS) technologies, has been applied in this study for analysing the distribution of road accidents and their factor. The main issue that has been focus for this study is the impact of road defect for the motorcycle accident cases in the study area. By using GIS technologies, this is the best medium to determine the relationship of road defect impact in road accidents and for the road safety especially for the group of motorcyclists as well as for effective supervision. GIS tools have become one of the most commonly used programs for the various fields of study and project. It has been widely used in a variety of applications for planning, presenting and analysing the data and result.

1. Introduction

Transportation especially motorcycle can be regarded as the necessity of a daily life for most people in Malaysia. According to the statistics from the Department of Road Works Malaysia (JKR) [1], being one of the developing countries Malaysia has up to 13,173,030 registered motorcycles in 2017 as described in Table 1. These numbers actually represent the 47.26 per cent from the total of 28,738,194 registered vehicles on road [2]. Therefore, it is essential to keep a public road safe and in good condition.

| Category | Registered vehicle | Percentage (%) |
|----------|-------------------|----------------|
| Motorcycle | 13,173,030        | 45.84          |
| Car      | 13,581,276        | 47.26          |
| Bus      | 61,078            | 0.21           |
| Taxi     | 97,122            | 0.34           |
| Lorry    | 1,223,865         | 4.26           |
| Others   | 601,823           | 2.09           |
| **Total** | **28,738,194**    | **100**        |

Table 1. Statistics of Registered Vehicle in Malaysia 2017 [2]
In addition, JKR also revealed that Selangor has the highest number of fatalities in road accidents as compared to other states in Malaysia from year 2008 to year 2017. According to the statistics from police, year 2016 recorded 7,152 deaths due to the road accidents and 4,484 cases which is 62.7 per cent from that were motorcyclist [3]. The high number of fatalities among motorcyclist does not come as a surprise because of the number registered motorcycle in this country was half the vehicles on the roads.

It had been revealed that most of the heatmap where the road accidents involving motorcyclists occurred have road defects. These defects including potholes and shoving could give impact for the motorcycle road safety. Ministry of Works Malaysia (MOW) has initiated a plan to provide a better safety of road in Malaysia alongside with other government efforts to reduce the accident cases and to achieve its safety target. The investigation shows that 13.2% of the accidents this country is influenced by the condition of road [4].

This study was conducted in four stages. The first stage was background study where the review of literature and software training was conducted to give deeper understanding on the study. Next, the data acquisition was conducted in two phases. First was listing the data required by the study followed by collecting them from available sources. The third stage was data processing which was divided into two parts of finding the heatmap of motorcycle road accidents using spatial analysis and determining the location of poor road conditions using mobile GIS. The final stage was to analyse the relationship between the poor road conditions with the heatmap.

2. Review of Literature

2.1. Motorcycle Accidents

Motorcycle is one of the major modes of personal transports for the urban community with low incomes. Motorcycles make up half of the vehicles among Malaysian than other vehicles. With this fact, it will be not surprising if motorcyclists can be generally the biggest contributor in road accident cases for the country. This has been proven as motorcyclists have a higher fatality rate per journey distance as compared to other vehicles on road [5]. Being the most popular transport for those people in the middle and lower income classes, the possibility of introducing special laws to enforce tighter controls on the amount of motorcycles on our highways is not something that the government may be prepared to consider unless it is requested to do it by the multiple sides. In 2017, the Federal Territories Minister at that time, Tengku Adnan Tengku Mansor, mentioned that the government had considered to ban the classic motorcycles on the roads, which is known locally as “kap-chai” from entering Kuala Lumpur as part of efforts to reduce carbon emissions and congestion in traffic also to reduce motorcycle theft cases [6].

The total number of vehicles being registered in this country has been increased year by year. Most of the vehicles that have the increasing number are the type of vehicles that had been used daily by community of people such as car and motorcycle. Therefore, it is important to keep a public road always in a good condition to ensure the road safety and trying to avoid the increasing number of road fatalities cases every year.

2.2. Road Defects Impact on Road Accidents

While the majority of road accidents are caused by the carelessness of drivers, there are another factor that could lead to road accidents which is poor road design or conditions that played a role in more than half of the road accident cases. Road accidents caused by road defects can often be more complicated than other types of cases of personal injury, particularly when they happen on a public road. The claim for the damages needs to be made against the government agency that’s responsible for the design, construction or maintenance in that road area. This is because that government agency is the one that should be responsible for providing warning of driving hazards on that particular road [7].

The Director for Department Civil Engineering and Urban Transportation, Kuala Lumpur City Hall (DBKL), Director Abdul Hamid Surip, stated that statistics shows that 70% of potholes and damage roads in this country are caused by the construction works especially those who are hired by companies
involved in utilities and development [8]. Usually during the on-going construction works, the company fails to follow the right specification which then leads to the damaged roads. The interviews from Malay Mail with some of the authorities that were in-charge of the maintenance of road in Malaysia which is Public Works Department (JKR), the Malaysian Highway Authority (LLM), the Kuala Lumpur City Hall (DBKL) and the Petaling Jaya City Council (MBPJ) said that their hands are tied when utility companies and others continue to re-hire the same contractors that failed to follow the specification of works, even with the financial penalties that have been charged against them. All four authorities told Malay Mail that they had no record of any blacklisted contractors have been made for the entire of 2017.

Usually the road authorities in Malaysia required one or two weeks to take action of road defects reports for the permanent repaired [8]. But for the temporary repaired, usually the authorities only take one or two days to take action. There is a standard procedure that needs to be followed by the authorities to get the roads to be repaired and the public needs to understand this flow of works. If there are problem of road defects that authority has missed it, the society in that area can lodge a report or complaint using their hotline number provided.

Developing and maintaining transport infrastructure is an important part of the economy [9]. The qualities of roads and effective management of the road are a priority for every human right because it can give impact for their road safety. Road design can have a significant impact in road user protection. Ideally, roads should be designed with safety for all road users. This would mean ensuring sufficient facilities are available for all type of road user. The previous studies from the Malaysian Institute of Road Safety Research (MIROS) (2016) found that there were about 1.24 million people die every year due to road crashes [10]. The most contributed road user stated in this statistic was the motorcyclist with 62.7% fatalities cases in 2016. Based on this study, the main factors of motorcycle crashes in Malaysia came from the behaviour of the road users and also from the collision type on the roads. The studies show, there are data of motorcycles accident due to hitting the road defects or object on the road. The method that was used for data collection of this study is by using analytics system developed by MIROS to support research about road safety and evidence based on road safety programs and with the cooperation from the MOT and PDRM.

Based on the statistics of road accident cases that rising in the country, thousands of kilometres of road defects must be inspected each year and the information of road defects always need to be update [11]. Nowadays, information on road defects was obtained by human inspectors manually. But these methods are very slow and slightly uncomfortable for the inspectors and road users. There are certain previous studies that showed appropriate techniques that can be used to determine the road defects and their impact on road accident cases in proper way.

Road defects can be classified into various category namely mild, moderate and severe conditions on the pavement. Examples of poor pavement condition are rutting, potholes, rupture of the road edge and more. Human factors have been widely recognized and listed as one of the major contributors to road accidents [12]. In addition, the macrotexture, microtexture and surface roughness play an important part in creating a suitable and ideal condition of pavement. In order to resist skid and rutting impact, greater friction between the tire and the pavement was identified on this project.

In many developed countries, the growing number of road users, road surface quality, expanded of road network and weather condition is major factors in increasing the number of road fatalities. For example, there was a study conducted to measure the pavement condition along the 206 km southern stretch of Malaysia highway by using the Multi Laser Profiler (MLP) [12]. The road accident data were also obtained from the authority's previous accident reports. Based on the observation, more than 70% of road traffic accidents in this country caused by certain factors include road conditions, human error and environmental conditions.
3. Methodology
This section will explain in detailed about the methodology for this study which involves the background of research, collection of data, data processing and analysis. In addition, this chapter will also describe each process and analysis in the form of a visualization until the final product is obtained. All the stages involve in the methodology of this research is illustrated in Figure 1.

![Figure 1. Research Workflow](image)

3.1. Generate the Heatmap of Road Accident Area
The hotspot of road accident is generated using a kernel density technique on spatial analyst tools in ArcGIS software. Kernel Density tools is a technique tools calculates the density of features in a neighborhood around the features. It can be used to calculate for both point and line features. It also including the finding the density of reported road accident cases in survey area. The hotspot of accidents area was determined by the frequent number of road accidents at that location and from the total victim from each case based on the accident report. Based on the analysis, the accident hotspot area can be examined and also can be used for analysing the factor of road accident happen on that risk area.

3.2. Analysing the Impact of Road Defects on Road Accident

| Type of Road Defects | Number of Defects |
|----------------------|-------------------|
| Pothole              | 9                 |
| Rutting              | 4                 |
| Cracking             | 7                 |
| Ravelling            | 2                 |

The analysing impact of road defect factor in road accident cases has been determined using multiple ring buffer technique in analysis tools on the ArcGIS. From this technique, the road defect location as described in Table 2 has been set the buffer distance in meter value and determined whether the road
accident risk area was inside or outside the buffer that has been setup. From this analysis, it can be used to determine whether road defect is a main factor of road accident cases in the study area. Another that, map of the pattern of road accidents with respect to the location of road defects can be used to determine the correlation between these two variables. In addition, the location of the road defects can also be used to analyse the type of road accident pattern in study area those are prone to accidents.

4. Results and Analysis

4.1. Distribution of Road Defects in Section 7, Shah Alam
This analysis also analysed the different types of road defects that leads to road accidents in study area as shown in Figure 2. From the obtained report, pothole defects is the most popular defect and this is so worrying because of this type of pavement can leads to serious injuries and damage for the victim especially for group of motorcyclist. The second highest number of road defects was road cracks. This kind of defects is mostly caused by the construction or maintenance of road in Section 7. For example, is on Persiaran Permai and Bulatan Bestari. Other than that, this area has high traffic densities especially during the peak hours. From this result, it can be concluded that the pothole and road cracks are the two major types of road defects existed in Section 7 roads which can lead to motorcycles’ accidents.

4.2. Heatmap for Motorcycles’ Accidents in Section 7, Shah Alam
Figure 3 visualised the heatmap for the motorcycle accidents in Section 7, Shah Alam for the year of 2019. The heat map was generated with the kernel density technique. From the investigation and analysis, the black spot of accident area can be identified from the number of motorcycle accident cases in the area of road. Persiaran Permai was shown as one of the riskiest roads in Section 7 for the road users especially motorcyclist including the nearest road with it, which is Jalan Plumbum and Persiaran Kayangan. In year 2019, Persiaran Permai is known as unsafely road in Section 7 because of road condition in this area is not achieved the safety material for the road user especially for the group of motorcyclists.

Based on the map visualising the heatmap of the road accidents, it can be seen that the area that has the highest rate of motorcycle accident in Section 7, Shah Alam is at Bulatan Bestari as the results showed the solid red colour for this area. This might because of the construction in this road has taking...
a long time to be completed. Moreover, this road has a high traffic density especially during the peak hours and there are many dividers dividing the main road and the exits or junction.

Following the area that has a highest risk of motorcycle accidents in study area is at Persiaran Permai including the nearest road from it which is Jalan Plumbum. This is because, this road is within the radius of the development of Light Rail Transit (LRT3) which affected the surface of this road. Bulatan Bestari also can be determined as high-risk area in 2019. From this observation, roads in Persiaran Permai, Jalan Plumbum, Persiaran Kayangan and as well as Bulatan Bestari are calculated and determined as the highest risk area for motorcycle accidents in study area.

There might be a reason why this accident was happening. As discussed before, road defects can be one of the factors contributing to the road accidents. Therefore, the next analysis will investigate the relationship between the road defects and road accidents.

Figure 3. Heatmap for Motorcycles’ Accidents in Section 7, Shah Alam

4.3. Relationship of Road Defects with the Motorcycles’ Accidents

Figure 4 shows the heatmap for motorcycles’ accidents with the distribution of road defects in Section 7, Shah Alam for the year of 2019. The analysis on the relationship between the road defects and the heatmap will be made based on the occurrence of accidents within 60 metres buffer from the location of road defects. The distance of 60 merges was chosen as it is the most possible distance for a motorcycle’s accident to occur when the motorcyclist hit a certain road defect. Based on statistics, the location with the highest number of road defects was around Persiaran Permai. It can be seen that the number of road defects in this area did contribute to the motorcycles’ accidents thus proven the hypothesis of the impact of road defects on road accidents.

From the analysis, it can be seen that all of the heatmap was located within the radius of 60 metres from the road defects thus met the hypothesis that road defects do contribute to motorcycles’ accidents. This particularly can be seen in Persiaran Permai which received the highest reported number of road defects among other roads in Section 7, Shah Alam. In addition, the least risky as or represented as cold spots was Jalan Platinum and Jalan Keluli.

The results had been verified as the author had personally ride motorcycle along the way to check the hot and cold spots. In Persiaran Permai, the author has done some checking and investigation, the condition of road is not fully achieving the criteria of the road safety especially for the group of motorcyclist. There are many road defects can be seen along the road and has been follow by the
construction that give effect for the condition of road on that area. Besides that, the author has done a checking by personally rides a motorcycle in the cold spots area which is Jalan Platinum. From the investigation, the author has found the surface and road design in this area has fulfilled the criteria of road safety. Most of the road or junction in this area is clear from any defects and can be determine easily by the road users especially for the group of motorcyclists.

Figure 4. Relationships of Motorcycle Accident and Road Defect

5. Conclusion

This study aims to analyse the relationship between road defects and the road accidents involving motorcycles. This is due to the number of cases of motorcycle accident in Shah Alam especially in Section 7 was a bit alarming and there have lack studies that used Spatial Analysis to find the risk area of motorcycle accidents. This study has produced the results using kernel density technique to display the risk area of motorcycle accidents. Then the result was compared with the accident report to see the correlation whether the area that has been display as risk area is same as reported area that have high road accident cases. The first objectives for this study are successfully achieved and solve the problem which is to determine motorcycle road safety hot area by using Spatial Analysis. The analysis to find the correlation of motorcycle accident risk area with the road condition have been generating on the previous chapter using GIS function which is buffer tools. Since the number of reported for road defect in study area has been determined and there is a least research about the impact of road defect for road safety, this analysing can be perform using analytical method which is spatial analysis. Based on the result, it can be determined that the motorcycle accident mostly was happen in road that has record of road defect. From the result and analysis from previous chapter, it can be concluded that the condition of pavement’s conditions can be one of the main factors and has contribute for motorcycle accident cases in study area which is Section 7, Shah Alam. The second objectives for this study are successfully achieved and solve the problem which is to determine the correlation of motorcycle accident hotspot area with the road condition factor. It is important to communicate the findings of this study to public to raise awareness for them so that they will be more careful when using roads with high number of road defects as well as heatmap. This is also for the local authority so that they can take extra care in the road maintenance. Therefore, it is vital to create a map that can visualise the findings of this study well. By integrating the GIS function, which is kernel density technique, this study proved that it is possible to
analyse and identify the location of the risk area for road user safety. The occurrence of motorcycle crash in study area has been determined and has located on the map from the high concentrated of road accident cases report. Therefore, with this, the third objectives for this study are successfully achieved and solve the problem which is to produce a map for visualization of high-risk area for motorcycle road safety in study area.

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