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The Challenges of Autonomous Vehicles In Malaysia: From The Perspective Of Motorcycle Traffic Crashes

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Abstract

The Level 3 autonomous vehicle (AV) is now a reality on the public roads. While the emergence of AV is to eliminate the traffic crashes due to human error by 90%, the unexpected or errant drivings on the roads would, however lead to traffic crashes as the operation of AVs are depending on the artificial intelligence, which involve constantly teaching the computer to learn. In Malaysia, motorcycle fatalities accounted for about 60% of the total traffic fatalities, of which the majority of the fatalities were due to human errors. - The presence of motorcyclists in the traffic stream then becomes challenge to the operation of AVs due to the unpredictable and inconsistent behaviour of the motorcyclists. Therefore, to ensure the safe deployment of AVs in the country, this study is taken to unveil the characteristics of certain traffic crashes involving motorcyclists. The findings show that as high as 40% of the motorcycle casualties were due to the motorcycles' faults. Careless driving, speeding, dangerous overtaking and turning are among the causal factors. The findings shed important insights to AV software programm developers in the process of detecting and processing necessary response plans. Besides, the car makers can also propose more crashworthiness vehicles from the perspective of vulnerable road users.

Keywords: Autonomous Vehicles, Motorcycle Safety, Interaction Safety, Errant Driving Behavior

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1.0 Introduction

In recent years, autonomous vehicle (AV) technology has marked a pivotal milestone in the automotive industry. With significant breakthroughs of capabilities in terms of sensors, cameras and vehicle-to-everything (V2X) communication, the automation level has successfully leaped from Level 2 (L2) to Level 3 (L3), whereby only L3 and above vehicles are legitimately considered as autonomous vehicles (Autocrypt, 2023). Specifically, the distinction between L2 and L3 is that L2 is a vehicle with advance driver support features while the L3 signifies a driver can take his eyes and hands off, but the drivers are expected to take over the driving task when the system fails to perform accordingly (Sae, 2018). Around the world, Mercedes-Benz L3 vehicle is the first vehicle being granted permission by German Transport Authority to be operated on public roads since May 2022 (Autocrypt, 2023). Subsequently, in 2023, the Mercedes-Benz obtained approval in Nevada, United States. The OEMs (Original equipment manufacturers) claim that more L3 AVs are ready to be commercialised in the markets.

The invention of AVs is propagated to be able to reduce traffic crashes due to human errors up to 90% (National Highway Traffic Safety Administration, 2015). Indeed, the operations of AVs are not without criticism. Many argued that it is too optimistic to ascertain the benefits now as the number of AVs on the road is too few. Presently, a report by Tomorrow City (2024) revealed that the rate of traffic crashes involving AVs is 9.1 crashes per million miles driven compared to human driven vehicles of about 4.1 crashes per million miles driven. The report further revealed that potential causes of faults include the unrealistic testing, technical faults, glitch in software and inaccuracy of data mapping. The first fatal incident was reported in 2018, where a pedestrian walking with a bike was killed by a self-driving vehicle. It was found that the bags on the handlebars of the bike had confused the AV computer and caused the program to fail to interpret the condition. The incident called off Uber's trials in driverless taxi. Another fatal incident was also reported in San Francisco in October 2023. A pedestrian walking on the road was killed by a robotaxi when a human-driven car encroached into the path of a robotaxi. As the robotaxi was programmed to pull over in the event of unknown conditions, it ran over the pedestrian instead of stopping

(Wolmar, 2023). This incident prompted the cessation of robotaxi operations in all of US cities (Autocrypt, 2023).

The approval of L3 AVs on public roads has signified a new paradigm shift of conventional vehicles into autonomous or self-driving vehicles on the roads. Debatably, the benefits of AVs in mitigating traffic crashes due to driver' error might be offset by the potential hazards brought to the vulnerable road users. The past traffic incidents expose the fragility of the technology where the autonomous companies consistently undervalue the sheer complexity of matching or surpassing the conventional human driving skills (Wolmar, 2023). Wolmar (2023) further highlighted that the autonomous vehicles are depending on artificial intelligence which involve constantly teaching the computer to learn and interpret the what is occurring within the highly intricate road environment. In other words, any possible object (i.e. a small debris) or unexpected moanuever might confuse the computer, thereby resulting in unpredicted consequences. In this respect, Morris et al. (2021) underscored the importance of interaction between the behavior of vulnerable road users (motorcyclists, cyclists and pedestrians) with AVs as their behavior are usually unpredictable. The understanding of various responses between the vulnerable road users and AVs in different traffic environments are essential for the safe operation of AVs on the roads (Hagenzieker et al., 2019). In the context of Malaysia, traffic fatalities involving motorcyclists accounted for about 60% of the total fatalities. Several studies have documented that risky and violation behavior are the main contributors to the motorcyclist fatalities (Harith & Mahmud, 2018; Lee, 2015; Manan, 2014).

These deliberant behavior or maneuvers of the motorcyclists can be hazardous in an environment with AVs as the computer is unable to program the unpredicted manuevres. Despite grappling with the complexity of the presence of motorcyclists on the roads in the current technological landscape, the L3 AVs are expected to penetrate into local markets by 2025. There have been prolific research on AVs, however very little studies exploring the interaction between AVs and other road users from the safety perspective (Morris et al., 2021). In order to ensure the safe operation of AVs on the roads, it is imperative to gain deeper understanding of the possible maneuvers of motorcyclists and identify the causal factors in the anticipated interaction breakdowns.

However, due to the fact that the AVs are still not massively deployed on the roads as of today, the objective can be achieved by exploring the characteristics of past crash data involving motorcyclists under various conditions. The indepth understand of crash patterns and causal factors can help the AV technology developers to forecast any potential crashes or conflicts and establishing the safest program for the implementation of AVs in the country and around the world. Hence, this study is taken to examine past traffic crashes involving the motorcyclists to unveil the profile of the crashes thereby able to gain a comprehensive view of the potential hazards that might happen between the AVs and motorcyclists.

2.0 Literature Review and Hypotheses Development

2.1 Evolution of Autonomous Vehicle Technology

The development of autonomous vehicle (AV) technology promises to reduce about 90% of traffic fatalities due to human error and promote sustainability goals from social, economic, and environmental aspects (Zhang et al., 2019; Park et al., 2021; Benleulmi and Ramdani, 2022). The AV is an automated vehicle AV that is classified into 6 levels (see Table 1) by the Society of Automotive Engineers (SAE, 2018), ranging from Level 0 (no automation) to Level 5 (full automation). AVs with Level 3 (conditional automation) are currently a reality in the market, and car makers are expected to introduce Level 4 and Level 5 on the roads by 2030. Some researchers forecast that by 2040, AVs will constitute about 25% of the global new car market (MIT Technology Reviews, 2017), and by 2050, it is estimated that fully automated vehicles (Level 5) will achieve 50% market share (Kyriakidis et al., 2015).

Table 1: Automation level (SAE, 2021)

Level	Human Role	Feature	Example Feature
0	Human drives	The limited feature is to provide warnings and momentary assistance	Automatic emergency braking, blind spot warning, lane departure warning
1		The features are to provide steering OR brake/Acceleration support to the driver	Lane-centering **OR** adaptive cruise control
2		The features are to provide steering AND brake/Acceleration support to the driver	Lane centering **AND** adaptive cruise control
3	Human Not driving	The features able to drive the vehicle under limited conditions and will not operate unless all required conditions are met	Traffic jam chauffeur
4			Local driverless taxi, Pedals/steering wheel may or may not be installed
5		The feature can drive the vehicle under all conditions	Similar to Level 4 but can be operated in any conditions

The concept of an automation vehicle was first introduced in 1918 and was made realistic in 1939 by General Motors (as shown in Figure 1). Since then, automated vehicle technology has consistently evolved and made several achievements over the years.

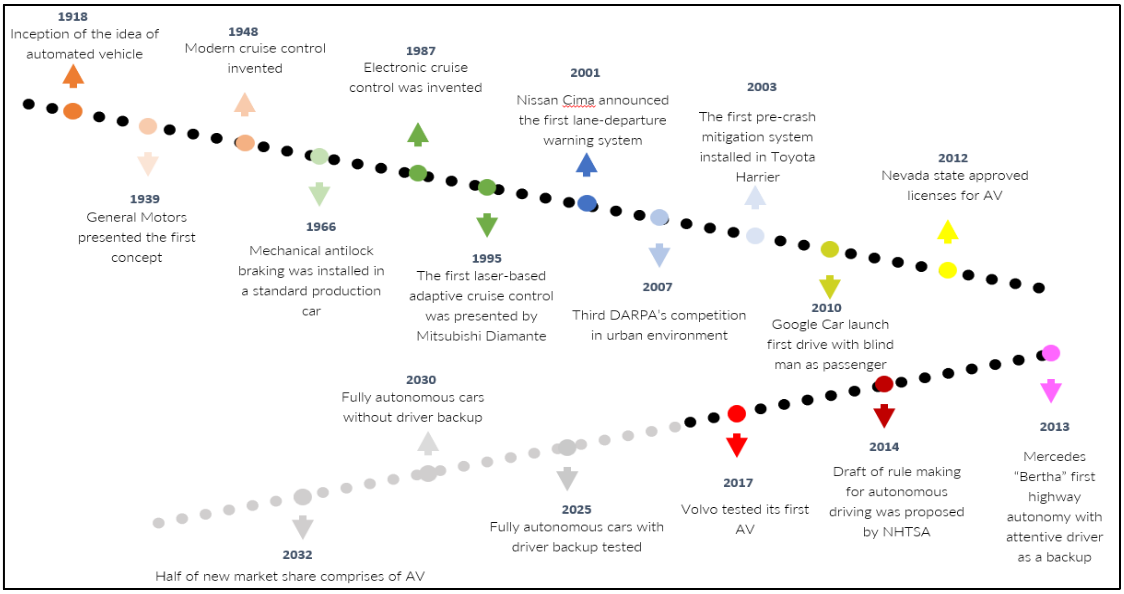

Figure 1: Evolution of AV Technology in the World
(Source: Developed for this study)

In recent decades, automakers such as Ford, Honda, Toyota, Google, Tesla, Uber, BMW have intensified their development of AVs, and test-runs have been deployed in several countries (Xing et al., 2022; Lee et al., 2019). Huge investment has been put into the development of AVs; Audi allocated $16 billion for electric and autonomous vehicles (Winkler et al., 2019), while Ford and Toyota invested $4 billion and $2.8 billion, respectively, in AV technology. On the other hand, since the testing took place in a real-world environment in 2007 in the United States, today, there are more than 130 cities in USA, Europe, and Asia are now ready for AVs with regard to policy making, pilot testing and adopting the AVs as bus or robotaxi (Korkmaz et al., 2021). In line with the forthcoming growth of global autonomous vehicle development and Industrial Revolution 4.0 (IR4.0), the National Automotive Policy (NAP 2020) announced that - the Level 3 autonomous vehicle also known as Next Generation Vehicle (NxGV) will be introducedto the Malaysian market by 2025 (NAP, 2020).

To ensure the smooth and safe implementation of AVs (NxGV) in Malaysia, the government has established a company under the Ministry of Finance, Futurise Sdn. Bhd. will lead the National Regulatory Sandbox initiative related to regulation, innovation and collaboration with other entrepreneurs, regulators and corporations (Futurise, 2022). One of the projects introduced in 2020, the MyAV (My Autonomous Vehicle) project is supported by the Sepang Municipal Council (MPSepang), Road Transport Department (JPJ), Land Public Transport Agency (APAD), Malaysian Institute of Road Safety Research (MIROS), Malaysia Automotive Robotics and IoT Institute (MARii) and Automotive Development Centre, Universiti Teknologi Malaysia (ADC, UTM) to provide a safe test site for AV technology in Malaysia. A 7-km test site has been demarcated in Cyberjaya to test the technology. Two test sites were also established in Johor and Putrajaya with the aim of expediting testing and preparing for the deployment of AVs in the country.

2.2 Motorcycle Traffic Safety in Malaysia

Due to its small compact physical size and ease of maneuver feature in traffic streams, the motorcycles become the dominating mode of transport In Malaysia. It was reported that by the end of 2022, motorcycle ownership has recorded 482 unit per 1000 people; in other words, approximate one motorcycle to every 2 people (AAA, 2023). In 2022 alone, a total of 720,000-unit motorcycles have been sold (NST, 2023).

The over-represented motorcycles in the traffic stream and their physical size have inevitably expose the vulnerability of motorcyclists as well as the risk of traffic crashes. In Malaysia, motorcycle fatalities hover around 50% to 60% of the total fatalities or between 3,000 to 4,000 fatalities annually. The number has not included the seriously injured road users who suffer various level of injuries. By using the value of statistical life (VOSL) for Malaysian, Malaysia has lost about RM 3.2 million for each life (MIROS, 2022) and a total of RM 964 million was paid as compensation to the traffic crash victims in 2016 (Bakar, 2018).

Many past studies have evidently shown that violation behaviour or errant driving are the main contributors of the motorcycle fatalities (Harith & Mahmud, 2018; Lee, 2015; Manan, 2014). For instance, speeding, running red and driving under influenced are among the causal factors (Idris et al. 2019; Manan, 2014; Manan et al. 2019). the scale of motorcycle crashes in the future might be uncertain with the forthcoming of AVs on public roads in Malaysia. Due to the unpredicted and inconsistent driving behavior, the inclusion of motorcycle traveling behavior into the program of AVs is challenging and remain unanswered at the present stage of development. Hence, this study provides a base for AV developers to understand the potential hazards on the roads by describing the crash patterns of motorcycle crashes.

3.0 Data and Methodology

The data used in this analysis were retrieved from Royal Malaysia Police (RMP) Database. Due to the limited data, the traffic crashes (fatalities, serious injury and slight injury) in relation to motorcyclists recorded in year 2019 were only discussed (the crashes in year 2020 – 2022 were not considered due to COVID-19 outbreak and the Movement Order Control had significantly reduced the vehicles on the roads thereby unable to reflect the actual traffic scenario). The motorcycle crashes in this study include also the motorcycle pillions. The characteristics of traffic crashes which can mimic the potential crashes between AVs and motorcycle were retrieved and analyzed by using descriptive analysis. Descriptive analysis is taken in this study to present the results.

4.0 Results and Discussion

4.1 Overview of Traffic Crashes in Malaysia

Over the years, about 18 people die on the roads in Malaysia daily, of which nearly 60% were motorcyclists. The total number of fatalities between 1997 to 2021 is illustrated in Figure 2. The fatalities involving car drivers or passengers were about 30%, and other road users accounted for the remaining 10%.

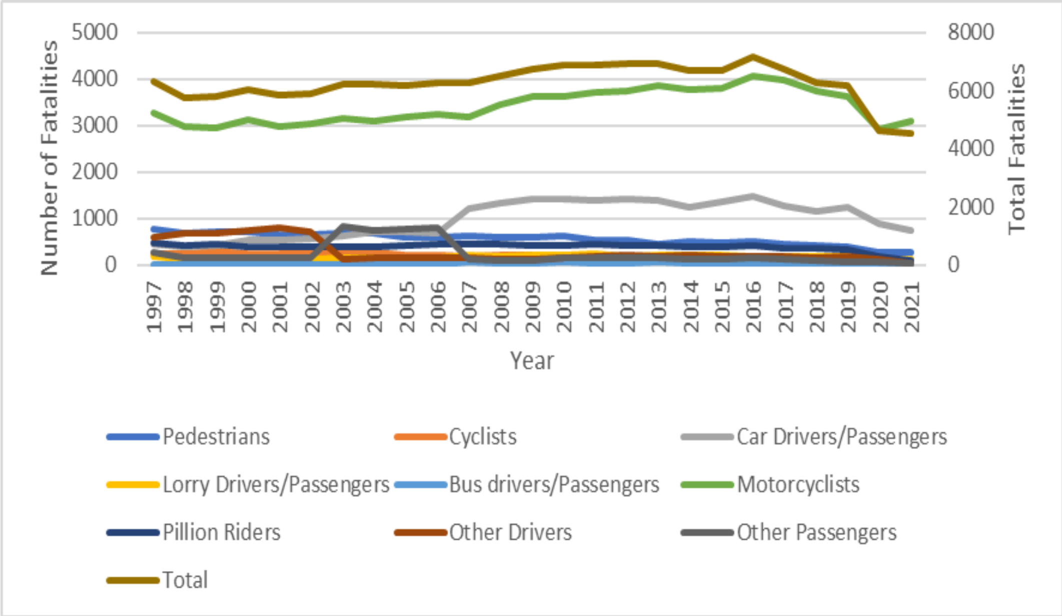

Figure 2: Number of Fatalities Between 1997 – 2021 (PDRM, 2019)

As mentioned earlier, only traffic crashes in the year 2019 are used for analysis in this study. A total 6167 fatalities and 8,877 injuries were recorded. The breakdown of the fatalities is shown in Figure 3.

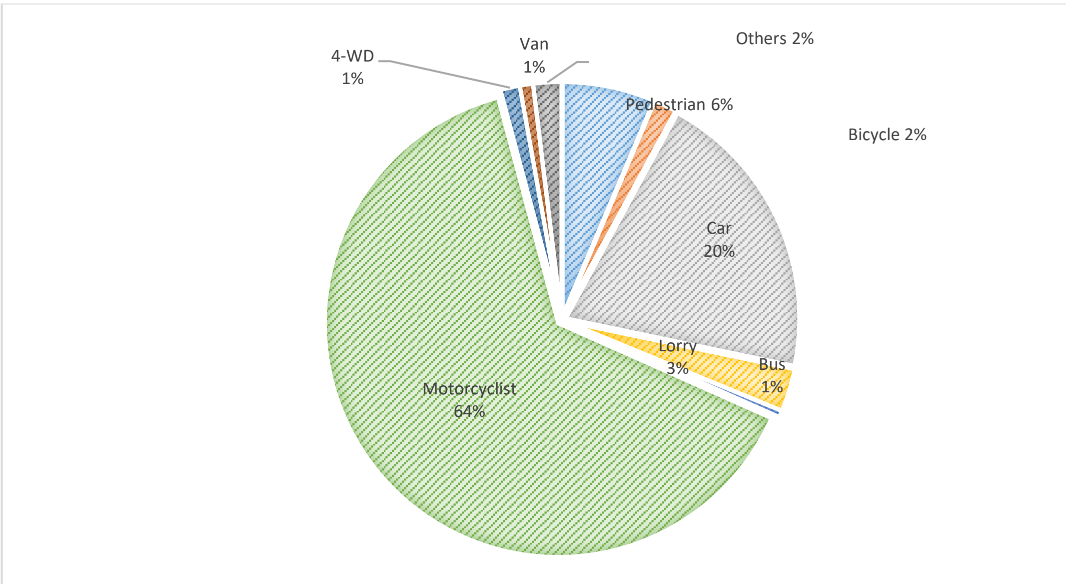

Figure 3: Breakdown of Fatalities

(Sourced: Developed for this study)

4.2 Motorcycle Crashes by Road Type (Geometry)

The understanding of crashes by road type (geometry) is important as these are the area where most of the conflicts would occur due to change of directions (where the traffic merges or diverge at this area). By exploring the motorcyclists' trajectories at various road types, the AV programmers can obtain an overview of the potential movements and assist the AVs in detecting, and predicting thereby safely responding to any interaction between the motorcyclists and AVs.

As shown in Table 2, majority of the casualties occurred at straight sections. The finding is alarming as it reveals that despite all the traffic moving in the same direction, the traffic crashes still happened thus prompting a more detail understanding of the second causal factor to the crashes. The second most common road type where motorcyclists were killed was in curve or bend areas. In contrast, the second-highest serious and minor casualties took place at T/Y junctions. Higher casualties (serious and slight injury) occurred at T/Y junctions as compared to cross junction might be due to the fact that the most of the cross junctions with more complex movements are governed by traffic signal lights thereby the lesser crashes are reported. In terms of T/Y junctions, even with the junctions being equipped with traffic signal, the motorcyclists are commonly seen to beat the red light and taking the advantage of the major straight section to cross the junctions.

Table 2: Number of Motorcycles Involved in Road Traffic Accident by Road Type (PDRM, 2019)

Road Type	Fatal		Serious		Minor		Total
	n	%	n	%	n	%	
Straight	3246	73.2	1477	56.2	3164	69.3	7887
Bend	638	14.4	328	12.5	396	8.7	1362
Roundabout	17	0.4	7	0.3	22	0.5	46
Cross Junction	157	3.5	173	6.6	167	3.7	497
T/Y Junction	373	8.4	613	23.3	797	17.4	1783
Staggered Junction	2	0.0	15	0.6	8	0.2	25
Interchanges	3	0.1	13	0.5	14	0.3	30
Total	4,436	100	2,626	100	4,568	100	11,630

4.3 Casualties of Motorcyclist by Vehicle Maneuver

The maneuvers of the motorcyclists that resulted in the crashes were further examined. Table 3 illustrates that about 40% of the crashes were due to errant behavior of the motorcyclists whereby the motorcyclists were performing various operating movement instead of moving forward. Of the vehicle maneuvers, it is interesting to note that diverging movements led to nearly 5% of the casualties. This calls for further investigation to understand other causal factors that leading to the crashes between the motorcyclists who attempted to leave the traffic stream. Indeed, the dispersal of motorcyclists from the main traffic streams can reduce the AV sensing loads as compared to the merging traffic. Against this backdrop, the AVs developers should pay more attentions in this respect.

On the other hand, it is worth to highlight that Turn-On-Red rule has been gazetted for left turn approaches at the traffic signal junctions in Malaysia. Under the rule, the motorists are allowed to make left turning under a safe gap. In this case, the programing of the AVs in recognizing the on-coming vehicles and pedestrians from all directions are required to ensure the safe crossings.

Table 3: Casualties of Motorcyclist Involved in Traffic Crashes by Vehicle Maneuver (PDRM, 2019)

Vehicle Manoeuvre	Type of Casualties						
	Fatal		Serious		Minor		Total
	n	%	n	%	n	%	
Parked	71	1.8	30	1.5	62	1.5	166
Sudden Stopped	55	1.4	57	2.8	101	2.5	217
Diverging	175	4.4	83	4.1	189	4.7	456
Slipped out	186	4.7	37	1.8	77	1.9	307
Right Turn	248	6.3	151	7.5	310	7.7	723
Left Turn	76	1.9	37	1.8	107	2.7	224
Overtaking	78	2.0	38	1.9	85	2.1	205
U-Turn	59	1.5	32	1.6	47	1.2	141
Forward	2,332	58.9	1,298	64.6	2,598	64.5	6,352
Reversing	0	0.0	0.0	0.0	0.0	0.0	0.0
Others	679	17.2	246	12.2	452	11.2	1,406
Total	3,959	100.0	2,009	100.0	4,028	100.0	10,196

4.4 Casualties of Motorcyclist (Rider) by Motorcyclist Fault

Table 4 presents the casualties of motorcyclists who involved in road crashes by motorcyclist fault. The results indicate that nearly 20% of the casualties (2,518 motorcyclists) were due to the deliberant behavior of the motorcyclists. Among the deliberate faults, speeding, careless driving, and not conforming traffic light were over-represented. The faulty actions should be taken seriously by the AV programmers as these are the operating maneuvers that would take place unexpectedly.

Table 4: Casualties by Motorcyclist Fault (PDRM, 2019)

Type of Faults	Type of Casualties						
	Fatal		Serious		Minor		Total
	n	%	n	%	n	%	n
Negligent Signalling	14	0.32	6	0.23	13	0.29	34
Overloading (Goods)	1	0.02	2	0.08	7	0.16	10
Overloading (Passengers)	2	0.05	2	0.08	5	0.11	9
Wrong Parking	2	0.05	3	0.12	28	0.62	33
Drugs	1	0.02	1	0.04	1	0.02	3
Careless Driving	105	2.41	79	3.03	75	1.66	264
Dangerous Driving	41	0.94	23	0.88	18	0.40	84
Dangerous Turning	68	1.56	40	1.53	169	3.75	280
Dangerous Overtaking	76	1.74	26	1.00	133	2.95	238
Driving Too Close	34	0.78	24	0.92	152	3.37	212
Speeding	125	2.87	61	2.34	222	4.92	413
Not Conforming to T/Light	85	1.95	62	2.38	101	2.24	252
Others Offences	154	3.53	209	8.01	311	6.90	686
Not at Fault	3,655	83.77	2,070	79.37	3,273	72.60	9,161
Total	4,363	100	2,608	100	4,508	100	11,679

5.0 Conclusion and Future Research

The high level of AVs are soon to replace the conventional vehicles in the world. The deployment of AVs has gathered wide range of interests particularly in the behavioral acceptance research. Howeve, it is found that very few studies look into the interaction between road users and AVs which might be attributed to the limited operation of AVs on the roads. This study provides a base understanding of the characteristics of traffic crashes involving motorcycles in 2019 for the development of AVs technology in Malaysia as motorcycle fatalities accounted for approximately 60% of the total fatalities and majority of them were due to deliberant behaviour (speeding, running red and driving under influenced). Despite only using one-year traffic crashes data, it is nonetheless deemed significant because it offers an indicative of the type of unpredicted behaviors of the motorcyclists on the roads that might be impediment to the deployment of AVs in the country. However, the motorcycles are still increasing in popularity mainly because of its physical size and ease of manuevre particularly in congested traffic. The conditions exacerbate with the increasing interests of the use of super motorcycles which is seen as a symbolic of freedom, and personal status. With the growth of number of vehicles on the roads, the safety of the motorcyclists is expected to be worsen.

Through highlighting the prevalent characteristics of the crashes, the AV developers can better incorporate the potential hazards into their programs, and subsequently enhance the traffic safety of all the road users. The safety of motorcyclists is always the main agenda of the policy makers. Many policies and interventions have been designed to tackle the problems, for instance, building motorcycle lanes (exclusive and non-exclusive) and advance stop box for motorcycle at junctions. The separation of the motorcycles on the roads might reduce the potential conflicts between motorcycle and AVs on the roads. However, separating the motorcyclists from the main traffic stream requires huge investment. In this regards, the AVs developer should incorporate the ADAS (Advanced driver-assistance systems) which can detect the presence of motorcyclists in advance thereby responding to the potential crashes. This unique design might be very useful to the countries with motorcycles dominating in the traffic streams (i.e. Malaysia, Vietnam, Taiwan etc). This in turn would promote the use of AVs in the country.

On the other hand, the technology of L3 AVs is still limited (Morris et al., 2021). The AV developers are still exploring to achieve high accuracy of detection as well as the software in processing the data in the fastest approach. The unpredicted errant behavior of the motorcyclists on the roads are in fact a big challenge to the AV developers. The understanding of the safe interaction with other road users can bright multifold of benefits to all the industry players. If the AV programs are able to detect the deliberant manuvres of the motorcyclists, then the traffic safety can be enhanced further reduce the national traffic crashes and achieve the goal of decade of action for road safety (reduce the traffic fatalities by 50% in 2030).

This study is not without limitations. The only one-year traffic crashes involving motorcycles might be inadequate to reach conclusive outcomes. In future, longer time series data can be used to establish more reliable profiles. Additionally, this study only looks into the crashes by geometry, vehicle manuevre and by motorcyclist's fault. Future research can include more causal factors to attain wider perspective of understanding. Lastly, other vulnerable road users such as the pedestrians and the cyclists, particularly those in early aged who are unable to cope with the traffic flow or the elderly with physical constraints are of interests. Therefore, the traffic crashes involving these groups shall be explored in future.

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