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A Preliminary Study on Motorcycle Conspicuity Improvement Based on Detection Distance

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Abstract – *Conspicuity has been one of the main contributing factors to the high percentage of motorcycle crashes around the world. In Malaysia, it is normal to observe a motorcycle ridden without its lights functioning. Furthermore, the ignorance of motorcyclists on attire selection also contributing to less contrast of motorcyclists against the background which has led to the increase of motorcycle conspicuity related crashes particularly at night time. This study aims to propose multiple ways to improve the conspicuity of the motorcycle in Malaysia road traffic including a new intervention of conspicuity enhancement. The preliminary results suggested that a brighter appearance helps the driver to detect motorcyclists further and earlier. It is also proved that the luminance of the headlight had contributed to better detection of a motorcycle at night. The new intervention of applying a set of retroreflective tape on the side body of the motorcycle has shown a promising result as it helps to improve motorcycle detection further especially at a junction. To conclude, brighter appearances of motorcyclists and motorcycle can improve their detection and enhance motorcycle conspicuity at night time while reducing the risk of motorcycle crashes and injury.*

Keywords: Conspicuity, visibility, motorcycle, motorcyclist, motorcycle safety

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1.0 INTRODUCTION

It is widely known that road crashes have contributed to almost 1.35 million fatalities with vulnerable road users (VRU) comprises of motorcyclists, cyclists, and pedestrians, constitute nearly half of the numbers (WHO, 2018). In Malaysia alone, motorcycle crashes have consistently contributed to more than 60 % of road fatalities for more than a decade (Abdul Manan & Várhelyi, 2012; Royal Malaysia Police, 2018).

Several past studies indicate that human error led to more than 80 % of motorcycle crashes with many of the crashes involved driver's failure in anticipating the motorcycle movement and violated the motorcycle right-of-way (ROW), particularly at intersections and mix traffics (Craen et al., 2011; Gershon and Shinar, 2013; Law et al., 2015; Lee and Sheppard, 2018; Pai et al., 2009; Pammer et al., 2018). Due to motorcycle smaller sizes, as compared to other road vehicles and its ability to swerve anywhere in the traffic, it makes the driver more difficult to detect motorcycle, particularly on its speed and arrival time. This eventually led motorcycle to higher risks of involving in a "look-but-fail-to-see" (LBFTS) crashes (Crundall et al., 2008; Helman et al., 2012; Mitsopoulos-Rubens and Lenné, 2012; Pai et al., 2009; Pammer et al., 2018) which said to be highly associated with motorcycle conspicuity (Crundall et al., 2012; Helman et al., 2012; Mitsopoulos-Rubens and Lenné, 2012).

Conspicuity is related to the ability of an object to be detected and located when an observer is not searching for it (Helman et al., 2012; Labbett and Langham, 2006; Law et al., 2016; Wells et al., 2004). It can be affected by the physical characteristic of the object such as the size, shape, colour, and whatnot. This somehow related to the low conspicuity of the motorcycle whereby it smaller size than other road vehicles have resulted in low contrasts from the background environment and makes it less detectable (Law et al., 2016; Wells et al., 2004).

Many previous studies have demonstrated multiple ways to improve motorcycle conspicuity and detectability on the road. Conspicuity measures such as brighter motorcyclist's appearances, modifying the headlights are some of the interventions to improve motorcycle conspicuity. For example, past studies have found that the use of Daytime Running Headlight (DRH) has improved motorcycle detection and reduce their risk of road crashes and injuries (Al-Awar Smither and Torrez, 2010; Lee and Sheppard, 2018; Radin Sohadi, 2005). There were also past researches that investigate the effects of different headlights configurations on motorcycle detection on the road and found that by modifying the DRH to a better configuration with additional yellow light or modulating light had a beneficial effect on motorcycle conspicuity (Ledbetter et al., 2012; Ranchet et al., 2016; Rößger et al., 2012).

On the other hand, (Gershon et al., 2012; Gershon and Shinar, 2013) suggested that a proper rider outfit that could help a rider to be more distinguished from the environment background would increase the conspicuity of the rider and motorcycle as the conspicuity of the motorcycle is highly associated with the background environment (Hole et al., 1996). Furthermore, (Law et al., 2015; Law et al., 2016) proved that a rider with brighter appearances riding on a motorcycle with DRH functioning can be detected earlier and would help to improve driver's judgement on motorcycle arrival time before making a safe turn.

Based on past researches, there were many ways and interventions suggested in order to improve motorcycle conspicuity. However, most of the studies were focusing on motorcycle conspicuity at day time and very few studies found to involve night time or dimmed environment. Moreover, the conspicuity issues in Malaysia are somehow a little bit different from what has been covered in past research. For example, it can be easily observed a motorcycle ridden on the road in Malaysia without its lights functioning either at day time or night time. Due to their ignorance in practicing proper maintenance (Abdul Khalid et al., 2018a; Abdul Khalid et al., 2018b), this eventually led to a high percentage of motorcycle crashes at night time especially at rural road area where lights sources are limited.

Therefore, this study aims to identify the effects of conspicuity enhancers in improving motorcycle detection focusing on Malaysia road situation. This study will demonstrate multiple ways to improve motorcyclist contrasts on the road such as the bright colour of helmet, attire, the presence of motorcycle headlight and a new intervention of motorcycle that could benefit the motorcycle conspicuity. Besides that, this study also will identify how further and quicker a driver can detect a motorcycle on the road based on their conspicuity level.

2.0 METHODOLOGY

This study implemented a video experiment data collection in order to evaluate the effectiveness of conspicuity enhancers on motorcycle detection distance. The experiment requires a video of real driving with the presence of a motorcycle of different configurations and simulating rural road conditions at night time. Further explanations will be discussed in this section.

2.1 Preparation & Location Selection

Prior to video recording, test scenarios and configurations were defined and simulated to suit to Malaysia road situation. Many of the motorcycle crash occurred at night time and in rural road area (Abdul Manan and Várhelyi, 2012; Royal Malaysia Police, 2018). Thus, these factors are considered in the test scenarios together with the road type condition (i.e. straight and junction road).

Configurations were set to include multiple conspicuity enhancers including the bright colour of helmet, attires, the presence of motorcycle light as well as a new conspicuity intervention which is by applying retroreflective sticker on the side of motorcycle body (refer Figure 1). The presence of motorcycle lights is also considered as part of the conspicuity aid. This is to suit with Malaysia road situation whereby it is not uncommon to observe motorcycle ridden without its lights functioning. A total of 48 different motorcycle configurations were set up and explained as follow:

1) The following configurations are used to simulate driving scenarios on a straight road:
   a) Motorcyclist's helmet colour (bright vs dark) – 2 levels
   b) Motorcyclist's attire colour (bright vs dark) – 2 levels
   c) Motorcycle's lights status (on vs off) – 2 levels
   d) Drivers approaching motorcycle (from rear vs from front) – 2 levels (refer Figure 2)
   e) Overall, 2 x 2 x 2 x 2 = 16 configurations on straight road driving scenario.

2) The following configurations are used to simulate driving scenarios on junction road:
   a) Motorcyclist's helmet colour (bright vs dark) – 2 levels
   b) Motorcyclist's attire colour (bright vs dark) – 2 levels
   c) Motorcycle's lights status (on vs off) – 2 levels
   d) Retroreflective tape application (yes vs no) – 2 levels
   e) Motorcycle's movement at the junction (same direction vs opposite direction) – 2 levels (refer Figure 2)
   f) Overall, 2 x 2 x 2 x 2 x 2 = 32 configurations on junction road driving scenario.

Figure 1: The location of retroreflective tape installed on the side body of the motorcycle

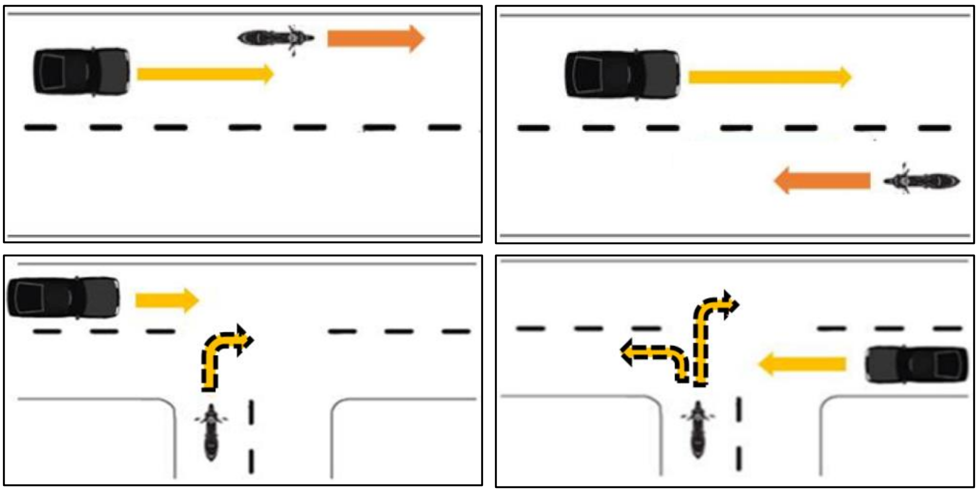

Figure 2: Traffic scenario of multiple motorcycle configuration that were included in this study

Several potential locations were identified to suit and cater to all the experimental conditions. As the experiment required to simulate night time driving, with motorcyclists somehow, have to ride in a very less conspicuous condition (i.e. no motorcycle lights, dark helmet, and attire colour), the recording has to be done in a controlled location and situation. Thus, considering all the scenarios and configurations, Putrajaya Wetland Park has been selected as the most suitable location as it offers a proper rural road driving situation and complete with junction and straight road. Figure 3 shows the situation at the selected location.

Figure 3: Environment of the selected location that simulates a rural road situation

2.2 Video Recording

In this study, the detection distance is the dependent measure. Thus, video recordings have to contain a few related data such as videos, timestamps, real-time and Global Positioning System (GPS) locations for the process of calculating the distance. Each motorcycle involved was given a GPS device to capture and record every location and movement of the motorcycle. While for the driver's vehicle, an iPhone was provided to collect all the necessary data due to its capabilities to record high definition videos and precise GPS location.

An application has been developed by the software team in order to enable the device to capture all the necessary data. Figure 4 shows the interface of the application on the iPhone. GPS timestamp is required to synchronize with motorcycle GPS data and timestamp in order to calculate the distance later during data collection. Multiple trials were performed to ensure the application is stable and able to collect accurate data. Validation on the GPS was also performed to ensure the accuracy of the GPS devices. The result is discussed in the next section.

Three motorcycles and one car were the vehicles used in the video recording. Before video recording, vehicles were set up and prepared according to the configurations required. The iPhone was placed outside of the car's windscreen, closest to the driver's view, to avoid lights reflections and disturbance that may affect the recorded video. A phone stabilizer used to hold the iPhone to reduce motion blur due to high vibration during car movement.

A total of 18 videos covering all 48 configurations, managed to be recorded in eight nights after a thorough review done to ensure the recorded videos are at the highest quality for data collection. One video may or may not have any motorcycle encounters and it is varying each video depending on the length of the course to reduce bias during the experiment.

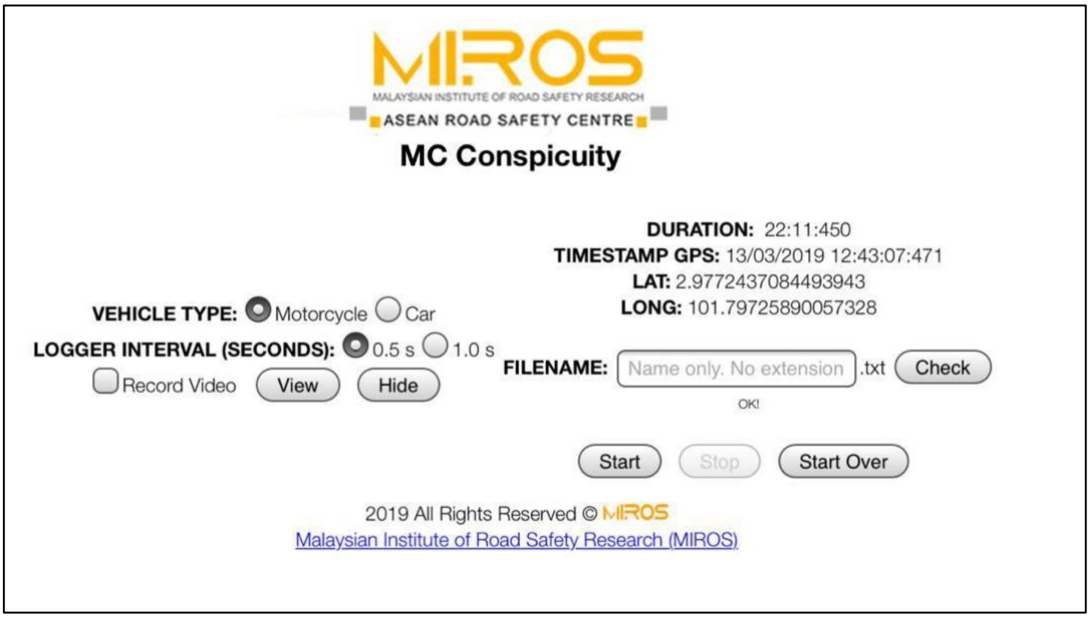

Figure 4: The interface of the application on the iPhone that required to capture the necessary data

2.3 Software Development

Desktop software was developed while video recording is still under progress. The software is programmed for data collection purposes by using Microsoft Visual Studio. It has the capability to capture all the details recorded from the video, GPS data from the GPS devices and auto-calculate the detection distance of a motorcycle once detected. The software also able to play the videos randomly, recorded and stored the respondent's demographic details and data collection.

Sample videos were inserted for software trials to ensure stability and ability to perform as required. Several trials are done and the problems occurred during the trials were resolved until the software finally stable, with videos able to be played smoothly and required data able to be gathered. The final software interface is shown in Figure 5. The final recorded videos were all inserted into the software for preparation. The software was tested again for a final check before the actual experiment.

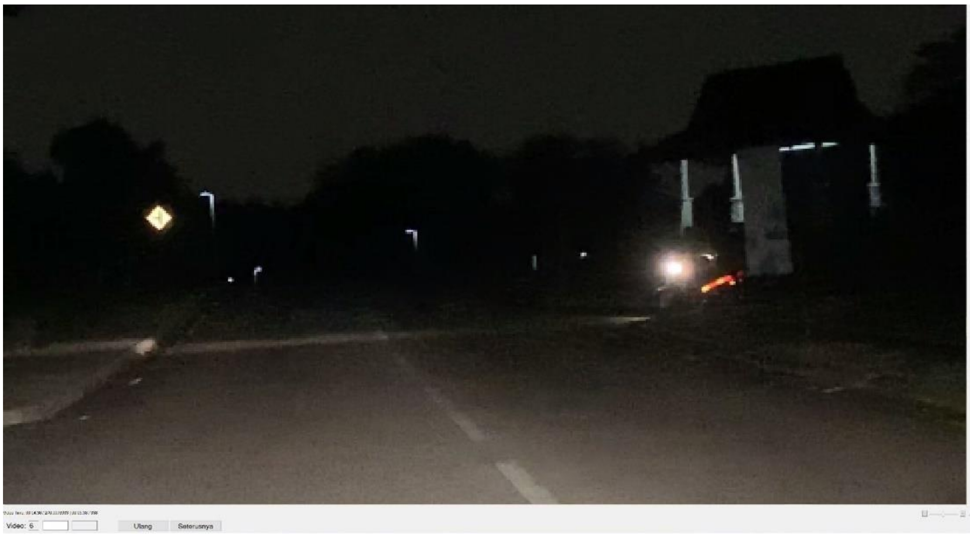

Figure 5: The interface of the software during data collection

2.4 Data Collection

Participants were recruited through a Google form, distributed randomly among the road users in the Klang Valley area. Only a driver with a valid driving license will be selected and higher driving experiences were prioritized as participants.

Experiments were done in a controlled room and condition, with supervision from a technical team. A thorough explanation regarding the process of the experiment were given to the participants before the experiment started. Prior to that, a consent form also was given and participants also required to fill in a demographic detail form before performing visual eye tests.

By using a 43-inch screen monitor (3840 x 2160 pixel resolution), participants were asked to sit 100 centimetre behind the screen and respond by clicking the space bar once they notice a motorcycle presence in the video. Before the actual data collection started, participants were given a set of trials to familiarize themselves with the experiments. The data collection would only start once the participants are fit and ready. Participants were given a 60-second break after completed each video. However, the experiment would be stopped if the participants reported to be exhausted or drowsy.

2.5 Data Analysis

The dependent variable in this study is detection distance whereby it shows how further a driver can detect a motorcycle. It also can represent the response time of a driver to detect a motorcycle. For example, a shorter detection distance indicates a late response time of a driver to detect the motorcycle. Recorded data from the experiment will be extracted and analyse by using SPSS software version 20.0. Statistical analysis of independent t-test and Analysis of Variance (ANOVA) will be performed in order to identify how significant the conspicuity aids in improving motorcycle detection.

3.0 PRELIMINARY RESULTS

The results of this study will discuss only a few data that we're able to collect as the experiment is still ongoing. Statistical analysis was unable to be performed due to a lack of data. However, graphical analysis will be discussed according to the driving scenarios of the roadways. In addition, the comparison was made based on conspicuity enhancers against the baseline where the baseline is a motorcycle with no conspicuity (wearing a dark helmet and attire, without the presence of motorcycle light). Graphs were plotted and discussed according to the conspicuity level based on the conspicuity enhancers as described in Table 1.

Table 1: Level of motorcycle conspicuity

Conspicuity Level		Description
(a)	No Conspicuity (NC)	Motorcycle with no lights, and motorcyclists wearing dark attire & helmet
(b)	Bright Attire (BA)	Motorcycle with head and tail lights on, and motorcyclists wearing dark attire & helmet
(c)	Bright Helmet (BH)	Motorcycle with head and tail lights off, and motorcyclists wearing bright attire & dark helmet
(e)	Lights Only (LO)	Motorcycle with head and tail lights off, and motorcyclists wearing bright attire & bright helmet
(f)	Retroreflective tape (RT)	Motorcycle with retroreflective tapes applied, no lights, and motorcyclists wearing dark attire & helmet
(h)	BA, BH & LO	Motorcycle with head and tail lights on, and motorcyclists wearing bright attire & bright helmet
(i)	BA, BH, LO & RT	Motorcycle with retroreflective tapes applied, head and tail lights on, and motorcyclists wearing bright attire & bright helmet

3.1 Validation of the Application

The GPS data recorded from the phone application and devices were undergone validation process. The validation was set by locating three motorcycles at three different exact distances of 50, 100 and 150 meters away from the driver's view. Once located, all the motorcyclists and the driver were asked to turn on their GPS devices. Captured data was stored into each device and extracted for the validation process. Figure 6 illustrates the validation processes.

The GPS data of the driver and motorcyclists were calculated using a GPS distance calculator and are tabulated in Table 2. The result indicates that all the GPS devices together with the iPhone successfully detect and record actual locations accurately. Thus, this result verifies that the application is stable and can be used for the video recording.

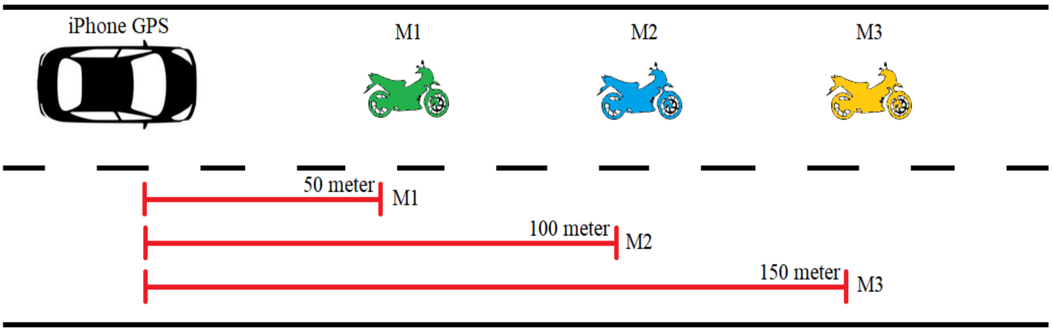

Figure 6: Figure illustration of the validation process – all vehicles were using a mobile phone GPS

Table 2: Comparison between exact distance and GPS distance calculation

Motorcycle	Exact Location of Motorcycle (m)	Distance Based on GPS Location (m)	Accuracy (%)
M1	50	49.82	99.64
M2	100	99.71	99.71
M3	150	149.73	99.82

3.2 Detection Distance of a Motorcycle Based on Conspicuity Enhancers

All the collected data from eight participants were tabulated in three graphs based on the roadways configurations. Figures 7, 8 and 9 show the recorded motorcycle detection distance when a driver is approaching them from various directions.

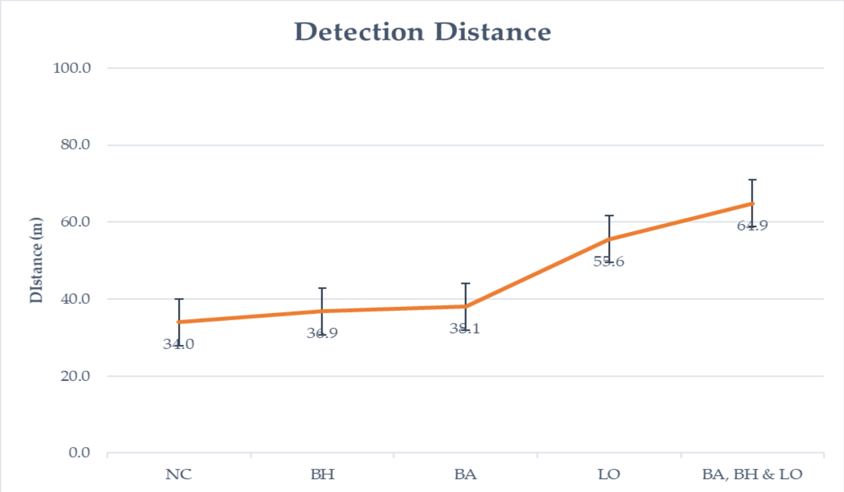

Figure 7: Detection distance of a driver towards motorcycle when approaching them from the rear, moving in the same direction

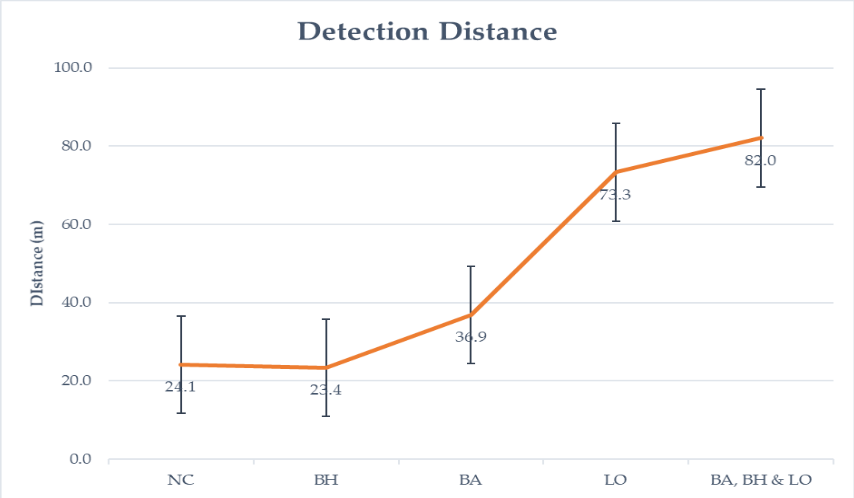

Figure 8: Detection distance of a driver towards motorcycle when approaching them from the front, moving in the opposite direction

Figure 9: Detection distance of a driver towards motorcycle when approaching them from the side, junction roadway

The result indicates that a motorcycle without conspicuity can only be detected at an average 34 meters from the rear, 24.1 meters from the front and 33.9 meters from the side of the motorcycle. It shows that motorcycles can be detected further from the rear and side as compared to from front. This may be due to the motorcycle was equipped with a standard reflecting strip at rear fender of the motorcycle and at each side of the motorcycle body which have helped the driver to notice the motorcycle presence earlier.

The usage of BH by the motorcyclists somehow did not improve motorcycle detection as only slight gain in distance were recorded as compared to motorcycle NC. This may be due to the size of the helmet which is too small to help motorcycle to be more distinguished especially when riding at night time. On the other hand, motorcyclists wearing BA also proved to have not largely helped on motorcycle detection, with the results recorded that only 4 to 12 meters gain in detection distance with the highest gain is when the driver is approaching motorcycle from the front.

As predicted, the presence of motorcycle lights shows a big gain in motorcycle detection distance. The motorcycle can be detected at an average of more than 50 meters away from the driver's view. The highest gain is when approaching a motorcycle from the front in which a motorcycle can detect three times further than a motorcycle with NC. This may be due to the luminance of the headlight (yellow colour) is better than tail light (red colour) which helps a driver to detect motorcycle from front further than from rear (Haferkemper et al., 2010; WorkWithColor.com, 2020). Further improvement in detection distance is recorded when the motorcyclist is wearing BA and BH, riding on a motorcycle with fully functioned light. As shown in Figures 9 and 10, a driver able to detect a motorcycle at an average of 65 meters from the rear and 82 meters from the front.

The new conspicuity intervention of applying retroreflective tapes (RT) on the side of the motorcycle body has proved to improve motorcycle detection at the junction. As shown in Figure 11, the presence of the RT alone has improved motorcycle detection distance to twofold when comparing to the motorcycle with NC. The RT installation somehow played a big role in improving the detection distance whereby the installation of RT on top of the motorcycle decals has helped to represent the shape of a motorcycle from far when it is reflecting the car's light as shown in Figure 12. Besides, the usage of RT has given a better gain in detection distance compared to the motorcycle with BA, BH, and LO. Furthermore, combining all conspicuity enhancers have improved motorcycle detection to threefold as a motorcycle can be detected 100 meters away from the driver when viewing motorcycle from the side.

Figure 12: View of motorcycle with RT from side

4.0 CONCLUSION

The preliminary findings of the study have shown a promising outcome whereby all conspicuity enhancers have contributed to the contrast of the motorcycle against the background and surrounding environment. This, in turn, has helped to improve motorcycle detection as well as its conspicuity. These can be considered as a cheaper and cost-effective way to improve motorcycle detection especially at night time in rural road areas. Despite the promising outcome from the preliminary analysis, more data is required in order to evaluate the effectiveness of the conspicuity enhancers and proved its efficacy in enhancing motorcycle conspicuity. Furthermore, it is also important to identify how significant the conspicuity enhancers have helped in improving motorcycle detection and conspicuity.

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