

Detection and Warning System for Motorcycle Vehicular Collision Avoidance

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Abstract – World Health Organisation has determined that South-East Asian region has the highest road traffic death in 2015 involving motorised 2-3 wheelers. Generally, motorcycles are lack of active safety features that capable to prevent road accident. Therefore, this study aims to design and develop active safety features for a motorcycle to prevent a frontal collision through an audible warning to the motorcyclist and detected object when the collision is about to happen. The system should consist of a simple algorithm with a minimum set of hardware. Based on the design criteria for the system, an audible warning will only be given when all three conditions stated below are met. (1) An object is within stopping distance limit, (2) object heading towards the centre of motorcycle and (3) relative velocity of an object might cause a frontal accident. The system called Detection and Warning System for Motorcycle Vehicular Collision Avoidance (DEWAMCA). It is expected that DEWAMCA can assist currently available Blind Spot Detection System (BSDS) to reduce accident involving motorcycles significantly.

Keywords: Active safety, motorcycle safety, collision warning, stopping distance, external audible warning

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1.0 INTRODUCTION

According to the World Health Organisation [WHO] (2015), as shown in Figure 1, 34% of road traffic death in Southeast Asian Region are from a motorcyclist, and only 16% accounted for car occupant. In Malaysia, 45.84% of the transportation medium are motorcycle and motorcyclist road death are the highest in the last ten years at 61.4% (Road Safety Department of Malaysia [JKJR], 2018) as shown in Figure 2. These are alarming statistics for motorcyclist safety, and it must be prioritised.

To reduce road accidents, many institutions have done various research and developed many safety features for vehicles (Broughton & Baughan, 2002; Jeong & Oh, 2017; Zhou et al., 2018). However, generally known that most of the motorcycles are not well equipped with safety equipment such as airbags, prevention devices, crumple zones which are found in a modern car. Some of these safety features are not feasible for a motorcycle, and some will significantly increase the cost of motorcycle production.

This study aims to unravel the issue by developing an active safety system specifically for the motorcycle. As for a start, the study will be focusing on a system that capable of detecting an object in front of the motorcycle that due to the user lack of awareness or objects moving into the motorcycle proximity. This type of accident possibly occurs during crossing a junction, making a U-turn, and changing driving lane by other vehicles. Avoidance of these type of accidents is highly dependent on the motorcyclist agile perception and reaction. This system has been extensively applied in passenger car vehicle and the system effectively reduce the rear end crash as much as 12% (Cicchino, 2017). Therefore, an automated system that helps to warn both the motorcycle user and approaching object faster than a human perception and reaction is required. The system may increase the motorcyclist reaction time to stop the motorcycle or manoeuvre away from danger. Furthermore, an approaching object that controlled by human such as a car may apply the early countermeasure to avoid further intrusion due to the warning given by the automated warning system.

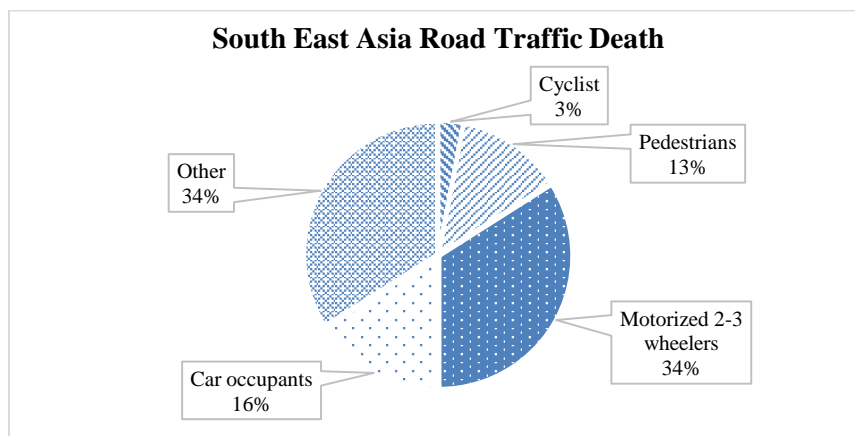


Figure 1: Road traffic deaths by type of road user (WHO, 2015)

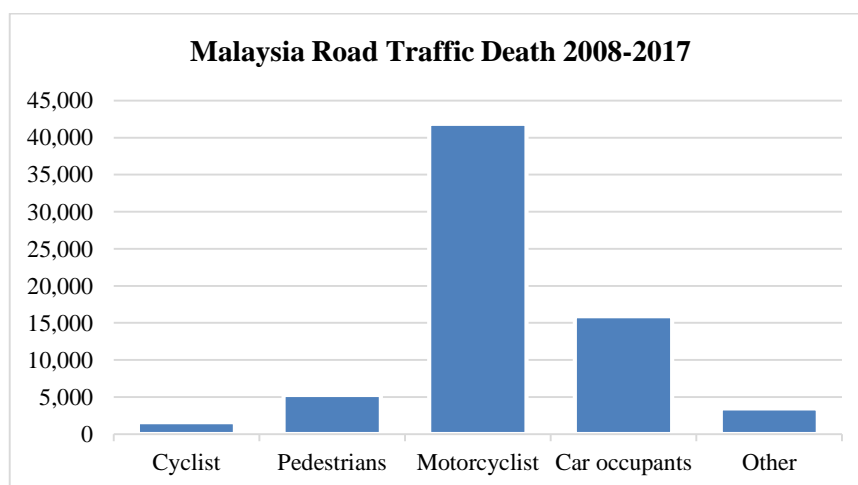


Figure 2: Malaysia road traffic deaths within ten years (JKJR, 2018)

In a passenger car, the front collision warning commonly used a laser sensor, radar sensor or a hybrid of both (Coelingh et al., 2010; Yimin et al., 2007). The advantages of these sensors are the capability of detecting long range front vehicle even with low visibility and poor illumination situation (Lin et al., 2012). Therefore, in this study, the concept of avoiding a frontal collision using warning system on a motorcycle will be developed using a laser sensor, and the aims are to (1) design automated warning system for a motorcycle and (2) determined a working algorithm for the system.

2.0 DESIGN CRITERIA

The design criteria of the system need to be determined in the first place before creating the system. Based on the possible scenarios for a motorcycle involved in an accident, the design criteria can be determined. There are three main scenarios of accidents that can be avoided with an early warning; (1) frontal vehicle deacceleration, (2) sudden change of lane of another vehicle and (3) intrusion by a vehicle that is moving from opposite or cross direction.

Based on the 1st scenario, the system must predetermine the distance required to stop the motorcycle when the front vehicle deaccelerate. The warning must set off well before the motorcycle reaches the limit of stopping distance to avoid the collision. The higher speed of vehicle requires longer distance and time to completely stop because of higher energy absorption required (Gillespie, 1996). Therefore, an input speed data with distance sensor are needed. In the second scenario, criteria that should possess by the system is the sense of direction of the vehicle changing lane. The system must determine whether the vehicle is moving into or moving out of the centre of the motorcycle. In the last scenario, intrusion by a vehicle that is moving from opposite or cross direction towards the motorcycle will have severe damage to the motorcyclist if accidents occur due to relative velocity or resultant force during the occurrence of an accident. Relative velocity of the approaching vehicle is important and need to be known to the system.

Therefore, the design criteria for the system can be categorized as follows; (1) determine the stopping distance limit, (2) detection of object's moving direction and (3) measurement of object's relative velocity. Table 1 conclude the criteria needed based on the scenario and factors of accidents.

Table 1: DEWAMCA criteria based on common accident factors

Common Accident Factors	System Criteria
Frontal vehicle deacceleration	Stopping distance limit
The sudden change of lane of the front vehicle	Object moving direction
Moving vehicle directly from opposite or cross direction	The relative velocity of the moving object

3.0 THE DESIGNED SYSTEM; DEWAMCA

Four main components are required for a complete Detection and Warning System for Motorcycle Vehicular Collision Avoidance (DEWAMCA) to be functions as required in design criteria. The devices are (1) distance sensor, (2) speed sensor, (3) data processor and (4) audible warning device. The speed sensor and audible warning device are generally installed as

standard equipment in all motorcycle. Distance sensor and data processor are the only additional components to complete the DEWAMCA. Figure 3 illustrates the location of the components in a motorcycle.

There are four distance sensors need to be installed at the motorcycle. Two distance sensors are placed at the most right side of the motorcycle while the other two distance sensors are mounted at the most left side of the motorcycle. These four distance sensors are mounted facing the front road and aligned in parallel. Figure 4 shows the position of the sensors.

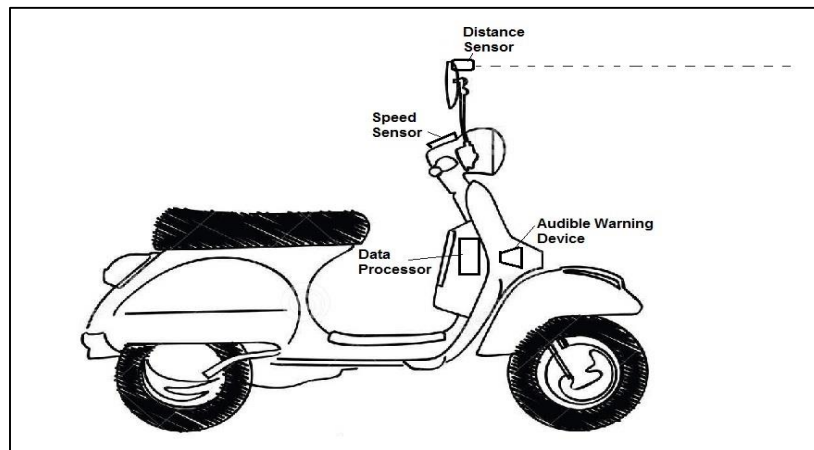


Figure 3: Illustration of DEWAMCA configuration

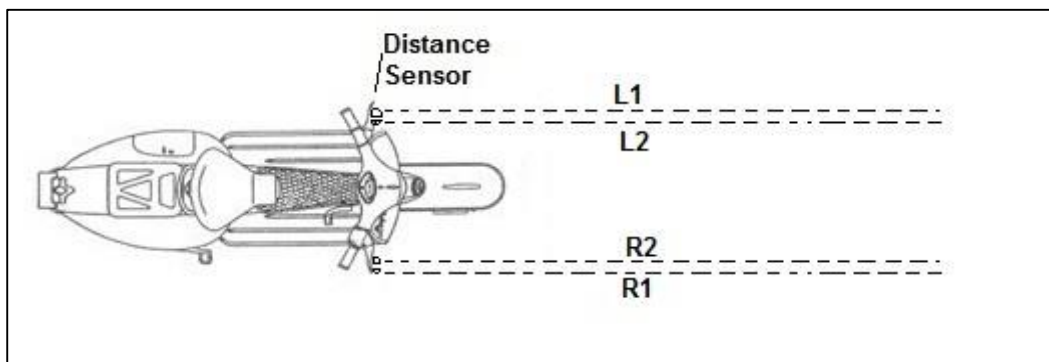


Figure 4: Positions of all four distance sensors

The distance sensors are configured to measure the distance of an object within the range that can be detected by the sensor. Two sensors at around the most right and two sensors at around the most left of the motorcycle are installed horizontally aligned. Data from the distance sensor will be sent to the data processor. The speed sensor is configured to measure the velocity of the motorcycle.

However, distance sensor such as a laser has the limitation to detect translucent material such as glass. This is a difficulty if the lasers are pointed at the windshield glass of another vehicle because the distance reading will be misleading. Proper positioning of the laser sensor will overcome this limitation. Another limitation is during curvy road; it seems the motorcyclist is driving towards stationary objects such as reflective road signs and guardrails. This will trigger a false alarm and create a nuisance for the user as illustrated in Figure 5.

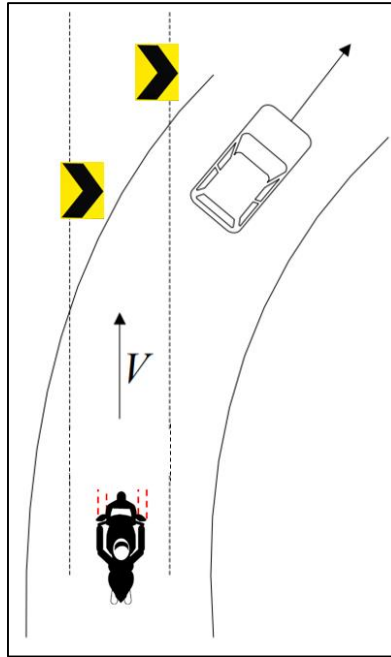


Figure 5: False alarm during curvy road condition

The data processor is configured to calculate information gathered from the distance sensor and speed sensor. If the result of calculation shows that there is an object approaching the motorcycle that might cause a frontal vehicular collision, a signal will be sent to the audible warning device.

The audible warning device is configured to give an audible warning to the operator of the motorcycle and the approaching object. It is expected that both parties could take a countermeasure to either stop their movement or avoid each other.

Table 2 shows the hardware specification for distance sensors and data processors. However, for speed sensors and audible device are dependent on the motorcycle manufacturer because both devices are readily available on every motorcycle.

Table 2: Hardware specifications for DEWAMCA system

Device	Hardware	Specifications
Distance Sensors	LW20 x 4	Resolution 1cm Accuracy $\pm 10\text{cm}$ Range 100m
Data Processors	Atmel ATmega 2560	Clockspeed 16 MHz Flash 256KB RAM 8KB
Speed Sensor and Audible	Using hardware equipped by the motorcycle manufacturer	

The data processors Atmel ATmega 2560 with the distance sensors LW20 have been tested initially to verify its capabilities to detect an object within the range of 50 meters. The initial verification shows that the data processor with a clock speed of 16MHz can process the data from the distance sensor with good accuracy and speed processing.

3.1 Algorithm for DEWAMCA

Figure 6 shows a flowchart of an algorithm for DEWAMCA data processor. The algorithm is divided into three stages A, B and C. As the design criteria defined previously, these three stages are designed to achieve those criteria. Stage A is a focus on the stopping distance, stage B is the determination of the object's direction, and stage C is to identify the relative velocity.

The stopping distance of a motorcycle is determined based on an experiment that relates a stopping distance and velocity of a motorcycle as done by the United States Department of Transportation (Green, 2006). High-velocity motorcycle generally will increase the stopping distance because of the higher kinetic energy compared to the slow-moving motorcycle. Therefore, in stage A, a detection range for a warning to be triggered is defined based on the motorcycle velocity. This will avoid any mislead warning triggered by data outside the detection range.

In stage B, the data processor, distinguish an object that moving towards the centre of the motorcycle or moving out of the centre. This determines the threat and non-threat moving object. If the object is moving and its move towards the centre of the motorcycle, it will be detected by the outer distance sensors first before the inner distance sensors. Since the motorcycle is moving towards the object, the distance detected by outer distance sensors " L_1 " or " R_1 " should be longer than " L_2 " or " R_2 ". Any movement of a detected object within stopping distance that is also moving away from the centre of the motorcycle where " L_1 " is lesser than " L_2 " or " R_1 " is lesser than " R_2 " will not be considered as a threat.

Stage C calculates the relative velocity of the detected approaching object towards the motorcycle. If the object is within stopping distance, moving towards the centre of the motorcycle and stay static or moving towards the motorcycle, the signal will be sent to the audible warning device. There is also a situation where the object is moving away from the motorcycle might give a threat if the object moves relatively very slow, therefore, a constant " k " incorporated into the equation so that the level of sensitivity towards an object that moves away from the motorcycle can be adjusted accordingly.

The audible warning device will continue to give an audible warning if all three (3) stages of this algorithm are fulfilled. This is to sufficiently inform the operator of the motorcycle and approaching object about the danger that about to occur. However, this algorithm itself has a weakness to cause a false alarm. The algorithm does not consider the deceleration of the motorcycle. Hence, if the user already applied a brake with sufficient deceleration before the alarm, but the algorithm only captures the high-velocity information, an alarm is triggered.

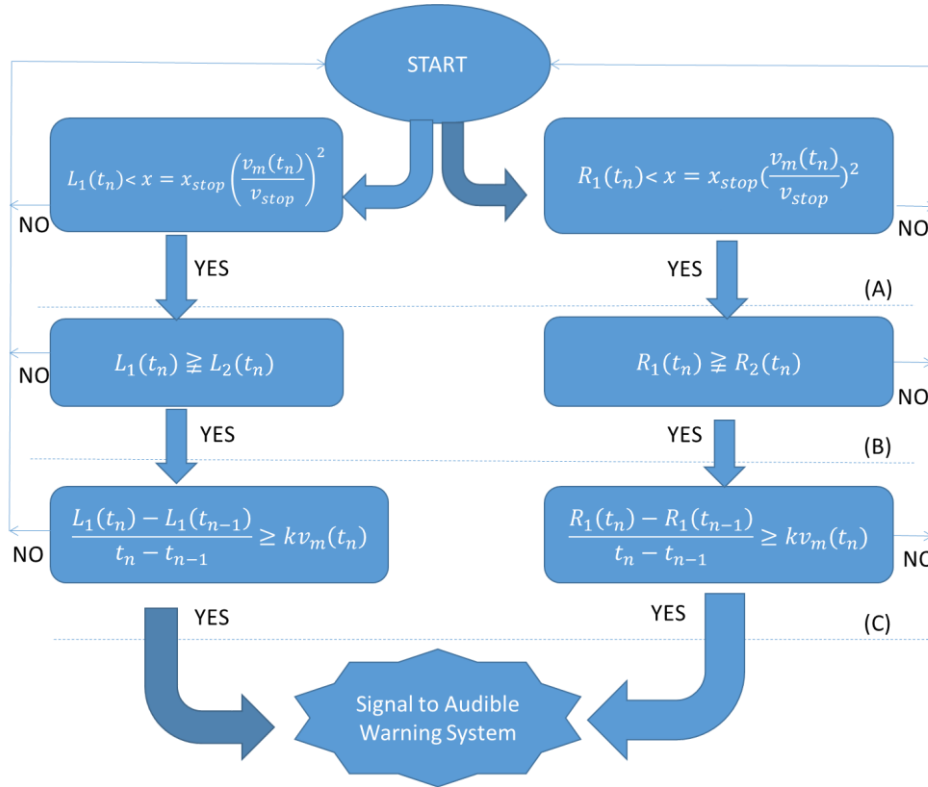


Figure 6: Algorithm for DEWAMCA data processor (Yahya et al., 2017)

- L_l Distance reading of left side outer detector [meter]
- R_l Distance reading of right side outer detector [meter]
- t_n Specific time
- v_m Velocity reading of speed sensor [km/h]
- x Detection range [meter]
- x_{stop} Defined stopping distance at specific velocity v_{stop}
- v_{stop} Specific velocity to defined stopping distance x_{stop} .
- L_2 Distance reading of left side inner detector [meter]
- R_2 Distance reading of right side inner detector [meter]
- t_{n-1} Time before specific time t_n
- k Constant:
 - 1=signal for warning sent if the object is entirely static or moving towards the vehicle
 - 0.9=signal for warning sent if the object is moving away from the vehicle with speed 90% slower than the V_m

4.0 CONCLUSIONS

The DEWAMCA have been designed to meet the outlined design criteria. The integration of multiple stages of the algorithm and minimal additional hardware components of the system are expected to contribute to a successful safety system. A working prototype of DEWAMCA needs to be developed and tested. By having this system, the safety of the motorcyclist is increased because of early warning and detection by the system. Thus, it increases the amount

of time for the motorcyclist to react. Furthermore, this helps passenger car driver to be aware of the presence of a motorcyclist by the audible sound and make the proper manoeuvre to avoid a collision.

In future, additional conditions in the algorithm could be added to balance the intrusiveness of the warning with the acceptance of the driver because if the system is too sensitive and intrusive, it is more likely to be ignored or turned off by the user (Lerner et al., 1996). The development of DEWAMCA might give some hope for a solid building block towards an affordable and safer motorcycle riding experience.

The concept can be improved by having more research on the location of the laser sensor and algorithm to process and gain deceleration data. Furthering the research on different weather conditions (fog, rain, snow, e.g.), real-world conditions, warning sensitivity and audible warning intrusiveness also should be conducted to make the prototype to be production-ready.

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