Motorcyclist Helmet Add-on Proximity Monitor

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***Abstract*— The aim for this project is to develop a Smart Motorcyclist Helmet by using an Arduino microcontroller which has the feature to alert the rider when there is object approaching the motorcyclist blind spot zone when riding. The overall objective is to develop a prototype helmet add-on blind spot proximity warning device for motorcyclists. There are a few tests that will need to be conducted to evaluate the performance of the Smart Motorcyclist Helmet, which are: first is distance measurement test (Dry test), this is to test the accuracy of sensor in dry atmosphere. Second is distance measurement test (Rain test), distance measurement test (Rain test) is to test the accuracy of sensor in raining condition. Lastly is angle measurement test, angle measurement test is to test the angle range of sensor that can detect object.**

Keywords*— *Smart Motorcyclist Helmet, Blind Spot, Arduino, Warning Device

I. INTRODUCTION

Up to August 2021, 70% of road deaths were caused by motorcyclists. From 2001 to 2021, the statistic shows a total of 89,953 of motorcyclists have died in Malaysia’s road. According to WHO director of safety and mobility Nhan Tran, about 30% of all traffic fatalities in Southeast Asia include powered two- and three-wheeled vehicles, including motorcycles, mopeds, scooters, and electrical bikes (e-bikes). According to Nhan, the main risk factors included not wearing a helmet, going too fast, drinking too much, being in heavy traffic, having bad roads, and encountering hazards at the side of the road. (Tamrin, 2022)

Most accidents that created by motorcyclists is due to their bad behavior as of not following the traffic rules, but the main causes of accident for motorcyclists is that they are not aware of vehicles in their blind spot when changing lane. A blind spot is a portion of your field of vision that you are unable to perceive clearly even though you should be able to. (Paul A. Miller 1, 2015)

For now, the only way for motorcyclists to observe what is behind or beside them is by looking at the two side mirrors. Therefore, when motorcyclists want to change lane, they will need to estimate the vehicle behind them through the mirrors. The danger in this situation is that motorcyclists are using intuition to ride on the road, there are no external equipment to let them know whether it is safe to change lane or not. The method to solve motorcyclists’ blind spot is to add sensors at blind spot region and able to detect the approach of danger vehicles. Therefore, a Smart Helmet will be developed in this project to help motorcyclists on the road.

To blind spot zone issue for motorcyclists is a typical one since it frequently results in collisions between motorcycles and cars or motorcycles and other vehicles. The issue of BSZ can arise for a variety of reasons, including when a motorcycle driver wants to change lanes, make a turn, or perform another maneuver without being aware of the presence of another vehicle, which could result in a terrible collision because the driver can only fully rely on small side mirrors, which provide a constrained field of vision. To narrow down the problem statement, there is a blind spot region where the motorcyclist could not see while riding on the motorcycle, so it is very dangerous for the motorcyclist while riding on the road.

To overcome this problem, it would be beneficial if there were a device that could be mounted to the helmet to monitor riding conditions and alert the rider whenever vehicles approached too closely. This will undoubtedly assist the rider in responding appropriately and, if required, averting undesirable situations. Therefore, the intention of this project is to build a Smart Motorcyclist Helmet with the help of sensor to detect dangers approaching and uses buzzer to alert rider. This Smart Helmet allows motorcyclists to ride without constantly turning their back to see.

In summary, a Motorcyclist Helmet with Add-On Proximity Monitor is proposed to make in this project to solve motorcyclists to change lane safely. With the help of this detective device, the percentage of road death will decrease. The aim for this project is to develop a Smart Motorcyclist Helmet by using Arduino microcontroller which has the feature to alert the rider when there is object approaching the motorcyclist blind spot zone when riding.

Failure to cede the right of way, a lack of awareness of potential risks lurking outside of their natural area of vision, and a lack of motorcycle control are the main factors that lead to motorcycle accidents. It is a problem for motorcycle riders to be unable to see or view what is going on behind them or with their vehicle. While determining whether there are vehicles to the side, back, or even in their blind spots, they shouldn't turn their entire body and head away from their path of travel. Motorcycle accidents and fatalities will result from this lack of skill. The purpose of Smart Helmet in this project is to alert motorcyclists when there is an object approaching rider in his or her blind spot region. As stated in the introduction, 70% of road deaths were caused by motorcyclists, therefore the reason for developing this Smart Helmet is to decrease the tragic road accident. This Smart Helmet can provide motorcyclists with a sense of security while riding on the road, especially changing lanes on the highway because cars tend to drive fast. The benefit of this Smart Helmet is not only for motorcyclists, but also for everyone such as their family, friends, or other vehicle drivers. When the motorcyclist miserably happens to be involved in an accident, their family and friends will be sad and also will traumatize other vehicle drivers when seeing such accident happen.

The population of registered motorcycle in Malaysia in 2021 is 15,506,690. (Total number of registered motorcycles (in thousand), n.d.). Population of motorcyclist is high in Malaysia, hence definitely there will be a market to launch Smart Helmet in Malaysia. Develop of Smart Helmet can contribute new product to appear in Malaysia market, thus it increases chances of new start up business or it can let existing motorcycle shop to have more product to sell. New product to develop in the market will always boost the entire economic ecosystem. Launching of new product require factory for manufacturing, thus workers are needed and it will provide more job opportunities. On the other hand, the product will need raw materials to build so there will be flow of selling and buying of raw materials appear in the market. Over the last decade, smart motorcyclist helmet has become a hot topic of research where many research have been carried out on smart motorcyclist helmet (Haqverdi et al., 2015, Branas & Knudson, 2001, Rice et al., 2016, (Lam et al., 2020).

II. SYSTEM IMPLEMENTATION

Fig 1. and 2 shows the block diagram of transmitter and receiver respectively. If there is an object approaching the motorcyclist, the Smart Helmet will alert the motorcyclist and display the distance between the motorcyclist and the object. Ultrasonic sensors will be the electronic component to detect the distance between the motorcyclist and the object. Waterproof ultrasonic sensors will be used because the objective is waterproof Smart Helmet. Two waterproof ultrasonic sensors will be place at left and right of the motorcyclist because the blind spot of motorcyclist is at rear left and right. (Engineering, 2019).

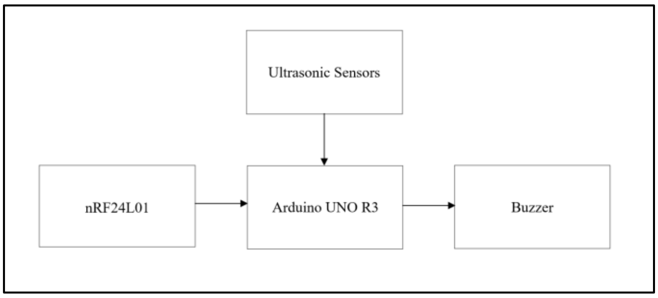

Fig. 1. Block diagram of transmitter system of smart motorcyclist helmet.

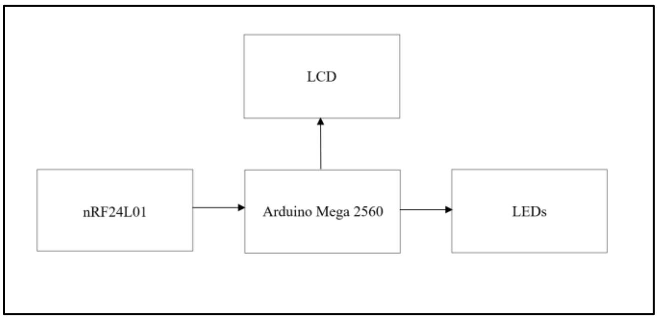

Fig. 2. Block diagram of receiver system of smart motorcyclist helmet

An LCD is used to display the distance between the object and motorcyclist in centimeters. A buzzer produces different beep sounds depending on the distance between the motorcyclist and the object. Red, yellow, and green LED lights will be used to visually notify the range between object and motorcyclist. The buzzer will produce three different types of beep sound. If the object has entered the detected zone and the distance between object and motorcyclist are far, then buzzer will produce slow beep and green LED will turn on. If the object has entered the detected zone and the distance between object and motorcyclist is near, then buzzer will produce fast beep and yellow LED will turn on. If the object has entered the detected zone and the distance between object and motorcyclist is super near, then buzzer will beep non – stop and red LED will turn on. Due to there is blind spot area at rear left and rear right of motorcyclist, hence there will be red, yellow, and green LED lights place at left side of breadboard and another set of red, yellow, and green LED lights at right side of breadboard. Left and right arrangement LED lights is to let motorcyclists know which direction the object is coming from. Fig 3. shows the diagram of transmitter system of smart motorcyclist helmet, while and Fig 4. shows the diagrams of receiver system.

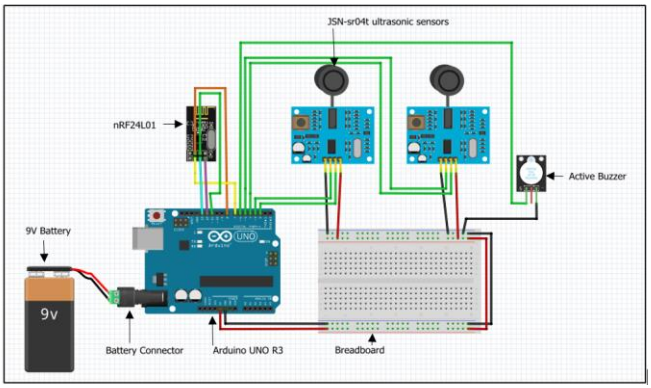

Fig. 3. Circuit diagram of transmitter system of smart motorcyclist helmet

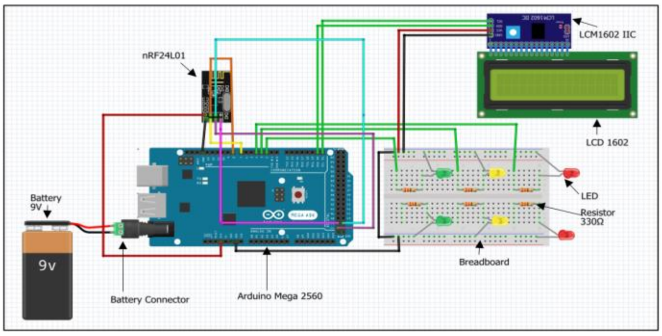

Fig. 4. Circuit diagram of receiver system of smart motorcyclist helmet

The system will be divided into two parts: sensor system and display system. Sensor system is to detect the distance between motorcyclist and the object, whereas display system is to display the distance between motorcyclist and the object. A microcontroller will be needed in the sensor system to control the ultrasonic sensor to function. On the other hand, a microcontroller will also be needed in display system to control the LED to turn on in certain condition. Two transducers will be needed in this entire system, one transducer in sensor system, the other transducer in display system.

In sensor system, ultrasonic sensors detect the distance between motorcyclist and the object. An algorithm will set on the microcontroller to calculate the measured distance in centimeters and also produce different beep sound based on the set distance. Lastly, a transducer is used to transmit the calculated distance to the display system. In the display system, transducer is used to receive the calculated distance from the sensor system side. An algorithm will set on the microcontroller to control LED lights to turn on based on the set distance. On the other hand, LCD is used to display the received calculated distance from sensor system side. In summary, sensor system is the transmitter and display system are the receiver. Two microcontrollers and two transducers will be needed for this Smart Helmet system. Fig 5. shows the 3D Drawing of Smart Motorcyclist Helmet, while Fig 6. shows the flow chart of smart motorcyclist helmet.

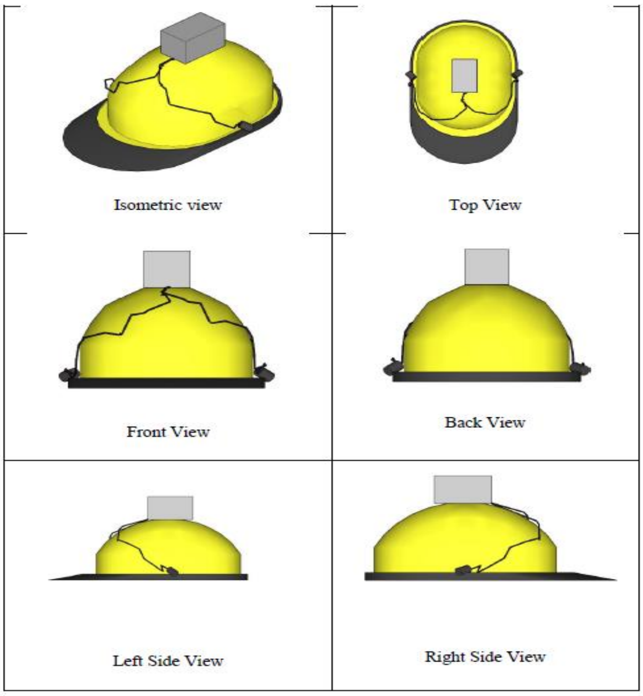

Fig. 5. 3D Drawing of Smart Motorcyclist Helmet

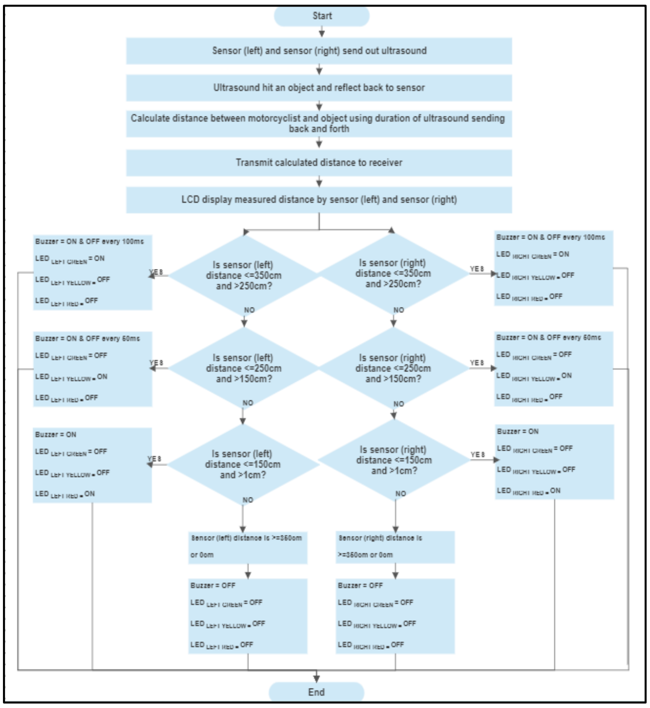

Fig. 6. Flow chart of smart motorcyclist helmet

III. EXPERIMENTAL RESULT

The purpose of this Smart Helmet is to protect the motorcyclist by giving alert to rider if there is object approaching blind spot of motorcyclist at rear left and right. The Smart Helmet displays the distance between motorcyclist and the object in an LCD, besides that it produces different beep sounds depending on the distance between motorcyclist and the object. There are 3 types of beep sound which is slow beep, fast beep, and constant beep.

There are also LEDs to virtually display the distance between the motorcyclist and the object. The Smart Helmet system can detect three types of danger depending on the distance between the motorcyclist and the object. Danger mode 1 is the distance between motorcyclist and the object is far (from 350cm to 250cm) but consider the object has entered danger zone. Buzzer will produce slow beep and green LED will turn on. Danger mode 2 is the distance between motorcyclist and the object is near (from 250cm to 150cm), thus buzzer will produce fast beep which the motorcyclist needs to pay more attention of the distance between the objects. Yellow LED will turn on. Danger mode 3 is the distance between motorcyclist and the object is super near (from 150cm to 1cm), red LED will turn on and buzzer will produce a constant beep which alerts the motorcyclist to stay away from the object. The buzzer and all the LEDs will turn off if there is no object entering the zone that the sensor is able to detect, which means the motorcyclist is safe. Fig 7. shows one of the hardware test pictures. The LED RIGHT RED gets turned on when the distance between Sensor RIGHT and the wall is 30cm.

Fig. 7. Smart Motorcyclist Helmet testing.

IV. TESTING OF SMART HELMET

A. *Distance measurement test (Dry test)*

Set Up

1. Ultrasonic sensor has sticked on a tall box as shown in Fig 8.
2. Find a flat surface of the floor and wall.
3. Starting point of measuring tape has place to the wall, measuring tape has pulled up to 600 cm then placed on the floor.
4. Ultrasonic sensor has placed at label 50cm on the measuring tape.

5. No object has been confirmed in between the sensor and the wall.
6. The measured distance by ultrasonic sensor has recorded in Table 8.
7. Step 4 to 6 has repeated using different distance.

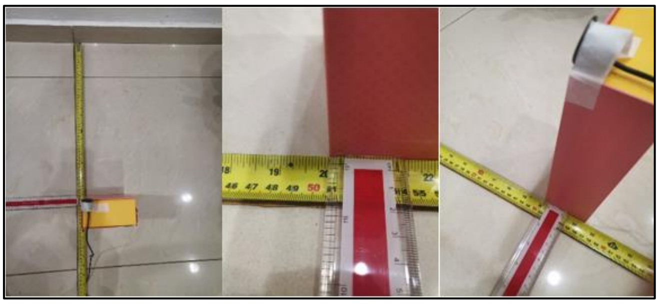

Fig. 8. set up to test distance measurement (Dry Test)

Fig 7. shows the line graph of ultrasonic sensor distance accuracy test in dry atmosphere. From the graph can observe that the accuracy of distance measured by ultrasonic sensor decreases when the distance between ultrasonic sensor and the wall increases. From the distance of 50cm to 350cm the line is constant, but after 350cm the line is not constant. According to the datasheet (Waterproof Ultrasonic Module, n.d.), it stated that JSN-SR04T ultrasonic sensors can detect distance up to 600cm. However, when testing out the ultrasonic sensor hardware, the maximum accurate distance that is capable to measure is only 350cm. Hence distance above 350cm will not be consider using in the Smart Helmet system.

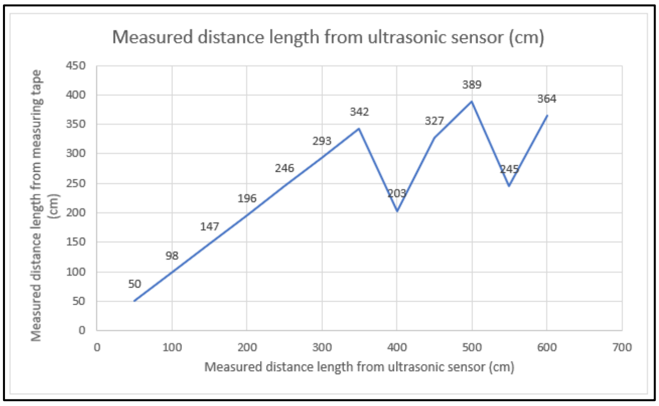

Fig. 9. Measured distance length from ultrasonic sensor (cm) (Dry Test).

B. Distance measurement test (Rain test)

Set up

1. Ultrasonic sensor has sticked on a tall box as shown in Fig 10..
2. Find a flat surface of the floor and wall.
3. Starting point of measuring tape has place to the wall, measuring tape has pulled up to 600 cm then placed on the floor.
4. Ultrasonic sensor has placed at label 50cm on the measuring tape.
5. Water has started to sprinkle water between ultrasonic sensor and the wall.
6. No object has been confirmed in between the sensor and the wall.
7. The measured distance by ultrasonic sensor has recorded in Table 10.
8. Step 4 to 7 has repeated using different distance.

Fig. 10. set up of distance measurement test (Rain test)

Fig 11. shows the line graph of ultrasonic sensor distance accuracy test in rainy day. From the graph can observe that the accuracy of distance measured by ultrasonic sensor decreases when the distance between ultrasonic sensor and the wall increases. From the distance of 50cm to 350cm the line is almost constant, but after 350cm the line is not constant. Comparing both result of Table 8 and 10, the range of 50cm to 350cm can be detected by the JSN-SR04T ultrasonic sensor, whereas after 350cm the distance measured by JSN-SR04T ultrasonic sensor is not accurate. Although JSN-SR04T ultrasonic sensor can detect distance from 50cm to 350cm in rainy day, but it is not as accurate as the measured distance in dry atmosphere. In summary, JSN-SR04T ultrasonic sensor is able to work on rainy day but is less accurate compared to dry atmosphere. This might because the water act as a obstacle blocking the soundwave and the soundwave got reflected back to the sensor before the soundwave has reached the wall. The water attenuates the ultrasound to other direction and lead to the ultrasound is not able to travel back and forth in a accurate distance.

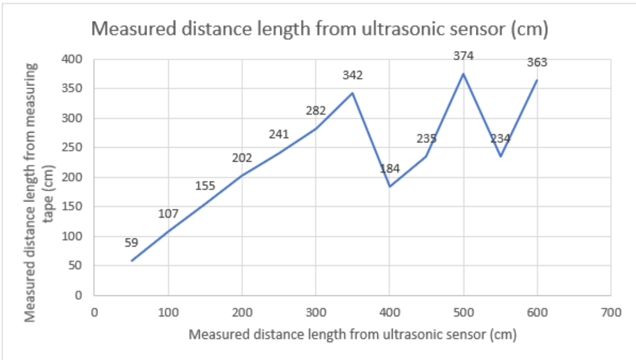

Fig. 11. Measured distance length from ultrasonic sensor (cm) (Rain Test)

C. Angle measurement test

Set up

1. A paper has drawn with different angle using protractor as shown in Figure 31. The paper has drawn with angle ranging from $0°$ to $-50°$ at left and $0°$ to $+50°$ right side.
2. Ultrasonic sensor has sticked on a tall box as shown in Fig 12.
3. Find a flat surface of floor and wall.

4. Starting point of measuring tape has place to the wall, measuring tape has pulled up to 100 cm then placed on the floor.
5. Measuring tape has put at 0° on the angle paper.
6. Ultrasonic sensor has placed at label 100cm on the measuring tape.
7. A flat surface rectangular box has placed at label 50cm on the measuring tape.
8. No object has been confirmed in between the sensor and the box.
9. The angle of sensor and the box has measured by the ultrasonic sensor.
10. If LCD display distance close to ±49cm (Figure 29), so object is able to detect by sensor. If LCD display distance close to ±97cm (Figure 28), so object is unable to detect by sensor.
11. Table 12 has fill up based on the experiment.
12. The box and measuring tape have moved to negative angle on the paper but the sensor still remained placing at 0°.
13. Step 5 to 12 has repeated using different angle to measure.
14. The box and measuring tape have moved to positive angle on the paper but the sensor still remained placing at 0°.
15. Step 5 to 12 has repeated using different angle to measure.

Objective of this angle measurement test is to test the range of angle that can be detected by JSN-SR04T ultrasonic sensor. A paper has drawn with different angles using protractor as shown in Figure 31. Angle of 0° is the midpoint of the paper. Angle ranging of 0° to 50° has drawn at both left and right of the paper. Reason of drawing angle 0° to 50° at both left and right is to test the capability of the sensor detecting object at left and right side.

First, the sensor has put on label of 100cm on the measuring tape. Figure 28 shows the LCD display 97cm, this is the distance detected by the sensor between the wall and sensor. A rectangular box then placed on label of 50cm on the measuring tape. Figure 29 shows the LCD display at 49cm, this is the distance detected by the sensor between the box and sensor. The box and measuring tape then move to different angle on the paper but the sensor remained at angle of 0° on the paper. To test the object can be detected by the sensor, the LCD needs display at ±49cm. LCD display at ±49cm means the sensor is still detecting at the box. If the LCD display ±97cm, that's mean the sensor is sensing the wall and unable to detect the object.

Fig. 12. Paper drawn with different angles using protractor

Table I shows the result of capability of JSN-SR04T ultrasonic sensor to detect object at left and right. The result shows that the sensor can only detect the object from - 15° to +15°. When combining both left and right side of the angle, this determines the sensor can detect an overall of 30°.

According to the product specification of JSN-SR04T ultrasonic sensor, it stated that it has a measuring angle of 75° (Waterproof Ultrasonic Module, n.d.). This angle measurement test shows the actual hardware and datasheet result are not the same.

TABLE I. DATA COLLECTION OF ANGLE MEASUREMENT TEST

Test 1		
Angle measurement test		
Angle in degree (°)	Distance display in LCD	Is the object able to detect?
-25°	97	No
-20°	97	No
-15°	51	Yes
-10°	50	Yes
-5°	49	Yes
0°	49	Yes
5°	49	Yes
10°	50	Yes
15°	51	Yes
20°	97	No
25°	97	No

V. CONCLUSION

The aim for this project is to develop a Smart Motorcyclist Helmet by using Arduino microcontroller which has the feature to alert the rider when there is object approaching the motorcyclist blind spot zone when riding. The Smart Helmet has integrated with ultrasonic sensors at blind spots of motorcyclists and buzzer has been used to alert motorcyclists. LCD has been used to display the distance between the motorcyclist and the object. Different colors of LEDs have been used to virtually tell the distance between the motorcyclist and the object. Performance of the Smart Helmet prototype has been tested and results have been recorded. The buzzer and LEDs is designed to operate in three different danger mode. The limitation in this Smart Helmet is the range of distance detected by JSN-SR04T ultrasonic sensor. The datasheet states that JSN-SR04T ultrasonic sensor can detect a distance up to 600cm. However, when testing the sensor, it is only capable of detecting a distance up to 350cm only. With this limited of distance detection by JSN-SR04T ultrasonic sensor, it does not give sufficient sense of protection to motorcyclist although the Smart Helmet system is able to operate. The recommendation for future improvement is to increase the range of distance detects by sensor.

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REFERENCES

Ahmad, M., Naveed, A., Riaz, S., Memon, A. G., Anwer, S., Zafar, M. H., ... & Shah, S. (2022). Prevalence of Helmet Induced Headache among Bikers. *Pakistan Journal of Medical & Health Sciences*, *16*(09), 42-42.

Branas, C. C., & Knudson, M. M. (2001). Helmet laws and motorcycle rider death rates. *Accident Analysis & Prevention*, *33*(5), 641–648. https://doi.org/10.1016/S0001-4575(00)00078-6.

Engineering, I. C. (2019). *Determination of blind spot zone for motorcycles*. Retrieved from IOP Science: https://iopscience.iop.org/article/10.1088/1757-899X/670/1/012075.

Haqverdi, M. Q., Seyedabrishami, S., & Groeger, J. A. (2015). Identifying psychological and socio-economic factors affecting motorcycle helmet use. *Accident Analysis & Prevention*, *85*, 102–110. https://doi.org/10.1016/j.aap.2015.09.007.

Lam, C., Wiratama, B. S., Chang, W.-H., Chen, P.-L., Chiu, W.-T., Saleh, W., & Pai, C.-W. (2020). Effect of motorcycle helmet types on head injuries: evidence from eight level-I trauma centres in Taiwan. *BMC Public Health*, *20*(1), 78. https://doi.org/10.1186/s12889-020-8191-1.

Ng, Y. R., Chong, Y. K., Mohammed, O., How, Y. H., & Abdul Salam, Z. A. (2023). Convolutional Neural Network for Fruit Image. Journal of Applied Technology and Innovation, 21-27.

Paul A. Miller 1, G. W. (2015, August 31). *Reducing the size of the human physiological blind spot through training*. Retrieved from ScienceDirect: https://www.sciencedirect.com/science/article/pii/S0960982215008295#:~:text=Summary,the%20surface%20of%20the%20retina.

Rice, T. M., Troszak, L., Ouellet, J. V., Erhardt, T., Smith, G. S., & Tsai, B.-W. (2016). Motorcycle helmet use and the risk of head, neck, and fatal injury: Revisiting the Hurt Study. *Accident Analysis & Prevention*, *91*, 200–207. https://doi.org/10.1016/j.aap.2016.03.002.

Tamrin, S. (2022, October 13). *Motorcyclist deaths alarming, take action, says WHO*. Retrieved from FMT: https://www.freemalaysiatoday.com/category/nation/2022/10/13/motorcyclist-deaths-alarming-take-action-says-who/.

Total number of registered motorcycles (in thousand). (n.d.). Retrieved from ASEANStatsDataPortal: https://data.aseanstats.org/indicator/ASE.TRP.ROD.B.01.

Waterproof Ultrasonic Module. (n.d.). Retrieved from Cytron: https://my.cytron.io/p-waterproof-ultrasonic-module.

Yamashita, R., Nishio, M., Do, R. K., & Togashi, K. (2018). Convolutional neural networks: an overview and application in radiology. SpringerOpen, 611–629.