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Smart System for Safety of Cyclists

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Abstract: In the age of globalization, cycling is more than just a means of transportation, it is also a hobby for all age groups. Cycling trends are increasing in Malaysia as more people own and begin to participate in bicycle groups. Transportation system problems and strict regulatory oversight can lead to traffic jams and accidents. Other means of transportation are one of the causes of accidents on bicycles, especially rear-mounted vehicles. Accidents can also occur because the cyclist is unaware of the current environment. Therefore, the purpose of this study is to design, develop, and test the capabilities of smart system prototypes for cyclist safety. This study used development model of five phases consisting of planning, analysis, design, prototype development and testing. The result of this study is that a prototype of smart system for safety of cyclist can alert users of potential accident and reduce the risk of an accident. Suggestions for improvement are that the entire electrical and electronic circuit needs to be optimized to be more compact and tidier.

Keywords: Smart, Safety, Cyclist, Development, Prototype

1. Introduction

In this era of globalization, cycling is not only a means of transportation, but also a hobby for everyone regardless of age. In Malaysia, the cycling trend is increasing as more and more people start owning and joining cycling groups. This increasingly popular sport has proven to be a trend when more and more cyclists can be seen in traffic and recreational parks, as well as social media sharing from artists to politicians (Abd Aziz, Shari & Kamarunzaman, 2021). However, bicycle users are still not exempt from any risk of accidents caused by various aspects. Therefore, cyclists are expected to obey road rules and laws for the safety of themselves and other road users (Traffic Investigation and Enforcement Department, 2021).

In connection with the increasing number of cycling activities among the Malaysian community, many accident cases have occurred involving cyclists. Among the things that cause these accidents to happen are such as an imperfect bicycle, not signaling, carrying passengers, inappropriate distances,

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busy and narrow roads, carrying pets, joking while riding, cutting or crossing the gaps of other vehicles, inappropriate bike size and more either happen before, during and after riding a bike.

Therefore, along with the rapid development of technology, bicycle safety systems also need to be improved. Riders feel that existing bikes are easy and safe to use, but the risk of accidents will still exist. Various sophisticated devices or tools for riders or bicycles have been created nowadays. Among them are night lights, lighted hats, etc. However, these tools are not able to prevent accidents against cyclists. Therefore, a smart system for the safety of advanced cyclists needs to be established to improve better safety. The objectives of this project are to design, develop and test the functionality of smart system for safety of cyclists.

2. Methodology

Prototype development model was used in order to developed the smart system for safety of cyclists. This model consists of 5 phases which are planning, analysis, design, prototype development and testing. Figure 1 shown a flowchart of prototype development model.

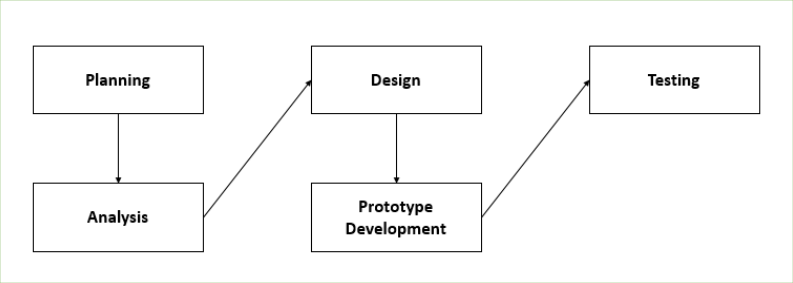

Figure 1: Model of Prototype Development.

In the prototype development model, researchers follow each phase step above in order to produce a prototype of a smart system for good cyclist safety. Starting from planning, analysis, design, prototype development and finally testing, researchers perform each phase correctly so that a good prototype can be produced.

2.1 Planning

In this phase, researchers have identified problems face by cyclists nowadays. In order to design a good product, critical planning have been done so that the product produced can provide benefits to the users. Therefore, the researcher has made a thorough plan in terms of product design, circuit design and software by considering the practicality for product development and cyclist. Sketchup has been used to designed the product, Proteus used to design the circuits and Arduino to designed the coding of this project.

2.2 Analysis

Analysis is the second phase in the prototype development model. The analysis that have been done before are designed analysis, circuit analysis and test the functionality of project analysis. Based on design analysis, researchers found that the design must be tiny and compact so that it can be attached to the bicycle and easy to use. Proteus was used to conduct circuit analysis by performing virtual development, demonstration and functionality test. The output of the distance and GPS module shown on the Blynk's application via mobile phone.

2.3 Design

This phase focuses on designing the system and how the system operates. This phase concludes by providing a system design documentation using various electronic circuits and software. The prototype design should complement of how the system operates. Aspects of shape and the size are also very important to set in advance. In this section the researcher has sketched a suitable design to be considered for the development of a product for a smart system for the safety of cyclists. Figure 3.2 shows an example of an early product to illustrate the prototype that will be developed. The design of the model has been built according to the needs of the user, which is cheap and easy to use. Here is a preview of a smart system for the safety of cyclists.

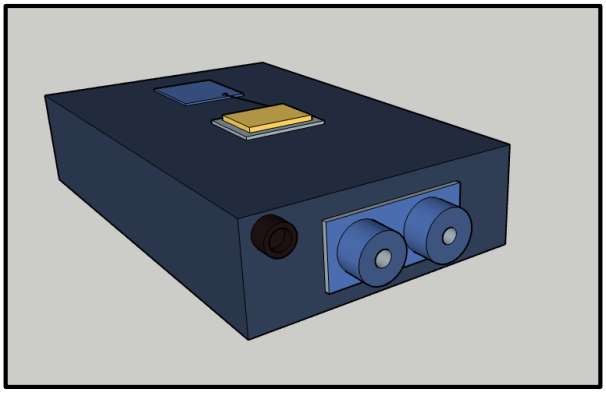

Figure 2: Isometric view

2.4 Prototype Development

Hardware design consist of electronic box and the full connection of the project including dynamo, electronic box and bicycle. As for the circuit design, consists of distance circuit and GPS module circuit. Both designs were integrated and connect as shown in figure 3.

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Figure 3: Prototype that have been developed.

Figure 3 shows the complete prototype of smart system for safety of bicycle users. The box is mainly consisting of electronic circuits such as microcontroller NodeMCU ESP-8266, car charger adapter and dc-dc converter. The electronic components such as ultrasonic sensor, GPS module Neo6M are also attached. The dynamo will generate power to supply power bank. Power bank act as switcher to turn on or turn off the prototype. The output of distance, current location and emergency text can be seen through application of Blynk which needed internet to operate.

2.5 Testing

Testing is the last phase of prototype development model. In this phase, it consists of 3 types of testing, which are, electrical testing, mechanical testing, and product functionality testing. In electrical testing, it is focused on the functionality of the power supply circuit that uses dynamo, microcontroller NodeMCU ESP8266, GPS module, ultrasonic sensor and notification system. On the mechanical side, aspects of testing such as strength, suitability of materials, safety and neatness of the product are carried out. As for product functionality testing, the full connection was tested by running the bicycle and found that the project was achieved the objectives.

3. Results and Discussion

Doing a prototype requires good and accurate research. It involves the development and testing of electric and electronic components and circuits. The design must be appropriate and easy to use by cyclists. Safety system also must be functioning well and make cyclists feel safe when riding. The results shown are based on testing of main components on prototype of smart safety for safety of cyclists.

3.1 Testing of Ultrasonic Sensor

As a result, researchers have tested on the output part of the smart system for the safety of cyclists through the Blynk application for GPS modules, ultrasonic detectors and buzzers to detect entities and dynamo circuits for power bank charging. NodeMCU ESP-8266 in this prototype works as a microcontroller that controls all the electronic components used. The output reading requires an internet network to connect to the NodeMCU ESP-8266 which is equipped with a WIFI module in order to empower the Internet-Of-Things (IOT).

This NodeMCU ESP-8266 has been programmed using Arduino IDE software to receive information from ultrasonic detectors and output information on General Purpose Input/Output (GPIO). This programming is written to program when any object is detected and at the same time the buzzer will sound and the reading can be seen on the Blynk application. Figure 4 below shows the distance reading on the Blynk application when any object is detected.

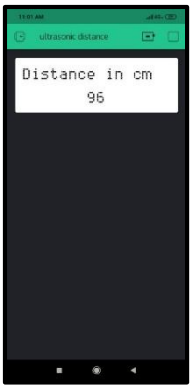

Figure 4: Distance shown in Blynk application.

Respond speed test were performed and recorded. The researcher conducted the test 10 times to see the functionality of the ultrasonic detector to detect object within a distance of 2 meters and below. Table 5.4 below shows the time taken by the buzzer to sound when the ultrasonic detector detects object within 2 meters and below.

Table 1: Time taken for buzzer sounded.

Testing	1	2	3	4	5	6	7	8	9	10
Time (s)	0.1	0.1	0.2	0.1	0.3	0.1	0.2	0.1	0.1	0.1

The table 1 shows time taken for buzzer respond. It is also to test the functionality of the buzzer when the ultrasonic detector detects an object. The buzzer is in good condition with an average time of 0.1 seconds respond time.

3.2 Testing of GPS Module Neo6M

GPS Module Neo6M is an electronic component use to record the current location of an object. The GPS module processes the information sent from the satellite to the antenna on the GPS module through a specific Radio Frequency. Figure 5.6 shows the GPS module attached to the housing of the electronic components. Researchers use GPS modules to obtain information such as latitude, longitude, speed, direction, satellites and even maps. The researcher used the Blynk application to view the output as shown in figure 5.

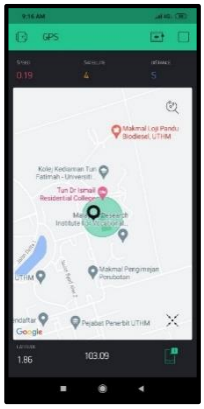

Figure 5: Output of GPS Module Neo 6M on Blynk application.

Figure 5 shown an output of GPS Module Neo 6M on Blynk application. It shows the location of GPS, location of user's smartphone, latitude, longitude, speed, distance and satellite.

3.3 Testing of Emergency Notification System

The emergency notification system in the smart system for the safety of cyclists is an aspect of safety for cyclists. A push button is used and connected to the NodeMCU ESP-8266 and then connected to the Blynk application to enable emergency notices to be read. It requires an internet network to get output. If the button is pressed, an emergency notification will be sent directly to the account holder of the Blynk application who is the owner of the cyclist. Figure 6 is an emergency notice in a smart system for the safety of cyclists.

Figure 6: Emergency Notification on smartphone via Blynk application.

Figure 6 shown an emergency notification on smartphone via Blynk application. The notice will be popped up after the cyclists press the button. A message will be sent directly to the same Blynk account that is log in on another device. An internet connection is a must and both Blynk application on each device must be turned on.

3.4 Testing of Dynamo Circuit

A 6V DC dynamo is connected to the bicycle tire to produce a direct current voltage, charging the power bank which functions as an ON or OFF switcher for the complete circuit of the smart system. Then connected with a Stepup DC Converter to increase the voltage to a value that can charge the power bank and connected to the Car Charger Adapter. Figure 7 below shows the dynamo connection circuit.

Figure 7: Connection of dynamo.

Figure 7 shows a complete connection of dynamo with electronics circuit on a bicycle. When the tire spins, dynamo will turn and produce energy to supply the power bank. The indicator light will be shown at the power bank when the charging happened.

3.5 Expert Evaluation

Expert evaluation has been done through meeting of three expertise. All the comments and reviews in table 2 written by the experts. The evaluation form consists of design, functionality, and market.

Table 2: Comments and reviews from expert.

Number Expertise	Comments and Reviews
Expertise number 1	i. Innovative. Can be consider to be uplift. ii. Usage of dynamo for regeneration of power and GPS as tracking is good. iii. Box of electronic components need to be tidier and compact.
Expertise number 2	i. Innovative. ii. Good electronics usage such as ultrasonic sensor and dynamo as generator. iii. Make sure the box is tidier.
Expertise number 3	i. Good innovation. ii. Dynamo is a good renewable energy. iii. Good usage of GPS as a tracker, USB as multi charging. iv. Design need to be fixed.

Based on reviews from expertise, it can be concluded that this project is a good innovation, yet need some improvement in terms of design. Good usage of electric and electronic components makes this project successful such as ultrasonic sensor, GPS module Neo 6M, dynamo and other. Unfortunately, the design needs to be fixed and tidier.

3.6 Discussions

The prototype of a smart system for the safety of cyclists was developed to reduce the risk of accident especially when cycling alone. Another problem that may arise is when the cyclist is disrupted by any object while riding a bicycle. The researcher found that the entire project was successful and achieved the objectives targeted which are designing, developing and testing the functionality of a smart system for safety of cyclists.

i. Designing Prototype of Smart System for Safety of Cyclists

In the development of smart system for the safety of cyclists, design phase is crucially important in producing functioning prototype. Product designs can be anything from simple parts to complex assembled model parts. It can easily be converted into a drawing sheet showing top, side and front views of the product along with its dimensions. This design is then transformed into a physical prototype, which saves time and also attracts user due to its aesthetics, fast respond and modern design. The prototype design of system for the safety of cyclists is based on the problem statement that has been identified. With that, the use of electronic components such as ultrasonic and GPS modules has been used. The component requires a container for storage of electronic components including NodeMCU ESP-8266, Car Charger Adapter and Stepup DC-DC Converter. All these electronic components must be in one place that is easy to maintain and suitable for this smart system for the safety of cyclists.

Once ultrasonic detects object within 2 meters distance, buzzer responded by producing sound in tandem with the ultrasonic detection of object. Likewise with the GPS Module Neo 6M, it must not have obstacles from the top to be able to receive the satellite signal and allow it to work well and get the desired information. The space for the cable route is made according to the connection on the outside of the casing. The notification system is attached to the bottom of the bicycle seat to make it easier for users to use it if needed. As for the dynamo, its position is on the rear or front frame of the bicycle

which allows the gear on the dynamo to be rotated by the bicycle tire in order to produce direct current voltage. The power bank is placed on the front to make it easier for users to use it if needed.

This design places the container of electronic components on the back of the bicycle, which is on the rear bicycle cushion, which helps to reduce vibration on the container and allows the electronic circuits to function properly. Overall, design of the prototype smart system for the safety of cyclists has been done as planned and also on-going improvement throughout the development process.

ii. Developing Prototype of Smart System for Safety of Cyclists

The researcher has chosen a prototype development model as a guide in developing a prototype of a smart system for the safety of cyclists. This prototype development model is easy to understand and an easy-to-follow workflow for developing the prototype.

Prototype development has been carried out based on the design that has been made using Sketchup web software. This development process involves the development of a prototype framework of a smart system for the safety of cyclists in particular and the development of a software system that will control the operation of the prototype. Each part of this development involves the use of different equipment and techniques. Various tools are used such as Cordless Screwdriver, saw, hot glue gun, soldering and so on. Problems and analysis of products or prototypes are analyzed first. Problem analysis is carried out to identify the problems experienced by bicycle users that involve activities while riding bicycle. Prototype analysis is also carried out to identify the components that are suitable for use, the appropriate circuit and the comparison of the developed prototype with products that are already on the market. The design phase is carried out by designing a design for the hardware requirements, the arrangement of components and the overall complete circuit of a prototype of a smart system for the safety of cyclists. This design process involves the use of software such as Sketchup and Proteus to ensure that the shape of the prototype and the arrangement of components are easy to maintain later.

The circuit design consists of several components - electronic components such as NodeMCU ESP-8266 circuit, ultrasonic detector, GPS module, 6V dynamo and notification system. NodeMCU ESP-8266 circuit is the microcontroller in enabling this prototype to function. The use on the input side of the NodeMCU ESP-8266 is an ultrasonic detector. This ultrasonic detector is used to detect any object within a distance of 2 meters and below and then the buzzer will sound and the distance reading can be seen on the Blynk application. Meanwhile, the GPS Module Neo 6m component is also an input for NodeMCU ESP-8266. Coding is done using Arduino IDE using C++ language. The information set is latitude, longitude, speed, direction, satellite and map. Output can be viewed on the Blynk app and must be connected to the internet. The notification system has also been installed and the user only needs to press the emergency button and the emergency notification will be sent to the owner who have the same Blynk account and must be online as well. The dynamo is used to charge the power bank when the tire turns and will generate direct current voltage.

In relation to the overall cost of the development of a smart system prototype for the safety of cyclists, this is a total of RM 159.80. Compared to product 1 is approximately RM 300.00, product 2 RM 500.00 and product 3 RM 420.00 because these products use expensive components to realize their project. The researcher ensures that the progress of prototype development work is done well as planned. Software development is using Arduino IDE and Proteus 8.0 software. The development of prototype design sketches was developed using Sketchup software. As for coding, the Arduino IDE software is used to identify the functionality of each circuit connected to the NodeMCU ESP-8266 and

the Blynk application. If there are any errors, the Arduino IDE software can help and troubleshooting will be carried out in solving the problems that occur.

Testing of each circuit is using the Arduino IDE, as it involves the Internet-of-Things (IOT). The coding used uses C++ language that can connect the NodeMCU ESP-8266 with the Blynk application for the purpose of seeing the output results from the input and through the NodeMCU ESP-8266 to get the functionality of the smart system prototype circuit for the safety of cyclists. The framework is developed according to the suitability of the circuit that has been identified as working and then the connection will be tested using a digital multimeter.

iii. Testing the Functionality of Smart System for Safety of Cyclists

Firstly, comparison between 3 similar products as the prototype was done. Product one allows the coach to monitor the speed, power generate and the whereabouts of the cyclist. While the second product focus to monitor stable wireless using the internet network. As for the third product, it is an electric bicycle that uses solar energy and a dynamo. Based on these three products, all of them do not have an object detector from the rear direction and a buzzer to warn the bicycle user.

Thus, this prototype has innovated the existing idea by combining a dynamo to obtain a source of direct current voltage and creating a smart system for the safety of cyclists by using NodeMCU ESP-8266 and assisted with the Blynk application to see the output through the network internet. Information such as latitude, longitude, speed, direction, satellite and map can also be obtained by using the Neo 6m GPS Module. In order to answer the third objective which is to test the functionality of the smart system prototype for the safety of cyclists that has been developed. The researcher has tested the functionality of the circuit in chapter 5, which is for the ultrasonic detector circuit and buzzer, the GPS module circuit and the notification system as well as the entire circuit. All the circuits have been tested for components, continuity testing and output testing. The researcher has also obtained validation from 3 experts and all three experts agree that the prototype of a smart system for the safety of cyclists has been successfully developed. Therefore, these tests show the overall functionality of the developed prototype. The testing should be carried out in detail and in stages to facilitate the maintenance process in the future.

The power supply of this bike safety system prototype is a power bank that works to turn on or off the ESP-8266 NodeMCU circuit. Overall, the dynamo is used to charge power banks but can also charge other objects such as smartphones and so on that have inputs according to the specifics of each cable. The dynamo in this prototype is connected to a Step-up DC-DC Converter to raise the direct current voltage to 12 V and then connected to the Car Charger Adapter for output purposes.

The researcher has also obtained three experts' opinion of one (1) bicycle user, one (1) assistant electrical engineer and one (1) lecturer at the Technical and Vocational Faculty of Electricity & Electronics. For the bicycle user, he has been active in cycling activities for 5 years and has various experiences joining cycling tour. The second expert is an assistant electrical engineer who graduated with a Diploma in Electrical and Electronics Engineering and a graduate of the Polytechnic. The third expert is a student who is doing his PhD studies at the Faculty of Mechanical and Manufacturing Engineering (FKMP), he is active in various sports particularly cycling.

This expert validation was done to verify the overall functionality of the smart system prototype for cyclist safety developed by the researcher.

4. Conclusion

The main goal of the researcher is to design, develop and test the functionality of a smart system prototype for the safety of cyclists that uses a NodeMCU ESP-8266 microcontroller as the main electronic component. Overall, the researcher stated that the prototype of this smart system for the safety of cyclists has succeeded in overcoming or reducing the problem of road accidents involving bicycle users while cycling. The current location can also be detected in case of any unwanted problems. With this, the risk of accidents can be reduced with the use of smart system prototypes for the safety of cyclists. At the design stage, the researcher successfully designed the framework and system by producing a preliminary sketch of the prototype design of a smart system for the safety of cyclists. The initial design proposal is made based on the study and preliminary information obtained as well as the selection of suitable materials or electronic components so that the development of this prototype can be developed successfully. In addition, the use of the right equipment also needs to be emphasized to facilitate the development works while taking care of the safety aspect of the work. Overall, the development of a smart system prototype for the safety of cyclists using NodeMCU ESP-8266 helps researchers to further develop knowledge with the innovations that have been made. In general, the prototype of this smart system for the safety of cyclists was successfully produced, but some improvements still need to be made so that this prototype can operate better to heighten the safety of cyclist.

Acknowledgement

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