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AUTOMATIC TURN SIGNAL FOR MOTOR VEHICLES USING ROAD NAVIGATION APPLICATION

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Abstract - *One of the causes of the traffic accidents is drivers making sudden and unexpected turns and failing to use their turn signals correctly. This "Automatic Turn Signal for Motor Vehicles using Road Navigation Application" aims to create a device that connects to a road navigation application and automatically activates turn signals of a motor vehicle. The system is designed to control the vehicle's turn signal lights by detecting the need of turning and assist the user in navigating to the desired location using the directions generated from Google Maps API. This study employed Developmental Quantitative research and Iterative Waterfall method in its development. A control box is installed to a motor vehicle which contains Atmega328P as its main controller, a relay to switch the turn signal lights and a HC-05 module to communicate with the mobile app through Bluetooth technology. System Testing was done to ensure that the device is working according to specification, the following were tested: unit testing, communication with the API, turn point detection, communication between hardware and software modules. The results show that the mobile app, control box and the API were successfully integrated.*

Keywords – *Android, mobile navigation, turn signals. Automation*

INTRODUCTION

Following the "rules of the road" requires the use of turn signals. Turn signals should be utilized more frequently, which can prevent many accidents. Most drivers do not realize how vital turn signals are. They are essential for communicating to drivers about the desired direction of a moving vehicle. A turn signal is a flashing light on a vehicle to indicate that it is preparing to change lanes or turn. The only indicator of where a car intends to travel is its turn signals. While some drivers consider turn signals a courtesy, the law requires it. Turn signals help communicate with other drivers so they know the intended direction and respond appropriately. It would help to keep everyone on the road safe by exchanging information with vehicles that are both in front of you and behind you, whether it be turning into a parking lot, changing lanes on the freeway, or pulling out of a side street. Using turn signals is essential to prevent collisions on the highway because vehicles are moving quickly and could get into severe accidents if not used. [1] [2]

In Dayton, Ohio, a study by the Society of Automotive Engineers [6] made an unexpected claim: Turn signal disregard may be more deadly than distracted driving, causing millions of crashes yearly. SAE studied 12,000 lane-changing and turning cars, and the company concluded that 25% of drivers failed to signal when turning, and an astounding 48% failed to do so when changing lanes. According to the study, if these percentages applied to all U.S. drivers, there would be 750 billion instances of turn signal disregard every year, or more than 2 billion daily occasions. An extra 10% of drivers leave their blinkers on incorrectly after changing lanes or mistakenly activate the wrong turn signal. [1]. A recent study shows that many Americans fail to activate their turn signals, which leads to more traffic accidents than distracted driving. However, turn signals are standard safety

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equipment in every motor vehicle, and drivers are required by law to use them to signal turns and lane changes. Drivers who fail to use their turn signals endanger other drivers, especially pedestrians, cyclists, and motorcyclists, who are more at risk in collisions with larger, heavier vehicles. Drivers who fail to signal cause about two million car accidents annually, nearly half of which end in injury or fatalities [4][5].

Over 2,000,000 accidents occur yearly due to drivers not utilizing their turn signals and over 950,000 accidents annually due to distracted drivers. Unfortunately, many drivers did not value the importance of turn signals. Young drivers are prevalent in neglecting turn signals. According to the survey, over 71% of drivers aged 18 to 24 do not use turn signals regularly [7].

Safety is the top priority when operating a motorcycle, so a GPS device is helpful for rides. After having all the required riding equipment, navigation systems, and GPS systems should be taken into account to ensure your safety while riding. The GPS is the most trustworthy instrument to get you there, whether it is used to map out a ride or to show you the way. The GPS turns into a man's closest buddy while embarking on an expedition. GPS lets you know exactly where you are and where you are heading in real-time. Stop driving around without knowing where you are going, where to turn at a light, or how many kilometers it will take you to get there. Not only that, but the GPS will provide alternate routes to minimize traffic congestion. The nearby restaurants and gas stations will also be made known to you. This tiny piece of information can be beneficial when you need to refuel. These gadgets are very simple to mount into your motorcycle, allowing you to view maps and routes in front of you while maintaining focus on the road. [3][8]

OBJECTIVES OF THE STUDY

The main objective of this research is to develop a device that is connected to a road navigation mobile application that automatically activates turn signals for motor vehicles. This device will greatly benefit motorists by accurately and automatically timing turning signal lights. This study aims to create a device In particular, the researchers aim to achieve the following sub-objectives:

- To provide directions and determine the best route to your destination.
- To design and develop a road navigation Android mobile application.
- To automatically turn on the signal light at every turning point.

MATERIALS AND METHOD

The study's research methodology was developmental. Developmental research is characterized as the systematic study of creating, implementing, and assessing instructional programs, procedures, and products that must meet internal consistency and effectiveness criteria instead of basic instructional development [9]. Quantitative research makes connections and summarizes the variables [10]. In this study, the system **"Automatic Turn Signal Activation for Motor Vehicles using Road Navigation Application"** was analyzed, described, designed, implemented, tested, and evaluated.

The system used the SDLC (Software Development Life Cycle). The SDLC framework organizes, plans, and controls the system development process [11]. The SDLC concept through the development phase of the system in this study

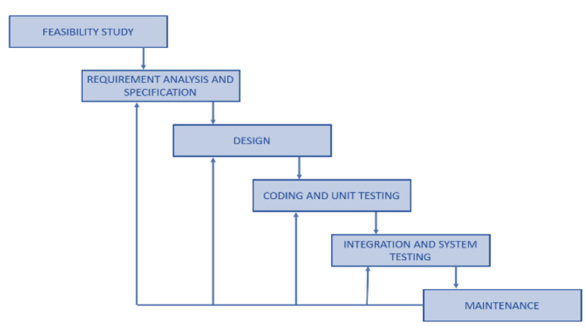

Fig 1. Iterative Waterfall Method

This system was created using the iterative Waterfall Method. It is a development process with a sequential flow of phases and feedback pathways from each phase to the previous phases [12]. The phases of development are as follows: analysis, design, testing, implementation, and maintenance.

Fig 2 shows the system process and stages of the device's utilization. User will enter the desired destination through the android application. The best route will then be fetched from the Google API, detects route and sends turning point signals. Control box contains an ATmega328p as its main controller, and relay that switches the turn signals on and off.

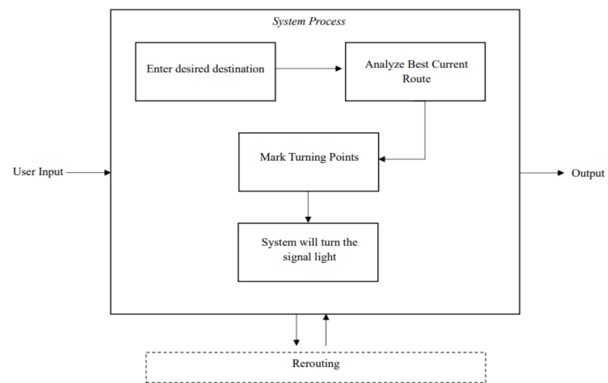

Fig 2. Block Diagram

Fig 3 illustrates the process flow of the system. User will set the desired destination and the fastest route will be fetched from API. A map and route will be displayed to the user to follow. In the case that the user did not follow the specified route, the application will update the route. Whenever the user comes near a turning point, the application will send a signal to the control box through Bluetooth, the control box will then activate the correct turn signal light. When the last turning point was passed, the application will send another signal for deactivation.

Fig 4 shows the schematic diagram of the system's hardware modules. An ATmega328p microcontroller serves as the brain of the control box. It is interfaced with a HC-05 module which allows Bluetooth communication with the mobile application. Lastly, a relay acts as a switch for the activation of the vehicles turn signal lights.

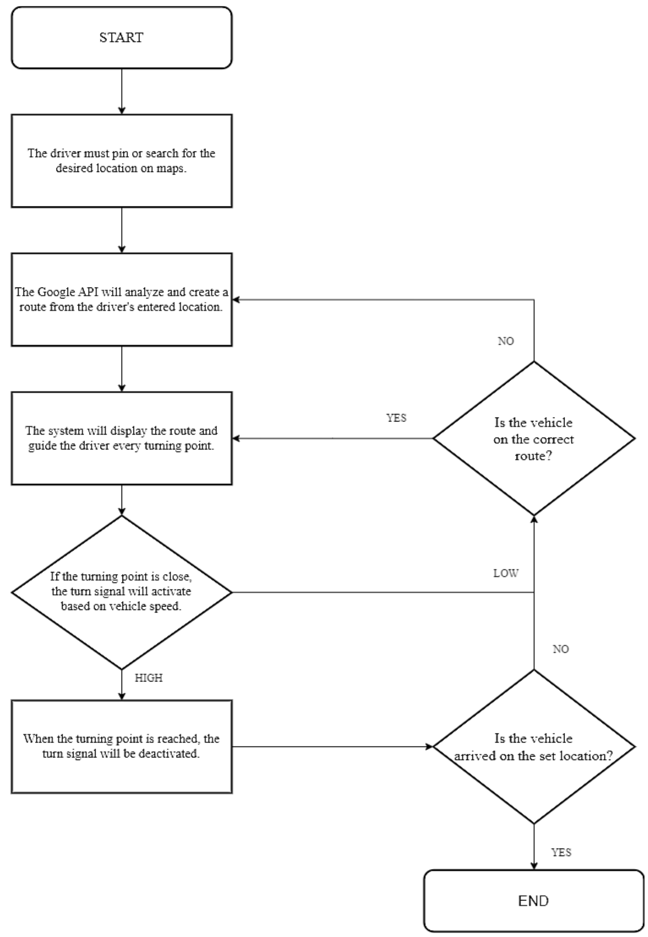

Fig 3. Flow Chart

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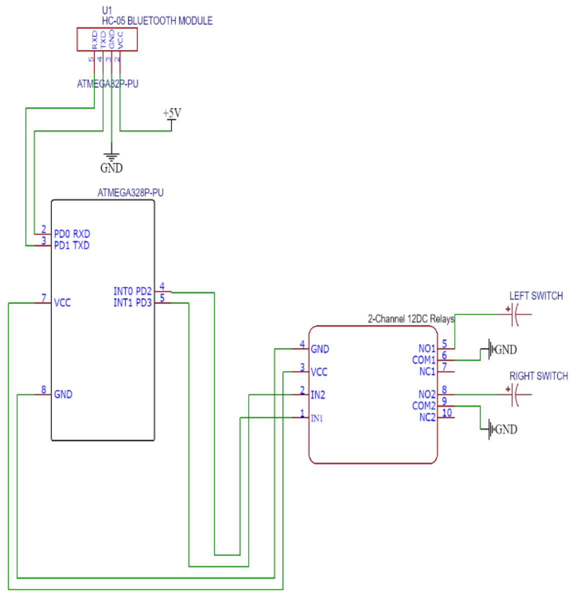


Fig 4. Schematic Diagram

The system was tested to ensure that it works according to the intended specification. Individual components and module were tested. In addition, integration of the various modules such as the communication between the software and hardware were also tested.

The device was also implemented on a motorcycle, a Yamaha Aerox 2020 equipped with a computer box.

During the testing, various factors were measured to assess the accuracy and responsiveness of the device. These factors include: mobile application functionality in terms of response time connecting to Google API to display and navigate maps, data reading, and measurement at each turning point to send instructions to the Atmega328p. The Approximation Error was used to determine how close the system reading was to the actual value. The approximation error is determined using the formula [13].

$$percent\ error = \left|\frac{\text{measured value} - \text{exact value}}{exact\ value}\right| x\ 100$$

System evaluation is the assessment of the performance of the system against defined technical qualities. The system was evaluated based on the product quality characteristics specified in the ISO 25010 quality model: functional suitability, reliability, performance efficiency, compatibility, Maintainability, Portability and usability [14].

The system was shown to drivers and computer-related professionals to evaluate the mobile application and device. The findings of the assessment, presented in Table 1, were used to determine system acceptability. As stated in Table 2, the measurement approach was a five-point Likert Scale.

TABLE 1: *ISO 25010 Quality Characteristics*

CHARACTERISTICS	DEFINITION
A. Functional Suitability	This refers to the Completeness, Correctness, and Appropriateness of the system.
B. Reliability	This refers to the system's Maturity, Availability, Fault Tolerance, and Recoverability.
C. Performance Efficiency	This refers to the Time Behavior, Resource Utilization, and Capacity of the system.
D. Usability	This refers to the Appropriateness, Recognizability, Learnability, Operability, User Error Protection, User Interface Aesthetics, and Accessibility of the system.
E. Compatibility	This refers to the Co-existence and Interoperability of the system.
F. Maintainability	This refers to the Modularity, Reusability, Analyzability, Modifiability, and Testability of the system.
G. Portability	It refers to the Adaptability, Installability, and Replaceability of the system.

TABLE 2: *Five-point Likert Scale [15]*

SCALE	WEIGHTED MEAN	DESCRIPTION
5	4.51 - 5.00	Excellent
4	3.51 - 4.50	Good
3	2.51 - 3.50	Fair
2	1.51 - 2.50	Poor
1	1.00 - 1.50	Very Poor

RESULTS AND DISCUSSION

As the first step of the development process, the researchers subscribed to Google Maps API service, shown in Fig 5, which will be utilized to fetch and configure maps information for road navigation. This service was integrated to the android mobile application developed for both user and hardware communications.

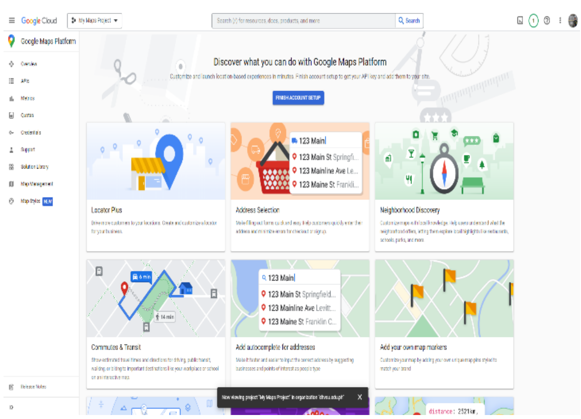


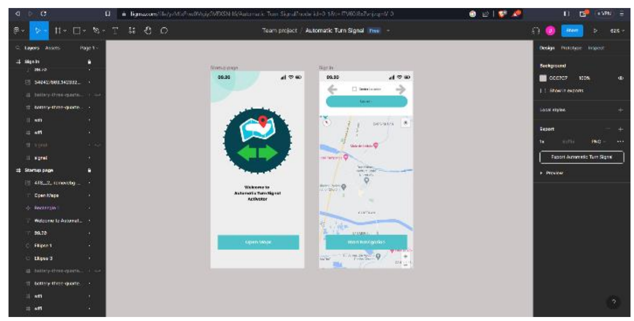
Fig 5. Google Maps Cloud Console Platform

The android application's road navigation process is divided into six (6) steps: get the current location, setting-up the pin-to-pin location, navigation mode selection, fetching the navigation route, navigation proper, and the sending of turning information to the hardware modules.

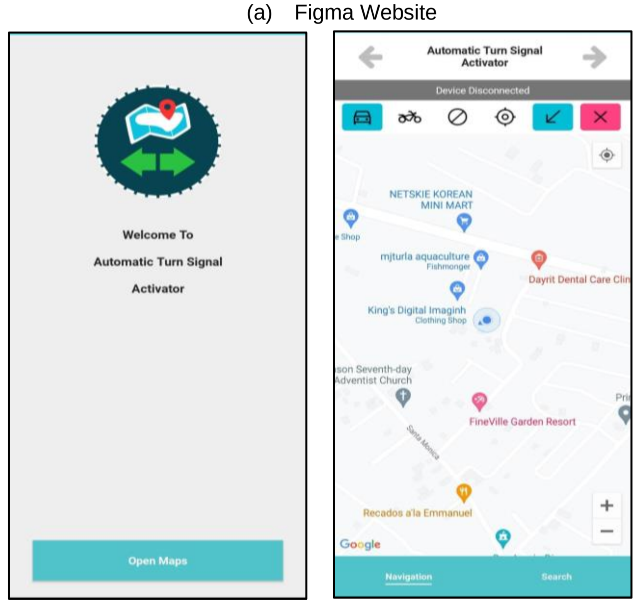
Fig 6 shows the development of the application user interface (UI), Figma was utilized to design and layout the UI. The user interface facilitates the communication between the users and the system, it lets the user input various information such as the destination pin, and the navigation mode.

The integration between the API service and mobile application is successful as shown in Fig 7. The application can successfully get the current location of the phone.

Fig 8 illustrates sample setting of pin-to-pin and calculation of the optimal route. The mobile application can successfully get and display the desired route.



(a) Figma Website



(b) Implemented UI

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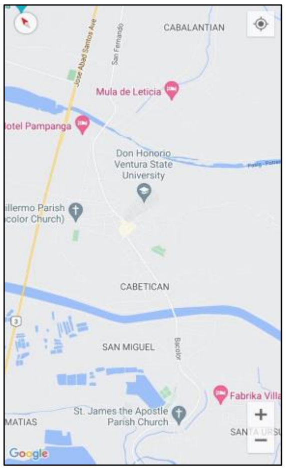
Fig 6: Application UI



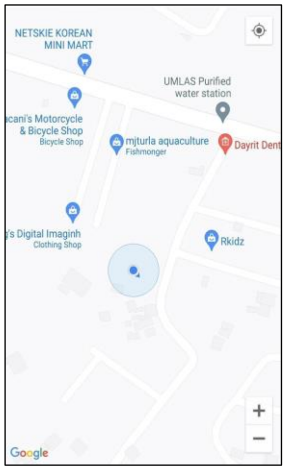


Fig 7: Google Maps API integration

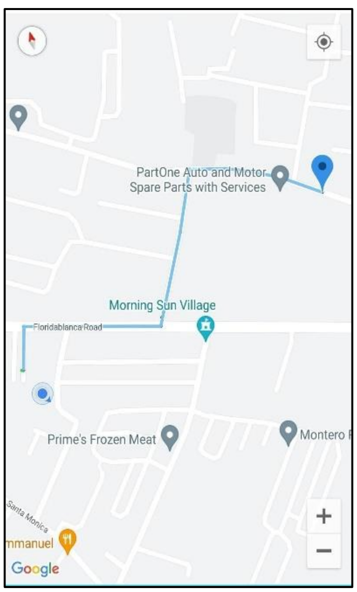
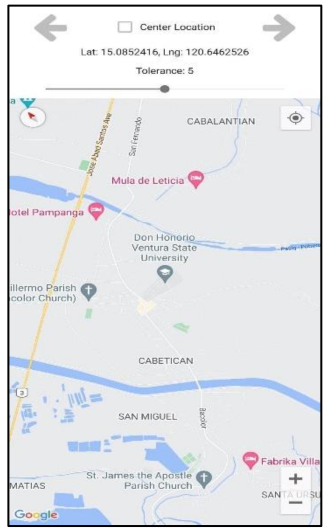


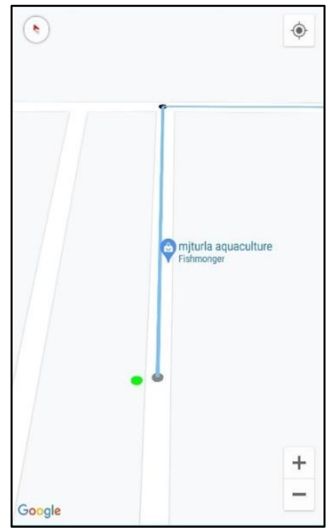
Fig 8: Pin-to-pin location

Navigation Mode as shown in Fig 9 provides visual information on the route to the user-pinned location. It also provides visual cues that shows whether the system is turn-signaling. Haversine Formula [16] is utilized to calculate the distance between the pinned destination and the last current location provided by the Google Maps API.

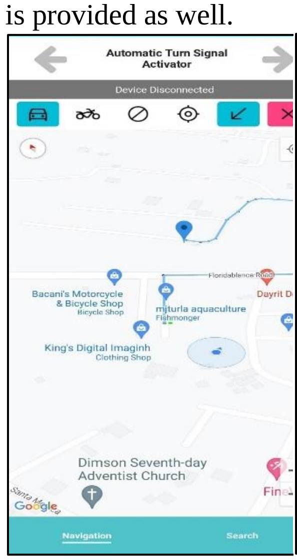
Fig 9: Navigation Mode

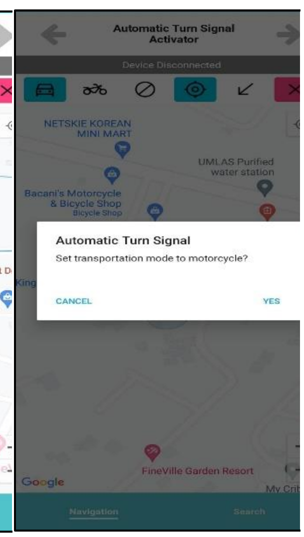
Additionally, Fig 10 shows the other important features that the mobile application provides. First is the selection between driving and motorcycle mode, this determines whether the API will consider toll gates in its route. Next is the selection between Top-view and Tilt-view. Functionalities for inputting the preferred destination and cancelling the current navigation



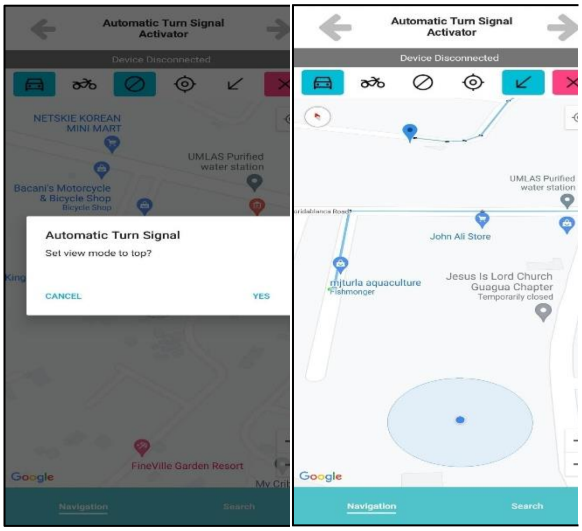


is provided as well.

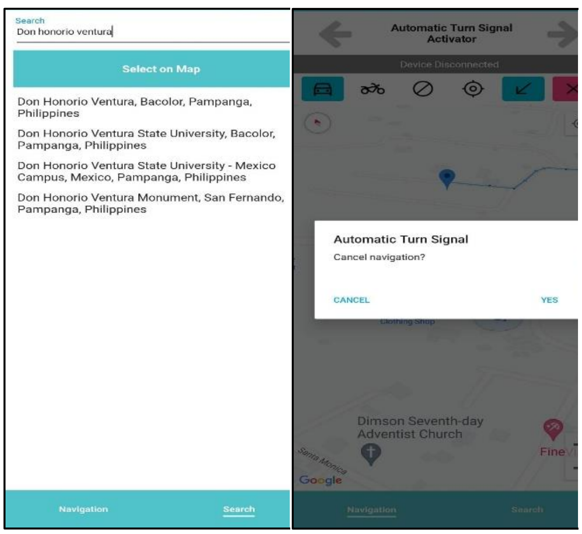




(a) Driving Mode (b) Motorcycle Mode



(c) Top-view mode (d) Tilt mode

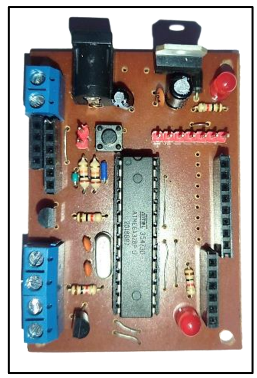


(e)Destination input (f) Cancel Navigation

Fig 10: Miscellaneous Features

The next step is the development of the hardware modules which will be installed on the motor vehicle to control the signal lights.

The boards were designed using EasyEDA and were etched on a pre-sensitized copper board. The PCB is photo exposed under UV light. The photo-exposed parts are removed using a developing solution. This exposes the unwanted copper that are chemically- etched using ferric chloride. The PCB pin holes are then drilled making room for the electronic components to assembled and soldered into the PCB.



(a) Microcontroller (b) Dual-Channel Relay

(c) HC-05 Module

Fig 11: Hardware Modules

Fig 11 shows the hardware modules utilized for the control box of the system. Atmega328p based microcontroller is interfaced with HC-05 Bluetooth module and Dual-channel relay. This allows the microcontroller to communicate with the application through Bluetooth using the HC-05 Module. The received data from the application is processed and used to control the relay in switching the turn signal lights on and off.

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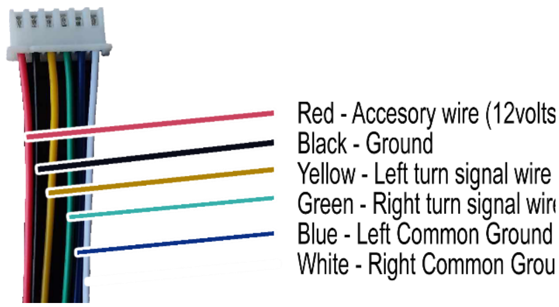

Fig 12: Signal Light Cable Wiring Diagram

In order for the control box to switch the motor vehicle's turn signal lights. The cable connected to the signal switch of the motor vehicle (Fig 12) is interfaced with the output of the relay module, each signal wire is connected to a relay and when the relay is activated the signal wire will be pulled to ground which will result in the flasher relay of the motor vehicle to activate hence switching on the respective signal light.

During the development software and hardware modules of the system, testing is also done to ensure that every part and integration of the said modules works according to the requirements and specification.

Table 3: *Map Rendering*

Attempt #	Response Time (ms)
1	180
2	177
3	192
4	181
5	190
Ave. Response Time (ms)	**184**

Map rendering pertains to the displaying of the map on the application. Table 3 shows that the average response time in for Map rendering in five (5) attempts is 184 ms.

Table 4: *Fetching Current Location*

Attempt #	Response Time (ms)
1	510
2	491
3	563
4	603
5	493
Ave. Response Time (ms)	**532**

Table 4 shows the response time for the operation of getting the current location coordinates from the API.

Table 5: *Setting Pin Destination*

Attempt #	Response Time (ms)
1	490
2	521
3	482
4	622
5	495
Ave. Response Time (ms)	**522**

Table 5 shows the response time on the operation of setting up the destination location on the API and getting the calculated route.

Table 6: *Route Rendering*

Attempt #	Response Time (ms)
1	650
2	784
3	946
4	786
5	614
Ave. Response Time (ms)	**756**

Table 6 shows the route rendering or the operation of displaying the calculated route on the application.

Table 7: *Rerouting*

Attempt #	Response Time (ms)
1	984
2	981
3	889
4	924
5	952
Ave. Response Time (ms)	**946**

Lastly, Rerouting is the operation which runs whenever the user deviates from the set route, the application will recalculate the route to adjust with the user's new location. Table 7 shows the response time for five (5) attempts and the average is 946 ms.

The time it took for various operations: map rendering, get current location, set destination, route calculation, and Re-routing, to execute were measured to test whether the system is responsive and consistent, as shown in Tables 3 through 7. Respectively, the system takes 184ms, 532ms, 522ms, 756ms, and 946ms on average to execute each operation. According to Nielsen, J. [17], a response time of less than 1 second is acceptable, and users will unlikely feel any interruptions during this delay. This signifies that users will feel slight to no delay when using the application. In addition, there are no failed attempts encountered during testing which signifies that the application works consistently under normal working conditions.

TABLE 8: *Turn Signal Light Control*

Scenario	Measured Value	Actual Value	Percent Error
Right Turn	45	46	2.17
Left Turn	33	34	2.94
Right to Left	17	17	0
Curves	12	14	14.2
U-turn and Intersection	10	15	33.3
Rerouting	10	11	9.09

Next, the control box's ability to properly switch the turn signal lights in different situations is tested, as shown in Table 8. Among the following scenario, Curves, U-turns and intersections shows the highest error rate. The false triggering of the turn signals were mainly caused by the need to navigate consecutive, or opposite turns especially on reverse curves are in opposite direction and close to each other.

TABLE 9: *System Acceptability Evaluation Summary*

CHARACTERISTIC	WEIGHTED MEAN	DESCRIPTION
Functional Suitability		
This system meets users' correct and relevant needs.	4.72	Excellent
Reliability	4.56	Excellent
The device was easy to use.	4.52	Excellent
The device was able to connect to the navigation application.	4.55	Excellent
The turn signal light activates before the turning point	4.61	Excellent
Performance Efficiency		
The device was able to perform its task in an ample amount of time.	4.57	Excellent
Usability		
The mobile application has a user-friendly user interface.	4.49	Good
Compatibility		
The system is compatible with many devices and vehicles.	4.63	Excellent
Maintainability		
The system can be easily repaired and modified to meet user needs	4.58	Excellent
Portability		
The system is portable in terms of size and installation.	4.66	Excellent
TOTAL MEAN	4.60	Excellent

CONCLUSION AND RECOMMENDATION

The research entitled "Automatic Turn Signal Activation for Motor Vehicles using Road Application" has been successfully designed and developed. The system provide means to input a destination location, track its current location and generate a guide route on a map through the utilization of an android application, this enables the user to navigate to a desired location by following the directions to a calculated route. The system is able to automatically switch the proper turn signal light according to the direction specified on the set route. In addition, the system can reliably control the turn signal lights in exception of scenarios in curves, and intersections where consecutive turning is required.

For future researchers who wish to upgrade and strengthen the development of this study, the following are recommended: application of image processing and computer vision to handle turn signal activations during lane changing and overtaking scenarios, improvement of the applications response time, improvement of turn detection for better reliability, and enabling manual switching for emergency purposes.

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