Global Scientific JOURNALS

GSJ: Volume 8, Issue 12, December 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

Apex: Next Generation Smart Helmet with Artificial Intelligence

W. V. Kodithuwakku, K. P. D. N. Kahatapitiya, W.M.R.P. Wasala, M. P. Y. J. Karunarathna and G. Fernando

Abstract **- Helmet has been always associated with bike riding since the invention of motorcycle. However, it has always been about protecting riders head in event of a crash. In essence it is a plastic or metal shell shaped for human head, padded inside with some material for increased comfort. Till now it has remains as simple yet functional apparatus. Here goal was to create a smart helmet that integrate with the bike itself to create a multipurpose, sophisticated device that assists the driver in his task without being a distraction. It contains heads-up display that relay useful information to the driver, various sensors that constantly monitor driver and surround area, companion app that contain various extended features and integration with the bike. Also, machine learning has been integrated into the system which in turn enrich the data supply. Research was aimed at bringing common drive aid features on motor vehicles such as lane departure warning, to a smaller platform that can be integrated into the helmet without losing its core functionality or performance.**

Index Terms **- Smart Helmet, Machine Learning, IoT, Android, Arduino, Automatic annotation, Deep learning, Object Classification, Object Detection, Lane Detection, and Object Tracking**

1. Introduction

Today, motorcycle is a very common mode of transport for individual riders. Motorcycle gives the freedom and flexibility for the riders to move anywhere they want and at any time. Riders do not have to be dependent on the public transportation services, which in many cities and countries are extremely unreliable. A motorcyclist's helmet, also called safety helmet, acts as a protective headgear to prevents any fatal head injury.

Rapid increase in motorcycle usage has led to significant increase in the motorcycle related accidents and fatalities. This has resulted in motorcycle riders being among the most vulnerable road users on roads as they have lack of protection in case of crash. The number of registered motorcycles in Sri Lanka in year 2016 was 3,699,630 which is 55% of the total registered vehicle population for the year [1]. From 2012 to 2016, the number of registered motorcycles increased by 45% with the growth rate of 11% per year, which shows the significant growth of motorcycle population in the country. There are 355 motorcycles per 1,000 households and 911 per 10,000 population available in Sri Lanka [2]. As the number of motorcycles increase so does the probability of their being involve in crashes also increases.

Helmets for riders are extremely important and many lives can be saved by the use of these Helmets in the event of accidents. Motorcyclists have a perception that wearing a helmet causes discomfort and they do not appreciate its importance, especially the youth. Perhaps the most misleading idea is that short trips do not involve any risk. Smart helmet helps the driver by supplying him with useful information and ensuring that he can be arrived at the destination safely. Larger

vehicles contain driver aid features that helps toward safer driving experience. However, on two-wheelers there has been no attempt at implementing these features. One aspect this will focus on will be bringing these features to smaller vehicle without losing functionality or usefulness.

Scope of this research was to create a smart helmet that also integrate with the bike to create a multipurpose, sophisticated device that assists the driver in his task without being a distraction. It will have heads-up display that will relay useful information to the driver, various sensors constantly monitor driver and surround area, companion app that contain various extended features and integration with the bike.

1.1. Benefits

Benefits of "Apex: Next Generation Smart Helmet with Artificial Intelligence" System :

- ✓ Can track alertness level of the driver
- ✓ Can show navigation information on HUD
- ✓ Can aid in detecting traffic signs, traffic lights and speed limits
- ✓ Can take necessary actions if driver is falling sleep.
- ✓ Wake up driver by vibrations of a small motor.
- ✓ Can detect if driver is drunk or not.
- ✓ Can prevent bike from starting if driver is not in a suitable condition to drive.
- ✓ Can detect air quality, temperature and humidity in surrounding environment.
- ✓ Companion application can be used to extend features.

1.2. Objectives and Goals

Objectives and Goals of "Apex: Next Generation Smart Helmet with Artificial Intelligence" System :

- ✓ To transform an ordinary helmet to a feature rich, more usable, sophisticated device.
- ✓ Encourage helmet waring by make it more usable.
- ✓ To bringing features that are only available in larger vehicles to small scale in more user-friendly package.
- ✓ Keep price point low.

2. Literature Review

Helmet has been always associated with bike riding since the invention of motorcycle. But it has always been about protecting riders head in event of a crash. In essence it is a plastic or metal shell shaped for human head, padded inside with some material for increased comfort.

Functionality of the helmet always remained the same. But throughout the times there has been attempts at changing this simple yet functional device to a multipurpose, sophisticated device. Most of the attempts were made at monitoring wearer's vitals and act accordingly and supply rider with information which can be hard to access while riding a motorcycle. This section explains various undertaking that were done to improve helmet's status and usability while also remain a useful and approachable apparatus.

2.1. Similar Applications

There have been few attempts at implementing a fully functional, commercial smart helmet for masses. Frontrunners for this are LiveMap[3], CrossHelmet[4],

Jarvish[5] and Skully[6]. One important thing is that all of these are still in development stage. Not even one of them has been made available to the public. All of these products are funded through crowdfunding platforms and one can pre-order them without knowing when they will be available if ever.

All of them have usual features like head-up display, sound control, rear-view camera, safety light, touch panel for operation and connectivity options. These were implemented at very basic level and only as a proof of concept since none of them has been released to the market. With this it is safe to assume that all these products are in very early development stage and possibility of coming to the market is very slim. Even if they came to the market it will be hard to deliver all the promised features. Another point is price. All these products are priced between $499 - $1500. Which is very high price for such a device specially for country like Sri Lanka. Proposed research is focused on integrating all these features and more into one integrated system that is more affordable and more accessible to the end user.

2.2. Deep Learning Based Automatic Video Annotation

Machine learning based video annotation tools are essential in building driver information systems. Through these processes it is possible to annotate and identify surroundings objects and inform and warn user about them.

Manikandan et al. [7] compare and contrast which are the best algorithms for video annotation and also compare it to the full manual - done by humans by hand - process. In deep learning-based video annotation object detection, object classification, lane detection, and object tracking are considered to be the crucial modules.

In object detection, algorithm detect object as vehicles, two-wheelers, and pedestrians. If the detected object is a vehicle it further classifies it as car, bus, truck, other-vehicle, and non-descript. For the object detection YOLO and Retinant-50 were used.

With this model it is possible to detect objects, classify them in to their respective categories and also detect lane markings. Using this method is faster and more accurate than manual method which researchers also tried. But disadvantages can be taken as it can be very resource intensive and impractical to implement with real-time data.

2.3. Anti-theft System

Agarwal et al. [17] have laid emphasis on the security of the two-wheeler and the rider. A prototype system is being proposed in which provides more security to two-wheeler systems with the help of biometrics system. This has been ensured by providing two layers of anti-theft protection. First access to the vehicle is limited only to authorized personals and at the time of entry person's fingerprints are cross checked with an authorized list. The second layer of protection is consisting of GSM (Global System for Mobile Communication) technology which sends SMS (Short Message services) to the owner in case of anomaly. If vehicle was moved without owner's prior knowledge, the current location of the vehicle is tracked by a GPS tracker. Then owner can track it through SMS and take appropriate actions. The system also consists of a rider safety system ensuring that the vehicle cannot be started if the driver is drunk or not wearing a helmet.

2.4. Reduce Drunk Driving

Reddy et al. [10] have laid emphasis on reducing the number of accidents caused by the carelessness of the riders such as driving in a drunken condition or not wearing a helmet while riding. The authors have tried to implement a system which does not allow operation when intoxicated and make it mandatory to wear a helmet while riding. A system is proposed which is an intelligent two-wheeler ignition system with an additional intelligent helmet for the safety of the rider. First access to the vehicle is limited only to authorized personals and at the time of entry person's fingerprints are cross checked with an authorized list. A module on the helmet synchronizes with a module fixed on the vehicle's ignition and if the rider is not wearing the helmed while turning on the ignition, vehicle will not be started.

3. Methodology

3.1. System Design

System consists of a helmet containing control modules, two cameras, a screen, and various sensors, control unit which fitted to the motorcycle that in charge of ignition and companion mobile application which extends various functionalities. In figure 3.1, block diagram demonstrates the overall architecture of the system.

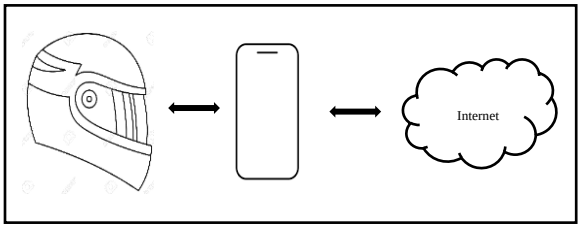

Figure 3-1 - Block Diagram

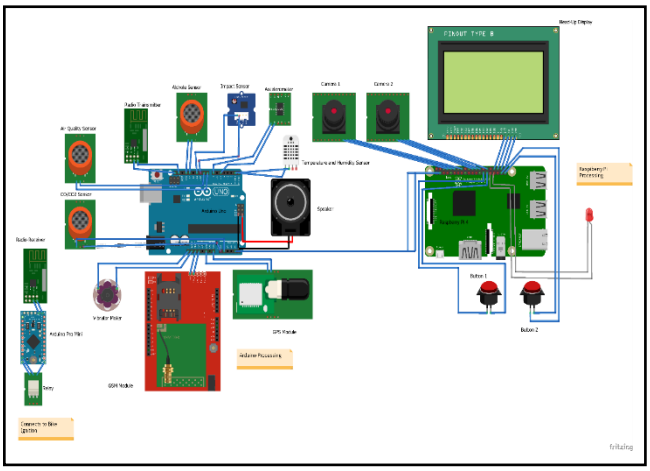

Figure 2-1 - Architecture Diagram

Figure 3.2 shows first part of the circuit. .This part contains a screen and two cameras which is controlled by raspberry pi. Screen is used as a heads-us display which relay various useful information to the rider throughout the ride. System contains two cameras, one is aimed toward oncoming traffic tasked with aid in driver-aid features and other one is aimed toward riders' eye tasked with detecting rider's alertness level. Two buttons are used for interacting with the screen and, LED acts as status light.

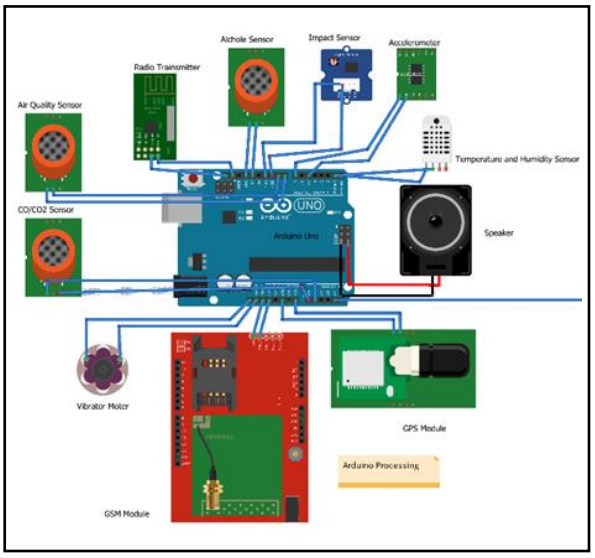

Figure 3-2 - Architecture Diagram - Arduino

Figure 3.3 shows second part. .This part contains arduino as controller unit and, other sensors and equipments getting controlled by it.

- ✓ Arduino Uno act as the main controller for sensors.
- ✓ Accelerometer and Impact sensor task with detection of falling and impact forces.
- ✓ Alcohol sensor tasked with continuously measuring rider's alcohol level.
- ✓ Small speaker act as a hearing aid for the rider.
- ✓ Temperature and Humidity sensors for continuously measuring ambient temperature and humidity both inside and outside the helmet.
- ✓ GPS module for continuously tracking current location.
- ✓ Air quality sensor, CO2 sensor and, CO sensor for tracking air quality in surrounding area.
- ✓ Vibrator motor for wake-up rider if he is falling sleep.
- ✓ Radio transmitter for connecting with ignition control unit.

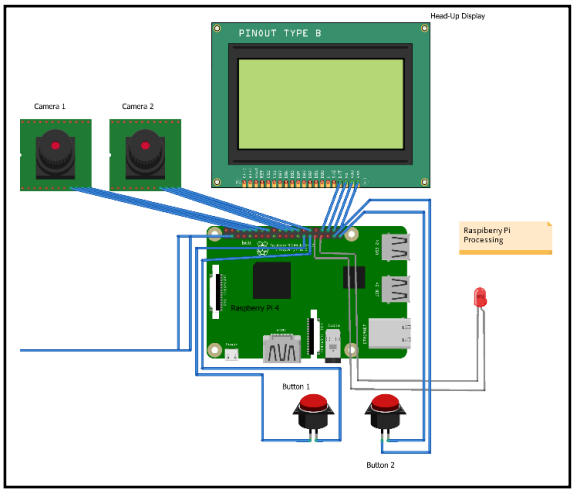

Figure 3-3 - Architecture Diagram - Raspberry Pi

Figure 3.4 shows last part of the circuit. This is the part that is fitted to the motorcycle. This controls the ignition. This communicate with main system through radio transmission.

- ✓ Arduino Pro Mini acts as controller unit for ignition control unit which is connect to bike ignition and communicate wireless with main unit. Task of this unit is to cut-off ignition if driver is too drunk to drive.
- ✓ Radio receiver is tasked with maintaining contact with main unit.
- ✓ Relay is directly connected to ignition.

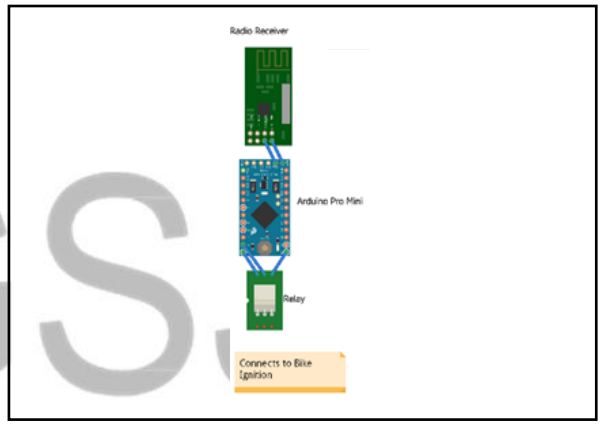

Figure 3-4 - Architecture Diagram - Arduino Pro Mini

3.2. Interface Design

First interface (Figure 3.5) appears when the user opens the application and logged in successfully. This interface is responsible for showing navigation information and weather conditions along the way.

User first enters their intended destination and then most optimal route from user's current location to their destination is shown in the map. Optimal route is calculated based on the traffic conditions and weather forecast. Also, when user entering their destination automatic locations suggestions are given based on their current location.

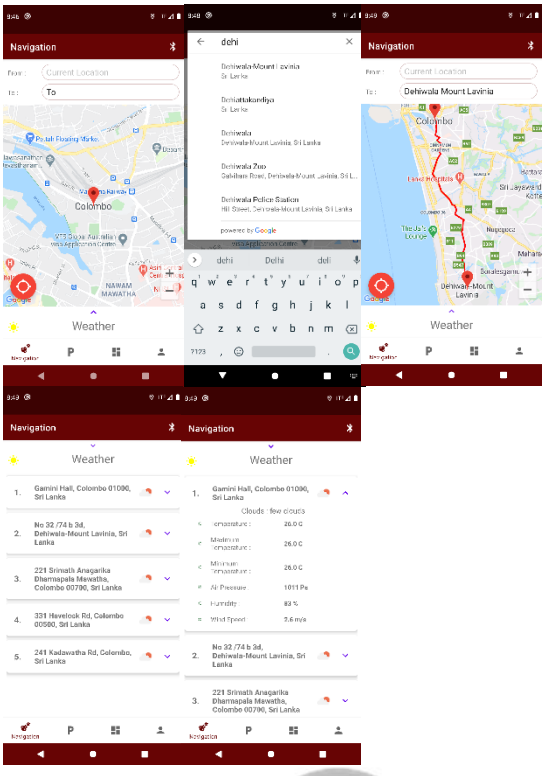

Figure 3-7 - Interface - Navigation

On the bottom of the screen there is a bottom sheet that can be slide up. In this panel

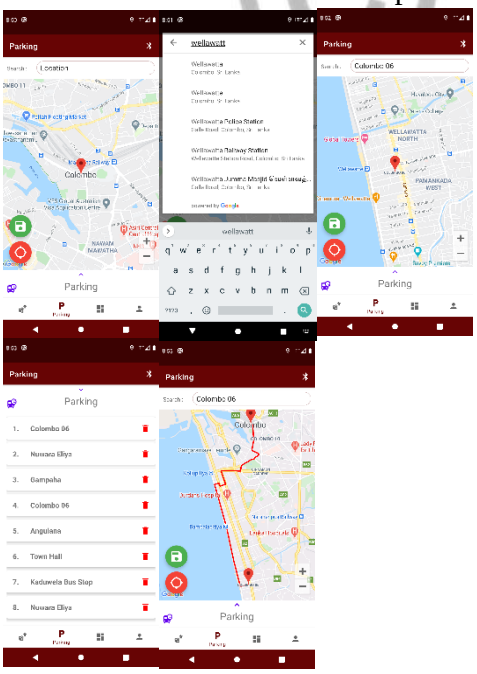

Figure 3-6 - Interfaces - Parking

weather information for five location which represents whole route weather details are shown. When clicked on one of the list items more details about that particular location is reveled.

Second screen (Figure 3.6) is responsible for handling parking location details. Parking location can be saved and later recalled from the bottom menu.

Third screen (Figure 3.7) is devoted to dashboard. Connection with the helmet can be initiated by clicking on the Bluetooth button on the top upper corner. Here it shows list of all the Bluetooth devices currently connected to the smartphone. When clicked on one of the listed devices, connection is initiated. Then in the dashboard screen real-time data collected from the sensors in the helmet are shown in graph. There are four data streams. Humidity, Temperature, Air Quality and Carbon Monoxide Level. Also, warnings are shown if Carbon Monoxide level or Air Quality level went above dangerous level.

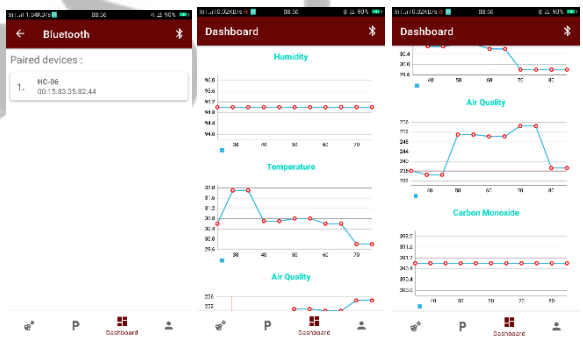

Figure 3-5 - Interfaces - Dashboard

4. Results & Discussion

The accuracy and the reliability of the system are expected to be at the utmost level due to the reason that the system as a whole was unit tested early in development stages in order to pinpoint and spot any kind of complications that could occur in the system. The team had to tackle a few problems, in

particular, earlier on the designing phase. The complications being:

Figure 4-1 - End Product

1. How the android application is connected with the helmet?

The android application is connected with the robot via Bluetooth. No communication between the application and the robot can be conducted without it.

2. How to determine which locations are selected for showing weather details?

Five to eight locations are selected based on the selected route to represent the weather conditions along the way.

3. Calculate the most optimal route?

Most optimal path between locations are calculated based on weather conditions and traffic situation.

4. Communication system between helmet and android application

Communication between helmet and android smartphone is done through Bluetooth. Every message is sent with an identifiable character followed by the actual message. This way both devices can identify what the message actually about.

5. Communication between helmet and motorcycle

Communication between helmet and motorcycle is done through RF communication. Devices get connected with each other when they are nearby starts the communication process.

6. Conclusion

Helmet has been always associated with bike riding since the invention of motorcycle. However, till now it has remains as simple yet functional apparatus. Here the goal was to create a smart helmet that integrate with the bike itself to create a multipurpose, sophisticated device that assists the driver in his/her task without being a distraction. It contains heads-up display that relay useful information to the driver, various sensors constantly monitor driver and surround area, companion app that contain various extended features and integration with the bike. Also, machine learning has been integrated into the system which in turn enrich the data supply. Also, it was aimed at bringing now common drive aid features on motor vehicles such as lane departure warning, to a smaller platform that can be integrated into the helmet without losing functionality or performance.

System was developed which has embedded systems which will monitor whether the rider is wearing a helmet and if the rider has consumed alcohol. In either of the cases the bike would not start and the rider would not be able to use it. This is a preventive method to reduce accidents and fatalities on the road. This system also has a

mechanism which will send a message and the location of the bike to the family members of the bike rider in the unfortunate event of an accident. This will help in providing timely help to the rider and reduce the fatalities. Through the smart helmet, the data of acceleration sensor, ultrasonic sensor, and carbon monoxide sensor were collected, and the data were analyzed to detect the specific situations.

7. Limitations

The limitations of the current system as follows, An android device is essential to run the application. As such, user(s) must have an android device to install and run the application. Internet connection should present at all times due to the fact the android application is connected to database via internet. Also, for map related items to work, internet connection is necessary. Without an interconnection loss of transmission would occur resulting in the overall system not working. Due to the system being powered with a battery unit it is essential that the battery is recharged regularly. Lack of battery would result in system not working. Also, system running time is short due to battery limitations. Hardware components being overheat would result in system failure.

8. Future Works

The future work for the current system as follows, To make circuit more simple, small and efficient. Next iteration will be on the flexible PCB so as to perfectly adjust the circuit inside the helmet and ultimately get a fully furnished complete market ready product. Next iteration will standardize the data by collecting and analyzing various data through more complex experimental tests.

References

[1] *"Statistics", Motortraffic.gov.lk, 2016. [Online]. Available: http://www.motortraffic.gov.lk/web/index.php?option=com_content&view=article&id=84&Itemid=115&lang=en. [Accessed: 02- Mar- 2020].*

[2] *Ntc.gov.lk, 2015. [Online]. Available: https://www.ntc.gov.lk/corporate/pdf/statistics%202015.pdf. [Accessed: 02- Mar- 2020].*

[3] *L. helmet, "LiveMap: Motorcycle smart helmet with Augmented Reality navigation", Livemap.info, 2018. [Online]. Available: https://livemap.info/. [Accessed: 02- Mar- 2020].*

[4] *"CrossHelmet X1 – Transform your riding experience", Crosshelmet.com, 2018. [Online]. Available: https://crosshelmet.com/. [Accessed: 02- Mar- 2020].*

[5] *"Jarvish", 2017. [Online]. Available: https://www.jarvish.com/. [Accessed: 02- Mar- 2020].*

[6] *"SKULLY AR-1 The World's Smartest Motorcycle Helmet", Indiegogo, 2017. [Online]. Available: https://www.indiegogo.com/projects/skully-ar-1-the-world-s-smartest-motorcycle-helmet#/. [Accessed: 02- Mar- 2020].*

[7] *N. Manikandan and K. Ganesan, "Deep Learning Based Automatic Video Annotation Tool for Self-Driving Car", 2018. [Accessed 28 February 2020].*

[8] *V. De Silva, J. Roche and A. Kondoz, "Robust Fusion of LiDAR and Wide-Angle Camera Data for Autonomous Mobile Robots", Sensors, vol. 18, no. 8, p. 2730, 2018. Available: 10.3390/s18082730.*

[9] *M. Realpe, B. Vintimilla and L. Vlacic, "Multi-sensor Fusion Module in a Fault Tolerant Perception System for Autonomous Vehicles", Journal of Automation and Control Engineering, pp. 460-466, 2016. Available: 10.18178/joace.4.6.460-466.*

[10] *S. Wang, Z. Deng and G. Yin, "An Accurate GPS-IMU/DR Data Fusion Method for Driverless Car Based on a Set of Predictive Models and Grid Constraints", Sensors, vol. 16, no. 3, p. 280, 2016. Available: 10.3390/s16030280.*

[11] *S. Angalaeswari, S. Sahni, A. Kumar, S. Ranjan and A. Shrivastav, "Smart Safety Helmet Intelligent Way To Drive", 2017. [Accessed 28 February 2020].*

[12] Youssef et al., "Towards Model-Based Online Monitoring of Cyclist's Head Thermal Comfort: Smart Helmet Concept and Prototype", Applied Sciences, vol. 9, no. 15, p. 3170, 2019. Available: 10.3390/app9153170.

[13] M. and Y. Gowda S., "Smart Helmet using GPS and GSM modem", 2020. [Accessed 28 February 2020].

[14] S. Sasirekha, I. Paul, S. Swamynathan, G. Y. and K. P., "Smart Helmet with Emergency Notification System–A Prototype", 2016. [Accessed 28 February 2020].

[15] D. Reddy, V. Suresh and T. Hemalatha, "Smart Helmet and Bike Management System", 2017. [Accessed 28 February 2020].

[16] S. Rao, V. S. M., M. Y. and P. R. S., "The High Security Smart Helmet using Internet of Things", 2019. [Accessed 28 February 2020].

[17] M. Areebuddin Aatif and A. Manoj, "Smart Helmet Based On IoT Technology", 2018. [Accessed 28 February 2020].

[18] S. K., A. B. S., L. Thomas and R. K. V., "Smart Helmet", 2018. [Accessed 28 February 2020].

[19] Rajputa, A. Saxenaa, A. Agarwalb, A. Bhatiab and A. Mishrab, "Smart Helmet with Rider Safety System", 2019. [Accessed 28 February 2020].

[20] Lee, J. Moonvvv, S. Dong Min, N. Sung and M. Hong, "Safety Analysis System using Smart Helmet", 2017. [Accessed 28 February 2020].

[21] S. Kar, D. Anshuman, H. Raj and P. Singh, "New Design and Fabrication of Smart Helmet", 2016. [Accessed 28 February 2020].

[22] M. Jadhawar, G. Kandepalli, A. Kohade and R. Komati, "Smart Helmet Safety System Using Atmega 32", 2020. [Accessed 28 February 2020].

[23] Agarwal, A. Saxena, A. Rajput, A. Bhatia and A. Mishra, "Intelligent System for Two-Wheelers along with Rider Safety", International Journal of Innovative and Emerging Research in Engineering, vol. 4, no. 7, 2017. [Accessed 1 March 2020].

[24] "Software Development Methodologies: Top Used Models - Velvetech", Velvetech, 2020. [Online]. Available: https://www.velvetech.com/blog/software-development-methodologies/. [Accessed: 01-Mar- 2020].