Наносистеми, наноматеріали, нанотехнології
Nanosistemi, Nanomateriali, Nanotehnologii
2024, т. 22, № 3, сс. 577–590
https://doi.org/10.15407/nnn.22.03.577

PACS numbers: 07.07.Df, 07.50.Qx, 85.40.Bh, 85.40.Xx, 85.85.+j, 89.20.Ff, 89.20.Hh

Accident Prevention Using IoT-Based Smart Helmet

P. Vivekanandan, P. Radhika, A. Sivamani, P. Pradeesh, and D. Rakesh

SNS College of Technology,
Department of Mechatronics Engineering,
Coimbatore, Tamilnadu, India

Many people die from not wearing helmets. They also die from delayed treatment. Remote accidents are hard for emergency services to detect. Helmets save lives. Early treatment prevents 60% of accident deaths. This scheme will ensure riders wear helmets and call 911, if they crash. Bike accidents are rising as our country's bikers. Many deaths occur due to not wearing helmets and not receiving prompt medical attention. The project protects bikers from traffic accidents. The primary aim of this work is to detect smart helmets and report accidents. The system uses sensors, Wi-Fi processors, and cloud computing. The processor checks accelerometer values from the accident detection system for irregularities. Cloud-based services send emergency contacts accident details. GPS locates vehicles. A smart helmet 'Konnect' guarantees real-time, verified accident information. Thus, a smart helmet for accident detection uses smart city's ubiquitous connectivity.

Багато людей помирає через відсутність шоломів. Вони також гинуть від несвоєчасного лікування. Екстреним службам важко виявити віддалені аварії. Шоломи рятують життя. Своєчасне лікування запобігає 60% смертельних випадків. Ця схема ґарантує, що водії одягнуть шоломи та зателефонують у 911 у разі аварії. Велосипедні аварії зростають із кількістю байкерів нашої країни. Багато смертей трапляються через відсутність шоломів і відсутність швидкої медичної допомоги. Проєкт захищає байкерів від ДТП. Екстреним службам важко виявити віддалені аварії. Основною метою цієї роботи є виявлення розумних шоломів і повідомлення про аварії. Система використовує датчики, процесори Wi-Fi і хмарні обчислення. Процесор перевіряє значення акселерометра від системи виявлення аварій на наявність порушень. Хмарні служби надсилають екстреним контактам деталі нещасного випадку. GPS визначає місцезнаходження транспортних засобів. Розумний шолом «Konnect» ґарантує перевірену інформацію про аварії в реальному часі. Таким чином, розумний шолом для виявлення аварій використовує повсюдне підключення розумного міста.

Key words: smart helmet, IR sensor, vibration sensor, MEMS sensor, temperature sensor, GSM, GPS.

Ключові слова: розумний шолом, інфрачервоний давач, давач вібрації, давач мікроелектромеханічної системи, датчик температури, глобальна система мобільного зв'язку з рухомими об'єктами, глобальна система навігації та визначення положення.

(Received 25 August, 2023)

1. INTRODUCTION

Technology dominates education, product manufacturing, transportation, communication, and health. Transportation has always supported the economy and governance. Youth and the world love motorcycles. Motorcycle safety involves equipment, vehicle design, and operator ability. Motorcyclists are unique. They are the most dangerous road users without protection. Even the smallest mistake can kill. Speeding, drunk driving, and traffic offenses kill people. Helmetlessness caused brain damage and death. Helmets save 80% of head injuries and lives. IoT prevents traffic accidents [20], modelling motorcycles with sensors, communicating with riders and the environment, and requiring helmets. Road accidents kill 4 people each hour, 70% without helmets, according to a poll. Global statistics show safety rules and new technology are being created to prevent such incidents and ensure rider safety. We encourage 'Safety on Two Wheels' for safe travel [11].

This method aims to build a helmet that protects bikers and prevents drunk driving. If the rider crashes, it alerts the guardian via SMS. Drunk driving causes most accidents in today's fast-paced world. Uncivilized drivers are breaking helmet laws in most nations. Thus, this project aims to get people to wear helmets and ride bikes. The cyclist must not be intoxicated. Drunken riders cannot ride bikes. Another goal is to reduce accident fatalities by notifying passengers' relatives. Advanced features including alcohol detection, accident recognition, location tracking, and hands-free, solar-powered use accomplish this. Helmets are required for ignition.

The IoT is a network of interconnected computers, mechanical and electronic devices, furniture, living things, and people, all of which have individual IDs and are able to exchange data without the need for human interaction. The IoT makes it possible to integrate the physical world more directly into computer-based systems, improving efficiency, accuracy, and economic value while minimizing human involvement. Additionally, it enables the use of existing network infrastructure for remote sensing and control of objects.

IoT was made possible by wireless technologies, MEMS, micro-services, and the internet [21].

The remote monitoring equipment receives data from the working environment through Wi-Fi. Wi-Fi is the latest data transfer technology and spans a broader region. Things peak application collects, stores, and analyses sent data. Things peak is a new IoT app that analyses wireless sensor network data.

2. LITERATURE REVIEW

A. Jesudoos [1] suggested using mems with IR, vibration, and gas sensors. The helmets' gas sensor checks a person's breathe for alcohol consumption. MEMS controls car bars. PIC microcontrollers connect sensors. The gas sensor displays alcohol consumption on the LED display. Vibration sensors detect accidents and relay GPS data to hospitals. The MEME sensor deducts the rider's bank account balance for reckless driving. IR sensors detect helmet wear. This system automatically books ambulances from ten locations and is precise.

K. M. Mehata [2] proposed a method to protect workers or detect workplace falls. The proposed system is two-part. Sensor-equipped wearable devices are one. Cell phones are another component. GSM module connects them. These gadgets continuously monitor worker health and safety. The register person receives medical attention via this fall detection system.

N. Divyasudha [3] presented a system using an IOT modem to prevent accidents and monitor alcohol intake. IOT modems notify police and specified numbers of accidents. This helmet is cheaper than others are. Manish Uniyal [4] proposed a helmet-two-wheeler system. The TW microcontroller continuously checks helmet position. The TW vehicle also has accelerometers, Hall-effect sensors, and GPS modules. If there is an internet connection, sensors provide data to the microcontroller, which then sends it to the server. This technology lets anyone check the vehicle speed anytime. This system shows vehicle speed. Parents may see if their kids wear helmets.

Shoeb Ahmed Shabbeer [5] designed smart helmets to detect and report incidents. This approach uses microcontroller with accelerometer and GSM module. Cloud infrastructures report accidents. This system identified accidents 94.82% of the time and sent correct coordinates 96.72%. P. Rojaet [6] presented a system with six units: remover sensor, IR sensor, air quality sensor, Arduino UNO microcontroller, GPRS, GSM. If removed, this helmet alerts miners to harmful gases and sends information to the server. IOT transmits this info. C. J. Bheret [7] presented a smart mining helmet that detects dangerous gases, helmet removal, and collisions. They use IR, gas, and accelerometer sensors.

Sreenithy Chandran *et al.* [8] proposed a smart helmet called 'Konnect'. They detect and prevent accidents using integrated sensor networks, Wi-Fi-enabled processors, and cloud computing infrastructures. If a speed exceeds the threshold, this system texts the contact. Mohammed *et al.* [9] used Arduino UNO, Bluetooth module, push button, and 9 V battery. The Bluetooth-enabled smart helmet connects to cell phones and has an emergency button. D. Archana *et al.* [10] presented a sensor that detects human EAI to reduce accidents. Agung Rahmat Budiman [12] designed a multifunctional smart helmet. If a rider does not wear a helmet, comes in risky conditions, or does not lock his helmet, he is warned.

Sayan Tapadar [13] proposed an IOT module and sensor prototype that identifies rider alcohol consumption and accidents. Real-time simulation is used to train Support Vector Machines to anticipate whether sensor values indicate an accident. This method works well. ***High accuracy and precision***. Prashant Ahuja *et al.* presented a GSM/GPRS smart helmet [14]. Since ambulances can arrive late, this prototype alerts the concerned party first, so, they can take action. This system is accurate, cost-effective, and provides accident information in minutes.

Mingi Jeong *et al.* [15] suggested a system including thermal cameras, visible light cameras, drone cameras, oxygen sensors, inertia sensors, smartwatches, HMDs, and command centres to prevent accidents. This framework simplifies IOT service integration, management, and real-time notification. M. Kabilan *et al.* [17] suggested employing vibration sensors. If the rider's helmet vibrator sensor reaches the threshold, this technology detects and reports accidents, saving lives. Vivekananda Reddy *et al.* [18] designed a helmet-bike system. The helmet has IR, alcohol, and LCD sensors to detect intoxication. Vibration sensors in bikes detect accidents and relay data through GSM and GPS.

3. METHODOLOGY

This module has a transmitter circuitry and various sensors. Three sensors are included in a microcontroller: an alcohol sensor, a vibrate sensor, and a temperature, MEMS, and infrared sensor. Alcohol focus has been recognized using an alcohol sensor. The alcohol sensor will be located within the rider's helmet, near to his or her mouth. The crash location is determined via a vibration sensor. The pulse sensor and UV sensor are two sensors on another microcontroller. The measurement of pulse rate has been done using a pulse sensor. The pulse rate stimulates LED1, causing it to blink white light. To prevent collisions and manage accidents, UV sensors will detect the front moving vehicle.

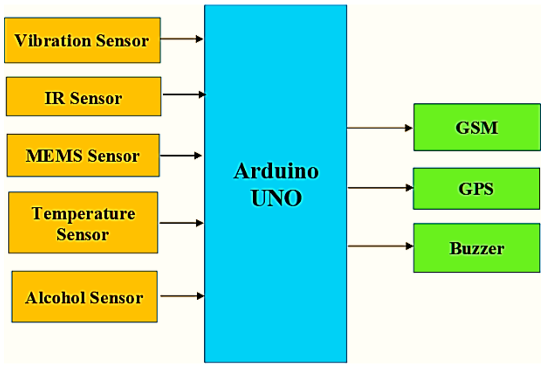

Fig. 1. Block diagram for proposed method.

Utilizing IoT technology to create a smart helmet that will ensure the riders' safety. The car will only start if the rider is wearing a helmet, which the system can detect. The bike engine will not start, if the rider has consumed too much alcohol. When a bike rider has an accident, the bike recognizes it and notifies the contacts that have been registered with a location. We are utilizing the most recent technologies for the bike rider's safety. IoT technology offers cutting-edge methods for warning the rider and ensuring that the rider complies with the law. Helmets are the most fundamental form of protection for two-wheeler riders and are required for all motorbike and bicycle riders. However, it does not guarantee the rider's safety, and the rider will not adhere to the traffic laws. The majority of individuals use regular helmets merely to avoid handing over a ticket to the traffic police; yet, these helmets do not protect the driver. Therefore, we must use the smart helmet to solve these issues. Figure 1 shows the proposed smart helmet.

3.1. Arduino

Microcontroller. A microcontroller is a single-chip computer with a CPU core, memory, and programmable input/output peripherals. A microcontroller has a CPU, memory, and controllable input/output pins—General Purpose Input Output Pins (GPIO). The Arduino Uno board, which is shown in Fig. 2, has a microcontroller and accessories to make building and debugging projects easier—ATmega328P-based microcontroller board Uno [16].

3.2. Temperature Sensor — LM35

The temperature sensors in the LM35 family are accurate integrat-

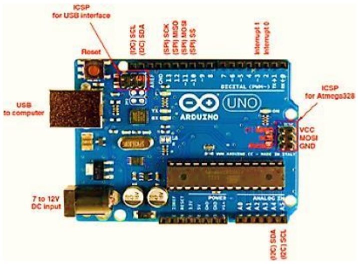

Fig. 2. Arduino UNO.

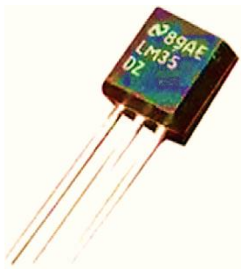

Fig. 3. Temperature sensor.

ed-circuit temperature sensors. These sensors' output voltage varies linearly with temperature in centigrade (Centigrade). Figure 3 depicts the temperature sensor.

3.3. MEMS Sensor

MEMS chips use capacitive sensors with a suspended mass between two plates (Fig. 4). Tilting the sensor creates an electrical potential differential from this hanging substance. The difference is measured *via* capacitance change. MEMS devices range from 20 micrometers to 0.02 to 1.0 mm.

MEMS is chip-based technology which is illustrates in Fig. 4. Sensors are suspended masses between capacitive plates. When the sensor tilts, the suspended mass changes electric potential. Capacitance changes measure the difference. MEMS may make compact integrated mechanical-electrical devices or systems. IC batch production procedures make them from a few micrometers to millimetres.

3.4. Vibration Sensor

The vibration sensors can pick up the vibration of the earth under-

Fig. 4. MEMS sensor.

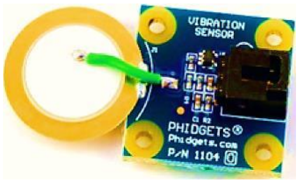

Fig. 5. Vibration sensor.

neath. It is crucial to establish the vibration level that will cause a vibration sensor to activate in the event of a debris flow before installing one. Additionally, it is crucial to consider the possibility of accidently activating the sensor due to earthquakes, as well as locations where there is construction traffic and other potential vibration sources. Figure 5 illustrates vibration sensor.

3.5. IR Sensor

Radiation-sensitive optoelectronic elements with spectral sensitivities ranging from 780 nm to 50 m are known as infrared sensors (IR sensors). IR sensors are being used more frequently in motion detectors that activate lights or alarm systems in buildings to detect unwanted visitors. IR sensors create and detect radiation. Active IR sensors have an LED and a receiver. The receiver detects infrared light from the LED reflected off an item as it approaches the sensor. Sensors detect humans privately. PIR sensors detect people. This only detects moving people. The Grid-EYE sensor overcomes the PIR sensor limitation by recognizing a stationary human. These sensors detect objects 100 cm to 500 cm (3–15 feet/1–5 meters). Their long range makes them superb sonar sensors. IR sensor is given in Fig. 6.

3.6. GPS Module

The GPS module L10 boosts the MTK positioning engines' industry-

Fig. 6. IR Sensor.

Fig. 7. GPS module.

leading performance. L10 supports 210 PRN channels. It can quickly acquire and track satellites at low indoor signal levels with 66 search channels and 22 concurrent tracking channels. This standalone receiver has several functions and flexible connectivity. Their easy integration speeds up consumer, industrial, and automotive applications. Figure 7 shows GPS module.

GNSS tracks GPS. GPS receivers use microwave signals from numerous satellites to locate, speed, time, and direction. Thus, a GPS tracking system provides historical and real-time navigational data for any journey. Receiver GPS signals. GPS receivers track location, velocity, and time. Four GPS satellites enable three-dimensional positioning. 27 GPS satellites orbit Earth. 24 functioning satellites and 3 backups orbit Earth every 12 hours, transmitting radio signals to the GPS receiver. Positioning System stations are widespread. These stations track GPS signals. Spacecraft send microwave signals. GPS receivers translate satellite signals into location, velocity, and time. Trilateration, a simple mathematical concept, powers the method. 2-D and 3-D trilateration exist. Simple math requires two things for the GPS receiver. It must first realize at least three satellites can pinpoint the spot. It also needs their distances.

GPS-equipped spacecraft. Radio waves travel at light speed. GPS tracking is multifaceted. Businesses track cars via GPS. A modem in the GPS system unit periodically sends data to a central database or stores it in the GPS tracking system (passive tracking). Passive GPS tracking devices track events. This GPS system can log 12 hours of travel. This GPS tracking technology stores data on a memory card or internal memory for computer processing.

3.7. GSM Modem

Digital cellular communication is standardized by GSM. GSM was founded in 1982 to produce specifications for a pan-European 900 MHz mobile cellular radio system.
GSM standardizes. GSM suggests, not commands. GSM specifications provide functionality and interface, but not hardware. The idea is to limit designers as little as possible while letting operators buy equipment from multiple suppliers.

GSM modems use GSM network, which is given in Fig. 8. Wireless modems work like dial-up modems. Wireless modems use radio waves to deliver and receive data, while dial-up modems use a telephone connection. GSM modems can be external or PC Card/PCMCIA Cards. External GSM modems are connected to computers using serial or USB cables. Laptops can use PC Card or PCMCIA GSM modems. It goes in the laptops' PC Card or PCMCIA Card slot. GSM modems, like GSM phones, need SIM cards from wireless carriers.

3.8. Alcohol Sensor

The MQ3 alcohol sensor detects airborne ethanol. An alcohol sensor monitors the amount of ethanol in an intoxicated person's breath and produces information. Higher alcohol percentages lit more LEDs (500 to 905). Thus, values above 650 indicate alcohol vapour, which degrades the sensor value slowly. MQ3 alcohol sensor is

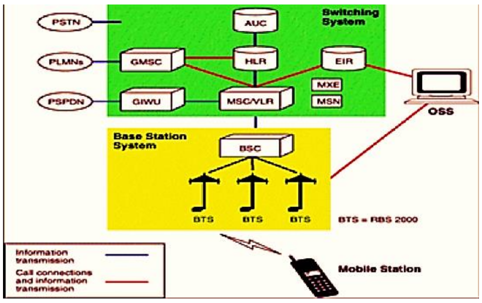

Fig. 8. GSM network elements.

Fig. 9. MQ-3 alcohol sensor.

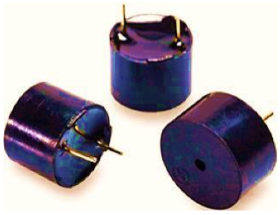

Fig. 10. Buzzer.

shown in Fig. 9.

The alcohol detector project can be installed in many cars to detect intoxication. Breathing analysers can also be used in enterprises to track employee alcohol use. An alcohol sensor infrared cell detects unabsorbed energy on the other side by passing energy through the sample. Like sunglasses, alcohol absorbs infrared light at higher ethanol concentrations.

3.9. Buzzer

Electronic buzzers or beepers are used in autos, microwaves, and game shows in Fig. 10. An electromechanical device resembling an electric bell without the metal gong that produces the ringing sound served as the foundation for the original design. Major industries use piezo buzzers to identify or alert. It can meet the most challenging audio alarm applications.

3.10. Arduino IDE

Arduino IDE is generally used to write and compile code for Arduino Modules. Code compilation is so easy with official Arduino software that even a beginner can learn. Uno, Mega, Leonardo, Micro, and others are Arduino modules. Each has a code-reading microcontroller on its board.

4. RESULTS AND DISCUSSION

The Internet of Things-based, intelligent helmet-based two-wheeler safety solution is very dependable and secure. The main objective of this system is to prevent injuries when a person wearing this helmet is engaged in an accident. It stops drunk driving from happening. The results are able to pinpoint the accident, and they send a 90% accurate location notification to the registered contacts so they are aware of the person's condition and can offer the necessary medical attention. The findings of a helmet tilt are compared to the threshold value and helmet fall value to determine whether an accident has occurred. The technology detected alcohol in the rider's breath, according to the results; if the rider is too drunk, the bike will not start. The whole operation of this system will be dictated by rider activity.

Figure 11 illustrates the simulation model. Figure 12 shows the proposed smart helmet. Figure 13 depicts the notification message from the smart helmet.

All of the parts have been put together and successfully tested.

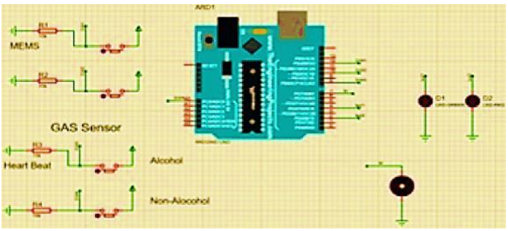

Fig. 11. Modelling and simulation.

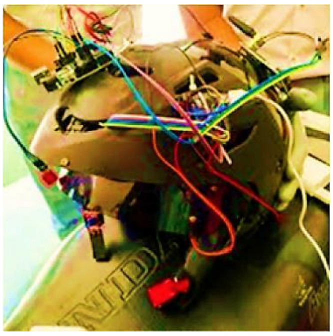

Fig. 12. Proposed smart helmet.

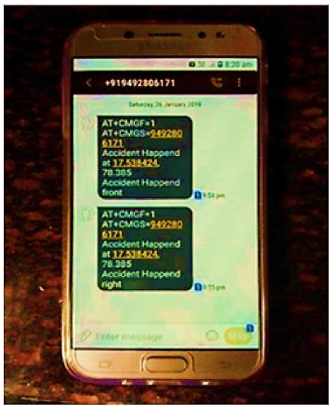

Fig. 13. Notification message.

The course is set up so that the bike will not start unless the rider is wearing a helmet. Additionally, if the rider is intoxicated, the bike will not start, and this helmet buzzes an alarm to warn the rider if he exceeds a set speed limit. The engine will immediately turn off in the event of an accident to prevent further injuries. Prototype Helmet Unit The experimentation stage was so over. This investigation was carried out in a planned manner. Therefore, there is no urgent need for additional real-world experimentation; however, more simulations must be run before full-time deployment. Future systems that use a sensor to alert family members and neighbouring law enforcement to an emergency situation can use GPS and GSM modules. This can be done by programming GSM and GPS modules to communicate the precise GPS locations of the accident to the relevant authorities, alerting them to the serious situation and urging them to take prompt action that might save lives. All the features were properly integrated when the project was successfully finished.

5. CONCLUSION

Smart helmet promotes motorcycle safety and awareness. Road safety is enhanced by the smart helmets' blind spot awareness. The smart helmet improves driver safety. The smart helmet team spent a lot of time studying and building a proximity measurement and subsystem communication system. Money limited the project. Unfortunately, cheaper proximity sensors lacked the wide-angle reading needed to meet specifications. It must develop an accurate proximity measurement algorithm to combine several proximity sensor data into a single measurement. It developed important engineering, communication, and teamwork skills. Smart Helmet will meet milestones. It can include GPS, a live stream, and brightness dimmer if they can build a working model ahead of deadline.

In future self-driving motorcycles can keep riders' safe to record the motorist with a tiny camera. Wireless transmitters allow vehicles to communicate. The helmets' bioelectric sensors can measure the rider's activity to use voice commands for bike basics. The rider can now park the two-wheeler with the helmet on without extra security to charge phones and electric cars with two-wheeler solar power.

REFERENCES

1. Li Li, Jikuang Yang, Dietmar Otte, Zhou Xuenong, Zhang Chao, Yu Xiaoping, and Li Weiqiang, *2013 Fifth Conference on Measuring Technology and Mechatronics Automation (ICMTMA 2013) (January 16–17, 2013, Hong Kong)* (Institute of Electrical and Electronics Engineers (IEEE): 2013), p. 110; https://www.proceedings.com/content/017/017826webtoc.pdf
2. Suwarna Gothane and M. V. Sarode, *2016 IEEE 6th International Conference on Advanced Computing (IACC 2016) (February 27–28, 2016, Bhimavaram, India)* (Institute of Electrical and Electronics Engineers (IEEE): 2016), p. 15; https://www.proceedings.com/content/030/030992webtoc.pdf
3. J. Zarif, '*16 Deaths Every Hour: Indian Roads Claim the Maximum Number of Lives in 2014*' (2020) [Online]; http://timesofindia.indiatimes.com/india/16-deaths-every-hourIndianroads-claim-the-maximum-number-of-lives-in 2014/articleshow/48128946.cms
4. Sayan Tapadar, Shinjini Ray, Himadri Nath Saha, Arnab Kumar Saha, and Robin Karlose, *IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC 2018) (January 8–10, 2018, Las Vegas, USA)* (Institute of Electrical and Electronics Engineers (IEEE): 2018), p. 584–590; doi:10.1109/CCWC.2018.8301639
5. N. Divyasudha, P. Arulmozhivarman, and E. R. Rajkumar, *2019 1st International Conference on Innovations in Information and Communication Technology (ICIICT 2019) (April 25–26, 2019, Chennai, India)* (Institute of Electrical and Electronics Engineers (IEEE): 2019), p. 146; https://www.proceedings.com/content/049/049318webtoc.pdf
6. Rashida Nazir, Ayesha Tariq, Sadia Murawwat, and Sajjad Rabbani, *Int. J. Communications, Network and System Sciences*, **7**, No. 8: 286 (2014); http://dx.doi.org/10.4236/ijcns.2014.78031
7. Dinesh Kumar HSDK, Shreya Gupta, Sumeet Kumar, and Sonali Srivastava, *Journal of Emerging Technologies and Innovative Research (JETIR)*, **2**, No. 5: 1433 (2015); https://www.jetir.org/download1.php?file=JETIR1505018.pdf
8. Namrata H. Sane, Damini S. Patil, Snehal D. Thakare, and Aditi V. Rokade, *International Journal on Recent and Innovation Trends in Computing and Communication*, **4**, Iss. 4: 479 (2016); https://ijritcc.org/download/conferences/ICMTEST_2016/ICMTEST_2016_Track/1462861671_10-05-2016.pdf

9. Chander Prabha, R. Sunitha, and R. Anitha, *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, **3**, Iss. 7: 2320 (2014); doi:10.15662/ijareeie.2014.0307062
10. N. Manjesh and Sudarshan Raj, *International Journal of Electrical and Electronics Research*, **2**, Iss. 4: 122 (2014); https://www.researchpublish.com/upload/book/Smart%20Helmet%20Using%20GSM-799.pdf
11. Jennifer William, Kaustubh Padwal, Nexon Samuel, Akshay Bawkar, and Smita Rukhande, *International Journal of Scientific and Engineering Research*, **2**, Iss. 3: 591 (2016); https://www.ijser.org/researchpaper/Intelligent-Helmet.pdf
12. Hasan Mehdi Naqvi and Geetam Tiwari, *International Journal of Injury Control and Safety Promotion*, **25**, No. 3: 319 (2018); https://doi.org/10.1080/17457300.2018.1431937
13. Khaled Shaaban and Anurag Pande, *Journal of Traffic and Transportation Engineering*, **5**, No. 1: 66 (2018); https://doi.org/10.1016/j.jtte.2017.04.005
14. Romuere Rodrigues Veloso e Silva, Kelson Rфmulo Teixeira Aires, and Rodrigo de Melo Souza Veras, *27th SIBGRAPI Conference on Graphics Patterns and Images (August 26–30, 2014, Rio de Janeiro, Brazil)*, p. 141–148; doi:10.1109/SIBGRAPI.2014.28
15. Sayan Tapadar, Shinjini Ray, Himadri Nath Saha, Arnab Kumar Saha, and Robin Karlose, *2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC) (January 8–10, 2018, Las Vegas, USA)*, p. 584–590; doi:10.1109/CCWC.2018.8301639
16. Sreenithy Chandran, Sneha Chandrasekar, and N. Edna Elizabeth, *2016 IEEE Annual India Conference (INDICON) (December 16–18, 2016, Bangalore, India)*; doi:10.1109/INDICON.2016.7839052
17. Jie Li, Huanming Liu, Tianzheng Wang, Min Jiang, Shuai Wang, Kang Li, and Xiaoguang Zhao, *2017 Ninth International Conference on Advanced Computational Intelligence (ICACI) (February 4–6, 2017, Doha, Qatar)*, p. 201–205; doi:10.1109/ICACI.2017.7974509
18. R. Rathinakumar and D. Manivannan, *Research Journal of Applied Sciences, Engineering and Technology*, **4**, No. 18: 3323 (2012); https://maxwellsci.com/print/rjaset/v4-3323-3326.pdf
19. Mohd Khairul Afiq Mohd Rasli, Nina Korlina Madzhi, and Juliana Johari, *2013 International Conference on Electrical, Electronics and System Engineering (ICEESE) (December 4–5, 2013, Kuala Lumpur, Malaysia)*, p. 21–26; doi:10.1109/ICEESE.2013.6895036
20. N. Manjesh and Sudarshan Raj, *International Journal of Electrical and Electronics Research*, **2**, Iss. 4: 122 (2014); https://doi.org/10.17577/IJERTV4IS041398
21. J. Vijay, B. Saritha, B. Priyadharshini, S. Deepeka, and R. Laxmi, *International Journal of Scientific & Engineering Research*, **2**, Iss. 12: 1 (2011).