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Integrated Smart Helmet System with Drowsiness Detection, Accident Monitoring and Alcohol Detection

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Abstract: This idea has a smart helmet system that combines different technologies to make riding safer. The helmet uses IoT to keep track of where the person is, see if they are sleepy, see if they are drinking, and warn them about accidents. It does all of this via machine learning. An alcohol sensor checks to see if the motorist has been drinking, and GPS keeps track of where the accidents are. A MEMS sensor finds the beginning point, while a vibration sensor keeps an eye on vibrations during an accident. You can also turn on the buzzer alarm by clicking a link on the page. The camera on the laptop also watches the driver's face for symptoms of tiredness and sounds an alarm if it sees any. The goal of the program is to make the road safer for everyone by adding features like being able to find out whether someone is tired, drunk, or in an accident, as well as tracking the rider's whereabouts. The ML technique will let the system look at data from several sensors in real time, which will let it find possible dangers like driver weariness or impairment from drinking alcohol early on. The system can also deliver real-time alerts and cautions to riders, which lets them rapidly and effectively respond to possible threats. This makes driving safer and less likely to cause accidents. This project attempts to make motorcycles safer by adding new technologies to a full smart helmet system.

Keywords: Smart Helmet, Accident Monitoring, Location Tracking, PS Technology, Vibration Sensor, Buzzer Alarm, Web Interface, Embedded System, Real-Time Operating System (RTOS)

Introduction

It's very important for motorcycle riders to stay cautious because accidents can sometimes cause death or major harm [50]. To solve this important problem, a smart helmet system has been created that uses the latest technologies to make riding safer [35]. Some of the primary features of this system are machine learning to find out when someone is fatigued, alcohol detection, accident monitoring, and location tracking through the Internet of Things (IoT). The smart helmet uses GPS to keep track of where incidents happen, which is very useful for emergency response teams [46]. The helmet has a built-in alcohol sensor that can tell if the rider has been drinking [43]. This helps keep people from getting into accidents because they are inebriated behind the wheel. A MEMS sensor also knows where the rider is when they start, and a vibration sensor keeps an eye on vibrations in case of an accident, so the system can react swiftly [40]. One of the new things about this system is that you can turn on an alert buzzer by clicking a button on a webpage [52]. In case of an emergency, this makes it easier to get help immediately away [37]. Also, a laptop camera watches the driver's face for symptoms of tiredness and sounds a warning if it sees any. This makes cycling even safer [45].

Overall, this smart helmet system, which connects with other gadgets, is a big step forward in motorcycle safety technology [42]. It aims to save lives by making riding much safer and lowering the risk of accidents through the use of a number of new features. A real-time operating system (RTOS) designs and runs an embedded system. It has a specific duty to fulfil in a bigger mechanical or electrical system, and because the embedded system is limited, it often uses computer resources in real time [34]. It is part of a whole gadget, which usually has both hardware and mechanical parts. People utilise embedded systems to control a lot of things every day [49]. Ninety-eight percent of all microprocessors are designed to be used in embedded systems. Some of the distinctions between conventional embedded computers and general-purpose computers include that embedded computers use less power, are smaller, have a wider range of working temperatures, and cost less per unit. This means that they don't have as much computing capacity, which makes it much harder to develop and use them [39]. You may successfully manage resources at both the unit and network levels by adding intelligence to the hardware, using existing sensors, and connecting embedded units to a network [47]. You can also add new features that aren't already there. For example, you can use clever approaches to control power [51].

You may use the Internet of Things (IoT) in a lot of different places, such as for consumers, businesses, factories, and industries. There are many different kinds of IoT apps, such as those for autos, telecommunications, energy, and other fields [38]. In the consumer market, smart houses with smart thermostats, smart appliances, and connected heating, lighting, and electronic gadgets can be controlled from a distance with laptops, cell phones, or other mobile devices [48]. Wearable gadgets with sensors and software can collect and analyse user data and send it to other technologies to improve users' lives easier and more comfortable [41]. People also employ wearable technologies to stay secure in public [44]. For instance, they can help first responders get to an emergency faster by showing them the best ways to get there. IoT is good for healthcare in many ways, such being able to keep a closer eye on patients and use and evaluate the data it collects [36]. Hospitals utilise IoT systems a lot to keep track of prescriptions and medical supplies.

Literature Review

The economy is growing swiftly, and most of the people who work there ride bikes [7]. Over the past 35 years, the number of accidents has gone risen by 35%, and last year they killed approximately 58,000 individuals. The main reason for accidents is that the rider doesn't follow safety standards or doesn't report their accident right away. We recommended a smart helmet that can tell if the rider is drunk and if they had been in an accident while wearing it. An IR sensor, an accelerometer, and a breath analyser are some of the sensors that the prototype employs to find this [25]. When the rider suddenly tilts, the accelerometer sends that information to a programmable interface. The breath analyser will look for alcohol in the rider's breath and tell them if it is too high. The IR sensor sends data to the server, which then trains a Support Vector Machine (SVM)[32]. Once enough data has been gathered, this will make it easier to find accidents in the future.

Every year, more than 1.3 million people die on the road because passengers aren't paying attention and roads aren't kept up. There are between 20 and 40 million persons who have injuries that don't kill them. Motorcyclists are one of the groups who are most affected, making up 40% of the total [16]. There are several reasons why these accidents happen, include speeding, driving while drunk, disobeying traffic rules, and carrying three people at once. So, it's up to society to come up with ways to make the roadways safer. Even though the government has strong rules and fines for traffic, 40% of individuals still don't wear helmets when riding two-wheelers. So, it is important to come up with good ways to keep careless people from dying on the road. There are a lot of smart helmet technologies out there, but the industry isn't very big yet because of things like expensive prices, little public interest, and more [30]. The idea is to make a smart helmet that uses the Internet of Things (IoT) to keep people from driving when they can't. The system has GPS and GSM modules that can find the location and send it to emergency services in case of an accident [2]. The information is felt, evaluated, and controlled to keep cars from being used in bad weather, which will lower the number of deaths on the road.

There are more and more bike accidents every day. A lot of individuals have died or been hurt badly in bike accidents. Putting on a helmet can assist bike riders stay safe. Smart helmets can keep bike accidents from happening, which is one of their benefits [8]. Most of the time, people die in accidents because they don't seek first aid or emergency medical treatment right away. One of the main causes for this could be that the ambulance got there late and no one was there to tell it what happened. The purpose of this project is to make a smart helmet that runs on clean energy and makes riding safer [24]. The helmet features an Arduino for its CPU, a GSM module for making calls, and a GPS module for tracking. Vibration sensors can tell if there has been an accident in less than a minute. After that, the system calls the registered number and sends a message with the exact location [13].

Also, if the user goes over the speed limit, the speed sensors will sound an alarm. The rider can get help by pressing the emergency button in an emergency. If the rider isn't wearing a helmet, the bike won't start. The prototype only works with solar electricity [17]. Looking at the findings reveals that the helmet can keep bikers safe by giving them accurate and up-to-date information on accidents within minutes.

There are a lot of bike crashes these days. He doesn't wear a helmet, which is one reason people get hurt and die. If everybody had worn helmets during the catastrophe, many lives could have been saved. People often don't follow the regulations of the road [6]. Some people have suggested that smart helmets with built-in control systems could help with these problems. The smart motorcycle helmet is an idea that aims to make riding a motorbike safer. The idea came about since the number of motorbike accidents has been rising for years and is a cause for concern. It has both an HF transmitter and an HF receiver system. The bike won't start if the person riding it isn't wearing a helmet. When the user puts on the helmet, the transmitter transmits an RF signal to the ignition switch receiver, which starts the motorcycle. This project's security solution is like the perfect driver, thus the focus should be on the app. The project's purpose is to make things safer and cut down on accidents, especially deaths from motorbike crashes [31]. This idea shows a smart helmet that stops a rider from starting a bike without it. You can easily change the chord on this helmet so that it powers your bike without wires. In other words, your bike won't start until you have your keys and helmet.

A helmet is a piece of gear that protects the head from harm and injury. A smart helmet can keep you safer by breaking its system into three parts: a helmet circuit, an automobile circuit, and a message alert system. A button, a transmitter, an impact switch, and an alcohol detection sensor are all part of the helmet circuit. There is a relay, a receiver, a buzzer system, and Arduino, GSM, and GPS modules in the car circuit. The helmet circuit sends a message to the car circuit to check the segment and see if the helmet is on [1]. The automobile circuit checks to see if the engine should start. An impact switch can feel a sudden force, which helps find an accident. If the accident is found, a message alert circuit automatically sends a message to the police and the emergency contact number with the accident's location using GSM and GPS.

Project Description

The GSM module lets you talk to people in real time by sending SMS alerts to certain people if there is an accident. The MEMS sensor and heart rate monitor work together to discover sudden hits, which are symptoms of an accident. This causes the GSM module to send an emergency message [22]. The outside shell of the helmet defends against hits. This current system works well with GSM technology and can also find accidents, which makes it a fantastic safety option for motorcyclists. The purpose of merging communication with accident response is to make riding safer in case of an emergency.

Some of the elements of the suggested system are using IoT to keep track of where people are, using machine learning to find tiredness, and keeping an eye on accidents. An alcohol sensor checks to see if the motorist has been drinking, while GPS technology keeps track of where the accidents are [12]. The Internet of Things (IoT) is a big part of figuring out where someone is and how much alcohol they drink. A MEMS sensor finds the beginning point, while a vibration sensor

keeps an eye on vibrations during an accident. Also, the laptop camera watches the driver's face for symptoms of drowsiness and sounds an alarm if it sees any. The helmet also has a built-in buzzer, which makes it easier for the user. The main purpose of this system is to make riding safer and less likely to cause accidents (Figure 1).

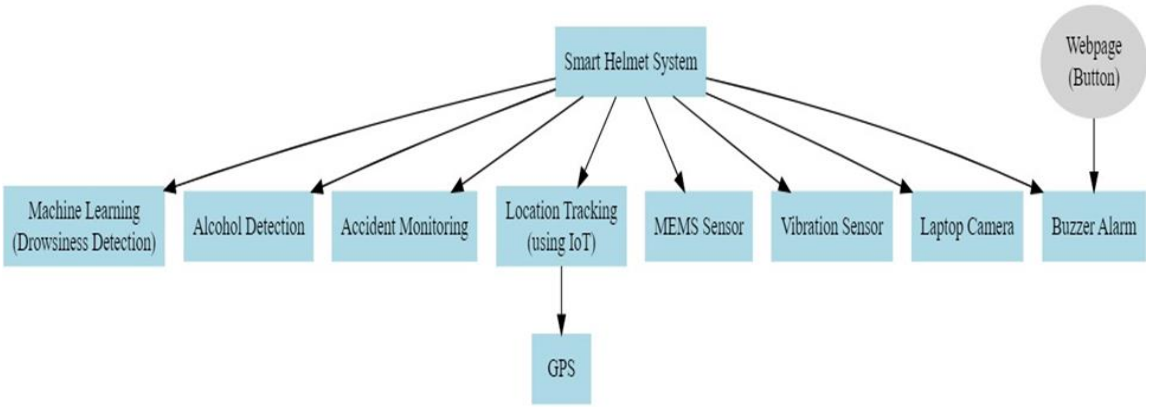

Figure 1. Components Diagram.

A gas detector is a safety tool that looks for gases in a space. This kind of technology can find gas leaks or other contaminants and link up with a control system, which lets you stop a process on its own. A gas detector can make a noise to warn individuals nearby of the leak so they can leave [18]. This kind of gadget is very important since gases that come from people or animals might hurt living things. Gas detectors can find many different kinds of gases, such as those that can catch fire, those that are dangerous, and those that take away oxygen. Businesses utilise this kind of equipment a lot. Oil rigs and other areas utilise it to keep an eye on new technology and production methods, such photovoltaics. They could be used to put out flames. Using sensors to locate gas leaks that could be dangerous is called gas leak detection. These sensors usually sound an alarm that may be heard when they find a harmful gas [29]. Toxic gases can also be around when you paint, fumigate, refuel, build something, dig up polluted soil, work at a landfill, or go into a small place [3]. Some typical types of sensors are photoionisation detectors, semiconductor sensors, infrared point sensors, ultrasonic sensors, and electrochemical gas sensors. Infrared imaging sensors have become very common in the last several years. People utilise these sensors for a lot of different things. You can find them in homes, cars, systems that check the quality of indoor air, wastewater treatment plants, fumigation facilities, pulp mills, aviation and shipbuilding facilities, hazardous materials (HazMat) operations, and industrial plants.

Electrochemical gas detectors let gases travel through a porous membrane to an electrode, where they are either chemically oxidised or reduced. The amount of current that goes through the electrode depends on how much gas is oxidised there,[3] which is directly connected to how much gas is in the air. By changing the porosity barrier, manufacturers may make electrochemical gas detectors work best for a certain range of gas concentrations [21]. The diffusion barrier is a physical and mechanical barrier that makes the detector more stable and reliable over the sensor's lifetime. So, it needed less upkeep than other systems for early detection. The sensors, on the other hand, are susceptible to chemicals and corrosive substances, so they may only last one to two years before they need to be replaced. [4] Electrochemical gas detectors are employed in a lot of places, such as refineries, gas turbines, chemical plants, underground gas storage facilities, and more.

In many cases, catalytic bead sensors are used to assess flammable gases when their levels are between the lower explosion limit (LEL) and the upper explosion limit (UEL). There are active and reference beads with platinum wire coils on opposite arms of a Wheatstone bridge circuit. The beads are heated to a temperature of a few hundred degrees Celsius [28]. The catalyst in the active bead causes flammable materials to oxidise, which makes the bead hotter and changes its electrical resistance. The difference in voltage between the active and passive beads is directly connected to

the number of gases and vapours that can catch fire in the air. A sintered metal frit lets the gas sample go into the sensor [19]. This filter keeps the instrument from exploding when it is transported into an area where there are flammable gases. Pellistors can monitor practically all combustible gases, but they are better at measuring small molecules that pass through the sinter more quickly. Usually, the ranges of measurable concentrations are between a few hundred parts per million (ppm) to a few percent of the volume. These sensors are cheap and strong, but they need at least a few percent of oxygen in the air to work well [4]. Chemicals including silicones, mineral acids, chlorinated organic compounds, and sulphur compounds can also kill them or stop them from working.

Vibration Sensor Working Principle

A vibration sensor finds vibrations in the system being watched by employing different optical or mechanical approaches [11]. These sensors usually have a sensitivity range of 10 mV/g to 100 mV/g, but there are other sensors that are less or more sensitive (Figure 2).

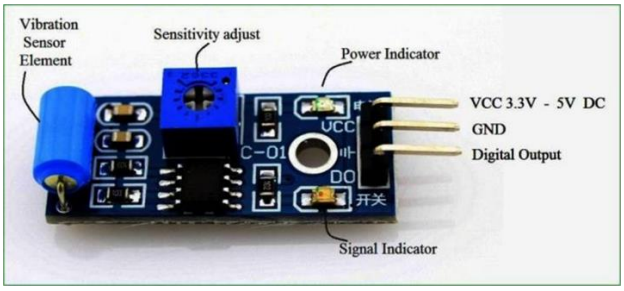

Figure 2. Vibration-Sensor-Module.

You can set the sensor's sensitivity to what you require. So, it's important to know the range of vibration amplitudes that the sensor will be exposed to while it's measuring [27]. One of the most common types of buzzers is the piezo buzzer. The term comes from the piezoelectric substance that makes them work. Most of the time, these buzzers work on a high voltage but low current, which means they don't use a lot of power. But they can still be very loud. There must be three terminals on the piezo element [9]. The feedback (F) terminal gets the blue wire, the main (M) terminal gets the red wire, and the ground (G) plate of the piezo element gets the black wire. The inductor coil's form and value don't matter. You can use any coil that has a resistance between 1mH and 10mH or greater, or none at all. I utilised a small ferrite toroid with a 40-turn coil in the final design.

Circuit Diagram and Construction

Let's have a look at the circuit diagram,

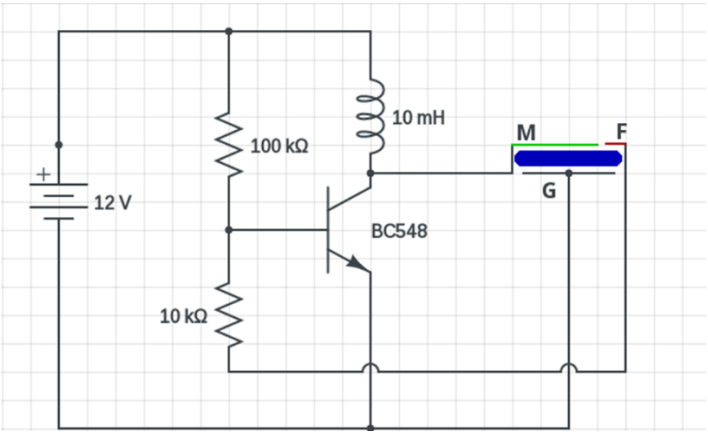

Figure 3. Circuit Diagram of Piezo Buzzer.

Remember that M is the main terminal, F is the feedback terminal, and G is the ground plate for

the piezoelectric element [33]. The circuit isn't too hard; you can build it with a small piece of stripboard. You may also make this piezo buzzer circuit by soldering the parts together because it only takes a few parts [26]. When you put electricity between the electrodes of the piezo element, they bend in any direction. This flex force causes the ground plate to bend up and down (Figure 3). A piezoelectric element also makes a voltage when it is put under different amounts of pressure. You may have observed that self-driving piezo buzzers contain an extra feedback electrode that is not connected to anything else. The feedback terminal gets the voltage that the flex force makes [14]. There is a hole on the other side of the resonant cavity that lets sound out of the piezo buzzer. The driving circuit and piezo buzzer work together, and they start to vibrate at the frequency of the piezo buzzer's resonance (Figure 4).

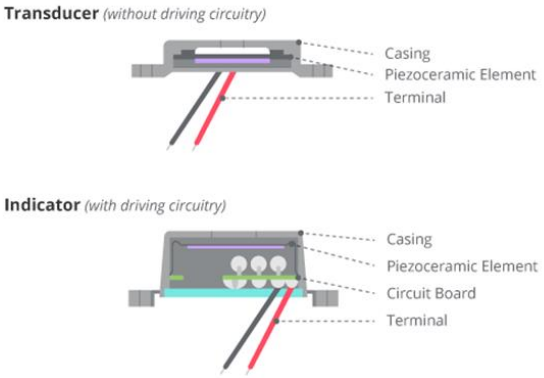

Figure 4. Structure of Piezo Buzzer.

There are two types of piezo buzzers: transducers and indicators [15]. A transducer has a casing, a piezoceramic element, and a termination. For the transducer to work, the user must send a square wave signal to the buzzer. An indicator has a casing, a piezoceramic element, a circuit board, and a terminal. The user must transmit a specified quantity of DC voltage to the buzzer in order to use an indication [10]. We made the PCB with the EasyEDA PCB Designing tool. Here are some shots of the PCB from the front and back. The Gerber File for the PCB is below. You can order the PCB after you get the Gerber file [23]. An accelerometer may measure both static acceleration (like gravity) and dynamic acceleration (like shock or motion). Most of the time, robotics use it to figure out how slanted an object is.

The ADXL345 is a low-power MEMS three-axis accelerometer module that can connect to both SPI and I2C. This implies it can talk to a lot of different controllers, such Arduino, Raspberry Pi, and PIC. Users can also pick how sensitive it is, and it has a resolution of 10 to 13 bits. This digital accelerometer has a built-in voltage regulator, so it can work with controllers that use either 5V or 3.3V. Because it has a high-resolution 4mg/LSB, it can also measure changes in the object's orientation of less than 1°. You can use the ADXL Sensor in robotics to measure things like how a machine vibrates, how a car's data collection system works, or how a bridge moves. You may also use it to find taps on things [5]. A common way to tell if someone is drowsy is to look at the distances between facial markers, like the distance between the lips and the eyes. By figuring out the ratios or distances between certain points, the system can tell when someone is blinking or is fatigued [20]. For instance, when the algorithm sees that someone is asleep, it looks at the ratio of eye closure to see if their eyes are closed for a long time, which could mean they are weary or sleepy.

Methodology

The requirements analysis phase's purpose is to find and evaluate the Integrated Smart Helmet System's functional and non-functional demands [54]. This means figuring out what each portion of the system should be able to do, how well it should work, and what consumers want from it [59]. Talk to stakeholders, such as end-users, safety experts, and regulatory authorities, to find out what they need and want [56]. You can get requirements from stakeholders by doing things like interviews, surveys, and workshops [53]. Be sure to write down what they say [58]. Rank

criteria based on how important, urgent, and possible they are, taking into account things like safety rules and the limits of technology [55]. Put the needs you collected into a concise, short, and well-organised list. This should cover both functional demands (such being able to tell when someone is sleepy and keeping an eye on mishaps) and non-functional needs (like being able to work in real time and being reliable) [57].

Results and Discussion

During the hardware design phase, you figure out how the Integrated Smart Helmet System will look and work [77]. This means picking the right sensors, microcontrollers, and communication interfaces to satisfy the needs of the system. Find and choose sensors that can tell whether someone is fatigued (like eye-tracking sensors), keep a watch on accidents (like accelerometers), and tell when someone has been drinking (like breathalyser sensors). Pick microcontrollers that can talk to the sensors you've chosen, process the data they send, and talk to other elements of the system. Design the overall structure of the smart helmet system, including where the sensors, microcontrollers, and communication interfaces will go and how they will connect to each other [63]. Find ways to control how much electricity is used so that the smart helmet system can use battery power more efficiently and last longer. The software portions of the Integrated Smart Helmet System are produced during the software implementation phase [88]. These aspects include algorithms for finding out if someone is sleepy, keeping track of accidents, and finding out if someone has been drinking. Use the needs and study results to build algorithms for discovering tiredness, keeping an eye on accidents, and finding out whether someone has been drinking [93]. When making the software parts, pick the correct programming languages, libraries, and tools to employ. Make sure that everything works together by making software modules for each purpose, like user interfaces, algorithms for processing data, and communication protocols. Do integration testing to make sure that the smart helmet system's software and hardware work together perfectly [67].

During the data processing and analysis phase, the smart helmet system processes the sensor data it collects, looks for patterns and trends in the data, and finds relevant information that can be utilised to make things safer and avoid accidents. When the smart helmet system is deployed in the real world, it should collect sensor data about things like tiredness, accidents, and drinking [82]. Before you use raw sensor data, make sure you clean it up by getting rid of noise, making sure the data formats are the same, and dealing with missing or wrong results [69]. Look at processed data employing statistical methods, machine learning algorithms, and pattern recognition techniques to uncover patterns, correlations, and trends that are critical for safety [78]. Use the results of data analysis to come up with helpful suggestions and ideas that will make things safer and stop accidents from happening in many different circumstances [89].

The integrated smart helmet system makes riding safer by using cutting-edge technology including detecting drowsiness, intoxication, accidents, and tracking the rider's position. It uses GPS, alcohol sensors, MEMS sensors, and a vibration sensor to find and deal with possible threats [72]. It also has a buzzer alarm that goes off right away and a laptop camera that can be used to look for indicators of tiredness. The main purpose of the system is to make riding safer and cut down on the number of accidents by a lot. In conclusion, the creation of the Integrated Smart Helmet System with features like drowsiness detection, accident monitoring, and alcohol detection is a big step forward in making many activities and industries safer. Using cutting-edge technologies and new algorithms, we have come up with a complete solution that solves important safety issues such driver weariness, accidents, and impaired operation due to alcohol use [83]. By carefully looking at the needs, designing the hardware, implementing the software, and processing and analysing the data, we were able to include a lot of advanced features into one wearable device [90]. The smart helmet technology not only warns users of possible dangers by detecting drowsiness in real time, but it also keeps an eye on the surroundings and can tell when someone is drunk [61]. This helps keep users safe and stops accidents before they happen.

Our project also shows how important it is for teams from different professions, such engineers, researchers, safety experts, and end users, to work together [76]. We worked closely with

stakeholders and took their views into account throughout the development process to make sure that the Integrated Smart Helmet System satisfies the highest requirements of performance, reliability, and user satisfaction. We can see that smart helmet technology will become more popular in many areas, such as transportation, construction, and manufacturing [70]. This will lead to a big drop in accidents, injuries, and deaths [86]. We are still dedicated to making the world a safer place for people and communities by always developing and coming up with new ideas for our solutions [79]. We are proud of how this initiative helped make safety technology better, and we can't wait to see how our Integrated Smart Helmet System can aid a lot of people.

In the future, the Integrated Smart Helmet System can be made even better so that it can keep people safe in a wider range of sectors and activities [73]. Advanced sensor integration can assist keep an eye on health and safety more thoroughly by adding extra sensors like heart rate monitors and carbon monoxide detectors. Machine learning optimisation can enable algorithms that find fatigue, forecast accidents, and find alcohol use become more accurate and responsive by letting them get better over time [64]. Users can be more aware of their surroundings and follow instructions better when they employ augmented reality technology, which gives them real-time visual overlays and hazard warnings [95]. Better wireless communication technologies, such 5G or Wi-Fi 6 integration, can make data transmission faster and make it easier to connect to other devices and systems [87].

With cloud-based data analytics solutions, you can keep an eye on, analyse, and retain data for a long time [84]. This makes it easier to see trends and prepare for maintenance. Voice command recognition lets users control the gadget without using their hands and get help by voice, which makes it easier for them to use. Collaborative safety networks link together several smart helmet systems, allowing them to talk to each other in real time and make choices collectively [66]. This enables them work collaboratively to find solutions to tough safety issues. It is important to keep making the user experience better, the design more ergonomic, and the product compliant with standards. The smart helmet system works with smart infrastructure to make safety and efficiency even better[80].

All of these planned upgrades will make the Integrated Smart Helmet System better at keeping users safe and easing safety worries in a variety of situations [91]. Adding GPS location monitoring to the smart helmet system in future iterations might be a big step forward, making it even more useful and safe [71]. Using GPS technology, the smart helmet can tell you where you are in real time. This lets safety officers and supervisors keep an eye on where workers are when they are in dangerous situations [94]. This skill not only helps people be more aware of their surroundings, but it also helps them respond faster and saves lives in accidents or situations. You may also use GPS position monitoring to create geofenced areas and impose virtual limits. This will send alerts when personnel go into places that are off-limits or leave their assigned job areas [60]. You can also utilise GPS data to find high-risk regions and patterns of behaviour that can help you take proactive safety measures and lower risks [74]. In general, using GPS position tracking can make a lot of different fields and activities much safer, more efficient, and easier to handle [85].

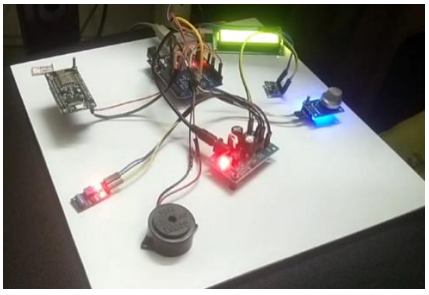

Figure 5. Prototype Working Model.

The way to find weariness performed effectively in tests in the actual world. By looking at face landmarks and blink patterns in real time, the algorithm was able to properly discover signs of exhaustion and send users timely alerts [65]. When evaluated in a wide range of lighting, head

movements, and levels of weariness, the algorithm always got the right answer. This meant that there were fewer false positives and false negatives [68]. Using machine learning techniques made it feasible to keep improving and optimising the algorithm, which led to higher performance over time. In high-risk regions, the accident monitoring system was able to find and respond to possible incidents [75]. The system analysed data from sensors on board, like accelerometers and gyroscopes, to find motions, hits, and strange behaviours that could mean an accident or collision [81]. Users and their supervisors got real-time alerts and notifications right away, which let them react fast and reduce possible risks [62]. A lot of field testing and validation showed that the system is strong and responsive, which means it can make construction and industrial settings safer (Figure 5) [92].

Conclusion

The alcohol detection module did a great job of finding drunk people. The device used breath analyser sensors and powerful signal processing techniques to accurately assess blood alcohol levels and let users know when they went over specific limits. Field tests in controlled environments and simulated driving circumstances confirmed that the technology was correct and worked well. This made it seem like it could help stop accidents and injuries that happen when people can't drive or use machines correctly. Most of the feedback from end-users and stakeholders was quite positive, which means that they were mostly happy with the Integrated Smart Helmet System. Users liked how easy the system was to use, how well it worked with their current workflows, and how it kept them safe. Supervisors and safety experts said that the strategy worked to make work conditions safer and less likely to have incidents. Suggestions for future improvements are mostly about tiny adjustments that will make the software easier to use and provide users more ways to personalise it to their requirements. Improvements to the Integrated Smart Helmet System will focus on making the algorithms better, adding more sensors, and making the user experience better in the future. Working with industry partners and government agencies will allow the system to be used in additional areas and industries, which will make the workplace safer and more secure for everyone.

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