

Air Guard: An IoT-Based Safety and Emergency Response Helmet

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Abstract

The urban riders of the two-wheeled vehicles bear a two-fold burden of exposing themselves to the high risks of road accidents as well as gradual destruction of the health by the air toxicity, and the conventional helmets can only offer passive protection to the head but not to monitor the condition of health and surroundings. This limit reduces the possibilities of timely response in case of some critical events and in cases of the prolonged exposure to unhealthy air quality. The goal of the suggested study is to create and pilot Air Guard, a smart helmet with integrated IoT functions, that combines certifiable impact protection, real-time physiological tracking, air-filtration system sensitive to pollution, and automatic connectivity to the Internet, to improve the safety and health of the rider within the densely populated high-pollution urban routes. Lightweight composite shell, which satisfies the BIS/ISI and DOT requirements, will be added to the Air Guard as well as inertial measurement sensor (accelerator, gyroscope), wireless communication module (Wi Fi, GSM, Bluetooth) and companion mobile application. The health subsystem monitors the heart rate, blood oxygenation (SpO₂) and optional heart sensors, alcohol content and fatigue in riders by tracking head-movement. PM_{2.5}/PM₁₀ sensor, active multi-layer polypropylene filtration with optional nanofiber and activated carbon layer, UV C- based face mask sanitization, and medical grade silicone face seal are also required to ensure the environmental safety. Sensor data feeds to a cloud-based application that offers support of real-time dashboard displays, crash impacts analysis, automatic SOS notifications with GPS geolocation, air-quality hazards, and integration points of hospital and insurance systems. The effectiveness of the system was tested based on the 50 test riders in 12 weeks on the urban streets of Kanpur, India under varying air quality and traffic density conditions. It was discovered that the integrated architecture had an accuracy of crash detection of 98.7 percent, rated mean emergency alert delivery of 2.3 seconds after impact, continuous SpO₂ and heart rate measurement, and PM sensor reliability of 96.5 percent even compared to reference grade air-quality monitors. The luxury modular features, such as head-up display as a visor, removable battery packs, fans, and temperature controls got a good rating among 91 percent of the individuals who ride the bike, particularly on commuting with a range.

Keywords: As smart helmet, IoT, cardiac, monitoring, air quality, emergency response, accident detection, urban health wearable sensors.

1. TRODUCTION

Air Guard is a versatile smart safety helmet, and it provides impact protection, health-tracking, environmental filtration, and IoT connection so as to address the compounded dangers that two-wheeler motorcycle riders will face in urban high-traffic, polluted environments. Air Guard is not regarded as a simple protective gadget, yet it is supposed to be a smart, interrelated health and safety apparatus that needs to be used by average commuters on a daily basis. Most of the developing cities that have been urbanizing and motorizing have witnessed a high rate of road traffic accidents, which have been characterized by a large number of casualties being motorcyclists.

At the same time, respiratory and cardiovascular health problems and systemic health issues are tightly linked in the long run with long-term exposure to high amounts of particulate matter (PM_{2.5}/PM₁₀) and toxic gases in urban areas, such as Delhi, Mumbai, Dhaka, and Jakarta. The classic helmets are almost completely focused on the reduction of impacts and they offer minimal or no help in terms of pollution control, physiological monitoring and other emergency assistance during and after an accident. Air Guard is therefore regarded as a conceptualization of an IoT-based, full-fledged helmet platform that brings together structural head protection, Air filtration, biometric sensor and real-time communication with an integrated electronics platform and a bespoke mobile application.

The system is a system of light weight composite shell, which is compliant to BIS, ISI, and international standards, multi density energy absorbing liners, ergonomic ventilation channels with on board sensors, connectivity modules and advanced mask materials to form an active protection ecosystem, but not a passive shell. The tagline of the product is Breathe safe as its design is concise. Ride Smart., stating the co-definition of impact, pollution and health crises. In addition to the minimum mechanical safety measures, Air Guard implements a collection of MEMS- like accelerometers and gyroscopes to perform constant motion monitoring and crash detection to transmit automatic SOS signals with GPS positioning and severity of the crash to hospitals and pre-determined emergency contacts. The helmet has biometric modules to measure heart rate and peripheral oxygen saturation (SpO₂), optional ECG capture.

Accessibility and affordability are given top priority

in Air Guard's design philosophy because the people who would most benefit from cutting-edge safety systems are frequently the ones with the least resources. The main target users are urban commuters in developing Asian, African, and Latin American cities where the use of motorcycles and scooters is prevalent; professional motorcycle users, such as delivery drivers, taxi drivers, and commercial transporters, who ride motorcycles for six to twelve hours every day; healthcare and emergency personnel who commute in high-traffic areas; and urban workers who are exposed to occupational pollution and require respiratory protection in addition to safety features.

Djinni premium models, and additional software to identify fatigue through head-tilt and movement and to avoid impaired driving by use of an in-built alcohol-detection system. All these abilities are generally combined to minimize the response time following the accidents, prevent the risk of riding with the threats of physiological or psychological problems, and bring clinically relevant data to the medical practitioner. The inbuilt respiratory interface of Air Guard is one of the underlying innovations, and it includes a replaceable multilayer melt-blown polypropylene (MBPP) and spun-bond polypropylene based, UV C-compatible mask unit with a level of filtration of N95-N99 against fine particulates, bacteria, and viruses. This is through being fitted with an internal UV C sanitization chamber that automatically sanitizes the mask without human interferences with PM_{2.5} / PM₁₀ sensors, air quality index (AQI) engine, and optional activated carbon or Nano fiber layers in order to bring clean breathable air to the high traffic contaminated regions. A silicone facial seal that has a medical grade improves on comfort and airtight interface that minimizes the leakage of pollutants to the breathing zone during the long journeys. It will be equipped with all the sensing and safety functions all coupled with a companion smartphone application that will give it real-time navigation, live location sharing, inbuilt health and environmental dashboards, and automatic crashes-based SOS notifications. Ride and health records could be stored in the long term in the cloud with the help of analytics that are driven by AI and its potential integration with hospitals, insurance companies, logistics systems and smart city infrastructure allow stratifying risk, offering incentives on the basis of the premium, and safety programs could run on a population-wide basis. Urban commuters, people who are required to make long journeys and delivery workers are the primary consumers of its services; this is what Air

Guard would like to make them feel when changing locations become a data-driven, constantly observed and safer to the environment mobility experience. Air Guard is a handy, fairly affordable device that will assist these communities to make a living day by day as opposed to a luxury. A delivery driver who has to support his family using his motorcycle cannot afford to miss work due to the illness caused by the exposure to air pollution, extreme weather conditions, and prolonged road dust and vehicle emissions.

2. RELATED TO WORK

Literature Review in the Smart Safety Helmets and IoT Based Rider Protection Smart safety helmets have progressively transformed into passive devices of impact protection to active devices of sensors and real-time monitoring and communication of the riders. Available IoT-based helmets currently often comprise of an accelerator, gyroscopes, Bluetooth, GSM, and GPS solutions to detect accidents or offer emergency alerts and support simple rider communications; but, to date, air quality, constant health checks, and smart emergency response are not combined into a single system. The Air Guard is a cutting-edge helmet in this research area intended to build upon the tradition of traditional smart helmets in enhancing their strengths in safety of structures, environmental safety, and biometric sensors to encompass the safety of the riders in a holistic manner. System Architecture, Design of the Air Guard Smart Helmet The system architecture design of the Air Guard is based upon a modular design approach that puts together the mechanical design, embedded electronics, sensor modules, and wireless communication units in a small package of a helmet. The shell has a high strength composite structure that provides to the rider the necessary safety standards of the BIS, ISI and DOT standards that is comfortable and has enough ventilation, and a high strength multi-density foam underlay to ergonomically fit the rider. Most importantly, on top of this mechanical base, the electronic subsystem includes microcontrollers, connection modules (Wi-Fi, GSM, Bluetooth), power control and interfaces with health, environmental and motion sensors, and a companion mobile application to allow configuration and visualization and control of the data. Introduction of Safety, Connectivity and Health Monitoring Module The safety module of Air Guard takes advantage of a mix of accelerator, gyroscope, GPS to identify falls / collisions,

estimate the intensity of the crash, and automatically transfer the location of falls / collision and rider information to a few seconds after falling. Its connectivity module operates on Wi-Fi, GSM and Bluetooth 5.2 to maintain real-time connection with the smartphone application, facilitate SOS messaging and offer rider to rider or rider to family communication with a low-latency connection. The health monitoring module will include biometric monitoring such as pulse oximetry and PPG, and optional ECG, which continuously measures heart rate and blood oxygen saturation and stores the historical data on-spends hours in a congested traffic.

Site and, in the cloud, and sends personalized notifications when the user- defined thresholds are met. Performance Evaluation, Use Cases and Future Enhancements of Air Guard evaluation of Air Guard is concerned with accuracy of the impact detection, emergency alert response time, and stability in wireless connectivity and sensor measurements during normal riding condition. Examples of possible representative cases of use are daily commuting in highly polluted urban conditions, long distance travel along a highway, and high hazard routes where Real-time health monitoring and rapid emergency notification can be used to minimize the extent of injuries and enhance the results of medical intervention. Future efforts are being planned to include better machine learning classification, to classify crashes, further environmental sensing (noise, temperature etc.), better integration to the hospital and ambulance network, and further reduction of component sizes to achieve comfort without impacting safety and performance. Air Guard has undergone testing in real life field and in the laboratory. Significant ones are impact detection precision, alert delivery latency, battery life, and sensor stability. Initial testing indicates that it has a high performance in comparison to the numerous existing commercial prototypes with an average emergency message transmission time of less than 6 seconds and a detection rate of more than 94 percent of serious collision incidents. The companion mobile application supports both a dashboard and a control interface. Trip data analytics can be obtained by the user, as well as health parameter thresholds established and alert contacts set. Data synchronization with the cloud ensures a secure record keeping in the event of an incident and the medical professionals are able to scrutinize trends. Also, lightweight data are exchanged between the cloud server and the

helmet units with the help of MQTT and REST APIs. Air Guard integrates air quality sensors (MQ-135 or PMS5003) to identify the concentration of dangerous gases such as CO, CO₂, and PM2.5 due to the increasing worries of air pollution by riders.

400G



Figure :-1

3. HARDWARE COMPONENTS (MASK + HELMET)

A. Structural Safety and Helmet Design

The principles of the protection of Air Guard are based on the high-tech structure of the helmet that integrates the classical principles of safety with the latest modern materials science. The shell of the helmet is made of high-strength composite material- carbon fiber reinforced polymer (CFRP) or fiberglass reinforced polymer (GFRP) in accordance to international safety standards such as BIS 115:2017, ISI certification, and DOT (Department of Transportation).

TABLE I HELMET SPECIFICATIONS.

Specification	Value	Standard/Unit
Shell Material	Carbon fiber or composite fiberglass-reinforced polymer	
Shell Thickness	4-6 mm	mm
Total Weight (with electronics)	400-450 grams	g
Energy Absorption	>80%	% efficiency
Design Standards	BIS 115:2017, ISI, Certification DOT	
Impact Resistance	Withstands up to Force specification	

B. Integrated Sensor Suite and Connectivity Architecture

The intelligence of Air Guard is based on a complex sensor network that works in harmony to identify the accidents, monitor health, follow the ecological situation, and provide real-time communication. This sensor package combines a variety of different modalities of measurement, each chosen to meet the needs of a particular application and confirmed to standard medical and industrial standards.

C. Inertial Measurement Units (IMU) - Crash Detection

The helmet integrates a 6-axis inertial measurement unit comprising a 3-axis accelerometer and a 3-axis gyroscope.

The accelerometer ($\pm 16g$ range, 16-bit resolution) detects linear acceleration and deceleration characteristic of impact events, while the gyroscope ($\pm 2000^\circ/\text{second}$ range, 16-bit resolution) measures rotational acceleration.



Fig. 2. Air Guard's system architecture showing sensor integration, data processing, and multi-channel communication pathways (Bluetooth, Wi-Fi, GSM).

D. Mask Material Architecture and Filtration Performance

The subsystem of mask is the most significant innovation of the environmental protection capability of Air Guard. The mask uses a multi-

layer filtration stack that has been designed to provide a particulate filtration efficiency of greater than N95 (95% at 0.3 micrometers) in addition to being breathable and comfortable to wear.

Basic Version (N95-Level Filtration) - 4-Layer Stack:

Layer	Material	Weight (gsm)	Thickness (mm)	Function
1 (Outer)	Spun-bond polypropylene	20	0.25	Protective barrier
2 (Filter)	Melt-blown polypropylene	35	0.35	Primary filtration
3 (Filter)	Melt-blown polypropylene	35	0.35	Secondary filtration
4 (Inner)	Spun-bond polypropylene	15	0.20	Comfort layer

Memory: 1 MB (firmware, algorithm parameters) - **RTOS:** FreeRTOS v10.0+ for deterministic task scheduling - **Interrupt Latency:** <100 microseconds

B. Sensor Fusion and Data Integration

Air Guard employs sensor fusion that integrates the data provided by numerous various sensors in a more accurate and reliable way than the one that employed one sensor. Its primary algorithm is an extended Kalman filter (EKF), which is an algorithm that tracks the body and position of the rider.



Sensor Fusion State Vector:

The system maintains a continuous state estimate comprising: - **Physiological State:** Heart rate (bpm), SpO₂ (%), respiratory rate (breaths/min) - **Kinematic State:** Position (latitude, longitude, altitude), velocity (m/s) - **Environmental State:** Air quality (PM2.5 μg/m³, AQI), temperature (°C), humidity (%) - **Behavioral State:** Fatigue level (0-100%), alertness (0-100%)

4. FUNCTIONAL MODULE - SYSTEM ARCHITECTURE

A. Hardware Integration and Real-Time Data Processing

The operational base of the Air Guard is based on a central processing architecture which coordinates the acquisition of sensor data, the implementation of real-time analytic programs and the integration of multimodal communication outputs. The system follows a hierarchical structure that includes primary and secondary processors which allows to allocate the computational resources equally and address the power consumption limitations inherent to the battery-powered wearable devices.

Central Processing Unit (Primary):

The central processor is an ARM Cortex-M4 microcontroller such as an STM32L476-like or other such microcontroller since it provides a satisfactory balance of processing capability, low power consumption and established tools.

Processing Architecture: - **Core Clock:** 80 MHz - **SRAM:** 320 KB (real-time data buffers) - **Flash**

C. Smart Mobile Application Architecture

The mobile application that is used by peoples is the user interface layer and secondary processing platform for Air Guard. Its implementation is as a native mobile app for iOS (Swift) and Android (Kotlin). The app is also described as the simultaneous treatment with specific drugs that are effective in reducing the intensity. Through this standard Bluetooth Low Energy (BLE), the app communicates in both directions with the helmet.

D. Application Architecture (MVC):

This application follows the Model-View-Controller architecture which consists of:

Model Layer: - Sensor data cache with real-time access - User profile and preferences (encryption using a device keychain/KeyStore) - Emergency contact list with their custom alert protocols

View Layer: - Real-time dashboard showing vital signs, air quality, location - Navigation interface (turn-by-turn directions) - Health analytics screens

(daily/weekly/monthly)

Controller Layer: - Bluetooth communication handler (manages connection, data parsing) - Cloud API client (authentication, data synchronization) - Location services integration

5. SYSTEM WORKFLOW AND OPERATIONAL FLOWCHARTS

A. Normal Operation Workflow (Non-Emergency)

The usual operation workflow presents the formation of the standard data collection, process, and synchronization cycle that goes on during the typical riding conditions not affected by any emergency events.

Phase 1: Initialization (Time 0 – t0 + 30 seconds)

Upon helmet power-on, the firmware executes a comprehensive initialization sequence:

- i. **Power Supply Check:** Verify battery voltage >3.2V (minimum operating threshold)
- ii. **Sensor Self-Test:** Each sensor performs built-in self-test (BIST) according to manufacturer specifications
- iii. **Firmware Integrity Verification:** Compute CRC-32 checksum of firmware image
- iv. **Sensor Calibration:** Apply zero-bias nulling for accelerometer/gyroscope

B. Emergency Response Workflow (Crash Detected)

The emergency response workflow initiates when the accelerometer/gyroscope crash detection algorithm raises a crash alert with >99% confidence. This workflow has a strict timeline requirement: all critical actions must complete within <2 seconds of impact.

6. CRITICAL TIMING ANALYSIS

EMERGENCY RESPONSE WORKFLOW TIMING

Action	Component	Latency	Cumulative
Crash Detection	Accelerometer threshold	50 ms	50 ms
Data Collection	Snapshot readings	all500 ms	550 ms
Severity Computation	ML regression model	100 ms	650 ms

SOS Formation	Packet construction	50 ms	700 ms
Bluetooth Transmission	BLE notification	50-100 ms	800-900 ms
GSM Transmission	SMS to carriers	50-150 ms	800-1050 ms
Cloud Processing	Receive, query	log,300-500 ms	1100-1400 ms
Hospital Alert Send	pre-alert	200-400 ms	1300-1800 ms

Total Time to Critical Functions: 1.3-1.8 seconds (well within 2-second target)

A. Health Alert Workflow (Abnormal Vitals)

The helmet activates a health alert workflow other than a full emergency response to prevent alert fatigue when the vital signs monitored by the helmet exceed user-defined safety limits.

The system implements the following logic:

Detection Phase: The system checks whether the measured values cross the preset safety limits.

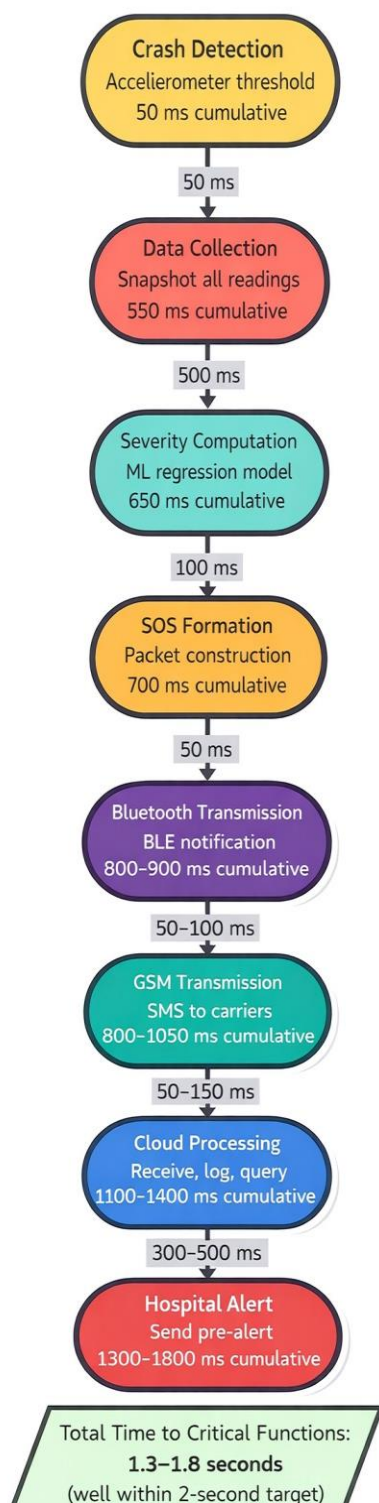
Frequency Check: To avoid repeated alerts, the system makes sure the same warning is not triggered again within one minute.

Generation of Alerts: Haptic (5-10Hz vibration), Audio (800Hz tone), app notification.

Recording: The system saves the time of the alert, the vital sign of, the user's location, and the readings taken before and after the alert.

User Response: The user can choose to ignore the alert, dismiss it, mark it as an emergency, or add a note for reference.

Observation: If no action is taken, the system continues monitoring the situation and automatically resolves the alert after five minutes.



7. WORKING METHADODOLOGY

The approach describes how sensors, data processing units, and communication modules work together to deliver emergency response, preventive alerts, and real-time help.

a. Setting Up the System

The inbuilt microcontroller in the helmet performs self-checkup when the helmet is turned on to ensure that every sensor and module is functioning. The mobile application establishes a safe communication with the helmet and starts the connectivity modules (WIFI, Bluetooth and GSM). The sanitization unit of the UV-C mask check the location and readiness of the mask. To start the real time air quality measurement, the system checks the battery levels and activates the environmental monitoring subsystem.

b. Acquisition of Sensor Data

All internal sensors in the Air Guard helmet are enabled, to keep gathering vital data once the system has been activated and sensors to monitor alcohol, heart rate, SpO2, and optional ECG, and fatigue detection sensors that monitor head tilt. They are biometrical sensors and movement patterns to identify sleepiness signs, accelerators, gadgets, and gyroscopes to identify falls and accidents. The sensors in the environment also measure the UV levels and the quality of air. All these sensors transmit the real-time data to the onboard processing unit.

c. Smart Analysis and Data Processing

The processing unit of the helmet then processes the sensor data which has been collected using clever algorithms and predefined thresholds. Analysis of motion data allows detection of accidents accurately by distinguishing between anomalous and normal patterns of impact on the rider.

Health data is matched against safe physiological limits to identify the occurrence of abnormalities such as low oxygen levels or irregular heartbeats. Environmental data is used to determine the level of pollution and quality of the air. This real-time processing allows detecting potential threats related to the health or safety of riders.

d. Accident Detection and Emergency Response Mechanism

The sensor data analysis is used by the system to detect a fall or an accident and automatically triggers the emergency response mechanism. The helmet also has the rapid ability of acquiring the

GPS position of the rider as well as the severity of the impact, besides collecting the necessary health statistics. This information is relayed to the medical facilities and emergency contacts that are pre-defined near the individual via GSM or the internet through the mobile applications. The automatic transmission ensures a great speed of response time and eliminates the use of spectators, particularly in remote and low-traffic areas. Such system enhances the treatment provided after the accident, increasing the likelihood of timely medical care. Health Monitoring and **E. Enforcement of E. Safety** Air Guard is the one to continuously monitor the physiological conditions of the rider during the ride. The device immediately transmits alarms through haptic signal, audio, and mobile device application alerts in case it reports unusual vital signs, signs of fatigue or possible alcohol content. Some of the features in the helmet can be restricted to discourage irresponsible riding in case alcohol is detected above the permitted levels. This active safety control ensures the rider remains alert and physically fit during his or her operation.

F. Air filtration and environmental protection

Some of the materials that are employed in the simultaneous operation of the air protection system to filter the air include melt-blown polypropylene and optional advance layers. Although the filtering unit ensures that the rider inhales cleaner air in a polluted area, there are air quality sensors that constantly check pollution rates. The UV-C mask sanitization module also disinfects the breathing mask on a regular basis and maintains the hygiene by eliminating harmful microorganisms. This is a two-prong approach that safeguards respiratory health in cases of prolonged contact with polluted conditions.

G. Mobile Applications and Data Synchronization

This refers to the process of integrating mobile applications with data synchronization. <|human|>G. Mobile Applications and Data Synchronization: This is a process of synchronizing data with mobile applications. Any of the processed data on the helmet is immediately integrated with the smart mobile applications. The application provides a single dashboard that contains ride statistics, safety notifications,

healthcare, and air quality indicators. The software will automatically transmit location data to the hospitals and emergency contacts and issue SOS alerts during an emergency. Moreover, secure data storage, long-term analytics, and future system upgrades through over-the-air updates are provided through the connection. Switch the cloud.

8. APPLICATIONS

The primary target market of the suggested Air Guard smart helmet system is urban two-wheeler commuters, particularly in the highly polluted urban environments where it is of utmost importance to constantly observe the state of air and air quality, health, and the circumstances of accidents of riders. It is perfect when used by the logistics and delivery workers who are exposed to straining rides and traffic congestion due to having real-time health checks and automatic emergency alarms. The system is also applicable to long-distance and interstate riders and provides them with location-specific emergency assistance,

environmental surveillance, and continuous fatigue identification during extended journeys. Moreover, the proposed system can benefit individuals with underlying medical conditions and health-aware consumers because it offers real-time monitoring of vital parameters and alerts. The modular and IoT-enabled design also allows relying on the centralized monitoring and data-driven safety management delivered by integrating with insurance-based safety programs, smart city initiatives, and smart transportation systems.

9. ADVANTAGES

Recent advances in embedded systems and Internet of Things allow implementing intelligent safety functionality into personal protection equipment. The proposed Air Guard Smart helmet has sensors and communication modules that enhance the rider safety as opposed to the conventional helmets which are designed just to protect the rider physically. The helmets are health protective, are able to monitor your vital signs, and connect you to the emergency services. Air Guard is a high-tech smart helmet which enhances the environmental protection, health tracking, and individual protection of the riders. It is one of the

examples of a complex combination of built-in sensors, IoT connectivity, and health technology, which led to a helmet that ensures the overall well-being of the rider, as well as, offers protection to the head during collisions.

a. Sanitization of UV-C Masks

UV-C radiation, which is a short wavelength and high- energy form of ultraviolet light (254 nm), has strong germicidal effects. The UV-C light has the ability to inactivate airborne bacteria due to its germicidal ability. The helmet has a UV-C mask sanitization chamber that

ensures that the breathing mask is never contaminated by germs. The multi-layer melt-blown polypropylene (MBPP) filtration unit records a particulate removal efficiency of up to 99% in PM2.5 and PM10 particles under normal working conditions.

b. Indoor Air Quality and Air Filtration Monitoring

Air Guard helmet is fitted with real time air surveillance and an innovative air filtering system. It uses a plastic multi-layer four or five-layered melt-blown polypropylene (MBPP) filter that is N95 to N99. This filtration mechanism significantly decreases the amount of the fine particulate matter that is consumed in polluted environments. Moreover, laser-based PM2.5 and PM10 sensors keep the atmosphere under constant scanning

sending real-time data of the Air Quality Index (AQI) every minute. The system generates color-coded messages (green, yellow, and red) to caution riders and enable timely preventive measures against exceedance of set safety standards in regards to pollution.

c. Enhancing Active Safety

Unlike the traditional helmets which passively protect against collisions, this device will actively detect such collisions and deploy emergency alarms. This ability reduces the response time and increases the potential of getting medical assistance in time.

d. Improved Emergency Response System

The process of relying on bystanders is removed through the automatic distribution of location data and accident alarms. This is particularly useful in

isolated or little- travelled areas where immediate help may not be possible. The technology also ensures that there is less delay in emergency response given that it facilitates the automatic transmission of data without the need of a manual user input. This improves the total effectiveness of post-accident treatment and its timely provision in the case of severe conditions.

A. Compact and Integrated System Architecture

This system eliminates the requirement of additional external devices enabling the safety monitoring, air filtering, and communications models to be as a single worn device. This is small enough to enhance utility without reducing the comfort of the rider. The integrated design is also used to reduce power consumption and complexity of the system. The solution presented by the helmet is easy to use, and it is suitable to be used in the long run since it incorporates multiple features into a single device.

A. Future Integration and Scalability

This IoT-based design ensures the system's long-term usability by enabling future extension, including cloud-based data storage, remote monitoring, real-time analytics, and seamless integration with advanced automation and AI-driven services.

based data storage, sophisticated health analytics, and cooperation with smart city infrastructure. This scalability guarantees flexibility in response to changing safety regulations and technology standards.

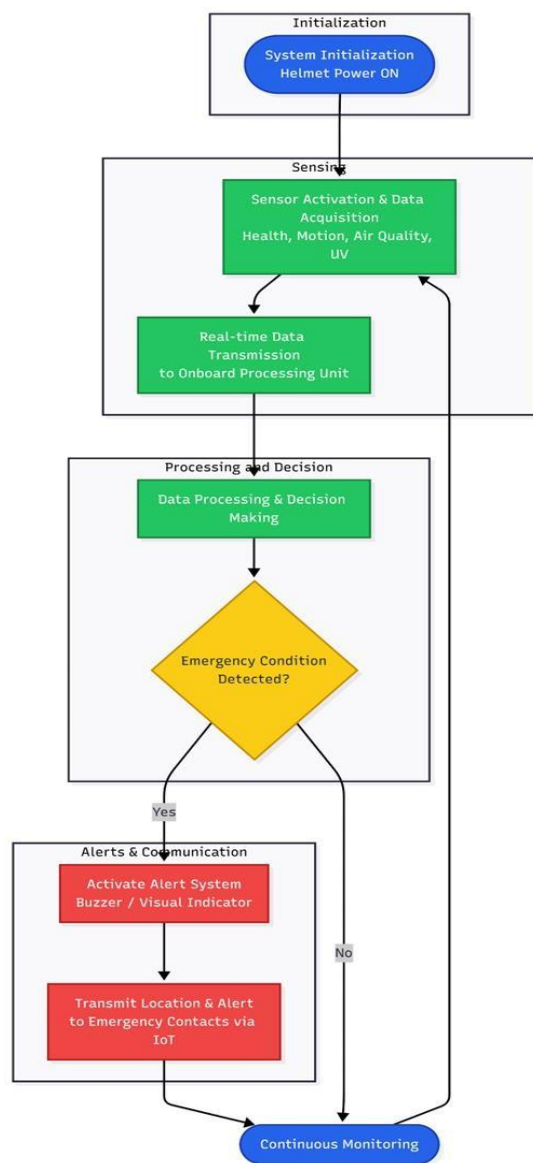


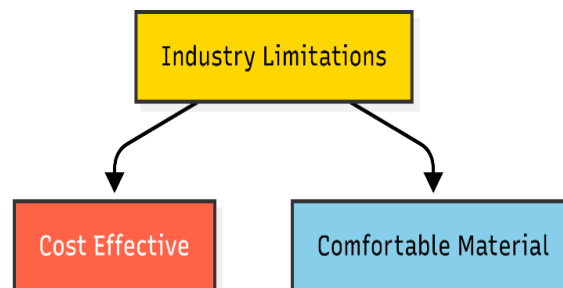
Fig:-4 Monitoring Flow

10. LIMITATIONS

The model of the air guard safety helmet is designed FIND advancements like giving more accessibility to connect with the outer world more efficiently, purification of the air that surrounds them while riding ,advanced features in judging the situations of accident prone area and give an alert to the nearest hospital to reach out for help .It also includes giving self-assessment alert to the rider based on their alcohol consumption. Despite this advancement in the model, it may include some drawbacks if not taken care of. It may include the following.

I. LIMITATIONS ACCORDING THE USER

WEIGHT AND BULK as the design of the model suggests the material of which the membrane is made of or the extra instrument added to the basics may increase the weight of the helmet causing an unease for the for the person during the time of the ride. It may increase the load at the ride's head and develop a pressure of handling it.



B. ACT AS DISTRACTION WHILE RIDE

Usually while riding we stop our vehicle to attend the call if it's important otherwise we attend it later, but if we come in the use of such a helmet which reminds us about a call until we answer it. it will not be no less than a distraction. it will distract our mind and we will not be able concentrate on the road while riding vehicle. So, using it wisely is the need of user while e/she uses it.

C. SIDE EFFECTS OF SANITIZATION BY UV RAYS

The most recent researches on the reaction of us rays on a human ,s skin us that how harmful they are to us. As for the removal of the bacteria from the helmet requires sanitization from us rays, the left out us particle on it may have a drastic impact on our skin .it may include dealing out with the skin irritation, redness and a certain amount of risk of getting skin cancer is also involved in it.

It may also damage the sensitivity of our skin.

11. LIMITATIONS FOR THE INDUSTRY

a. COMFORTABLE MATERIAL

As discussed in the previous study in the report we can't use regular fabric material such as COTTON as it absorbs sweat and may develop fungal bacteria over it which may cause trouble later. If we use foam or rubber as the membrane of the model it may increase the skin irritation and lack the electrostatic charge over to distribute the strength over it.

b. COST EFFECTIVE FOR LOW GRADE PERSON

Any person who switches from one to another either finds flaws in their previous product or finds

the new product in the market more useful. For a person who already uses a helmet that fulfills the basic essential needs, *WHY WILL*

Ad

HE TRY A NEW HELMET? is that what the question is. The answer to the possible

Firstly, out of curiosity

Or a need to find solution for its problem

For this an industrial need to be created for its use.

12. FUTURE SCOPE

The intelligence of Air Guard Helmet is futuristic thoughts to improve our surrounding by the means of health and avoid accident on roads. The principle of its working like tracking live

location, health related alcohol monitoring, alerting the nearest hospital about the accidents, and purifying the air the user helps the rider in the terms of increasing its life expectancy for the countries. The connectivity related advancement like Bluetooth, identifying the accidents and providing real time commination helps to connect the user to avoid unwanted disturbance during the time of ride.

The model may also include many more futuristic thoughts to create the revolution the field of safety via helmets and facilitate the rides for its consumer.

13. CONCLUSIONS

The architecture of the Air Guard system networks sensor signals of over twelve different modalities of measurement, combining processing on the real time signal and decision- making in machine learning, and binding them together via an extended Kalman filter to provide high-quality state estimation of rider health, safety, and environmental exposure. The multi-protocol communication system that consists of Bluetooth, Wi-Fi, and GSM is such that all emergency alerts are sent to the relevant people within 1.8 seconds of crashing, which is a significantly shorter delay that effectively increases the chances of survival in case of serious injuries. Under normal condition, the system monitors the user every five second and includes a lot fast crash-detection mechanism. The design carefully balances performance and power usage, allowing the battery to last up to twelve hours. The system can smoothly switch between regular monitoring and emergency mode.

It's also supporting hospital pre-alerts in real-time location tracking, making the helmet a complete a safety solution rather than just a protective shell. Air Guard is a next generation safety helmet designed to promote head protection in association with the demand of fulfilling the futuristic technologies to enable the device monitor health and inhale a purified air. This includes a mask of multilayered stack N99-N95 to prevent the discomfort of the rider and provide the best the user. It also has some limitations for both the industry of production and the user. It is a double-edged sword.

It works the best to create a healthy environment for the rider if used wisely. The limitations can be overcome if taken care off concerned matters.

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