Smart Helmet: Enhancing Safety and Connectivity

Overview of Computing Technology Trends

# 1. Augmented Reality Integration

* **Head-Up Displays (HUDs):**   
  Whilst not specifically made for a smart helmet, the Even Realities G1 glasses feature a seamless Augmented Reality (AR) system within a small glasses frame.



(@EvenRealities, 2024)

* **Remote Assistance:**   
  Current remote assistance AR technologies allow experts to assess situations and help the customer in real time. For example, if you were to have a bike breakdown and you could not wait for someone to physically come to you – such as being in a traffic-heavy area which may pose dangers if you were to stay in one place for too long – you could make a call and be connected to an expert. The AR technologies would allow them to remotely observe and communicate with you, offering advice and recommendations regarding the problem – or even talk you through fixing the problem on the spot ([www.ptc.com](https://www.ptc.com), n.d.).

* **Gaming and Entertainment Applications:**   
  AR games have been in the public eye for several years. One of the most notable games to utilise AR was Pokémon Go, which was released by Niantic for all major mobile phones in 2016. The AR technology allows you to roam around your local area and use GPS/Camera to catch and battle Pokémon, with AR allowing the movement and speed of the player to directly impact the gameplay – as if the player moves too fast, the Pokémon will potentially flee (Pokémon GO, n.d.)

In November 2024, Niantic Labs released an article detailing how the updated implementation of AR was utlised to capture photographs which would then be used to create a large geospatial model. In the future, this geospatial model could be used to locate an image in the world using spatial intelligence (Nianticlabs.com, 2024).

## 2. Enhanced Safety Features

* **Crash Detection and Alerts:**

Smart helmets use accelerometers and gyroscopes to detect crashes and automatically send emergency notifications, including GPS coordinates, to pre-configured contacts or services (ABUS, 2018).

* **Blind Spot Detection:**

Cameras and sensors monitor the surroundings to warn users of potential hazards, such as vehicles approaching from a blind spot. Using cameras and AR, it would be possible to create a “rearview” mirror to help eliminate blind spots (innovv.co.uk, 2023).

* **Airbag Systems:**

Some companies, such as Voltbikes, have helmets that integrate inflatable systems that activate during an impact over a certain force to reduce injuries. (Voltbikes.co.uk, 2024)

## 3. Communication Capabilities

* **Bluetooth and Intercom Systems:**

Integrated communication tools allow riders to connect to their devices or other users’ devices seamlessly, which is useful for cyclists. An intercom system would be especially useful in events such as a bike race, where communication with a coach or non-cycling team member could potentially warn the cyclists of any upcoming obstacles or accidents (ABUS, 2018).  
A similar type of communication can be seen in Formula 1 racing where there is a constant connection between the driver of the car and their team, allowing for any problems that arise to be brought up and solved before significant injury can occur. Being able to successfully implement this for other sporting events such as the Tour de France could reduce the risk of significant injury, and even potentially death, by a significant amount.

* **5G and IoT Connectivity:**

With 5G, smart helmets can connect to Internet of Things (IoT) ecosystems, enabling real-time data sharing, location sharing and GPS increased in accuracy by 5G to within 1.5m of error (J, Lota (2022). Pairing devices with the local IoT systems in conjunction with 5G networks increases the accuracy of the location-sharing to such an extent that emergency services such as the ambulance service are more likely to be able to find an accurate location much faster.

In some more rural areas of the United Kingdom, cycling is a far more common method of travelling. However, the risk of significant injury to a cyclist in a rural area becomes greater the longer they must wait following an accident taking place. Rural areas, such as country back roads, are known to have poorer signal or insignificant location signage. Being able to implement more accurate location sharing into cycling helmets would allow for services to locate and reach a cyclist much faster following the initial call for help.

## 4. Artificial Intelligence (AI) and Machine Learning Integration

* **Smart Assistance:**

AI-powered features analyse user behaviour to offer suggestions, such as optimising routes or alerting fatigued drivers (Smart Eye, 2024). Smart Eye is incorporated into vehicles such as long-haul transit fleet cabs, using their Driver Monitoring System to “draw conclusions about a person’s alertness, attention, focus and much more” which it does by monitoring eye, face, and body movements. Implementing this into a visored cycling helmet could allow cyclists to be warned when they start displaying signs of fatigue – potentially preventing serious accidents occurring due to overexertion or exhaustion.

* **Voice Command Interfaces:**

Hands-free controls via virtual assistants (e.g., Siri, Alexa, or custom AI assistants) allow safer interaction with the helmet’s functionalities (DSM Design Ltd, 2020). Using voice commands would take away the risk of looking at a separate device thus taking their eyes off the road. However, there would still be the risk of distraction as there are hands-free controls in vehicles.

## 5. Lightweight and Sustainable Design

* **Material Innovations:**

Advances in carbon fiber composites and graphene are enabling lighter yet stronger helmets (Newcomb, 2016). These helmets could result in reduced neck-strain during impact and having a material that absorbs the impact more than standard helmets could help reduce the rate of potential traumatic head injuries following a high-force impact.

* **Solar Power Integration:**

Solar panels embedded in helmets allow for sustainable energy to power electronic features (Bikeradar.com, 2021). This would mean a bulky battery pack would not be taking away from the protective material and would not run the risk of causing further penetrating injuries that an extra addition to a helmet may add depending on the type of injury sustained.

# Role of IoT in Smart Helmets

## Real-Time Monitoring

* **Embedded Sensors and Actuators:**

IoT devices, such as smart helmets or wearables, are equipped with sensors (e.g., temperature, GPS, motion, and biometric) to continuously collect data this would allow for future fine tuning and describing the type or seriousness of an impact upon it happening allowing for quick response and triage.

* **Edge Computing:**

Devices process critical data locally (on the "edge") for immediate decision-making, such as issuing alerts for hazardous conditions or fatigue detection. Using the Smart Eye technology referenced earlier, regarding exhaustion monitoring using edge computing it can direct the operator towards a “rest zone” and continue to assess conditions in conjunction with biometrics.

* **Event-Driven Responses:**

Real-time monitoring enables automatic triggers, such as sending notifications during abnormal readings or emergencies, like a crash detected by a smart helmet or facial recognition and biometrics with exhaustion.

## Data Transmission

* **Wireless Connectivity:**

IoT devices leverage wireless communication protocols such as Wi-Fi, Bluetooth, Zigbee, and LoRa WAN for short- and long-range data transmission. Short range for simplified hands-free controls using a mobile device and long-range data transmission saving “ride-data” for later overview or repackaging for display on an AR visor interface.

* **Cloud Integration:**

Data from IoT devices is sent to the cloud for storage, analysis, and processing. This enables users to access information via apps, dashboards on other devices or with the AR visor system.

* **Low Latency Networks:**

Technologies like 5G drastically reduce latency, ensuring faster, more dependable data transfer between devices, critical for applications like autonomous vehicles and real-time safety systems this critically assists with emergency situations and quick turn of events.

## Integration with Smart Ecosystems

* **Interoperability:**

IoT devices adhere to standard protocols (e.g., MQTT, RESTful APIs) to integrate with other devices and platforms, creating cohesive smart ecosystems. For instance:

* A smart helmet with air quality sensors can alert a connected mobile device or AR display system to suggest leaving the area if the air is unsuitable or if it were to be within a whole head covered model enable a HVAC additional system to filter the air to suitable quality.
* A fitness tracker can synchronize data with smart home equipment to suggest wellness routines, routes for regular commuting/exercise or using the ride history of the user dynamically display the amount of time they can ride without exhaustion safely.
* **Data Analytics and Insights:**

IoT platforms analyse collected data to derive actionable insights. For example:

* A smart city ecosystem uses data from traffic sensors and vehicles to optimise traffic flow.
* Industrial IoT (IIoT) integrates real-time equipment monitoring with predictive maintenance systems.
* **Cross-Device Communication:**

Devices work together for enhanced functionality. For example:

* A smart helmet’s proximity sensors can interact with a smart car’s system to warn drivers of a nearby cyclist.
* Smart appliances adjust based on user behaviour tracked by wearable IoT devices.

## Benefits and Key Use Cases

* **Enhanced Automation:**

Real-time monitoring and communication streamline processes like home automation, industrial control, or fleet management.

* **Improved Safety:**

IoT enables critical safety applications, such as remote monitoring in hazardous environments or emergency response coordination.

* **Personalisation:**

IoT adapts ecosystems to individual preferences by analysing historical data and real-time inputs, creating customized user experiences.

## Circuit Components and Functions:

1. **Force Sensitive Resistor (FSR)**: Detects impact force and outputs a signal based on the force threshold.
2. **Arduino**: Processes input signals and determines the activation of the alert system.
3. **LED**: Provides a visual alert if the impact exceeds the threshold.
4. **Piezo Buzzer**: Emits an audible alert for severe impacts.

#### Boolean Logic for the Circuit:

## Inputs:

*F:* Signal from the FSR (1 if force exceeds a predefined threshold; 0 otherwise).

*M:* Mode switch for operational state (e.g., 1 = active, 0 = inactive for maintenance or no battery).

#### **Outputs:**

* *L:* LED (1 = on, 0 = off).
* *B:* Buzzer (1 = on, 0 = off).

## Logic Rules:

* *F=1* and *M=1*: The Alert system activates both the LED and Buzzer.
* *F=0* or *M=0*: Alert system remains off.

## Boolean Expressions:

* *L=F∧M* (LED is on only if force exceeds the threshold and the mode is active).
* *B=F∧M* (Buzzer follows the same condition as the LED).

*Truth Table:*

|  |  |  |  |
| --- | --- | --- | --- |
| F | M | L | B |
| 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 |

#### 

## System Architecture

**Input Layer**:

* The FSR sends analogue signals to the Arduino to measure the force.
* A mode switch provides a manual override or operational state toggle.

**Processing Layer**:

* The Arduino processes the inputs using programmed thresholds and logical conditions.
* Calibration ensures minor bumps do not trigger alerts.

**Output Layer**:

* If the conditions are met, the Arduino activates the LED and Piezo Buzzer to alert others.
* Optional future features include GPS or Bluetooth modules for enhanced communication.

**Integration**:

* Embedding the circuit into the helmet for safety and reliability.
* Use of eco-friendly materials and solar-powered rechargeable batteries for sustainability.

## Component List

* **Force Sensitive Resistor (FSR)**:

Detects impact force and sends an analogue signal corresponding to the pressure applied.

Key role: Trigger alerts when impact exceeds a safety threshold.

* **Arduino (Microcontroller)**:

Processes signals from the FSR.

Controls outputs such as LEDs and buzzers based on programmed logic.

Potential for expansion with GPS, Bluetooth, or GSM modules.

* **LED**:

Provides a visual alert when an impact is detected.

Enhances visibility in emergencies.

* **Piezo Buzzer**:

Emits an audible alert in case of severe impacts.

Serves as an additional warning mechanism.

* **Power Source**:

Battery-powered system (with a potential future solar-powered rechargeable battery option).

Ensures portability and ease of use.

* **Connecting Wires**:

Routes signals and power between components.

Routed through helmet grooves for safety and durability.

* **Protective Casing**:

Shock-resistant and waterproof casing to protect components.

Ensures system longevity and reliability under various conditions.

## Circuit Schematic

A circuit board with wires and a microphone

Description automatically generated

## Implementation Results

* The Force Sensor works as intended once enough force has been applied.
* The Tilt Sensor works as intended once the overturned piezo buzzer sounds off.
* LED works as intended when either the Tilt Sensor or Force Sensor goes past the set threshold.

## Code for Sensors (C++)

int forceSensorPin = A0;

int tiltSensorPin = 2;

int ledPin = 8;

int buzzerPin = 9;

const int forceThreshold =850; // Adjust based on testing

bool crashDetected = false;

void setup() {

pinMode(forceSensorPin, INPUT); // Force sensor input

pinMode(tiltSensorPin, INPUT); // Tilt sensor input

pinMode(ledPin, OUTPUT); // LED output

pinMode(buzzerPin, OUTPUT); // Buzzer output

Serial.begin(9600); // Initialize serial communication

}

void loop() {

int forceValue = analogRead(forceSensorPin); // Read force sensor

int tiltState = digitalRead(tiltSensorPin); // Read tilt sensor

// Check if either force or tilt sensors detect a potential crash

if (forceValue > forceThreshold || tiltState == HIGH) {

digitalWrite(ledPin, HIGH); // Turn on LED

tone(buzzerPin, 2000); // Activate buzzer at 2000 Hz

Serial.println("Crash detected!");

crashDetected = true;

} else {

digitalWrite(ledPin, LOW); // Turn off LED

noTone(buzzerPin); // Deactivate buzzer

crashDetected = false;

}

// Print sensor values to Serial Monitor for debugging

Serial.print("Force Sensor Value: ");

Serial.print(forceValue);

Serial.print(" | Tilt Sensor State: ");

Serial.println(tiltState);

delay(100); // Delay for debounce and to reduce serial output frequency

}

## Future Changes/Additions

**GPS Module**:

Sends location data to emergency contacts in case of an accident.

**Bluetooth/GSM Module**:

Integrates with smartphones or smart city systems for alerts and data sharing.

**Health Monitoring Sensors**:

Tracks post-crash vitals such as heart rate or body temperature.

**SD Card Module**:

Logs impact data for analysis and future improvement.

**Eco-Friendly Materials**:

Enhance sustainability and align with environmental goals.

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