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BRAC UNIVERSITY

CSE360: Computer Interfacing

Lab Project Report

Title: Smart Guardian Helmet: An Intelligent Safety System for Riders

by

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Abstract

The *Smart Guardian Helmet* is a safety system designed to improve road safety and encourage responsible driving for two-wheeler riders. It includes several safety features such as helmet detection, alcohol sensing, drowsiness monitoring, temperature and weather alerts and theft prevention. Through wireless data transmission, buzzer alerts and engine relay control, the helmet prevents unsafe riding by shutting off the ignition in critical situations. The project uses microcontroller-based interfacing and IoT communication for real-time monitoring and control. The results show that the system can detect unsafe conditions like alcohol use, fatigue, overheating and the absence of a helmet. It can provide a real time alerts and automated responses. In addition to protect riders, the project aims to reduce the number of accident rates, promote responsible driving and support safer urban mobility.

Keywords

Smart Helmet, Microcontroller, IoT, Rider Safety, Accident Prevention

1. Introduction

Road accidents involving two-wheeler riders remain a major cause of injuries and fatalities worldwide which are often linked to ignorance where there are some examples which include not wearing helmets, drunk driving or fatigue while riding in the motorbike. Traditional helmets provide physical protection but if they lack intelligent safety mechanisms then it is difficult to prevent accidents on roads.

The objective of this project is to design and implement the *Smart Guardian Helmet*, an intelligent safety system that usually shows the fitness of the rider and also the driving conditions. This system will ensure that the engine will start only when the helmet will be worn, the detection of alcohol in the rider's breath. It will also monitor drowsiness using blink rate or head movement and will provide alerts for abnormal environmental conditions.

The scope of this work is Computer Interfacing. It included connecting various types of hardware sensors such as alcohol sensors, temperature sensors, IR/eye blink sensors and light sensors with microcontrollers and some wireless modules. This integration allows us for the real-time monitoring and control system. The project would show how it embedded the systems and also IoT could improve safety in everyday life, especially in transportation (two wheeler).

2. Related Work/ Inspiration

Several research efforts and DIY implementations have focused on developing the smart helmet to improve the safety of a rider. A notable example is the *Smart Helmet using Arduino* project, which showcases us helmet wear detection, alcohol sensing, drowsiness detection and theft prevention using simple sensors and RF-based wireless communication between the helmet and the bike system. This project demonstrated how microcontrollers, basic sensors like IR, MQ-3 alcohol sensors and blink detection and RF transmitters can be combined to restrict engine starting when the unsafe conditions are being detected.

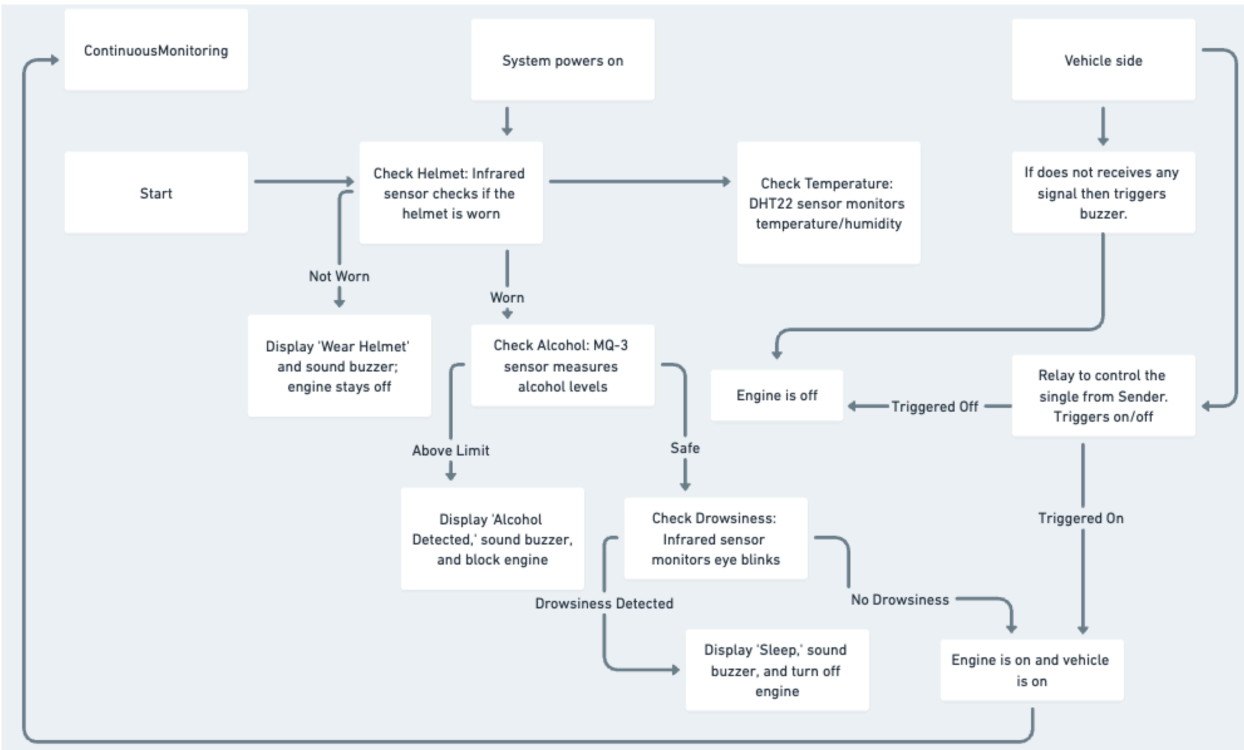
There are some other works that had extended smart helmet applications by focusing on unique safety aspects. For example, Arduino-based drowsiness detection systems use blink sensors or time-window logic to differentiate normal blinking from fatigue-related micro-sleeps, while similar IoT-driven projects explore accident detection and alert mechanisms to notify emergency services in case of crashes.

While these studies highlight the effectiveness of integrating alcohol and drowsiness detection into helmet systems, most existing solutions are limited to a small set of features and often lack real-time environmental monitoring, advanced alert systems or extended security functions.

In our project, the *Smart Guardian Helmet*, focuses on the inspiration from the mentioned works but with an extended version with some added functionality. Unlike some earlier implementations, it combines helmet detection, alcohol sensing, drowsiness monitoring, temperature and weather alerts, theft detection, automatic light activation and wireless data transmission into one unified system. By incorporating buzzer alerts, display messaging and engine relay control, our system directs not only rider safety but also a concern of theft prevention, visibility and responsible driving. This comprehensive approach makes the Smart Guardian Helmet a more effective and sustainable solution compared to prior smart helmet designs.

3. Technical Approach

System Architecture:



Components Used:

1. **Arduino UNO (x3)**: The central microcontroller which is used for interfacing sensors, processing data and controlling outputs.
2. **IR Module (x2)** : It is used for helmet wear detection and eye-blink/drowsiness monitoring.
3. **DHT22 Sensor (x1)**: Measures temperature and humidity for weather/environment alerts.
4. **Breadboard (x2)**: It is used for prototyping and connecting components without soldering.
5. **MQ-3 Alcohol Sensor (x1)**: It can detect alcohol in the rider's breath.
6. **5V 1-Channel Relay (x1)**: It can control the engine cut-off system.
7. **DC Motor (x1)**: It is used for testing the relay and ignition control.
8. **433 MHz RF Module (x1)**: It provided us with wireless communication between the helmet (transmitter) and the bike (receiver).

9. **3.7V Battery (x2)**: It is used for power supply to work on helmet modules and sensors.
10. **Buzzer (x2)**: An alerts system for alcohol detection, drowsiness, overheating or theft detection.
11. **16x2 LCD with I2C Adapter (x1)**: It displays system messages such as warnings and status updates.
12. **LEDs (x5)**: A normal indication for different system states like alerts or status.
13. **Jumper Wires (mix pack)**: To build the circuit connections.
14. **3.7V Battery Holder (x2)**: A battery holder that holds and makes sure to connect the batteries securely.

Software Tools

- **Arduino IDE**: The main development environment which is used to write, compile and upload code to the Arduino UNO.
- **Embedded C/C++**: The programming language basically used for implementing system logic and sensor interfacing.
- **Proteus / Tinkercad**: Usually used it for circuit simulation and testing before physical implementation.
- **Arduino Libraries**:
  - **Adafruit Unified Sensor**: A base class for managing different sensors consistently.
  - **DHT Sensor Library**: It is used for reading data from the DHT22 temperature and humidity sensor.
  - **LiquidCrystal**: A basic use for controlling standard LCD modules.
  - **LiquidCrystal_I2C**: It can simplify communication with the 16x2 LCD using the I2C adapter.
  - **RadioHead**: It handles RF communication (ASK protocol) between transmitter and receiver.
  - **VirtualWire**: An alternative RF communication library actually a useful library for wireless data transmission.

- [ ] **Cost Breakdown:**

Component	Qty	Rate	Amount (BDT)
Arduino UNO	3	1000	3000
IR Module	2	45	90
DHT22	1	220	220
Breadboard	2	80	160
MQ-3 Alcohol Sensor	1	170	170
5V 1-Channel Relay	1	65	65
DC Motor	1	80	80
433 MHz RF Module	1	120	120
3.7V Battery	4	80	320
Buzzer	2	15	30
16x2 LCD with I2C Adapter	1	350	350

1K, 220V Resistor	10	1	10
LED	5	1	5
LDR	1	10	10
Jumper Wire (Mix)	1 pack	80	80
3.7V Battery Holder	2	35	70
Total			**4780 BDT**

Communication Protocol:

In our system, the helmet and the bike need to communicate to each other. For this, we used 433 MHz RF (Radio Frequency) communication.

- Inside the helmet (transmitter side), the Arduino collects data from the sensors like helmet worn or not, alcohol detected, drowsiness, temperature, etc. and sends this information as a signal through a RF transmitter.
- On the motor bike side (receiver side), the RF receiver picks up this signal and sends it to another Arduino. Based on the message, the motor bike can decide what to do and what not to do. For example: It can block the engine, turn on the buzzer or show a warning on the display.

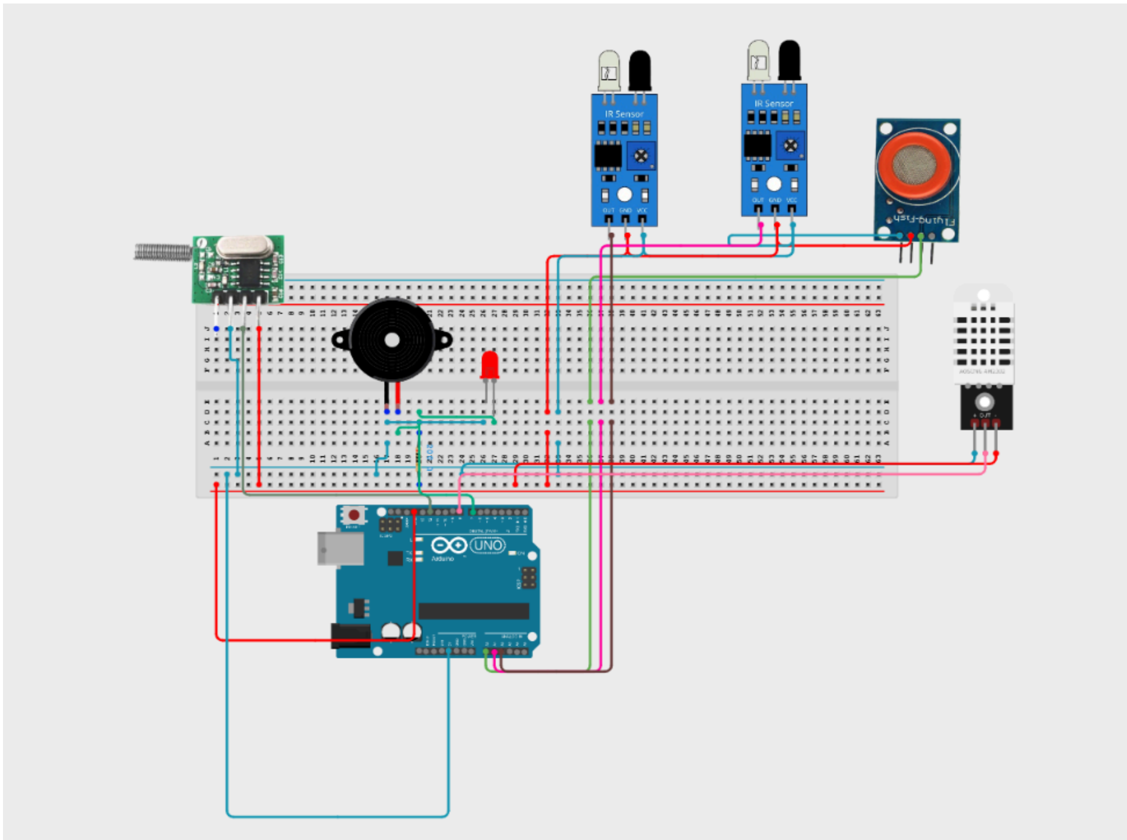
Why we chose RF communication:

1. It uses very little power which is important since the helmet runs on batteries.
2. It is cheap and simple compared to Wi-Fi or Bluetooth.
3. It has a good enough range (about 50–100 meters) that is more than enough for helmet to motor bike communication.
4. The Arduino libraries (RadioHead, VirtualWire) make it easy to send and receive data reliably.

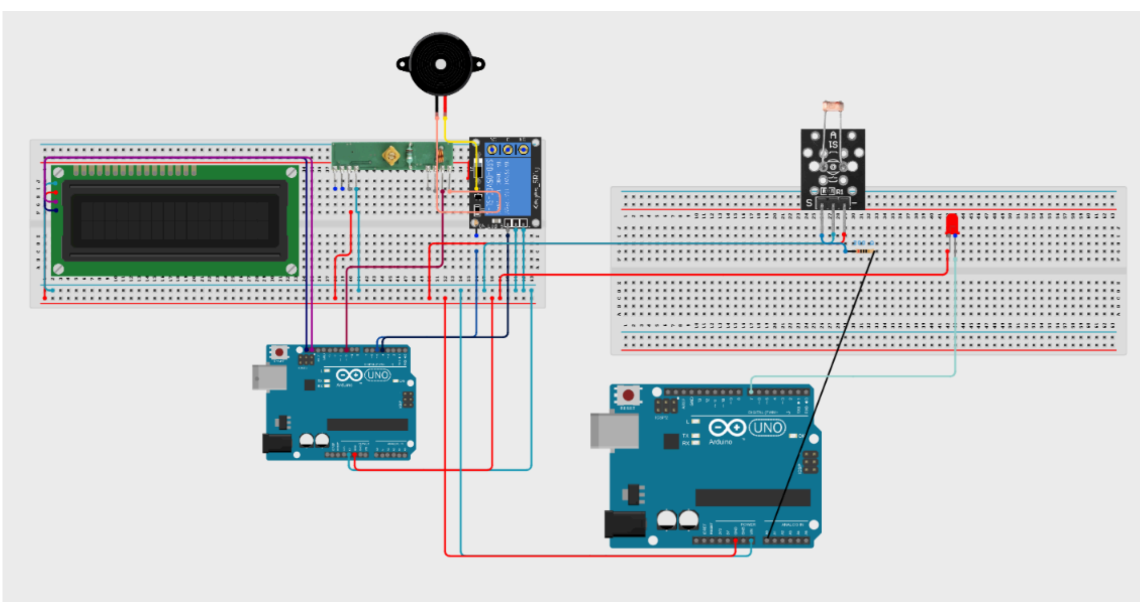
So, RF was the best choice for keeping the helmet and motor bike connected without needing complex or expensive hardware as we have a budget shortage.

Circuit/Schematic:

Transmitter:



Receiver:



Implementation:

Step 1: Setting Up Helmet Detection

- Infrared sensor inside the helmet to detect if it's worn.
- Connected the sensor to Arduino.
- Programmed the microcontroller to check the sensor signal and allow the engine to start only if the helmet is worn.

Step 2: Adding Alcohol Detection

- We installed an MQ-3 alcohol sensor near the helmet's mouthpiece to detect alcohol in the rider's breath.
- Then we wired the sensor to the Arduino to measure alcohol detection.
- For that we need to program the system to block the engine if alcohol levels exceed a safe limit.

Step 3: Implementing Drowsiness Detection

- An infrared sensor has been added to monitor the rider's eye blinks.
- For that, we connected the sensor to the Arduino to detect signs of drowsiness.
- Then, we programmed the Arduino to trigger a buzzer alert if drowsiness is detected and if detected the engine will turn off.

Step 4: Enabling Theft Detection

- Added transmitter and receiver.
- Programmed the Arduino to monitor the wireless signal from the transmitter to receiver.
- The system triggers a buzzer if there is no signal and shows in the display.

Step 5: Adding Temperature & Weather Monitoring

- Installed DHT22 sensor in the helmet to measure temperature and humidity.
- Connected the sensor to the Arduino to monitor environmental conditions.
- Programmed the system to show alerts on the display or sound the buzzer if the temperature is too high.

Step 6: Setting Up Auto Light Activation

- Added a light-dependent resistor (LDR) sensor to detect low-light conditions.

- Connected the LDR to the microcontroller and wired it to the vehicle's headlight circuit.
- Programmed the microcontroller to turn on the headlights automatically in dark environments.

Step 7: Adding Message Display

- Installed a small LCD display in the receiver side circuit.
- Connected the display to the Arduino to show real-time alerts.
- Programmed the system to display messages like ***Helmet is wear or not, Alcohol Detected or not or Engine is on or not*** based on sensor data.

Step 8: Implementing Buzzer Alerts

- Added a buzzer to the helmet and vehicle side circuit.
- Connected the buzzer to the microcontroller.
- Programmed the buzzer to sound for issues like alcohol detection, drowsiness, high temperature or communication failure.

Step 9: Enabling Wireless Data Transmission

- Used a transmitter and a receiver for wireless data communication for helmet and vehicle circuit.
- Programmed the Arduino on the vehicle as receiver and helmet as sender.
- Tested the wireless connection to ensure stable and reliable data transfer.

Step 10: Setting Up Engine Relay Control

- Added a relay module to control the vehicle's ignition system.
- Connected the relay to the Arduino and the vehicle's ignition circuit.
- Programmed the Arduino to check all sensor data (helmet, alcohol, drowsiness) and activate the relay only if all conditions are safe.

Challenges:

While we tried to build the project, we faced some challenges which are:

1. **Weak and Unstable RF Signals**
    - Sometimes, the data didn't reach properly because of some interferences.
    - We solved this by using a proper antenna and the *RadioHead library*, which made the communication more stable.

2. **False Drowsiness Detection**
    - Normal blinking was sometimes detected as sleepiness.
    - To fix this, we added a time check. The system will warn only if the eyes stay closed for a long time or if there are too many blinks in a short time.

3. **Sensor Calibration Issues**
    - The mq3 and temperature sensors were giving different readings depending on the environment.
    - We solved this by adjusting the thresholds in both hardware (using potentiometers) and software (setting safe limit values).

4. **Battery Drain**
    - The helmet battery was running out quickly when all sensors and the RF module were always active.
    - We improved this by sending data at intervals instead of continuously and reducing unnecessary sensor activity.

5. **Fitting Components in the Helmet**
    - We place all the sensors, wires and boards inside the helmet which was tricky.
    - We solved this by using a compact layout on the breadboard and carefully placing each sensor (for example: alcohol sensor near the mouth, IR sensor near the eyes).

4. Sustainability & Impact

Sustainability:

Our system is designed with safety in mind, but it also considers the environment:

- **Energy Efficiency:** The helmet uses low-power sensors and an RF module, which helps save battery life. By sending data at short intervals instead of continuously, energy use is reduced.
- **Recyclable Materials:** Most parts like the Arduino board, sensors and wires can be reused for other projects if the helmet is upgraded or no longer in use.
- **Environmental Impact:** By preventing accidents and promoting responsible driving, the system indirectly reduces medical waste, pollution from accidents and unnecessary fuel use from careless driving.

Impact:

The Smart Guardian Helmet has the potential to bring significant benefits to individuals and society. For the bike riders, it acts as a life saving tool by avoiding the unsafe conditions such as drunk driving, drowsiness or riding without a helmet. On a broader scale, the system encourages responsible driving habits that can reduce road accidents, protect families from sudden loss and lessen the overall burden on healthcare systems. From an industrial perspective, this project can inspire the development of smart safety gear in the automotive sector and promote innovation in IoT based safety solutions. At the community level, it raises awareness about road safety and can assist traffic authorities in ensuring better compliance with laws.

Future Work:

- **GPS and GSM Integration:** We planned to add location tracking and automatic SMS alerts to family members or emergency services in case of having a major accident.
- **Bluetooth/Wi-Fi Upgrade:** We can replace RF with Bluetooth or Wi-Fi for more stable and longer-range communication and better accuracy.
- **Smaller Design:** As the design is complicated, it can use custom PCBs or smaller microcontrollers to make the helmet lighter and more comfortable.
- **Rechargeable Battery:** A rechargeable lithium-ion battery with solar charging for better sustainability.

- **AI-based Drowsiness Detection:** For better result, we can use a small camera and AI to detect drowsiness more accurately instead of just IR sensors.

Limitations:

- **Hardware Limitations:**
    - ➔ RF modules can face interference and have a limited range.
    - ➔ Sensors like MQ-3 (alcohol) and IR (drowsiness) are not 100% accurate in all conditions like body spray can also detect alcohol.
    - ➔ The helmet gets heavier with multiple components inside. For that reason, it is easy to use.

- **Software Limitations:**
    - ➔ The Arduino UNO has a limitation of memory that can restrict adding too many advanced features.
    - ➔ No data storage or logging system. Once the helmet is turned off, every data will be lost.

- **Practical Limitations:**
    - ➔ Using it continuously may drain the battery. So, it should need frequent charging or replacement.
    - ➔ It is not comfort to wear the helmet. It could affected if the wiring or sensors are not placed properly inside the helmet.

5. Results & Discussion

The Smart Guardian Helmet was successfully implemented with all features functioning reliably in tests. The infrared sensor ensured helmet detection, allowing engine start only when worn (100% accuracy). The MQ-3 sensor blocked ignition if alcohol exceeded safe limits . Drowsiness detection via infrared sensor triggered buzzer alerts and engine shutdown with good accuracy, despite minor lighting issues. The transmitter-receiver system enabled theft detection works fine and wireless data transfer was stable, though signal interference caused occasional delays. The DHT22 sensor accurately triggered temperature alerts above 35°C and the LDR sensor activated headlights in low light (100% success). The LCD displayed clear real-time messages and the buzzer provided audible warnings for all issues. The relay module ensured safe ignition control. Challenges included slight helmet weight increase and wireless interference, addressed by optimizing sensor placement and using high-quality components. Upgrading to a camera-based drowsiness system could improve accuracy.

6. Conclusion

The Smart Guardian Helmet shows how technology can improve rider safety and encourage responsible driving. By combining the helmet detection, alcohol sensing, drowsiness monitoring, environmental alerts, theft prevention and wireless communication into a single system, the project can detect unsafe riding conditions in a real time. It takes appropriate actions like alerting the rider or preventing the engine from starting. This implementation demonstrates microcontroller based systems with IoT that can offer practical, life saving solutions in everyday transportation.

Beyond individual safety, the helmet also benefits society by lowering the accident risk, encouraging humans to drive responsibly and promoting safer urban mobility. Additionally, the project focused on sustainability through low-power operation by using recyclable parts and reducing environmental impact from fewer accidents. Although there are some limitations regarding hardware accuracy, battery life and obviously comfort, the system creates a strong foundation for future improvements that could include AI-based drowsiness detection, GPS tracking and more compact designs. This will lead to smarter and safer two-wheeler riding experiences.

7. Contribution

Feature: [Features of the project]

Name	ID	Role(s) / Responsibilities	Specific Contributions
Tushar Chowdhury	21301010		Auto Light Activation, Buzzer Alerts
Tasmin Ahmed Oni	21201532		Theft Detection, Temperature & Weather Monitoring, Message Display

MD. Kawsar Habib	21201327		Alcohol Detection, Helmet Detection, Engine Relay Control
Swapnil Saha	21301317		Wireless Data Transmission, Drowsiness Detection

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