L&T EduTech
Electronics and Communication Engineering

Course Title: Industrial Applications of Microcontrollers – A Practice Based Approach

By:

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Development of a Drowsiness Detection System

I. Problem Statement:

Develop a simple Microcontroller based system that can detect the drowsiness of drivers and can alert the driver.

II. Objectives:

- To develop a simple yet effective system to detect drowsiness of vehicle drivers and alert them.
- To explore the use of Microcontrollers and apply skills learned through the course.
- To analyze the working of the circuit and its effectiveness and propose improvements.

III. Scope of the Solution:

Drowsiness while driving is a significant contributor to road accidents worldwide. According to the World Health Organization (WHO) and various traffic safety studies, driver fatigue is responsible for an estimated 10–20% of serious road accidents globally. In India alone, government data suggests that thousands of accidents each year are attributed to driver inattention or sleep-related fatigue, particularly on highways and during night-time travel.

This project aims to address this issue by developing a low-cost, non-intrusive drowsiness detection system using an infrared (IR) reflective sensor mounted on wearable goggles. The system monitors eye closure duration and triggers an alert when signs of drowsiness are detected, providing a timely warning to prevent potential accidents.

The solution is designed to be simple, portable, and cost-effective, making it suitable for personal vehicles, commercial transport drivers, and industrial machine operators. While the current implementation focuses on detecting prolonged eye closure, the system serves as a foundational platform for future enhancements, such as integrating additional sensors (e.g., accelerometers or heart rate monitors), IoT connectivity, and cloud-based logging for broader safety applications.

By offering a practical and accessible approach to fatigue monitoring, this project contributes toward improving road safety and reducing the risk of accidents caused by drowsy driving.

IV. Components:

For the software Simulation and PCB Construction the following software has been used:

1. TinkerCAD
2. Arduino IDE
3. KiCAD
4. GitHub

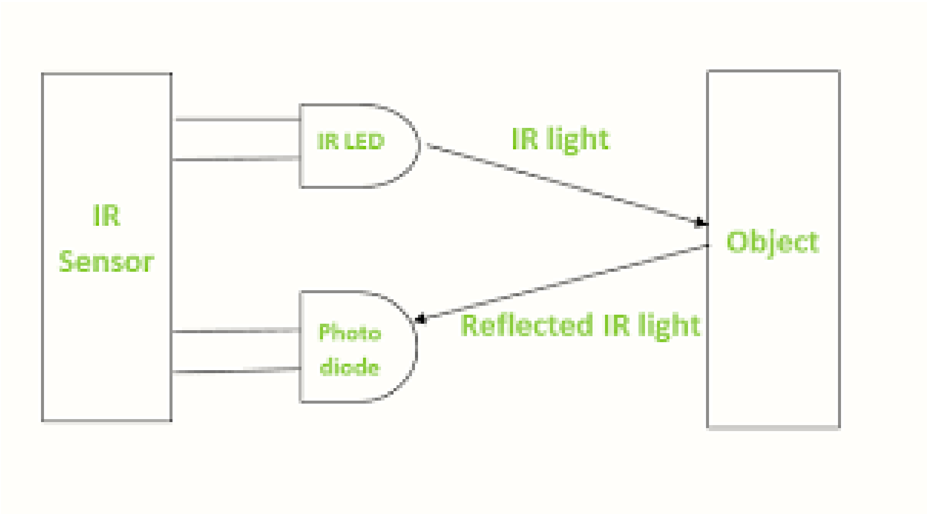
Given below is the list of components for the Hardware Construction:

Name	Quantity
Arduino UNO	1
Jumper Wires	As needed
Buzzer	1
Breadboard	1
IR Reflective Module	1
USB Cable for Arduino	1

V. Working Principle

The given model is dependant on its principal component—the IR reflective sensor module. The IR module consists of three main components: the IR transmitter, IR receiver and a potentiometer.

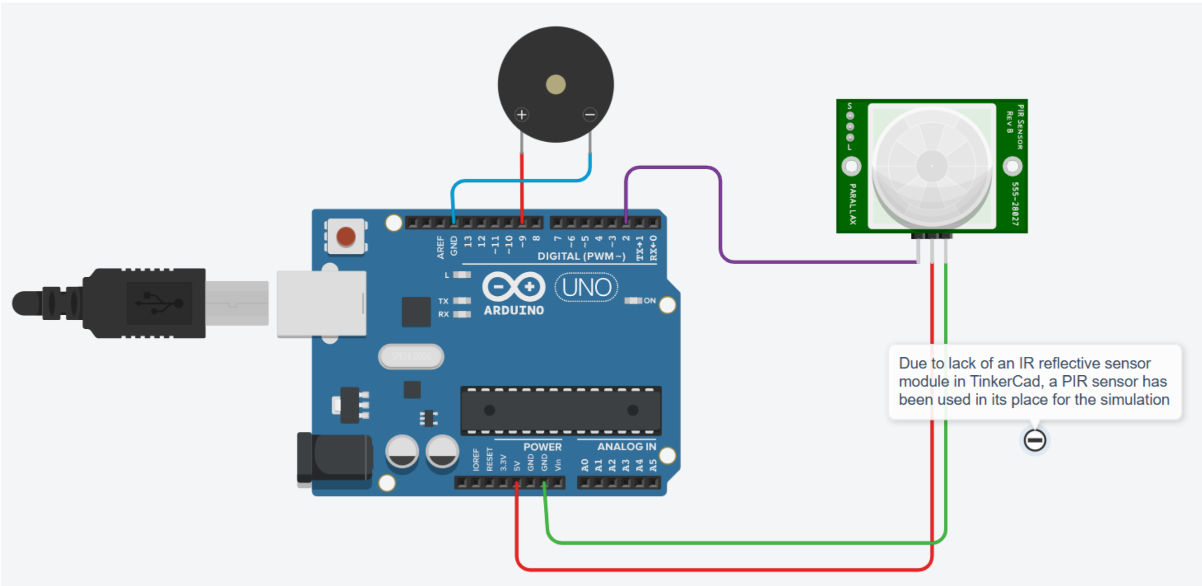
The IR transmitter, here an IR LED, is the source of the infrared radiation. The rays when encountering an object bounce off the surface and reflect back into the receiver. The receiver is a photodiode whose output voltage drops significantly. When the photodiode receives more incident infrared radiation, a larger voltage drop occurs across the series resistor or potentiometer. This voltage is then compared to a preset reference voltage using a comparator IC, typically an operational amplifier (Op-Amp). If the voltage across the resistor exceeds the reference voltage, the comparator outputs a HIGH signal; otherwise, it outputs LOW. The comparator's output is connected to an LED, which lights up when the sensor detects an event such as an eye blink. The threshold for detection can be adjusted by tuning the potentiometer based on surrounding light conditions.



VI. Circuit Diagram:

Refer to the link for the TinkerCAD solution:

https://www.tinkercad.com/things/47WQ6e7rxhx-drowsiness-detection-system?sharecode=fSKRRlgVJWJmdlS2SvWRT7haaBz6NRdKL9mxJ_Fmktg



VII. Code:

Given below is the code fed to the Arduino IDE:

```
// C++ code

//

int irPin = 2;        // IR output connected here

int buzzerPin = 9;

unsigned long lastOpen = 0;
```

```
unsigned long threshold = 4000;


void setup() {
  pinMode(irPin, INPUT);
  pinMode(buzzerPin, OUTPUT);
  Serial.begin(9600);
}


void loop() {
  int eyeStatus = digitalRead(irPin); // HIGH = eye open, LOW = eye closed (adjust as needed)


  if ((eyeStatus == HIGH)) {
    lastOpen = millis();
    digitalWrite(buzzerPin, LOW);
  } else {
    if ((millis() - lastOpen > threshold)) {
      digitalWrite(buzzerPin, HIGH); // Drowsy detected
      Serial.println("Alert!!!!!!!!!!!!!!!!!");
    }
  }


  delay(100);
}
```

VIII. Results:

The drowsiness detection system, utilizing an IR reflective sensor mounted on wearable goggles, effectively detected prolonged eye closure and triggered timely alerts via a buzzer. It consistently identified closures exceeding the 3-second threshold during testing. The inclusion of a potentiometer allowed for easy calibration of sensor sensitivity based on individual user characteristics and environmental conditions.

The system performed reliably in controlled indoor settings, though its accuracy was affected in high ambient light environments, highlighting the IR sensor's sensitivity to external interference. Proper sensor alignment and positioning were also essential for consistent detection.

Overall, the prototype demonstrated that a simple, low-cost IR-based solution can provide effective basic drowsiness detection without relying on complex image processing. The results support its potential use in driver safety applications and as a foundation for further development in wearable fatigue-monitoring systems.

GitHub link to project:

https://github.com/AnantaJ/CourseProject.git

IX. Limitations:

During the development of this project, several limitations were noticed that might impact the accuracy or the efficiency of the system.

Sensitivity to Ambient Light

The performance of the IR sensor can be adversely affected by external lighting conditions, particularly in environments with direct sunlight or reflective surfaces. Such interference may result in inaccurate readings or false triggers.

Clunky and Bulky Hardware

As the sensor is integrated with the Arduino and the buzzer through wires, the setup is awkward and large in usage and lacks a stable mount in front of the eyes. It does not lend to a seamless user experience.

Limited Detection Scope

The system is designed to detect only prolonged eye closure and cannot identify more subtle indicators of drowsiness, such as yawning, head drooping, or lowered pulse beats. This limits its ability to provide comprehensive fatigue monitoring.

Potential Distraction

The setup impedes the user's vision in one eye and may increase the risk of rash driving and collisions unless the model setup can be reduced significantly in size.

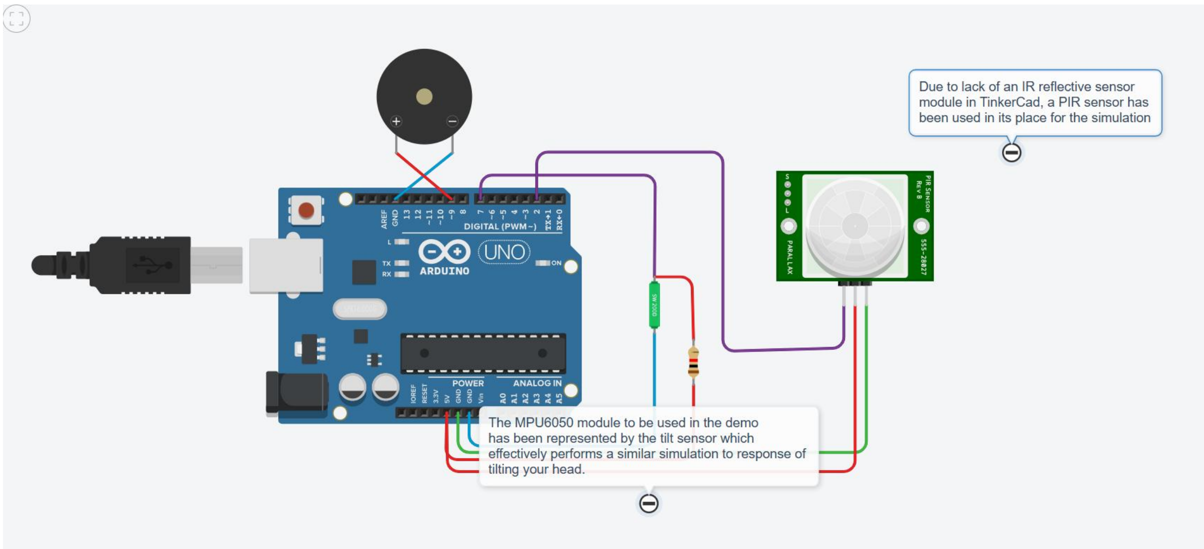
Some of these issues can be solved easily through a wearable eye blinking sensor available on the market. The goggles provide a stable setup and is calibrated to detect eye blinks specifically therefore guaranteeing a cleaner output.

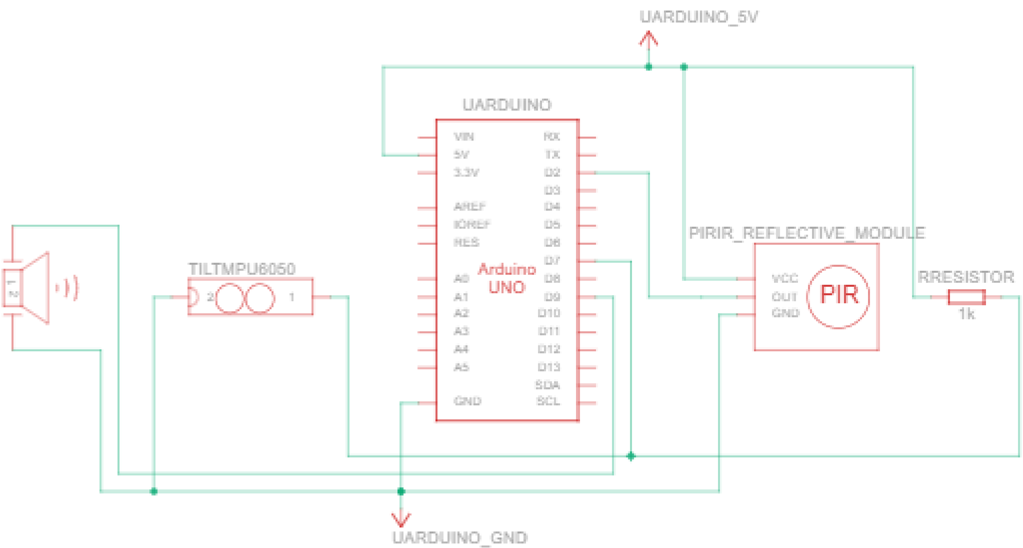
X. Future Improvements:

For further improvements, an accelerometer and an EEG sensor can be connected in addition to the IR module to increase the detection scope of the system. Head drooping and dropped pulse rates are effective measures of exhaustion and together will provide more accurate data. Furthermore, a microcontroller with wifi or Bluetooth capabilities should be used to eliminate the need for wires cluttering the steup.

Below, a potential circuit design including an MPU6050 module has been attached with further schematics to illustrate the direction in which the project can be taken forward.

https://www.tinkercad.com/things/4KiIlc1KBTL-drowsiness-detection-system-ananta-jaiswal?sharecode=xetOnkl0Z6hWIdxdmXpu6OEgCrRIX-h4eUjUfjOalGQ





Proposed code with the implementation of the MPU6050 module.

```
#include <Wire.h>

#include <MPU6050.h>


MPU6050 accelgyro;


int blinkPin = 2;      // IR sensor

int buzzerPin = 9;


unsigned long lastEyeOpen = 0;

unsigned long eyeThreshold = 3000; // 3 seconds
```

```
bool drowsyDetected = false;

void setup() {
  pinMode(blinkPin, INPUT);
  pinMode(buzzerPin, OUTPUT);
  Serial.begin(9600);

  Wire.begin();
  accelgyro.initialize();

  if (!accelgyro.testConnection()) {
    Serial.println("MPU6050 connection failed!");
    while (1);
  }
}

void loop() {
  int eyeState = digitalRead(blinkPin); // HIGH = open, LOW = closed
  int16_t ax, ay, az;
  accelgyro.getAcceleration(&ax, &ay, &az);

  bool headTilted = (ay < 12000); // Threshold: adjust if needed

  // Eye logic
  if (eyeState == HIGH) {
    lastEyeOpen = millis();
    drowsyDetected = false;
    digitalWrite(buzzerPin, LOW);
  } else {
    if ((millis() - lastEyeOpen > eyeThreshold) && headTilted) {
      drowsyDetected = true;
      digitalWrite(buzzerPin, HIGH);
    } else {
      digitalWrite(buzzerPin, LOW);
```

```
    }
  }

  // Debug info
  Serial.print("Eye: ");
  Serial.print(eyeState == HIGH ? "Open" : "Closed");
  Serial.print(" | Y-Axis: ");
  Serial.println(ay);

  delay(200);
}
```

XI. Conclusion:

The objective of this model has been successfully achieved through a combination of simulation and demo. The proposed model is a simple cost effective measure to reduce accidents on the road due to the driver’s inattention. The limitations and scope of this project have been clearly analyzed and further improvements have been outlined. Therefore, this project is a viable drowsiness detection system.