Human Trust in Automation / Human Robot Interaction

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Abstract

This lab focuses on developing and implementing a portable and embedded pre-warning system to enhance user awareness and safety through multi-modal feedback mechanisms. The system combines visual, auditory, and haptic signals to provide timely warnings in scenarios such as a car approaching a pedestrian or an object rapidly nearing a vehicle. Visual feedback is delivered through an LED display, auditory warnings via a speaker. The compact design ensures ease of use and mobility, making the device suitable for various applications, including car dashboards and bicycles.

Tools Used:

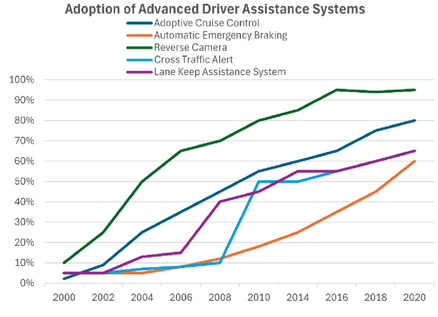
Solidworks, 3d printing, C++, Arduino

Background

According to a study released by the National Highway Traffic Safety Administration (NHTSA), 80% of collisions involve some form of driver distraction. In order to combat this, we've designed a cyclist proactive feedback system, and a car interior pre-warning system, in order to alert the driver to potential hazards.

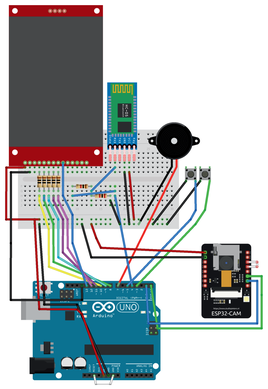
Why enhancing driver awareness and response time is crucial for safety?

- Reducing Reaction Time
- Minimizing Human Error
- Enhanced Situational Awareness
- Supporting Safe Driving Practices
- Mitigating the Severity of Accidents
- Adapting to Environmental Conditions



Jeffs, Dr James. "A History of Adas: Emergence to Essential." IDTechEx, IDTechEx, 4 Jan. 2022, www.idtechex.com/en/research-article/a-history-of-adas-emergence-to-essential/25592.

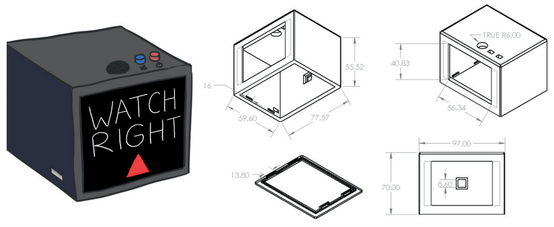
Cyclist Proactive Feedback System



Components

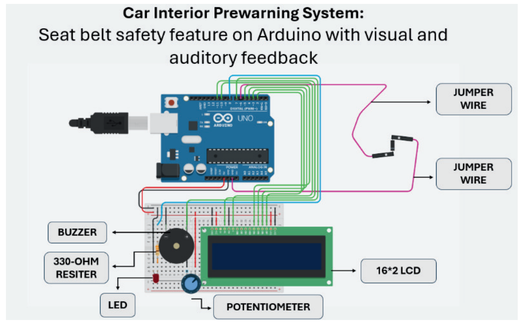
- Arduino Uno
- ESP-32 Camera
- HC-05 Bluetooth Module
- 1 Red, 1 Blue button
- 2.8" SPI TFT LCD Screen
- Piezo Buzzer
- 10Ω, 2kΩ, 1kΩ Resistors

The box design includes a screen for visual feedback, a buzzer for auditory feedback, buttons for Bluetooth and power, a camera to capture footage, and a mini-USB port for power. The box is composed of two pieces—the top and bottom covers—connected via snap-fit joints, which reduce production costs and simplify mass production. The early conceptual design is shown at the bottom left, while the final design, completed in SolidWorks and ready for printing, is shown at the bottom right.



Car Interior Pre-Warning System

According to the National Highway Traffic Safety Administration (NHTSA), having both seat belts and airbags can reduce the chance of death from a head-on collision by 61%. That's a big reduction, but there's still plenty of room left on the table for further improvements.

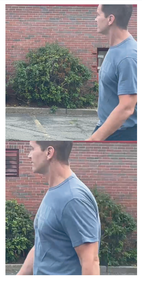


The function monitors the seat belt status with multiple feedback based on whether the seat belt is connected or disconnected.

```
void loop() {
  int seatBeltStatus = digitalRead(seatBeltPin); // Read the seat belt status

  if (seatBeltStatus == HIGH) { // If seat belt is disconnected
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Warning!!!");
    lcd.setCursor(0, 1);
    lcd.print("Fasten Seatbelt!");

    digitalWrite(ledPin, HIGH);  // Turn on the LED
    tone(buzzerPin, 1000);          // Play a 1kHz tone on the buzzer
  }
  else { // If seat belt is connected
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Good to go");
    lcd.setCursor(0, 1);
    lcd.print("Safe trip!");

    digitalWrite(ledPin, LOW);   // Turn off the LED
    noTone(buzzerPin);              // Turn off the buzzer
  }

  delay(100); // Short delay for debounce
```

Hazard Detection Feedback System

Step 1



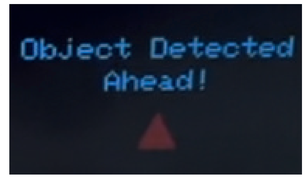
Capture the current and previous frames.

Step 2

```
binary difference of two images. Assumes each image is a 3d array of a width, height
d 3 color channels
uble binary_difference(unsigned char *** img1, unsigned char *** img2,
t width1, int height1, int width2, int height2) {
 double total = width1 * height1;
 double different = 0;
 if (width1 == width2 && height1 == height2) {
   for (int x = 0; x < width1; x++) {
     for (int y = 0; y < height1; y++) {
       bool same = true;
       for (int c = 0; c < 3; c++) {
         if (img1[x][y][c] != img2[x][y][c]) {
           same = false;
           break;
         }
       }
       if (!same) {
         different ++;
       }
     }
   }
 }
return different/total;
```

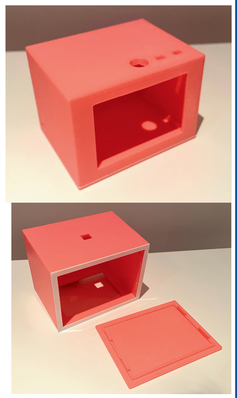
Calculate the difference between the two images as a percentage, giving more importance to differences in the center of the screen than to those on the sides.

Step 3



If the percentage is high, send both a visual and auditory alert to make the driver aware of the situation and help prevent a collision.

Cyclist Proactive Feedback System Results

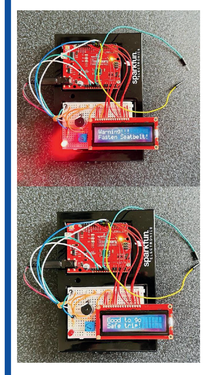


This Arduino-based proactive feedback system is both accessible and portable, with a production cost of $200. The device can be attached to the front of the vehicle or placed on the dashboard, making it versatile and multipurpose. Its ease of installation and use makes it an ideal choice for enhancing vehicle safety.

Next Steps:

- Analyze the success rate of the product based on trial runs.
- Use into gained from product testing to improve first prototype.
- Refine the Hazard Detection Feedback system to be more accurate.

Car Interior Pre-warning System Results



This Arduino-based seat belt monitoring system is a practical and cost-effective solution to enhance vehicle safety. By providing immediate and clear alerts, it encourages consistent seat belt use, thereby reducing the risk of injury in the event of an accident.

Next Steps:

- The system accurately detects and displays seat belt status.
- Visual and auditory alerts effectively notify the user when the seat belt is unfastened.
- Feedback mechanisms are clear and prompt, improving the likelihood of seat belt usage.

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Zhu, W., Kucyi, A., Kramer, A. F., & Lin, Y. (2022, November). Multimodal physiological assessment of the task-related attentional states in a vr driving environment. In 2022 28th International Conference on Mechatronics and Machine Vision in Practice (M2VIP) (pp. 1-5). IEEE.
Liang, B., & Lin, Y. (2018). Using physiological and behavioral measurements in a picture-based road hazard perception experiment to classify risky and safe drivers. Transportation research part F: traffic psychology and behaviour, 58, 93-105.
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