ME2400

Project Report

Submitted by Group 8

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Introduction

While on the road, a driver has to keep track of other vehicles and obstacles, that keep changing position relative to her/his vehicle, in order to ensure safety from mishaps and traffic. Several devices are employed in a vehicle to assist the driver in this process. These include the side mirrors (ORVMs), the IRVM (except in two-wheelers), reverse-parking sensor and camera. With the help of these devices, a driver can generally observe and judge the situation s/he is in, and can accordingly react. But this generality is lost because of a limitation, called blind spot.

A blind spot is a region that is not easily observable by the driver while maintaining her/his normal driving posture, neither by her/his eyes nor by the vision-assist devices mentioned above. Considering this obscure nature of the blind spots and their obstacles within them, blind spots are a major safety concern for drivers. More so, they are the sole reason for at least 5 per cent of all road accidents worldwide, and are indirectly attributed for many more. While an awareness about the existence of and danger pertaining to blind spots has been around for a few decades, even today many cars don't have proper mechanisms to mitigate this danger. While ADAS (Advanced Driver-Assistance System) is a necessity in the current traffic conditions, still over 50 per cent of cars in India today don't even have it yet. Blind spot monitoring system is a far cry, and is considered a feature exclusive to high-end cars like the MG Gloster and recently, the Toyota Innova Hycross. The reasons for this negligence of safety among the car manufacturers and the consumers in India are many, but the most prominent one is the cost-cutting mindset, which is why ADAS is not provided in most of the cars under 20 Lacs INR.

As the number of deaths reported in road accidents are on the rise owing to very good road infrastructure coming up throughout the world, the need for cost-effective safety solutions, particularly a blind spot monitoring system is rising. This project aims to develop a vehicle blind-spot detection system using an ATmega328P microcontroller, an ultrasonic sensor (HC-SR04), 16x2 LCD screen, I2C module, a servo motor and an LED strip to provide an alert to drivers when a vehicle enters their blind spot.

Aim and Objective

The objective of this project is to design and build a prototype blind-spot detection system using readily available components. The system will:

- Utilize an ultrasonic sensor fixed atop a servo motor to detect objects within a designated blind-spot zone.
- Process the sensor data using an UNO R3 microcontroller device to determine object distance.
- Provide a visual alert (LED illumination) based on object proximity.
- Display the distance to obstacle on an LCD screen.

Methodology

System Overview

The proposed blind-spot detection system operates by continuously scanning a designated area from the contour of the left ORVM to the left rear of the vehicle, using an ultrasonic sensor mounted on a servo motor, sweeping an angle of 80 degrees at frequent intervals. The sensor transmits ultrasonic pulses and measures the time it takes for the reflected sound wave to return. This time is used to calculate the distance of any object within the sensor's range. The Arduino calculates and processes the distance data on a metric scale, and controls an LED strip to provide a visual alert based on the object's proximity.

When obstacle distance

1. D > 30cm, the red LED strip will be OFF.
2. 15cm < D < 30cm, the red LED strip will blink, and the frequency will increase as the obstacle moves closer to the vehicle and vice-versa.
3. D < 15cm, the red LED will become ON and will stay ON as long as the obstacle is closer than 15 cm to the vehicle.

An LCD screen displays the measured distance for debugging purposes.

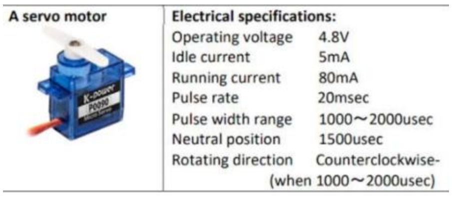
Sensors:

- HC-SR04 Ultrasonic Sensor:
  - Operating Voltage: 5V
  - Range: 2cm - 400cm
  - Operating Current: 15mA
  - Working Frequency: 40kHz

Actuators:

- LED Strip:
  - Operating Voltage: 12V
  - Operating Temperature: -25 - 60°C

- Servo Motor:
  - Operating Voltage: 4.8V – 6V
  - Torque: 1.6 kg cm at 4.8V
  - Speed: 0.12 seconds per 60 degrees at 4.8V
  - Operating Temperature: -30 – 60°C



Microcontroller:

- Generic UNO (based on Arduino Uno):
  - Operating Voltage: 5V
  - Input Voltage (recommended): 7-12V
  - Digital I/O Pins: 14 (of which 6 provide PWM output)
  - Analog Input Pins: 6

- **Control Block Diagram:**

```
+---------------+
|   Sensor   |
| (HC-SR04) |
+---------------+

       |
       v

+---------------+
|  Arduino   |
|     Uno      |
+---------------+

       |
       v

+---------------+
|      LED      |
|     Strip     |
+---------------+

       |
       v

+--------------+
|     LCD      |
|   Display   |
+--------------+
```

- **Data Acquisition System Block Diagram:**

```
+---------------+              +---------------+
|   Sensor   |  --------->  |  Arduino  |
| (HC-SR04) |  --------->  |     Uno     |
+---------------+              +---------------+

       |                              |
       v                              v

 Trigger Signal              Control Signal

       |                              v
       v                       +------------+
+-------------+                |   LED    |
| Arduino  |                |  Strip   |
|   Uno     |                +------------+
+-------------+

       |
       v

+------------+
|   LCD    |
| Display |
+------------+
```

- **Signal Conditioning**

The HC-SR04 sensor provides a digital pulse with a width proportional to the round-trip travel time of the ultrasonic wave. The Arduino program directly measures this pulse width using the pulseIn function.

- **A/D and D/A Converters**

This system does not require any Analog-to-Digital (A/D) or Digital-to-Analog (D/A) converters. The HC-SR04 sensor provides a digital output, and the LED strip can be controlled directly using digital signals from the Arduino.

Programming

- **Program Flowchart:**

The program follows this basic flow:

1. Initialize variables and components (pins, LCD, servo)
2. Continuously rotate the servo motor to scan the designated blind-spot area
3. Trigger the ultrasonic sensor and measure the echo pulse width
4. Calculate the object distance based on the pulse width
5. Display the distance on the LCD screen (for debugging)
6. Control the LED strip based on the object distance:
    - Turn off LED if object is beyond a safe distance threshold
    - Turn on LED to a dark red color if object is very close
    - Blink the LED at a faster rate as the object gets closer (within a medium distance range)

- **Libraries:**
    - Servo.h: Controls the servo motor
    - LiquidCrystal_I2C.h: Provides functions to control alphanumerical Liquid Crystal Displays (LCDs) connected to an Arduino board
    - Wire.h: Allows us to communicate with devices using the Inter-Integrated Circuit (I2C) communication protocol

- **Code:**
    - The code is available in the GitHub repository of Aadityanshu Abhinav ME22B088, a member of the group.

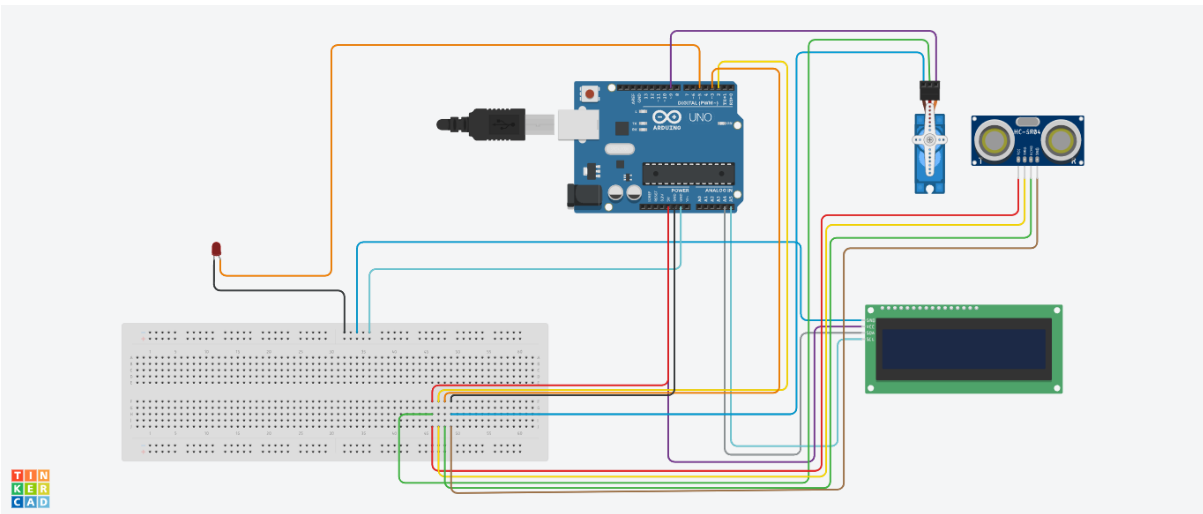
- **Logic Diagram:**

```
Object Detected (distance != 0)?
                |
               Yes
                |
     Distance > MAX_DISTANCE?
               / \
              /   \
           Yes     No
           /       / \
          /       /   \
  Turn off LED   /     \
                /       \
               /         \
        Blink LED     Set LED to
        (based on     Dark Red
        distance)
            |
            v
          Delay
```

Testing and Demonstration of Working Model

1. Hardware Setup:

- The ultrasonic sensor was fixed on top of a servo and it was ensured that it swept 80 degrees from the contour parallel to the first row till the rear of the vehicle on the left side, when placed near the left ORVM, considering that India follows a right-hand drive system.
- It was ensured that the servo rotates freely with the sensor on top.
- It was ensured that the LEDs glow and dim as desired

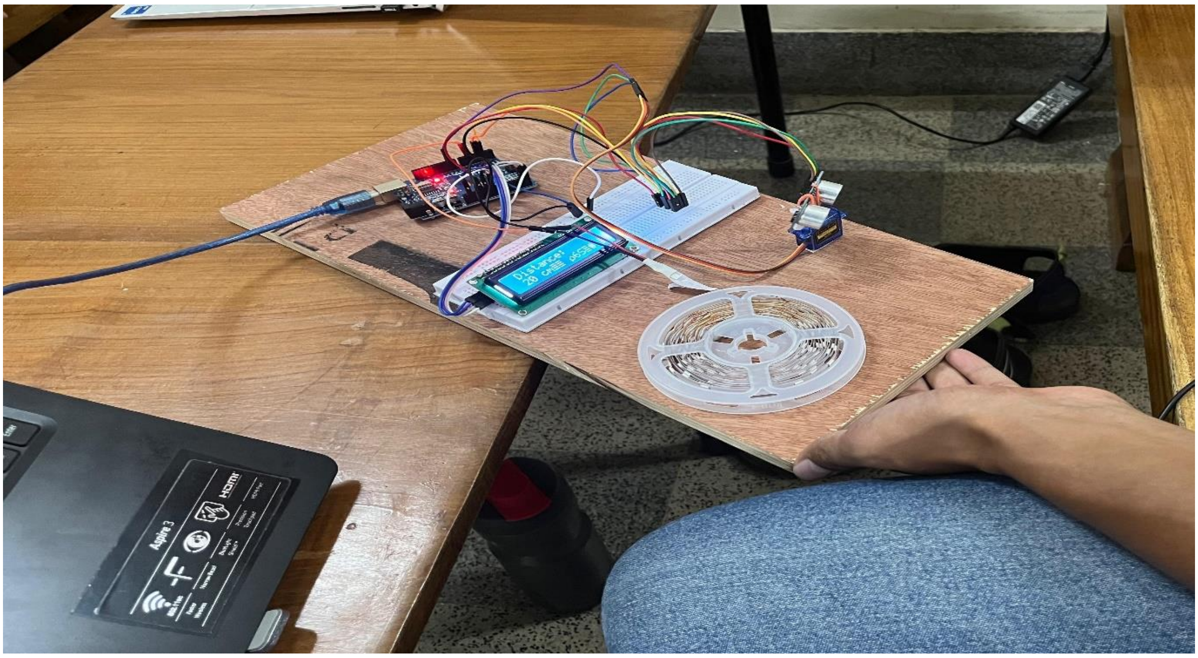


2. **Software Testing:**

- The microcontroller code was uploaded to the board.
- It was ensured that the LCD displayed the measured distance during operation.
- The LED behaviour was verified based on different object distances (simulated by manually approaching an object to the sensor).

3. **Demonstration:** [(Video Link)]

- The system was installed on a platform (representing a vehicle).
- The system's functionality was demonstrated, as to how it detects objects entering the blind spot and provides visual alerts using the LED strip.



Results

The developed prototype successfully demonstrated the ability to detect objects in the vehicle's blind spot using an ultrasonic sensor and UNO (ATmega328P) microcontroller. The system provided a visual alert (LED illumination) based on object proximity, potentially enhancing driver awareness and reducing the risk of blind-spot related accidents.

Future Work

- **Improve Sensor Range and Accuracy:** Using ultrasonic sensors with a longer range and higher accuracy can be helpful for better blind-spot coverage.
- **Multi-sensor Integration:** Incorporating additional sensors (e.g., radar) may help to improve detection capabilities in various weather conditions and for smaller objects.
- **Blind Spot Zone Customization:** Developing a mechanism to adjust the scanning area based on the vehicle type and user preferences will make the system more universal.
- **Audio Alerts:** Integrating an audio buzzer or speaker to provide an additional alert alongside the visual LED indication might help, but it will come at the cost of drier’s peace.
- **Wireless Communication:** Implementing Bluetooth or WiFi connectivity will help transmit blind-spot detection data to a smartphone app for real-time monitoring.
- **Integration with Vehicle Electronics:** Interfacing the system with the vehicle's turn signal lights to activate only when the driver intends to change lanes can help improve efficiency and performance.