Vellore Institute of Technology
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TECHNICAL ANSWERS FOR REAL WORLD PROBLEMS (CSE1905)

Title : Smart Elevator System Based On Human Detection Sensor

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ABSTRACT

In modern buildings,the elevator systems are essential for ensuring smooth travel to each floor. However, the existing elevator system lacks the ability to determine and differentiate between genuine floor requests and unnecessary or unintentional stops. This leads to increased energy consumption ,inefficient operation and unwanted waits. In order to optimize elevator operations, this research introduces a Smart Elevator System that includes human detection sensors. This system makes sure the elevator only stops at floors where passengers are present. The lift control unit receives information from the system when sensors within a radius of the lift button identify the presence of a human. This proposed system focuses on minimizing operations on elevator components, increasing energy efficiency, and decreasing needless stops.

This paper presents a Smart Elevator System that integrates human detection sensors to reduce the inefficiencies of traditional systems. The suggested system makes use of sensors that are placed next to the lift buttons on each floor to identify when someone is waiting for a lift. The system avoids needless stops when there are no passengers by only permitting the lift to stop at a specific floor if a person is detected within a specific radius of the button.

Through the use of both software and hardware components, this research attempts to develop and assess the system's performance. Because of their affordability and dependability, ultrasonic sensors and IR sensors were chosen and used as the main detecting method. These sensors are wired to a microcontroller, which interfaces with the lift control unit by processing the signals of the human detection and decides whether to stop the lift or not at the particular floor. Mainly to evaluate whether the system can cut down on pointless stops, energy usage, and lift wait times.

Keywords - Smart Elevator , Human detection, sensors

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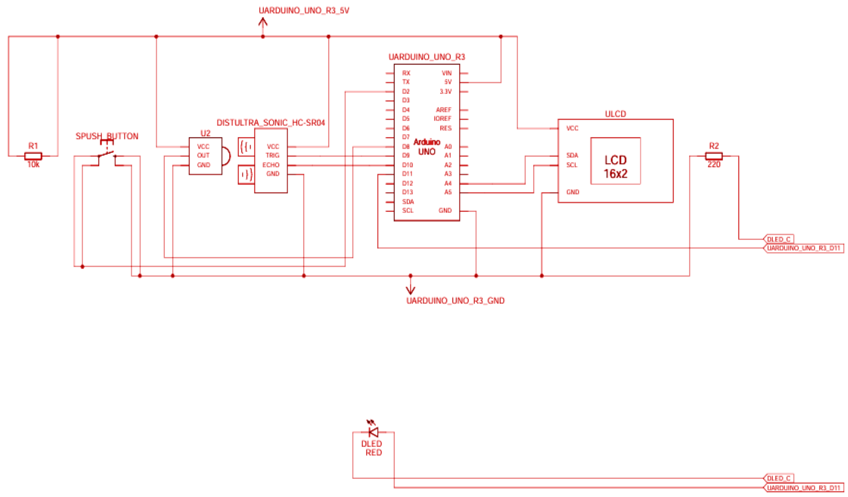

Fig 1. Block Diagram of Hardware components

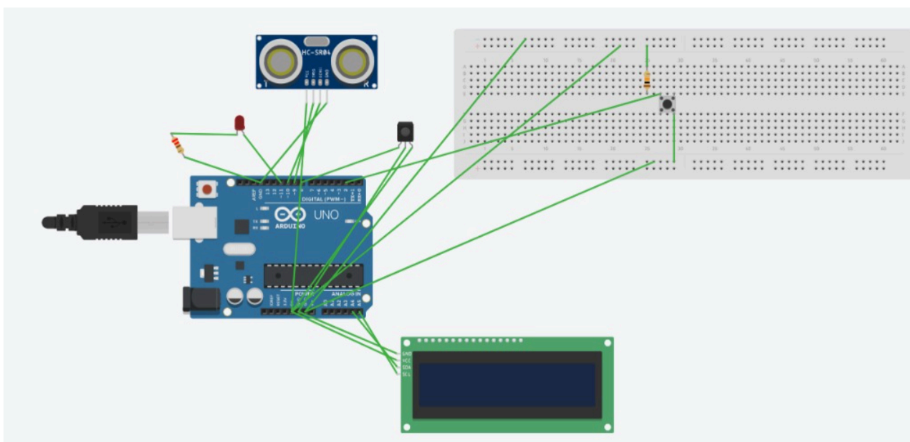

Fig 2. Hardware Setup of the Components

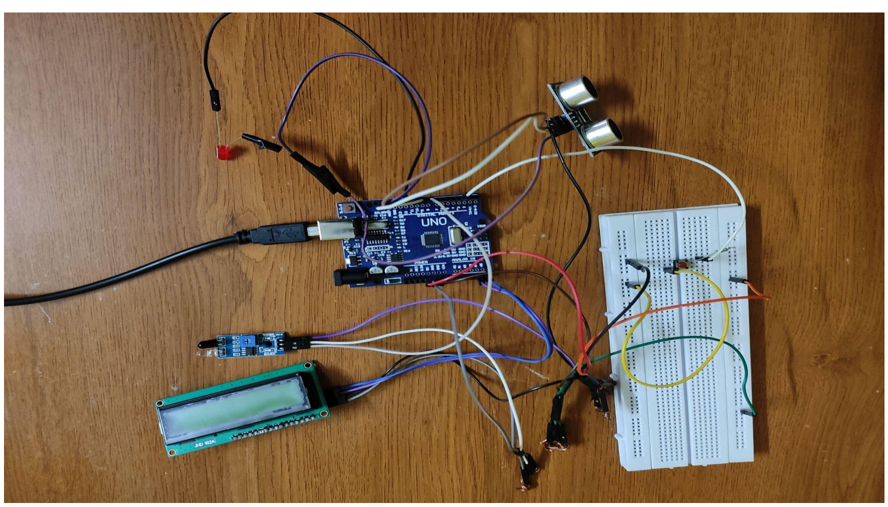

Fig 3. Hardware Components Setup

CHAPTERS

1. Introduction

1.1 Background

In high-rise buildings where vertical transportation is essential to day-to-day operations, lifts are an essential part of today's urban infrastructure. The need for faster, more effective, and energy-efficient lift systems has grown as cities continue to expand vertically. Passengers in conventional lifts use a straightforward mechanism to request a stop on a particular floor by pressing a button. This is an efficient method, but it also causes inefficiencies like needless stops when the button is pressed and no one is there to board or exit the lift at that floor. These pointless stops waste energy, prolong passenger wait times, and cause needless work on lift parts.The need for smarter lift systems has become apparent as operational efficiency and energy conservation receive more attention.

1.2 Problem Statement

This project mainly focuses on these two problems and provides solutions for these problems. The normal elevators stop at each and every floor that are requested even without any human presence which leads to inefficiency, energy waste and increased waiting times. The people who travel to higher floors often experience the cumulative delays caused by multiple unnecessary stops at the floors where no one is waiting or no one wants to get off. This is highly inconvenient for those who are in a rush.

1.3 Objectives

This project's main goal is to design and create a smart lift system that uses human detection sensors to decide whether or not to stop a lift on a given floor. The objective is to increase the overall operational efficiency of lifts in large buildings by minimizing needless stops and optimizing energy consumption.

1.4 Scope of the Project

The scope of this project focuses on integrating human detection sensors in elevators, preventing stops without human presence on requested floors. The project will involve developing and testing the integration of various sensors into a prototype elevator system as well as implementing an algorithm that enables the elevator to bypass certain floors whenever a button is pressed and there is no one on that floor.

2. Literature Review

2.1 Related Work

Many contemporary elevator systems were developed to make the best use of available technologies; nonetheless, all of the current methods concentrate on scheduling and optimizing the elevator rather than increasing the precision of pauses at each floor. The application of human detection in elevators to avoid unnecessary stops is still not well understood, despite the fact that sensors are widely used for tasks like counting people entering or exiting a facility.

Kwon, O., Lee, E., & Bahn, H. (2014)[1]. The sensor aware elevator scheduling for smart buildings sought to develop a system with a strong emphasis on the hypothesis of queuing systems, particularly the average waiting time and maximum waiting time, energy consumption of elevator systems, and indoor sensor technologies in designing an elevator scheduler. Skog, I, et al. (2017)[2] conducted research titled Smart Sensor Node for the Internet-of-Elevators Non-Invasive Condition and Fault Monitoring. This continued the trend of the papers focusing on monitoring with a high level of tolerance to faults in order to prevent the occurrence of any dangers. The magnetic field measurement carried out in the elevator suggests the presence of a system that is used to track door closure time, even the slightest differences in the closing of the door are recorded and can also be used to track its delays.

2.2 Research Gaps

Most of the systems aim at controlling the flow of traffic, but rather they do not prevent the unwanted halts designed to conserve power. The elevators coupled with human detection to enhance efficiency at the same time ensuring the comfort of the user is a gap in research

3. System/Project Design

3. 1 Architecture Diagram

This proposed architecture uses a human detection sensor such as ultrasonic sensor and infrared sensor and it is placed next to the lift button panel on each floor. The sensor is used by the system to determine whether a person is within a given radius when the button is pressed. The lift will move to that floor if it detects a person. Even though the button is pressed, the lift will bypass the floor if no one is detected.

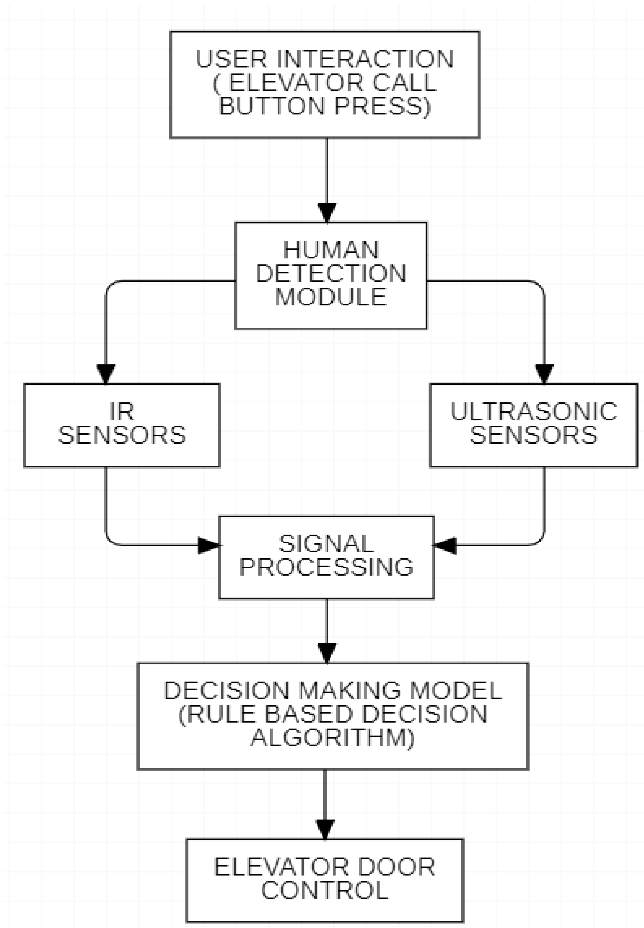

Fig 1 . Proposed Architecture

3.2 Tools and Technologies Used

A. Hardware Tools

- Arduino Uno

  It is a microcontroller used to control all the activity and take actions based on the data collected from the sensors and proceed with the help of any software platform.
- Ultrasonic Sensor

The ultrasonic sensor detects how far away something is by emitting sound waves and measuring the time it takes for them to bounce back.

- IR Sensor

  The IR sensor detects if a person is standing near the button by sensing infrared light reflected back from them

- Push Button

  The push button simulates the lift call button. When pressed, it will trigger the sensors to scan for people.

- LCD Display

  The LCD display will show messages like "Lift will not stop here" or "Lift will stop here."

- Resistors

  The resistors make sure the activities of the buttons are updated and connected without any errors

- LED

  The LED will blink when no one is detected at the floor after a button press, and it will turn off the button after a few seconds.

B. Software Description

The sensor's software components contain simple code that connects the sensors to IoT platforms and demonstrates how to utilize each sensor that is linked to a server on the internet for quick access . It interprets the sensors' data, which is really basic and makes understanding the environment straightforward. The platform that we used to connect the hardware components is the Arduino IDE .

3.3 Design Methodology

The design methodology framework of the smart elevator system comprises different segments contributing not only to its scalability and adaptability but also to incorporation in the already existing infrastructure. This comprises the human detection component that employs sensors such as infrared or ultrasonic to detect a person to any of the elevator call buttons and the Elevator Management component that makes the decision on whether to stop or skip a floor based on sensor information. The wired connections linking them allow fast deep integration and decision making among these units. The logic of operation of the system minimizes the number of false positives and false negatives by calibration of the sensors and other improvement techniques as detection mechanisms become better with time.

4. Methodology

4.1 Research Methodology

The smart elevator system's research methodology is based on an experimental development strategy. The major objective is to use human detection sensors to design, deploy, and assess a system that minimizes needless elevator stops.

4.2 Data Collection and Analysis

The data collection and analysis is done on a real time basis. The data is obtained from a number of experiments, such as the quantity of pointless stops (in which no people are present) and the energy usage both before and after the system is put into place. The data is collected from the button press and the collected data is then analyzed using human detection sensors and the decision is made with the help of sensors by human detection.

4.3 Implementation Steps

- human sensing and detection module

This module is in charge of determining the presence of humans When a person approaches each floor's lift buttons, . Lift call buttons are fitted with infrared (IR) or ultrasonic (sound) sensors that work by sending out waves that return when they come into contact with an object. It is ensured that the system only reacts when a person is within the designated detection radius by configuring the module to detect human presence within a specific range of distance.This module detects whether a human is present when a button is pressed and sends data to the control unit. The alarm for the lift to stop is ignored if no human is found within the designated area.

- control and decision making module

The information gathered by the human sensing and detection module is processed by the control and decision-making module. With a microcontroller that evaluates sensor data and determines whether the lift should stop at the requested floor, it functions as the system's central processor. The real-time decision-making process minimizes the elevator's operating time and energy consumption by ensuring that the system responds only to human presence and interactions.

- execution and feedback module

The control module's decisions must be carried out by the execution and feedback module. The execution module communicates with the lift's hardware system to either initiate or bypass the stop after the control module determines whether or not the lift should stop at a floor. The module initiates the lift's braking system, opens the doors, and waits for the passenger to board if a stop is necessary. Additionally, it gives the user feedback through LCD displays or lights to project the status of lifts.

5. Implementation

5.1 Detailed Description of Implementation

- Step 1: Wiring the Ultrasonic Sensor (HC-SR04)

The ultrasonic sensor detects how far away something is by emitting sound waves and measuring the time it takes for them to bounce back.

Connection setup:

VCC Pin (on the sensor) → Connect to 5V pin on the Arduino.

This provides power to the sensor.

GND Pin (on the sensor) → Connect to GND on the Arduino.

This grounds the sensor, completing the power circuit.

Trig Pin (on the sensor) → Connect to Pin 9 on the Arduino.

This pin sends out a signal (sound wave) when triggered.

Echo Pin (on the sensor) → Connect to Pin 10 on the Arduino.

This pin receives the signal when it bounces back, allowing the Arduino to calculate distance.

The Role:

When triggered, the sensor emits sound waves (too high-pitched for us to hear).

It waits for the sound to reflect back from an object. The time it takes to return is used to calculate how far away the object is.

- Step 2: Wiring the Infrared (IR) Sensor

The IR sensor detects if a person is standing near the button by sensing infrared light reflected back from them.

Connection setup:

VCC Pin (on the sensor) → Connect to 5V pin on the Arduino.

This powers the IR sensor.

GND Pin (on the sensor) → Connect to GND on the Arduino.

Grounds the sensor.

OUT Pin (on the sensor) → Connect to Pin 8 on the Arduino.

The sensor will send a signal to this pin when it detects an object (such as a person).

The Role:

When the IR sensor detects something (like a person in front of the button), it sends a signal to the Arduino, letting it know someone is present.

- Step 3: Wiring the Push Button

The push button simulates the lift call button. When pressed, it will trigger the sensors to scan for people.

Connection setup (with a Pull-Down Resistor):

One leg of the button → Connect to Pin 2 on the Arduino.

This tells the Arduino when the button is pressed.

Second leg of the button → Connect to 5V on the Arduino.

This completes the power circuit when the button is pressed.

Resistor (1kΩ):

Connect one side of the resistor to GND (ground rail on the breadboard).

Connect the other side to the same leg of the button that goes to GND.

The Role:

When the button is pressed, it sends a signal to the Arduino (via Pin 2) that the button is activated. The pull-down resistor makes sure the pin reads LOW (0) when the button is not pressed, preventing noise or false readings.

- Step 4: Wiring the LED (Optional for Blinking)

The LED will blink when no one is detected at the floor after a button press, and it will turn off the button after a few seconds.

Connection setup:

Anode (+) of LED → Connect to Pin 11 on the Arduino through a 220Ω resistor.

This controls the LED blinking when triggered.

Cathode (-) of LED → Connect to GND on the Arduino.

This grounds the LED, completing the circuit.

The Role:

The LED will blink to indicate the button is about to be turned off when no one is detected.

- Step 5: Wiring the LCD Display (16x2) (address: 39 (0x27))

The LCD display will show messages like "Lift will not stop here" or "Lift will stop here."

Connection setup (Using I2C Interface for Simplicity):

VCC Pin (on the LCD) → Connect to 5V pin on the Arduino.

Powers the LCD display.

GND Pin (on the LCD) → Connect to GND on the Arduino.

Grounds the LCD.

SDA Pin (on the LCD) → Connect to A4 on the Arduino.

This is the data line for I2C communication.

SCL Pin (on the LCD) → Connect to A5 on the Arduino.

This is the clock line for I2C communication.

The Role:

The LCD will display different messages based on whether someone is detected after pressing the button. If no one is detected, it will blink and eventually turn off the button.

- Step 6: Programming the Arduino

Now that everything is wired, we need to program the Arduino so it knows what to do when the button is pressed and the sensors detect (or don't detect) a person.

Steps for the Code:

Initialize Components: The sensors, button, LED, and LCD are initialized in the code.

Button Press Logic: When the button is pressed, the sensors are activated.

Person Detection: If the sensors detect someone, the LED stays on, and the LCD displays a message saying, "Lift will stop here."

No Person Detected: If no one is detected:

The LED blinks to indicate the button is about to turn off.

The LCD displays a message, "Lift will not stop here."

Time Delay: After a delay (e.g., 5 seconds), the LED and button turn off.

5.2 Code/Algorithm Highlights

- Rule-Based Decision Algorithm

The Rule-Based Decision Algorithm works by executing predefined decision rules to evaluate sensor data and determine the lift's operational behavior. It uses human detection sensors, such as ultrasonic and infrared (IR) sensors, to determine the presence of a human near the lift. These sensors continuously send real-time data to the algorithm, which processes it according to a set of predefined conditions.

5.3 System Functionality

This system functions to minimize unnecessary stops, reducing energy consumption, and ensures that the elevator serves only floors with waiting passengers.

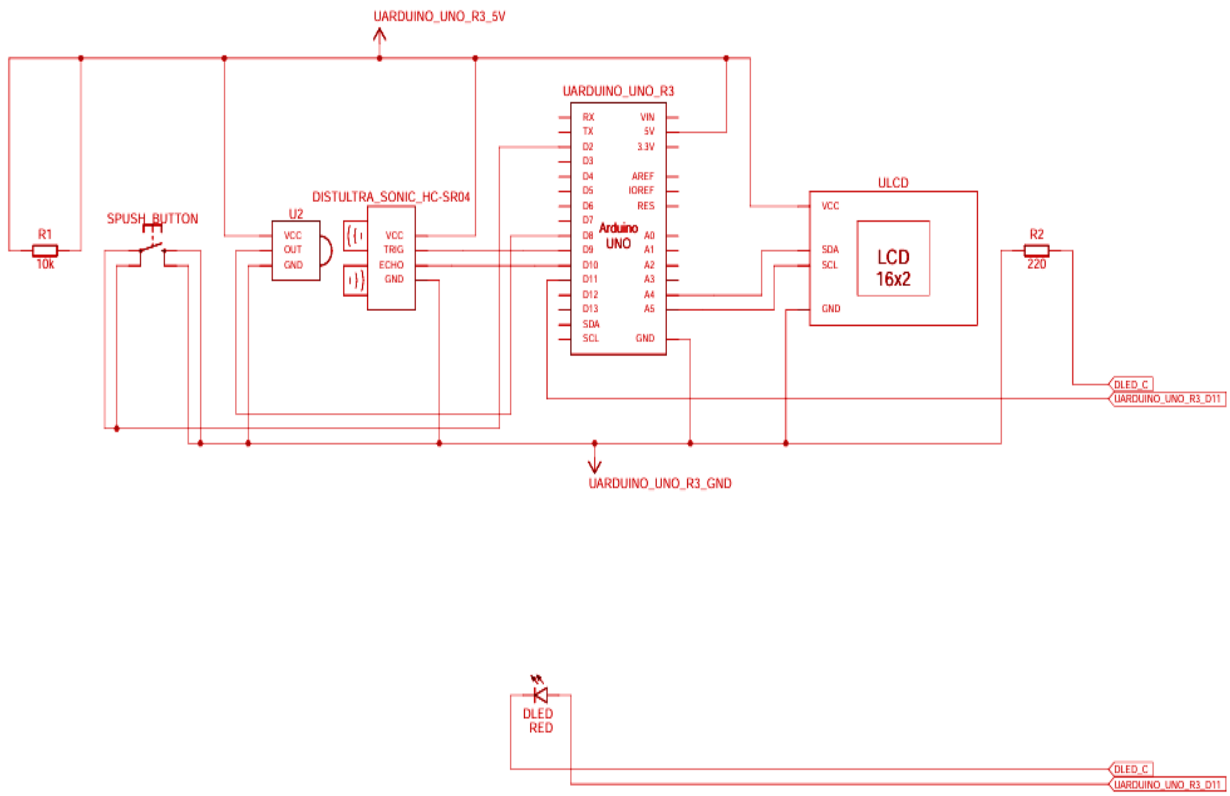

Fig 2. system functionality Block Diagram of Hardware components

6. Results and Discussions

6.1 Data Analysis

The data analysis that was collected from the code used to perform the necessary tasks is mentioned in that software . The first step is to Initialize the LCD with the I2C address and then need to mention the connection pin of each hardware component in the code and simulate code to detect humans . if detected it will return true which is a human is detected else false . Once the base is set we need to create a loop that keeps track of button state all the time. No actions will be done if the button is not pressed however if the button press is identified the program starts working with the detection of humans through sensors and decides whether to stop or not on that particular floor.

6.2 Visualizations

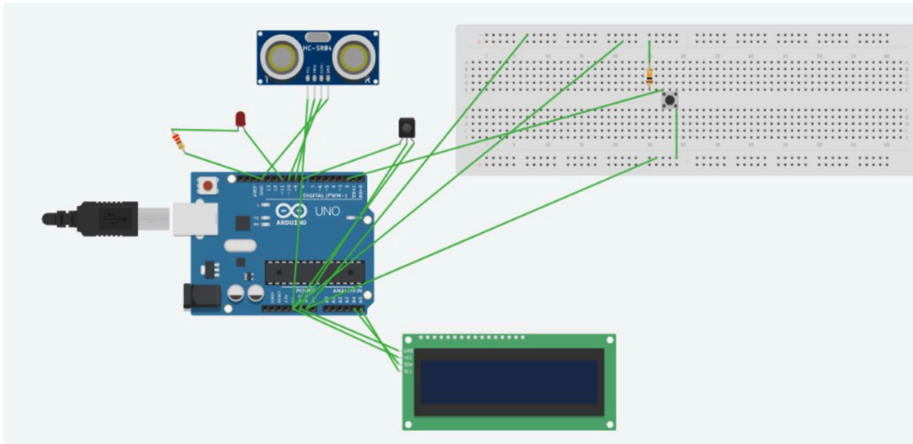

Fig 3. Hardware Setup of the Components

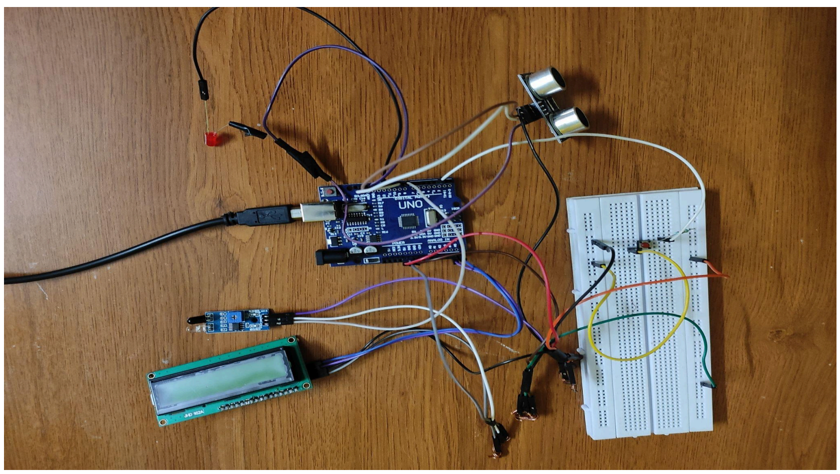

Fig 4. Hardware Components Setup

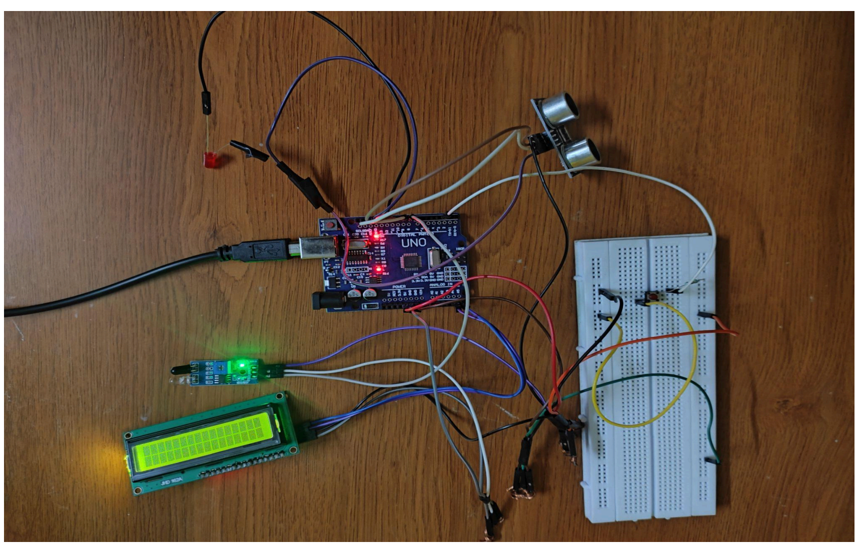

Fig 5. Working Setup

6.3 Interpretation of Results

The interpretation of this project results shows that human detection is a reliable method for optimizing elevator performance, with a significant reduction in idle stops and improved overall efficiency.

7. Testing and Validation

7.1 Test Cases and Scenarios

Test Case 1: If a button is pressed and a human is detected within the detection radius, the lift should stop at the appropriate floor.

Test Case 2: If a button is pressed but no human is detected within the detection radius, instruct the lift to skip the floor and proceed to the next destination.

Test Case 3: If multiple floors are requested and humans are detected on multiple floors, prioritize the floors closest to the current direction of travel.

Test Case 4: If the lift is idle and a button is pressed with human presence detected, send it to the appropriate floor.

Input : The algorithm continuously monitors the signals from the ultrasonic and IR sensors(Human detection sensors).

Output: Based on the evaluation of the rules, the algorithm either sends a command to stop the elevator or to continue moving.

7.2 Validation Techniques

The validation of this project is done by multiple testing with real users and displayed outputs as the project is expected. The Simulation of sensor accuracy and system response are also tested and validated according to this project objective.

- Field Testing with Real Users
- Simulation of High-Traffic Scenarios

7.3 Performance Metrics

- Reduction in Idle Stops: The number of unnecessary halts which would be eradicated by the intelligent system will be an important parameter. In order to assess operational efficiency enhancement due to elimination of idle stops or minimization of wasted stops, this will be compared to a regular lift system.

- Energy Consumption Before and After the Application of System: The energy use of the lift system will be determined before the implementation of the smart human detection capabilities and after. It will be evidenced by a significant drop in energy consumption that the system is capable of enhancing energy saving by curtailing useless stops.

8. Conclusion and Future Work

8.1 Summary of Findings

The smart elevator system with human sensors significantly decreases energy waste from excessive stops by detecting their presence. Thus the efficiency of the lift is improved overall. The efficiency of the system in detecting human presence is very critical to its performance.

8.2 Limitations

The present system still has a limitation such as accidental button presses inside the elevator are not inhibited to some extent. This remains a challenge for further research. Sensor limitations in the same complicated context may also alter detection accuracy and human detection inside the lift is also not yet implemented.

8.3 Future Enhancements

The system will undergo evaluation in laboratory settings, where it's impact on work efficiency, energy economizing and end user's experience will be assessed. However, the current context does not cover executing management of elevator button clicks inside the lift associated with possible reckless action or intentional action without a will to exit at a specific floor. Further steps of the initiative may build on this and aim to extend the policy to cover these cases of accidental button pushing or even implement the detection system in busy commercial centers where intervention wire may require a shift in the rigidity of the sensor structure. Investigating further the anticipation of crowding and optimization of the elevator management system using techniques of machine learning.

REFERENCES

1. Kwon, O., Lee, E., & Bahn, H. (2014). Sensor-aware elevator scheduling for smart building environments. In Building and Environment (Vol. 72, pp. 332–342). Elsevier BV. https://doi.org/10.1016/j.buildenv.2013.11.013
2. Gupta, S., Tyagi, S., & Kishor, K. (2022). Study and Development of Self Sanitizing Smart Elevators. In Lecture Notes on Data Engineering and Communications Technologies (pp. 165–179). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-6289-8_15
3. Skog, I., Karagiannis, I., Bergsten, A. B., Harden, J., Gustafsson, L., & Handel, P. (2017). A Smart Sensor Node for the Internet-of-Elevators—Non-Invasive Condition and Fault Monitoring. In IEEE Sensors Journal (Vol. 17, Issue 16, pp. 5198–5208). Institute of Electrical and Electronics Engineers (IEEE). https://doi.org/10.1109/jsen.2017.2719630
4. Guo, Y., Liu, Y., Zhang, X., & Wang, G. (2021). The Real-Time Elevator Monitoring System Based on Multi-sensor Fusion. In Journal of Physics: Conference Series (Vol. 2010, Issue 1, p. 012182). IOP Publishing. https://doi.org/10.1088/1742-6596/2010/1/012182
5. Le, S., Lei, Q., Wei, X., Zhong, J., Wang, Y., Zhou, J., & Wang, W. (2020). Smart Elevator Cotrol System Based on Human Hand Gesture Recognition. In 2020 IEEE 6th International Conference on Computer and Communications (ICCC) (Vol. 2, pp. 1378–1385). 2020 IEEE 6th International Conference on Computer and Communications (ICCC). IEEE. https://doi.org/10.1109/iccc51575.2020.9344869
6. Minghui Geng, Bo Ai, & Hang Li. (2019). Human behavior identification in elevator based on sensor data. In IET 8th International Conference on Wireless, Mobile & Multimedia Networks (p. 5 (25-30)). IET 8th International Conference on Wireless, Mobile & Multimedia Networks. Institution of Engineering and Technology. https://doi.org/10.1049/cp.2019.1144
7. Al-Kodmany, K. (2023). Smart Elevator Systems. In Journal of Mechanical Materials and Mechanics Research (Vol. 6, Issue 1, pp. 41–53). Bilingual Publishing Group. https://doi.org/10.30564/jmmmr.v6i1.5503
8. Li, H.-Y., & Chu, E. T.-H. (2024). SmartRide: Intelligent reservation and scheduling for elevators. In Journal of Ambient Intelligence and Smart Environments (pp. 1–27). IOS Press. https://doi.org/10.3233/ais-230330
9. Choi, J. W., Yim, D. H., & Cho, S. H. (2017). People Counting Based on an IR-UWB Radar Sensor. In IEEE Sensors Journal (Vol. 17, Issue 17, pp. 5717–5727). Institute of Electrical and Electronics Engineers (IEEE). https://doi.org/10.1109/jsen.2017.2723766

APPENDIX

Libraries:

Wire.h and LiquidCrystal_I2C.h are the libraries for controlling the LCD when connected to I2C.

Initialization:

- lcd(0x27, 16, 2) creates an instance of the lcd with the i2c address and the size of 16*2 which is a character display. which depends on the hardware, i2c address used to connect a character lcd to the microcontroller is 0x27.
- Wiring of the button, LED, IR sensor and ultrasonic sensor is done.
- In setup(), the pins are put into INPUT, OUTPUT modes, the screen is turned on and the words, "System Ready" are shown for 2 seconds.

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Initialize the LCD with the I2C address (adjust the address if necessary)
LiquidCrystal_I2C lcd(0x27, 16, 2); // Change 0x27 to your I2C address if needed

const int buttonPin = 2;      // Push button pin
const int ledPin = 11;        // LED pin
const int irSensorPin = 8;    // IR sensor pin
const int trigPin = 9;        // Ultrasonic trig pin
const int echoPin = 10;       // Ultrasonic echo pin

void setup() {
    Serial.begin(9600);                   // Start serial communication
    pinMode(buttonPin, INPUT_PULLUP);     // Button pin
    pinMode(ledPin, OUTPUT);               // LED pin
    pinMode(irSensorPin, INPUT);           // IR sensor pin
    pinMode(trigPin, OUTPUT);              // Ultrasonic trig pin
    pinMode(echoPin, INPUT);               // Ultrasonic echo pin

    // Initialize the LCD
    lcd.init();                            // Initialize the LCD
    lcd.backlight();                       // Turn on the backlight
    lcd.clear();                           // Clear the display
    lcd.print("System Ready");             // Display initial message
    delay(2000);                           // Wait 2 seconds for startup
}

void loop() {
    // Read the button state
    int buttonState = digitalRead(buttonPin);
```

Main Loop:

Detecting a button press: The system now checks if a button is pressed or not by reading the buttonPin using digitalRead(). If the button is active (LOW), the loop waits for the button to be inactive by the sensors, and does continue to monitor the sensors.

```
    // Check for button press
    if (buttonState == LOW) {
      while (true) { // Continuously check sensors after button is pressed
        // Trigger the ultrasonic sensor
        digitalWrite(trigPin, LOW);
        delayMicroseconds(2);
        digitalWrite(trigPin, HIGH);
        delayMicroseconds(10);
        digitalWrite(trigPin, LOW);

        // Measure the echo time
        long duration = pulseIn(echoPin, HIGH);
        // Calculate the distance (in cm)
        long distance = (duration / 2) * 0.0343;

        // Check if the IR sensor detects a person
        int irState = digitalRead(irSensorPin);

        // Debug output to verify the sensor readings
        Serial.print("IR Sensor: ");
        Serial.print(irState);
        Serial.print(" | Distance: ");
        Serial.println(distance);
```

```
        // If human is detected (IR sensor is HIGH and distance is < 50 cm)
        if (irState == HIGH && distance < 20) {
          digitalWrite(ledPin, LOW);   // Turn on LED continuously
          lcd.clear();                  // Clear previous messages
          lcd.print("Lift will not ");   // Display message
          lcd.setCursor(0, 1);          // Move to the second line
          lcd.print("stop here");            // Display message on second line
        }
        // If no human is detected (IR sensor LOW or distance > 50 cm)
        else {
          digitalWrite(ledPin, HIGH);     // Turn off LED
          lcd.clear();                    // Clear previous messages
          lcd.print("Lift will ");
          lcd.setCursor(0, 1);            // Move to the second line
          lcd.print("stop here");         // Display message on second line
          for (int i = 0; i < 5; i++) {  // Blink LED 5 times
            digitalWrite(ledPin, HIGH); // Turn on LED
            delay(500);                  // Wait for half a second
            digitalWrite(ledPin, LOW);  // Turn off LED
            delay(500);                  // Wait for half a second
          }
        }

        delay(2000);  // Delay for human detection update

        // Check if the button is pressed again to stop the loop
        if (digitalRead(buttonPin) == LOW) {
          break;  // Break out of the loop if button is pressed again
        }
      }
    }
}
```

This is a project that involves the design and coding of an elevator system to be driven by an Arduino and various sensors in conjunction with a display. The task is to decide when it should stop at one of the floors based on the detection of people using an IR sensor and an ultrasonic sensor. An LCD is used to display the messages, there is a button allowing to commence the process of detection and an LED used for indication.