Project /Assignment Title: Crowd management device

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Abstract:

A crowd management device is a tool which helps to manage crowds in places where overcrowding is a problem. Overcrowding causes work stress of the employees and the process becomes slow [1]. Besides, the experience of the customers is not good when the place is overcrowded. This device manages, how many people can stay in a room. So, the room is never overcrowded. This device uses ultrasonic sensors to detect the crowd flow. It detects how many people are getting in and how many people are getting out. Then it processes the data and it makes decision and show on the display. After implementing this device, overcrowding in a specific region will be solved by managing crowd flow at the door.

Keywords: Crowd management, Ultrasonic sensor, Overcrowding, Room occupancy control

1. Introduction:

The device is named as crowd management device which is a arduino based device. This device uses ultrasonic sensors and I2c Lcd display. This device detects the crowd flow in both directions, in and out, using ultrasonic sensor's obstacle detecting feature [2]. So, the device can detect real time room occupancy. It is processed by arduino uno which have been in the project [3].It is a code based device and in the code we have written last logic of detecting getting in and getting out. Crowd management systems are becoming important day by day in a world where high-density public gatherings are frequent. Crowd management is important because it affects work experience. Overcrowding causes stress to employees which may reduce their work efficiency [1]. In places like banks , hospitals , ticket counters where overcrowding is a major issue, it can be used. In many traditional setups, crowd controlling is managed manually by humans, which is often inefficient and it has lacking in real-time responsiveness. For solving these issues, automated crowd monitoring device is made by our team. This has wide applications across public**,** commercial**,** and institutional environments like banks, ticket counters, clinics, public vehicles and so on. In banks , it can be placed at the door and monitor the amount of customers coming in to the main room of the bank to reduce overcrowding problem in bank. In this scenario, the main room can contain people according

to its capacity , but when more people enter , the situation becomes a mess. So, we need a device which will notify the people when the room is full and prevent overcrowding. Our crowd management device works perfectly in this situation. Besides, hospitals and clinics can use this device to control the number of visitors.

Managing human traffic in confined or high-occupancy areas is a huge challenge, especially in public places like shopping malls, clinics, religious institutions, schools, and transportation hubs. When there are too many people in large shopping malls, crowd congestion accidents are likely to occur. To ensure the rapid and safe evacuation of indoor crowds, research has been made which uses crowd density maps to determine the location of crowded areas and uses an improved ant colony algorithm to optimize the evacuation route from this location to the exit [12]. So, Overcrowding in small and medium-sized public places is a common problem that can significantly impact service quality, safety, and user experience. There is a need of low-cost and user-friendly devices that can be used to solve this problem. Motivated by these real-world challenges, our team developed an arduino based crowd management device which uses ultrasonic sensors to track entry and exit. This device measures the number of people in a room and ensures that it does not exceed a preset limit. It does not need human control and it also displays real time messages on an LCD screen based on the room is occupied or not by the people. This automation reduces the burden and improves customer satisfaction by preventing long waits. Beside, unlike high-end surveillance systems or complex sensor networks, this device is simple and affordable. It is also easy to install which is making it ideal for huge use in banks, service centers etc. Our goal was simple. We wanted to create a smart solution that helps manage crowd flow effectively and which is not costly, complex etc.

Our primary objective for developing this project is simple. We want to design and develop a low-cost device that can accurately detect and monitor room occupancy in real time using ultrasonic sensors and arduino. In today's world, high-density gatherings in public and semi-public spaces are common. We need to manage crowd flow because it is essential for maintaining safety and quality. Besides, it improves service quality and increases the overall user experience. So the first objective of making this project and doing this research is making a device for controlling overcrowding. Then our next objective is that the device can count people entering and exiting using ultrasonic sensors. Our third objective is that they should detect direction of movement accurately for ensuring a man is coming in or getting out. Then we need to ensure that, it can display occupancy status on an LCD.

We believe that we have a little contribution in this field and this field needs more contribution. But our little contribution should be told. They are:

- We have Developed a low-cost crowd management system using ultrasonic sensors which is arduino based.
- We have implemented bidirectional people counting logic (entry and exit detection) .
- We have designed a system that operates autonomously without the need of human control.

- We integrated an I2C LCD display which show real-time room occupancy status and alerts.
- We have offered a better solution which is suitable for banks, clinics, ticket counters, and similar environments.
- We have reduced overcrowding issues.
- We have demonstrated a practical use case for arduino microcontrollers and ultrasonic sensors in real-world public safety applications.

2. Literature Review:

We have made another implementation of ultrasonic sensors and arduino. Many people made many implementations on it. Ultrasonic sensors are being used for measuring distances in robotics [4].Ultrasonic sensors are also used for making automatic floor cleaning robot using arduino [5]. It is also used to to accurately analyze microseismic events in laboratory earthquake experiments. for developing a new acoustic emission (AE) monitoring method using embedded polyvinylidene fluoride (PVDF)[6]. Arduino is a microcontroller and it is used in many projects. It is a easy to use microcontroller. It is user friendly. It can be used for Computational thinking and programming with arduino in education [7]. Actually, arduino microcontroller is an open-source that can be easily programmed and can update at any time. First Arduino was introduced in 2005. arduino microcontroller was originally designed for professionals and students to develop devices that can interact with the environment using sensors. Arduino microcontrollers have inputs and outputs that can be used to get information and based on received data Arduino can send output. Arduino microcontrollers can also send and receive data via the internet using HTTP requests. The simple microcontroller that can be connected to the internet is Esp board. Esp microcontrollers can be connected to a Wi-Fi server or they can act as a Wi-Fi server[8].Besides, Line follower robots are autonomous robots that detect the black line by infrared ray (IR) sensors which send and receive infrared waves to identify the black line. Moving along with complicated paths such as dashed, spiral, and sharp angles requires a more appropriate configuration of the IR sensors. The goal of this study is to propose a line follower robot that can pass regular and irregular, dashed-line, and spiral paths. The structure of the robot includes three main parts: the L298 module, the programmable board Arduino UNO board, and twelve IR sensors.[9]. So we can say that arduino and ultrasonic Sensors has a huge use in the field of robotics. I have made another use of this tools by making a crowd management device. Crowd management is essential because more crowd creates more noise and it impacts on the employees mental health. Exposure to environmental noise from within homes has been associated with poor mental health. Existing evidence rests on cross-sectional studies prone to residual confounding, reverse causation, and small sample sizes, failing to adequately consider the causal nature of this relationship. Furthermore, few studies have examined the sociodemographic distribution of noise exposure at a country level[10].Besides, Office noise and background speech, which is probably due to the fact that office and office-like workplaces are nowadays one of the most common workplace types. In group and open-plan offices, background speech from colleagues at distant workplaces is the dominant noise problem for employees who are

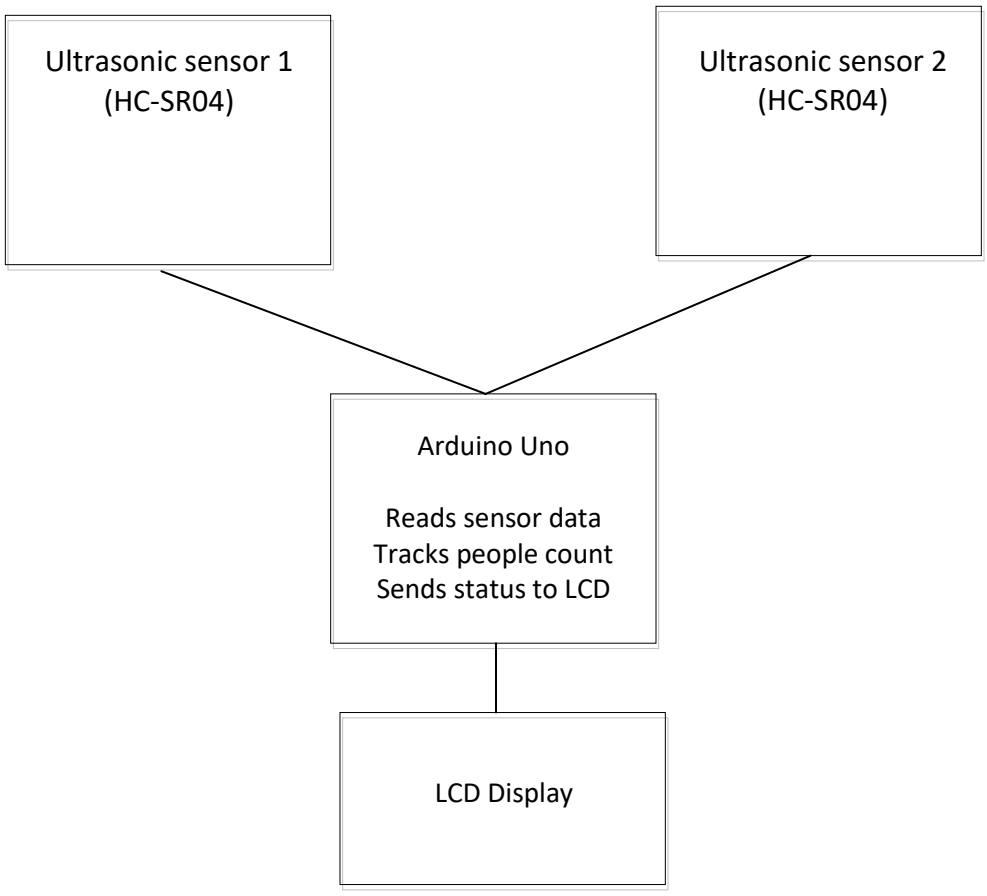
supposed to do concentrated silent work. Since complete silence cannot be achieved in occupied group[11].So ,We have understood that noise is not a good thing for employees and customers experience. But overcrowding creates noise. So that is why crowd management is important.That is why we have made this device.

3. Methodology:

3.1 Description of the proposed device:

This device is used for crowd management. This device uses two ultrasonic sensors which detects the crowd flow and also its direction. When a person is entering, he is actually detected by the ultrasonic sensor placed at first then the ultrasonic sensor which is placed at after the first ultrasonic sensor. So, it will process that first ultrasonic sensors detected first and second detected after him and it will take it as someone is entering. When the second ultrasonic sensor detects first and first ultrasonic sensor detects after him, it processes that someone is exiting. When some keeps standing on the door, it can also detect that. I have used a i2c LCD display which display the people count and it show notification when the limit is reached and when someone is standing on the door.

3.2 Block Diagram of the Proposed System:



3.3 Theoretical Framework

This system needs to explore educational and technological concepts applicable in the secondary and undergraduate level, especially within Science, Technology, Engineering, and Mathematics education.

Key Educational Concepts are:

1. **Computational Thinking**
   The system uses computational thinking to perform logics, the system take data and computes the distance and uses the values of distance in decision making.
2. **Embedded Systems**
   Students learn how sensors, microcontrollers work and interact with the real world and then takes data and gives a decision by processing it.
3. **Human-Computer Interaction (HCI)**
   Gui can be included to make interactions more user friendly.
4. **Digital Logic and Timing**
   Time-based conditions (e.g., 5-second linger detection) teach logical conditions and basic real-time processing which is important.

3.4 Hardware and Software Design:

3.4.1 Circuit Design:

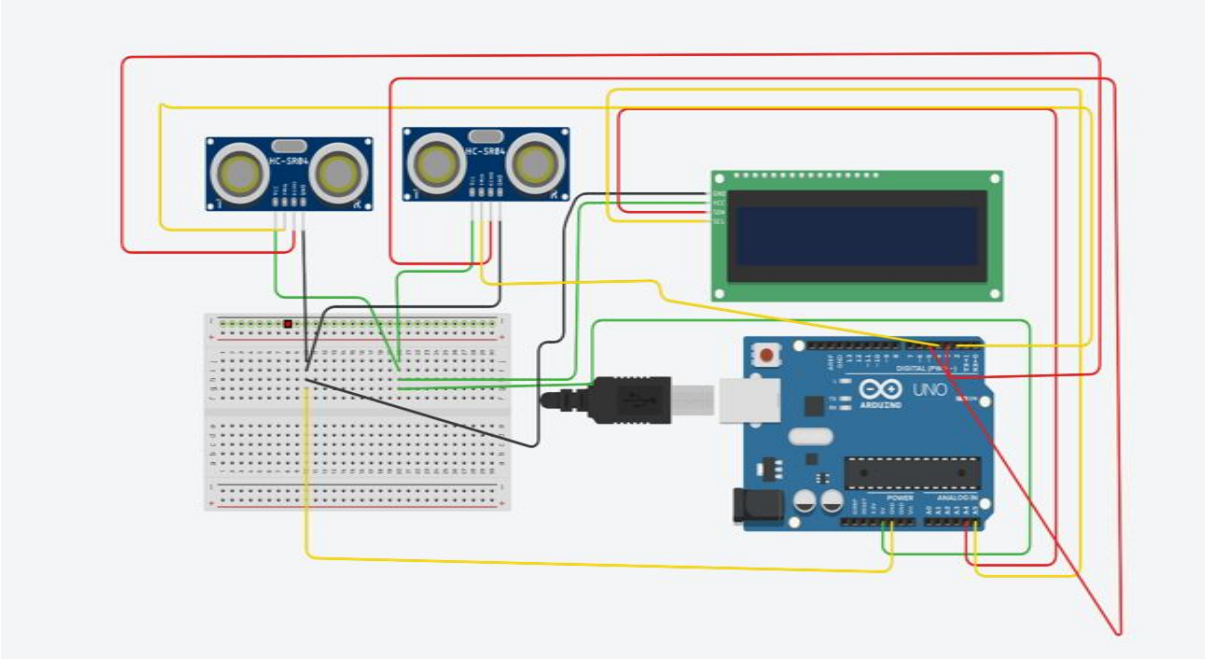
Components Used for this device:

- Arduino Uno R3
- 2 × HC-SR04 Ultrasonic Sensors
- 1 × 16x2 LCD (I2C Module)
- Jumper Wires

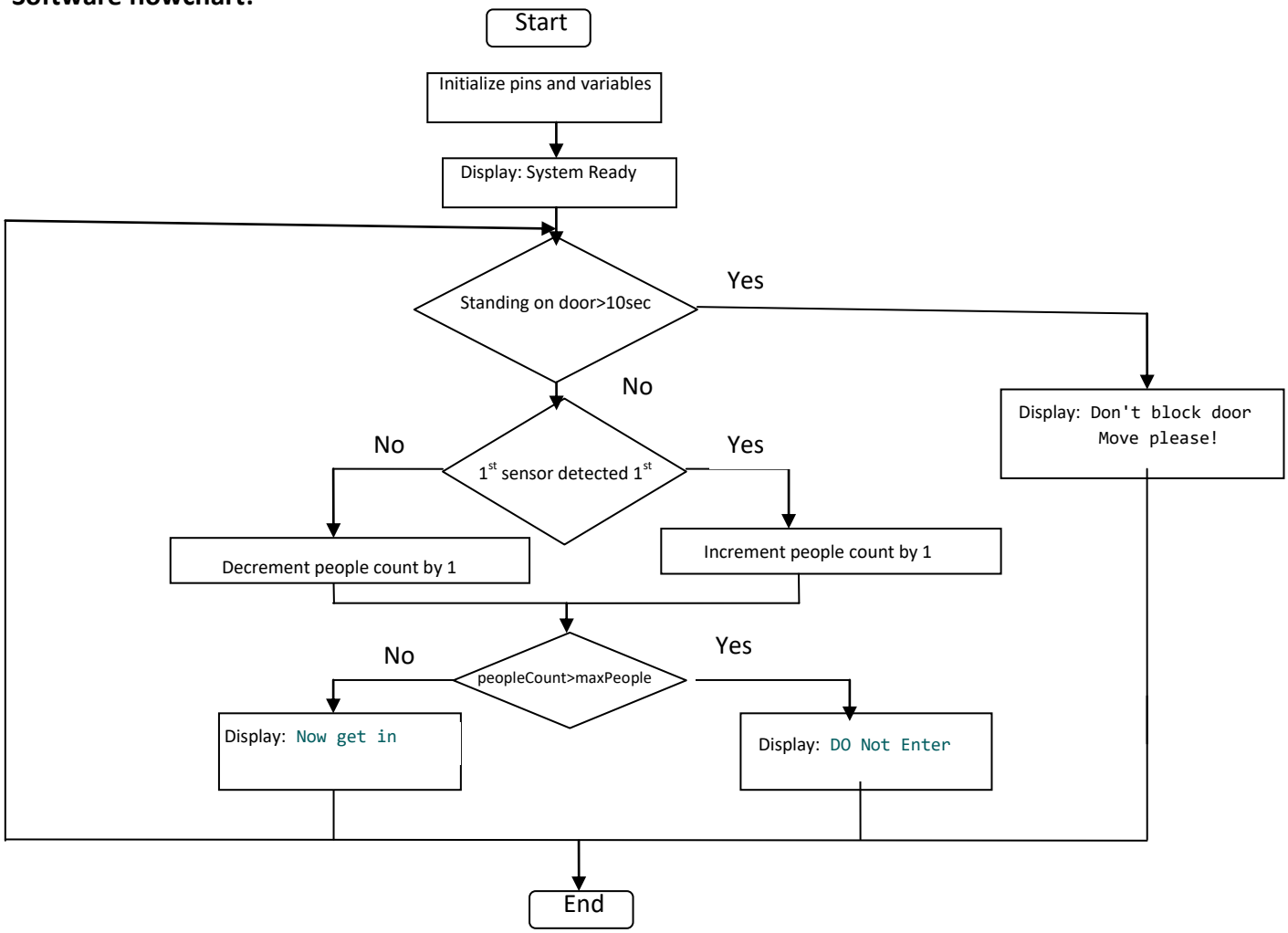
Circuit Description:

The project is using arduino Uno microcontroller board which is connected to two ultrasonic distance sensors (HC-SR04) and a 16x2 LCD display with I2C interface to monitor and control the number of people entering or exiting a room. The first ultrasonic sensor is at the entrance and its trig pin is connected to digital pin 2 and echo pin is connected to digital pin 3 on the arduino. The second ultrasonic sensor is placed at the exit. It has its trig pin which is connected to digital pin 4 and echo pin is connected to digital pin 5. These sensors detect motion based on the time it takes for an ultrasonic pulse to return after hitting an object (i.e., a person passing through). The 16x2 LCD display is connected via the I2C interface. The SDA (Serial Data) line is connected to the analog pin A4, and the SCL (Serial Clock) line is connected to the analog pin A5 of the arduino Uno. Additionally, the LCD and ultrasonic sensors VCC and GND pins are connected to the Arduino's 5V and GND, respectively, to power the module.

Circuit Diagram (made by tinkercad):



Software flowchart:



4. Results and Discussion:

4.1 Presentation of Key Findings:

For measuring the effectiveness and accuracy of the crowd management system we have conducted a series of controlled test cases using two ultrasonic sensors and an I2C LCD display. The following table summarizes the observed test cases:

Test Case No	Scenario	Sensor Trigger Order	Expected Output	People Count	LCD Display
1	System Initialization	None	Display:"System Ready"	**0**	Blank (after 2s)
2	Single Entry Detected	trig1 → trig2	Person enters and count increases	**1**	Now Get In
3	Single Exit Detected	trig2 → trig1	Person exits, count decreases	0	Now Get In
4	Limit reaches	trig1 → trig2	Count increases to max	maxPeople	DO Not Enter
5	Entry Attempt When Max Reached	trig1 → trig2	increase and count	maxPeople+1	DO Not Enter
6	Exit After Max Reached	trig2 → trig1	decrease and count	maxPeople-1	Now Get In
7	Standing on the door	trig1 or trig2 stays <10cm for >10s	Displays "Don't block door" + "Move please!"	No change	Don't block door Move please!

4.2 Interpretation of Results:

The results which are taken from the test cases confirm that the proposed crowd management system is capable of accurately tracking the number of people entering and exiting using two ultrasonic sensors. The logic which is comparing the sequence of triggers (trig1 → trig2 for entry and trig2 → trig1 for exit) successfully differentiates between entry and exit events. The system reliably displayed warnings when someone blocked the door for over 10 seconds and fulfills the safety feature requirement. Moreover, the LCD displays real-time feedback. It shows notifications based on the feedback.

4.3 Limitations:

This project has some limitation. First of all, there is no user interface for better control. We have to set max people by changing the number in the code. But if we had a user interface, we set the number of max people dynamically. Besides, we could add online token system to reduce the hassle of the customers more. Because without the online token system, the hassle of the employees and customers who are inside the room would be reduced but the customers who are waiting outside has to wait in a queue. It is a hassle which cannot be solved by only implementing the device. So the project needs a user interface which has option for online token system. Otherwise, this limitation wil remain unsolved. The project only displays warnings but it would be better to add some extra features to manage that crowd. But this is not a major limitation because adding more feature is optional because we have to consider about the cost. The user interface should online. Besides its structural material is weak and its structure is not durable. We have limitations in structural design. We have to improve it.

5.Conclusion and Future Work:

The proposed crowd management system is successfully creating an efficient, low-cost, and real-time solution for monitoring the number of people within a given space. We have used two ultrasonic sensors in combination with an I2C LCD display and arduino microcontroller. The system can accurately detect and differentiate between entry and exit events which are what we needed. We have made the proper use of logic based on sensor activation order which is allowing us to reliable people counting, while the additional feature of warning users if someone blocks the door for more than 10 seconds which is enhancing its safety and usability. Real-time feedback on the LCD display ensures clear communication with users, making the system suitable for public areas such as classrooms, offices and so on.

In future, we will need a user interface. This project needs a user interface to control the max people number easily and show messages on the display which is not common. Besides, the user interface should be accessed through online for adding online based token system. We should integrate IOT for controlling it through the internet. Then, the structure of the device should be improved. More durable and strong material should be used for making the structure of the device. The structural design should be updated in future work.

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