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IOT – Based Multizone Ultrasonic Glove

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Abstract:
This paper presents a smart industrial safety system designed to reduce accidents caused by human interaction with hazardous machinery. The system uses an ultrasonic sensor to continuously monitor the distance between a worker and a machine. Based on the measured distance, the system classifies the area into safe, warning, and danger zones. When the worker enters the danger zone, an immediate alert is generated using a buzzer and LED indicator. The proposed system is simple, cost-effective, and capable of detecting objects up to approximately 240 cm. This solution improves worker awareness and can help prevent injuries such as hand entrapment. The system can be further enhanced using IoT-based monitoring for advanced industrial safety applications.

Keywords — Industrial Safety, Ultrasonic Sensor, Arduino, Hazard Detection, Worker Safety

I. INTRODUCTION

Most industries operate with heavy equipment, which can create significant safety risks for workers if proper precautions are not allowed. Accidents often occur when workers unknowingly enter dangerous zones near moving machine parts. Such incidents may lead to injuries including cuts, burns, or entrapment.

Traditional safety measures like protective equipment and manual supervision are not always sufficient to ensure complete safety. Therefore, there is a need for an automated system that can detect unsafe conditions in real time and alert workers immediately.

In this project, a smart safety system is developed using an ultrasonic sensor and a microcontroller. The system continuously measures the distance between the worker and the machine and provides alerts when the distance becomes unsafe. Industrial accidents can be reduced using sensor-based monitoring systems as discussed in [2].

II. LITERATURE REVIEW

Several research works have been carried out in the field of industrial safety systems. Traditional safety approaches mainly rely on manual supervision and protective equipment, which are not always effective in preventing accidents.

Infrared (IR) sensors have been used in some systems for object detection, but they are sensitive to environmental lighting conditions. Ultrasonic sensors provide better accuracy and reliability as they are not affected by light. Ultrasonic sensors provide better accuracy compared to other sensors as explained in [4].

Recent advancements include IoT-based safety systems and wearable devices such as smart helmets and gloves. These systems offer advanced monitoring but are often expensive and complex. Therefore, a simple ultrasonic-based system provides a cost-effective alternative for industrial safety applications.

III. METHODOLOGY

A. System Overview

The proposed system consists of three main components: an ultrasonic sensor, a microcontroller, and output devices such as a buzzer and LED. The sensor detects the distance, the controller processes the data, and the output devices generate alerts.

B. Working Principle

The ultrasonic sensor emits high-frequency sound waves and receives the reflected signal from nearby objects. The time taken for the signal to return is used to calculate the distance between the sensor and the object.

C. Distance Calculation

The distance is calculated using the formula:

Distance = (Speed of Sound * Time) / 2

Where the speed of the sound is approximately 343 m/s. The distance measurement technique used in this system is similar to methods described in [2].

D. Safety Zone Calculation

TABLE I
SAFETY ZONES

SNO	Distance	Zone Type	Action
1	>150 cm	Safe Zone	No alert
2	80 – 150 cm	Warning Zone	LED indication
3	< 80 cm	Danger Zone	Buzzer + LED

E. System Operation

1. The sensor continuously measures distance
2. The microcontroller processes the data
3.The distance is compared with predefined thresholds
4. Alerts are generated based on safety zones

IV. SYSTEM DESIGN

The system is designed using a modular approach consisting of three main units:

- **Input Unit:** The ultrasonic sensor acts as the input device, detecting the presence and distance of objects.
- **Processing Unit:** The Arduino microcontroller processes the sensor data and determines the safety condition.
- **Output Unit:** LEDs and a buzzer are used to alert the worker about unsafe proximity.

The system is compact, energy-efficient, and can be easily integrated into existing industrial setups. The design ensures quick response time and reliable performance.

The overall architecture of the proposed system is shown in Fig. 1.

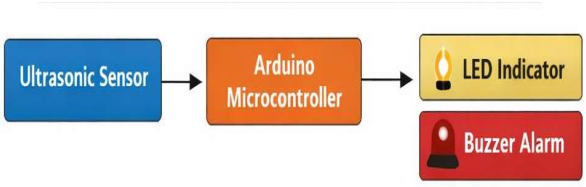

Fig. 1: Block Diagram of Proposed Industrial Safety System

V. RESULTS AND DISCUSSION

The system was tested under various environmental conditions to evaluate its performance. It successfully detected objects within a range of approximately 240 cm with consistent accuracy. The response time was observed to be minimal, allowing real-time alerts. The obtained results are consistent with previously developed systems [8].

The safety zone classification worked effectively, providing clear indications for safe, warning, and danger conditions. However, it was observed that in noisy industrial environments, the buzzer sound might not always be clearly audible. Therefore, additional alert mechanisms such as vibration motors or display indicators can be considered in future implementations.

Overall, the system demonstrated reliable performance and proved to be effective in enhancing worker safety.

The working principle of the system is illustrated in Fig. 2.

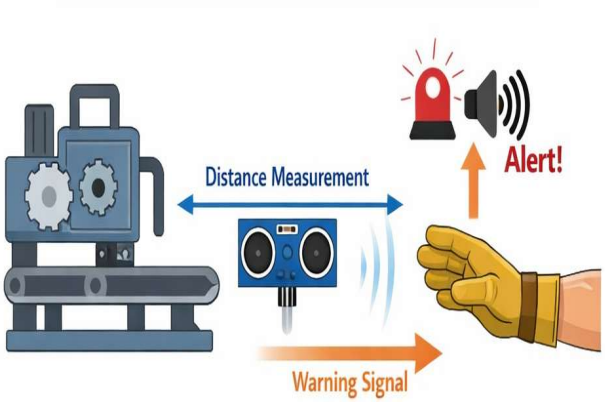

Fig.2: Working Model of Safety Detection System

VI. APPLICATIONS

- Industrial worker safety monitoring
- Hazard detection near machinery
- Conveyor belt safety systems
- Construction site safety monitoring
- Smart factory and automation systems
- Laboratory equipment safety

VII. ADVANTAGES

- Cost-effective solution suitable for small industries
- Provides real-time monitoring and alerts
- Easy to install and operate
- Not affected by lighting conditions
- Compact and portable design

VIII. LIMITATIONS

- Limited detection range compared to advanced systems
- Cannot differentiate between human and non-human objects
- Performance may be affected by extreme temperature or humidity
- Single sensor limits coverage area

IX. CONCLUSION

This paper presents a smart industrial safety system using an ultrasonic sensor and microcontroller. The system effectively detects unsafe proximity and provides real-time alerts to prevent accidents such as hand entrapment. The simplicity, low cost, and reliability of the system make it suitable for small and medium-scale industries.

With further improvements such as IoT integration and multi-sensor deployment, the system can be developed into a more advanced industrial safety solution.

X. FUTURE SCOPE

The proposed system can be further enhanced by integrating advanced technologies. Multiple ultrasonic sensors can be used to increase coverage area and improve accuracy. IoT integration can enable remote monitoring and real-time data analysis.

In addition, vibration-based alerts can be incorporated for noisy industrial environments where audio alerts may not be effective. Machine learning techniques can also be applied to predict hazardous situations based on sensor data patterns.

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