COLLISION ALERT SYSTEM AT BLIND SPOT USING MOTION SENSOR

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Abstract – *This paper introduces a system designed to help prevent people from accidentally running into each other during activities like walking or jogging at blind corners. The system uses motion detection to recognize movement patterns and gives a warning when a potential collision is likely. It has been tested in real-life situations and shown to work effectively. The paper explores the idea behind the system, how it was built, and how well it performs in practice, showing its usefulness in helping people avoid accidental collisions.*

***Key Words*: Collision Alert, Motion Detection, Safety, Real time operating system, Blind spot.**

1.INTRODUCTION

Human collision avoidance is a critical concern in a wide range of environments where individuals are constantly on the move. These include educational institutions, healthcare facilities, workplaces, and public venues. In such places, individuals may be walking or running, often unaware of others approaching from different directions. Traditional methods to prevent collisions, such as visual signage, designated lanes, or human vigilance, are often insufficient due to limited visibility, distractions, or high-speed movements. For instance, in schools and universities, students rushing between classes can unintentionally collide with one another, leading to minor or serious injuries. In hospitals or elder-care facilities, such collisions can be even more dangerous due to the frailty of patients or elderly residents.

The need for a non-intrusive, automated, and efficient collision avoidance mechanism has never been more relevant. With the growing complexity of indoor infrastructure and increased human density in confined spaces, technology-driven solutions are essential to proactively manage human movement. This is especially important in environments where visual contact between individuals may be restricted due to architectural design or obstructions, making manual collision prevention ineffective.

With the advent of smart sensing technologies and embedded systems, there is an increasing shift toward automated solutions for safety and monitoring. Sensor-based detection systems have emerged as reliable tools for capturing real-time human movement without requiring direct user interaction. Among these, Passive Infrared (PIR) sensors are particularly effective and affordable for motion detection applications. PIR sensors measure infrared radiation emitted from bodies, enabling them to detect motion within a specific range. They offer advantages such as low power consumption, ease of deployment, and immunity to ambient light conditions.

This research introduces a novel system that leverages PIR motion sensors and a simple alert mechanism (buzzer) to detect potential human-to-human collision paths in real time. The design is centered around four strategically placed PIR sensors to monitor two individuals approaching each other from opposite directions. When motion is detected by the rear sensors (3 and 4), a countdown begins. If the front-facing sensors (1 and 2) also detect motion within a limited window, the system activates a buzzer to alert both users of an imminent collision.

The purpose of this study is to demonstrate how a low-cost, low-complexity sensing mechanism can be integrated into common indoor spaces to significantly enhance human safety. Through systematic testing, we show that the proposed system can achieve high accuracy in detecting motion and delivering timely alerts, thereby minimizing the risk of accidental collisions. This system serves as a scalable and practical solution for real-time collision prevention in everyday setting

2. Literature Review

Automotive collision avoidance systems (CAS) have been extensively studied and developed to prevent vehicle-to-vehicle collisions. These systems utilize sensors such as radar, lidar, and cameras to detect potential obstacles and provide warnings or automatic braking to avoid accidents. A comprehensive review by John Dahl et al. (2018) categorizes threat-assessment algorithms used in CAS, including single-behavior threat metrics, optimization methods, formal methods, probabilistic frameworks, and data-driven approaches like machine learning. These methodologies could be adapted for human-to-human collision detection by employing appropriate sensors and algorithms.[1]

Pedestrian detection systems in vehicles aim to identify and prevent collisions with individuals on foot. These systems often employ computer vision techniques and artificial intelligence to recognize pedestrians in the vehicle's path and initiate warnings or automatic braking. The principles of pedestrian detection, such as real-time image processing and pattern recognition, can be applied to detect individuals approaching a doorway from opposite sides. Implementing similar sensor technologies and algorithms could enhance the accuracy and reliability of a doorway collision warning system. [2]

Understanding human behavior and response to warning systems is crucial in designing effective collision avoidance technologies. Research by Shreeraman (2018) examines the effects of driver, vehicle, and environment characteristics on collision warning system design, emphasizing the importance of user acceptance and appropriate warning strategies. These insights highlight the need for intuitive and non-intrusive alert mechanisms in human-to-human collision warning systems to ensure users respond effectively without experiencing alarm fatigue. [3]

The selection of appropriate sensors is vital for accurate detection in collision warning systems. Ultrasonic sensors, infrared sensors, and cameras have been utilized in various applications to detect obstacles and measure distances. For instance, an Arduino-based forward collision detection system employs ultrasonic sensors to detect vehicles ahead and alert drivers to potential collisions. Adapting such sensor technologies for doorway applications involves configuring them to detect human presence and movement accurately, considering factors like sensor range, field of view, and environmental conditions.[4]

Research into door collision avoidance has primarily focused on preventing accidents between doors and obstacles, including humans. For instance, a patent by Rhode et al. (2018) discusses systems and methods for vehicle door collision avoidance, utilizing sensors to detect obstacles and prevent door operation to avoid collisions. Although centered on vehicle applications, the principles of obstacle detection and preventive measures can be adapted for human-to-human collision scenarios in doorway settings. [5]

Advancements in sensor technologies have significantly contributed to collision prevention systems. Pepperl and Fuchs offers dual-technology sensors combining motion detection and presence sensing to enhance safety in automatic door applications. These sensors utilize active infrared technology to create protective fields, preventing collisions by detecting the presence of individuals near doorways. Such technologies can be adapted to monitor both sides of a door, providing warnings when two people approach simultaneously. [6]

Similarly, OndoSense provides radar sensors designed for collision avoidance, capable of reliable obstacle detection even in challenging environmental conditions. These sensors can be employed in various applications, including monitoring pedestrian traffic in doorways to prevent collisions. [7]

PIR (Passive Infrared) sensors have been widely utilized for motion detection due to their affordability, energy efficiency, and ease of deployment. Mainetti et al. (2013) demonstrated that PIR sensors could effectively detect human presence in smart building applications, especially in low-light conditions where vision-based systems underperform. Rida et al. (2015) further illustrated how PIR sensors could be integrated into Internet of Things (IoT) frameworks for intelligent home automation and presence-based energy control.[8]

In the wake of the COVID-19 pandemic, wearable sensor technologies gained attention for enforcing social distancing. Ahmed et al. (2021) developed a wearable system using ultrasonic sensors that alerted users when interpersonal distance dropped below a threshold. However, the practicality of wearable systems is often challenged by issues such as discomfort, battery constraints, and the need for user compliance.[9]

For mobility assistance, Smith and Lee (2019) designed a collision detection system for motorized wheelchairs using infrared sensors. Although their system was effective for obstacle avoidance in a controlled setting, it was tailored to assistive devices and lacked generalizability to common pedestrian interactions.[10]

Zhao and Cook (2018) reviewed the concept of ambient intelligence, where unobtrusive sensors embedded in the environment monitor and respond to user behavior. They emphasized the use of PIR sensors for non-intrusive presence detection without compromising privacy, supporting the direction of the present study.[11]

More complex approaches utilize computer vision systems, such as the YOLO (You Only Look Once) object detection model by Redmon and Farhadi (2018). While these models offer real-time, high-accuracy object tracking, they require substantial processing power and raise concerns about surveillance and privacy, making them unsuitable for lightweight, privacy-preserving applications.[12]

3. Methodology used to develop the model

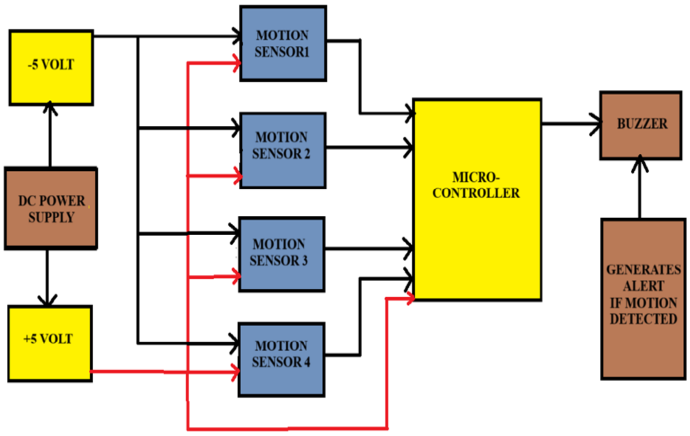

Figure-1 : Block Diagram of System

1. System Overview:

The collision alert system is designed to monitor two individuals walking or running toward each other from opposite directions in a defined indoor space. The setup uses four PIR sensors to detect motion within a range of 30 feet. The system operates based on specific timing conditions and sensor activation sequences that indicate a possible collision scenario. When such a pattern is detected, the system activates a buzzer to alert both individuals, thus preventing potential contact.

2. Power Supply and Voltage Regulation:

To power the motion sensors and microcontroller, a 5V regulated DC power supply is required. Since the available power source is AC, a custom-designed 5V AC to DC converter circuit was developed.

This +5V output is used to power the four PIR motion sensors and the microcontroller unit.

3. Sensor Configuration and Placement:

The four PIR motion sensors are strategically positioned to cover two movement paths from opposite directions:

Sensor 3 and Sensor 4 are placed at the rear entry points of two opposing paths. Their role is to detect initial motion, indicating the entry of a person.

Sensor 1 and Sensor 2 are placed further along each path, closer to the potential point of collision.

The sensors are configured to send a digital HIGH signal to the microcontroller when motion is detected in their field of view.

4. Microcontroller Integration

Functional Logic Flow:

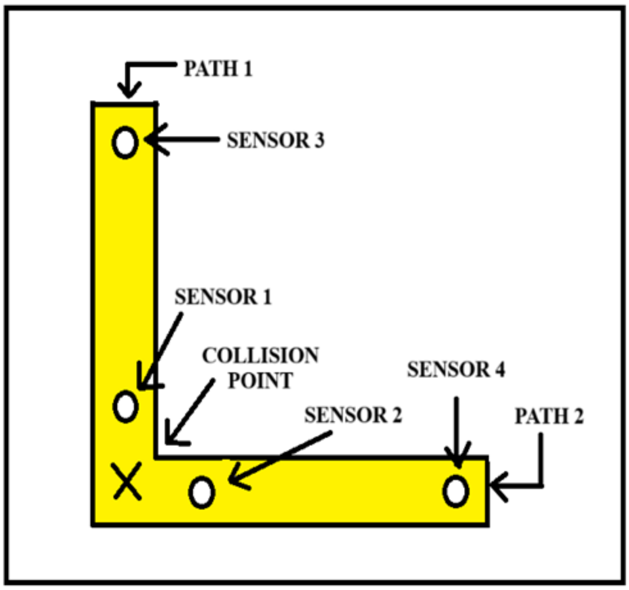

Figure-2 : Schematic of sensor placement

4.1. Activation Window 1 (Rear Detection):

As shown in fig.2. If Sensor 3 or Sensor 4 detects motion, a 7-second timer is started.

Within this 7-second window, if both Sensor 1 and Sensor 2 detect motion, the system interprets this as two individuals approaching each other and activates the buzzer to issue an alert.

If no motion is detected by Sensor 1 and Sensor 2 within 7 seconds, the activation window is closed, and no alert is triggered.

4.2. Activation Window 2 (Direct Detection):

If Sensor 1 and Sensor 2 detect motion simultaneously or within 5 seconds of each other without prior activation of Sensor 3 or Sensor 4, the system still interprets this as a direct potential collision.

In this case, the buzzer is triggered as a safety measure.

This two-condition logic allows the system to detect both approaching individuals from opposite ends and individuals approaching directly without rear detection, thereby increasing accuracy and reducing false positives.

5. Buzzer Alert Mechanism

The buzzer is connected to a digital output pin of the microcontroller. Once the logic conditions are met, the buzzer is turned on using a HIGH signal. The alert continues for a fixed duration or until the collision window is resolved. The buzzer is powered through a transistor switch circuit to ensure sufficient current drive and isolation from the microcontroller.

4. CONCLUSIONS

This paper introduces a reliable and efficient collision alert system using four PIR motion sensors to improve personal safety in indoor environments such as corridors, schools, and public facilities. By employing four motion sensors instead of the conventional two, the system can determine the direction of individuals' movement, significantly reducing false alerts—especially in cases where people are moving away from each other rather than toward a collision point.

The microcontroller processes sensor output data using a logical, time-based sequence. When motion is first detected by rear sensors (Sensor 3 or 4), a time window is activated, and further motion detected by front sensors (Sensor 1 and 2) confirms a potential head-on path, triggering the buzzer alert. The system also accounts for direct motion detection by Sensor 1 and 2 within a short span, even without rear detection, ensuring that no genuine collision risk is missed.

The system's low-power design, ease of deployment, and privacy-preserving characteristics make it a strong alternative to camera-based solutions. With further improvements such as wireless communication or machine learning for pattern recognition, this framework can be scaled into more advanced safety systems for smart environments.

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