



IEEE CASS 2026 Student Design Competition Report

SAFETY MONITORING SYSTEM FOR CHILDREN WITH AUTISM

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Problem Definition

The project's prime goal is designing a safety monitoring system for autistic children that can detect and alert parents and caregivers to both environmental risks and child-specific distress behaviors, using a non-intrusive real-time clip-on device. The design addresses the following factors:

1. **Dual-trigger detection:** monitoring both the surrounding environment and the child's behaviour to identify potentially overwhelming or dangerous situations.
2. **Hardware Integration:** developing a lightweight system using sensors while ensuring the device remains comfortable and minimally intrusive for children for children who may reject traditional wearables.
3. **Caregiver Notification:** building an alert system that can receive signals from the sensors to notify parents and caregivers about the possible environmental factors and child-specific distress behaviour.

Abstract

Children with autism spectrum disorder (ASD) often experience difficulty communicating distress and are highly sensitive to environmental stimuli such as loud noises, bright lights, and chaotic environments. These factors can lead to overwhelming or unsafe situations, especially when continuous supervision is not possible. The project presents a lightweight, clip-on safety monitoring system designed to detect both environmental triggers and child-specific behavioural indicators of distress in real time. The system integrates multiple sensors, including a microphone, light-dependent resistor, infrared motion sensor, and a camera module that assesses visual chaos. Sensor data is processed onboard and transmitted wirelessly to a caregiver's receiver unit using ESP-NOW, a low-latency communication protocol. The parent device provides immediate alerts via an OLED screen, RGB LED, a buzzer, and a manual acknowledgement feature to confirm caregiver response. Unlike existing solutions that rely heavily on wearables, this system emphasizes non-intrusive monitoring and dual-trigger detection. Planned enhancements include data logging, a mobile app interface, and a machine learning-based refinement. Overall, this solution aims to provide a practical, accessible, and a real-time safety net for autistic children in diverse environments.

I. Introduction

Autism cases vary widely from one child to another: some autistic children can manage with minimal supervision, while others cannot be left alone for even short periods. In everyday life, parents and caregivers may not always be able to keep eyes on the child at all times, which can unintentionally expose the child to risky situations or environments that can cause discomfort and distress. For that reason, a reliable monitoring system that can detect and respond to these situations can help reduce this challenge and ease the burden on caregivers. Yet, relying on a wearable device is not always a practical solution since many children, especially in more severe cases, may refuse to wear or tolerate

anything attached to their body. Hence, there is a need for a supportive monitoring approach that enhances safety and comfort without requiring the child to wear the device.

II. Literature Review

Several technologies have been developed to address the safety and well-being of autistic children. Each system provides important insights and capabilities, but also presents limitations that need to be addressed. One of the most widely used solutions is the *AngelSense GPS Tracker*, a wearable device that enables real-time location tracking. It is a valuable preventer of elopement that detects missing children. However, it does not detect sensory or behavioral distress and requires wearability, which may not be suitable for all children with autism spectrum. Physiological monitoring systems, such as *Reveal Band by Awake Labs*, provide early warning signs of emotional distress by measuring biometric signals like heart rate. Such devices provide promising proactive intervention, particularly in non-verbal children. Yet, they also rely on full-time wear and may generate false positives due to physical changes that are not stress-related. Other existing solutions include the *Vivint Smart Housing System* that uses fixed sensors to monitor household risks. It is helpful for nighttime safety or home-based monitoring, but is non-portable and context-limited in the area related to behavioural risk factors.

III. System and Structure

To address the limitations of the previous existing devices, two systems were developed:

A. Child-Related Device

Lightweight, clip-on equipped with multiple sensors that continuously monitor the child's behaviour and surrounding environment to detect signs of distress or potential safety risks.

- Problem 1: External Environmental Triggers

1. Loud or sudden sounds (noise spikes, prolonged noise)
2. Harsh / bright / flickering light
3. Environmental chaos
4. Sudden motion around the child
5. Crowded / highly dynamic surroundings

Components Used:

1. Microphone Module – MAX9814
2. IR Motion Sensor
3. Light-Dependent Resistor Module
5. ESP32-CAM Module
6. ESP32 Microcontroller

Thresholds defining sensor-triggering conditions:

Condition (MAX9814)	Threshold
Loud Noise	> 75 dB
Sudden Noise Spike	+20 dB within 0.5 sec
Prolonged Noise	> 70 dB for +10 sec

Condition (LDR Module)	Threshold
Harsh Light	>80% LDR Value
Sudden Brightness Change	+/- 30% in <1sec
Flickering Light	>15% change repeated 5x in 2 sec

Condition (IR Motion Sensor)	Threshold
Sudden Motion	Single IR trigger
Repeated Motion	> 5 PIR triggers in 10 sec

Condition (ESP32-CAM)	Threshold
Visual Chaos	>25% pixel change
Sudden Chaos	>40% pixel change in <1sec
Sustained Chaos	>20% for 5+ sec

- Problem 2: Child-Centered Risk and Distress Detection

1. Child distress or inability to communicate
2. Vocalizations (crying, repetitive sounds)
3. Sudden or repetitive movement patterns

Thresholds defining sensor-triggering conditions:

Condition (MAX9814)	Threshold
Distress Vocalization	>70 dB near child
Repetitive Sounds	Same pattern >5 times
Sudden Crying	Spike + Sustain >3 sec

Condition (ESP32-CAM)	Threshold
Moderate Movement	>30% frame motion
Agitated Movement	>50% frame motion
Repetitive Motion	Same motion 5x

B. Parent-Related Device

Wearable receiver unit that provides real-time alerts through indicators that enable caregivers to quickly identify and respond to environmental and behavioural triggers detected by the child device.

Components Used:

1. OLED Display → Displays the triggers
2. RGB LED → Indicates the severity of the problem
3. Buzzer → Vibrates when the trigger is critical.
4. Push Button → Pressed by the parent to indicate that the situation has been attended to.
5. ESP32 → Main Microcontroller

RGB Colors	Meaning
Green	Everything is normal
Yellow	Warning but not acknowledged
Blue	Warning that has been acknowledged
Red	Critical Alert
Purple	Connection Lost

Overall, both ESPs communicate via code; using a connectionless wireless protocol, *ESP-NOW*, that allows device-to-device communication over WI-FI without requiring an internet connection or router.

IV. System Improvements

- Companion App Integration

1. Receive real-time events from the child device.

2. Allow caregivers to view incident history.
 3. Allow customization of threshold levels and alert settings.
- **Data Logging and Pattern Tracking**
 1. Log every event detected with a timestamp.
 2. Enables behavioural/sensory pattern analysis over time.
 - **Smarter Detection with Artificial Intelligence**
 1. Rely on accurate motion detection rather than pixel frame difference.
 2. Reduce false alarms from harmless sounds and movements.
 3. Personalize detection to each child's unique behaviour patterns.

Resources

- *Tracking devices – pathfinders for autism.* (n.d.). Pathfinders for Autism - Improving the Lives of Individuals With Autism and the People Who Care for Them. <https://pathfindersforautism.org/resources/safety/tracking-devices/#:~:text=Angel%20Sense%20AngelSense%20is%20the,The%20parents%E2%80%99%20monitoring%20app%20is>
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