TECHIN 514 Final Project:

Children's Safety Habit Builder

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Github: https://github.com/yeyfreya/TECHIN514-Final-Project.git

Introduction

The Vulnerability of Children Under 5

Children under the age of five possess a natural curiosity that drives them to explore every corner of their environment. However, their developing motor skills and limited understanding of risk make them particularly vulnerable to the hazards that our homes, unwittingly, may present. From the sharp edges of furniture to the allure of household chemicals, the dangers are numerous and varied.

The Challenge of Keeping Them Safe

The challenge we face is twofold: firstly, to understand the myriad dangers that our homes can present to a young child's safety and, secondly, to devise and implement effective strategies to prevent these incidents. This isn't just about close supervision; it's about creating a safe space that encourages their curiosity and learning while protecting them from harm.

Solution

In response to the critical challenge of safeguarding young children from the dangers within their home environments, I propose a cutting-edge, yet intuitive solution: the integration of wearable sensors for children, paired with stationary sensors positioned around hazardous areas. This sophisticated system is designed to monitor the proximity between a child's hand and potentially dangerous locations within the home.

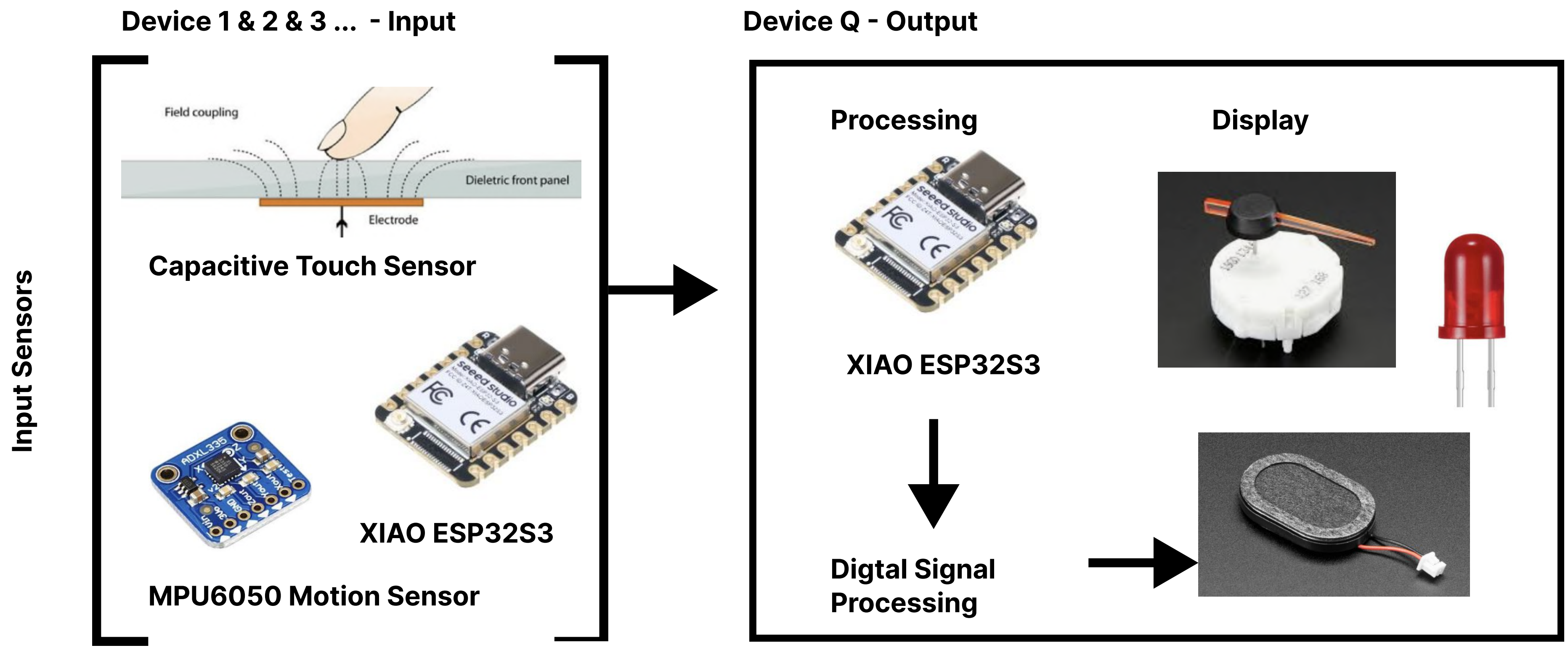
How It Works

Utilizing advanced sensor technology, my solution actively tracks the distance between the child and predefined danger zones. When a child approaches too close to a hazardous area, the system immediately triggers a dual-response mechanism—emitting both light and sound warnings. These warnings are specifically designed to gently deter the child, leveraging their natural aversion to sudden, bright lights and loud noises to discourage further approach.

Cultivating Safe Habits

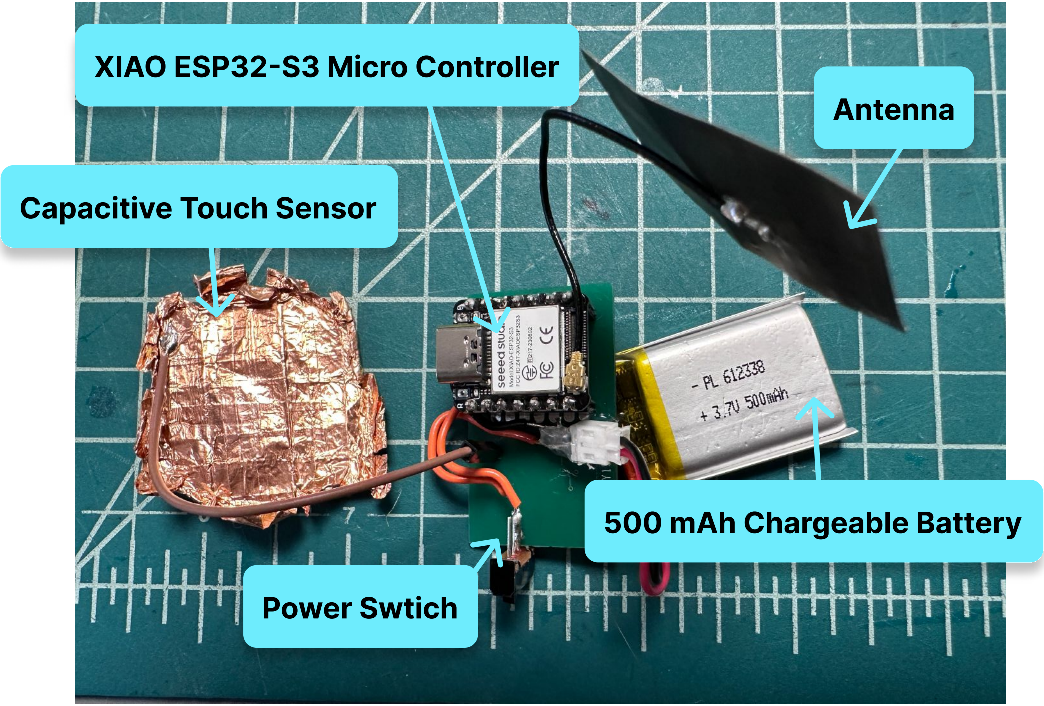
More than just a deterrent, my approach aims at behavioral modification. Through consistent use, my sensor-based solution educates and conditions young children to associate these auditory and visual cues with caution, thereby nurturing a habit of avoiding dangerous areas. This method not only provides immediate protection but also instills a long-lasting awareness of safety in young explorers.

System Architecture

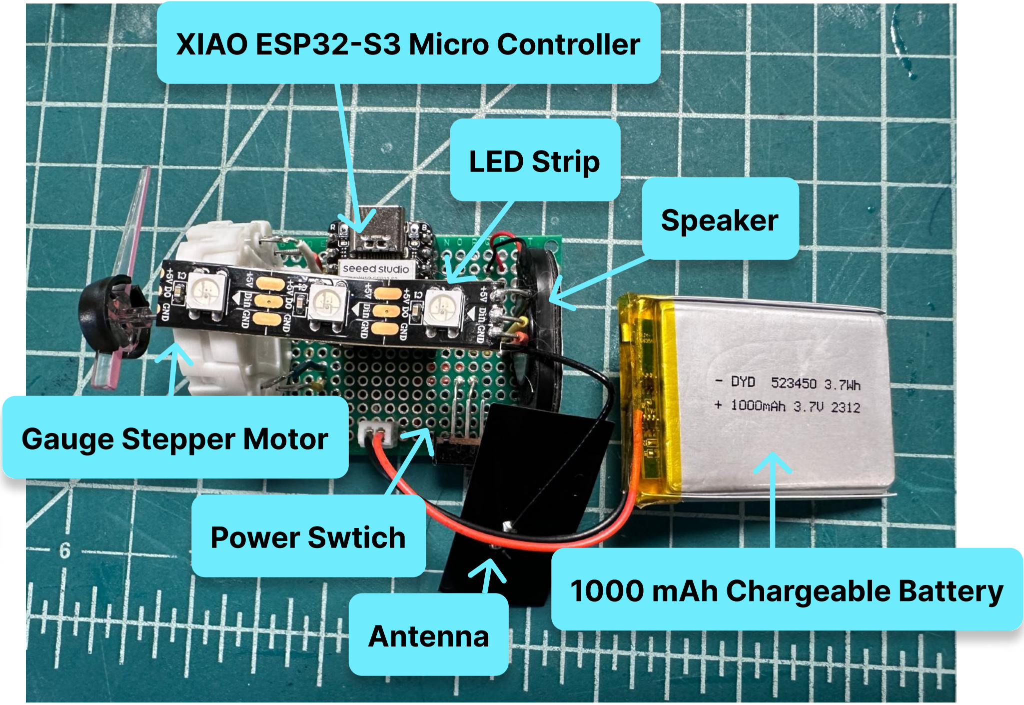


Critical Components

Sensor Device



Display Device



Signal Processing

Sensors & Data Acquisition

- Utilizes an Adafruit MPU6050 for motion tracking, capturing acceleration and gyroscopic data.
- Employs a touch sensor to detect direct contact, enhancing motion data reliability.

Data Processing & Transmission

- The MPU6050 data (acceleration, gyroscopic readings) are analyzed to detect movements indicative of a child attempting to reach hazardous areas.
- Touch sensor activation is monitored for additional context to movement data.
- Processed signals are transmitted via BLE, signaling potential hazardous approaches.

Response Activation

- Upon detecting signals exceeding predefined safety thresholds, the wearable device communicates with the stationary display unit.
- The display unit triggers visual (LED flashing) and auditory (tone emission) deterrents, designed to redirect the child's attention away from danger.
- A stepper motor acts as a physical indicator of the child's proximity to the hazardous area, with its movements calibrated to the intensity of the approach, informed by RSSI values from BLE communication.

Key DSP Elements

- Real-time analysis of acceleration and gyroscopic data to detect hazardous movements.
- Integration of touch sensor readings for enhanced motion context.
- Wireless signal transmission and responsive actuator control based on processed data.

Battery Strategy

Energy Efficiency & Capacity

- Sensor Device: 500 mAh rechargeable battery optimized for continuous motion tracking and BLE communication.
- Display Device: 1000 mAh rechargeable battery to support increased energy demands from signal processing, visual/audio alerts, and stepper motor control.

Volume & Weight Impact

- Wearable Sensor: Compact and lightweight design prioritizing child comfort and wearability.
- Stationary Display: Larger battery accommodates without impacting usability, focusing on extended operation.

Convenience & Sustainability

- Rechargeable batteries across both units to reduce waste and costs.
- User-friendly charging solutions and battery level indicators ensure devices are always ready.
- Balancing operational longevity with the practicality of daily use.

Key Takeaway

- Effective power management ensures our child safety system is energy-efficient, convenient, and designed with the end-user in mind, providing peace of mind without frequent interruptions for charging.

Budget Summary

1. **MPU-6050 (Motion Tracking Device)**
   - Use: Captures motion data (acceleration and gyroscopic) for detecting child's movements towards hazardous areas.

2. **SEEED Studio XIAO Sense ESP32S3 (Microcontroller)**
   - Use: Acts as the central processing unit, handling data from sensors, managing BLE communication, and controlling response mechanisms.

3. **AKZYTUE 3.7V 1000mAh 803040 Lipo Battery (Rechargeable)**
   - Use: Powers the display device, supporting energy demands from signal processing, alerts, and stepper motor actuation.

4. **YDL 3.7V 500mAh 612338 Lipo Battery (Rechargeable)**
   - Use: Powers the wearable sensor device, ensuring it remains lightweight and maintains adequate battery life for daily use.

5. **Adafruit Micro-Lipo Charger for LiPoly Batt with USB Type C Jack**
   - Use: Offers a convenient and efficient charging solution for the LiPo batteries, enhancing the system's overall user-friendliness.

6. **Breadboard-friendly SPDT Slide Switch**
   - Use: Allows for manual power control of the system, enabling easy on/off functionality without removing the battery.

7. **Mini Oval Speaker with Short Wires - 8 Ohm 1 Watt**
   - Use: Generates auditory alerts as part of the display device's response mechanism, warning children away from hazardous areas.

Future Work

Enhanced Battery Life

- Research into alternative energy sources, like energy harvesting from ambient sources, could lead to a significant increase in the battery life of both devices.

Improved Sensor Accuracy

- Ongoing refinement of sensor technology will aim to increase the precision of the movement and proximity detection, reducing false positives and enhancing reliability.

User Experience Design

- Development of a user-friendly app will allow parents to monitor the system, customize alerts, and receive real-time updates on their child’s safety.

Miniaturization of Components

- Advancements in miniaturization will be explored to make the wearable sensors even less intrusive and more comfortable for continuous wear by children.