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Project Synopsis (2024-25) - Sem V

SafeGuard: AI-Driven Child Safety Monitoring System

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Abstract
Child safety in India remains a significant concern, with prevailing solutions predominantly limited to reactive and location-based tracking via basic wearable technologies. These systems often lack the intelligence to assess behavioral anomalies or provide timely intervention. This research presents an integrated, AI-driven framework designed to offer a comprehensive, proactive approach to child protection. The proposed system combines IoT-enabled wearable devices with cloud-based real-time monitoring and machine learning algorithms and natural language processing that is capable of detecting behavioral deviations, empathy detection, social intelligence, sentiment analysis and physiological distress. It uniquely incorporates Social Quotient (SQ) and Emotional Quotient (EQ) assessments to evaluate a child's emotional and social well-being alongside judging physical safety. Furthermore, automated alert mechanisms ensure rapid communication with caregivers and authorities when risk thresholds are exceeded. By integrating real-time anomaly detection and psychological evaluation into a unified platform, this research advances the field of intelligent child safety systems, providing a scalable, context-aware, and ethically grounded solution for vulnerable populations.

Introduction

According to UNICEF India, more than 30 % of young adults face the risk of security and safety among rural and urban populations. Therefore, keeping in mind the UN SDGs, it is a prime responsibility of all stakeholders to devise some solutions to mitigate the issues. Most hyperthermia-related child fatalities in India between 2011 and 2020 occurred when children, primarily aged 4–6, accidentally locked themselves in unattended vehicles while playing [1], as revealed by a descriptive analysis of news reports .

While Intelligence Quotient (IQ) has long been emphasized in child development, recent perspectives highlight the significance of Adversity Quotient (AQ) as a critical factor.AQ equips children with the ability to navigate challenges [2], recover from setbacks, and demonstrate emotional resilience.

Children in India face increasing safety threats, including abduction, neglect, accidents, and unsafe environments. Cases of children being left unattended in locked vehicles, unsafe school premises, and isolated rooms highlight the urgent need for continuous monitoring and proactive intervention.

While existing safety measures, such as CCTV surveillance, GPS tracking, and emergency helplines offer some protection; but they lack real-time behavioral analysis and predictive risk assessment. Traditional methods focus only on location tracking, failing to evaluate a child's emotional state, interactions, and potential distress signals. Physically and mentally challenged children become easy targets to social, physical and emotional abuse and therefore require a full-fledged system to track their physical movements inside and outside closed spaces along with a complete support system for their day-to-day behavioral analysis to provide better support and guidance.

Social Quotient (SQ) and Emotional Quotient (EQ) are crucial in assessing a child's well-being, decision-making, and responses to social situations. Current systems do not analyze these factors, leaving a gap in holistic child safety solutions. Integrating AI-driven monitoring, biometric tracking, and intelligent alerts can enable a proactive, data-driven approach to safeguarding children in all environments.

Children today face a multitude of challenges that impact their emotional, social, and psychological well-being. Bullying and peer pressure are common issues that can lead to low self-esteem and a lack of confidence. Many children struggle with emotional difficulties such as

anxiety, fear, and loneliness, which are often compounded by academic stress and the pressure to perform well in school. Social isolation or exclusion further deepens these emotional struggles, making it difficult for children to form healthy relationships. Additionally, the absence of safe and supportive environments, both at home and in schools, leaves children vulnerable. Parental expectations can sometimes add to the stress, especially when children feel the need to constantly meet high standards. Moreover, increased digital exposure brings new safety concerns, including cyberbullying and inappropriate content, making digital safety a critical area of concern for children's overall well-being.

Children with learning or physical disabilities often face a range of specific challenges that can hinder their overall development and well-being. One of the major difficulties is in communication, where children may struggle to express their thoughts or understand others effectively. This barrier can impact their ability to form connections, both academically and socially. Educational settings may also pose significant hurdles due to the lack of inclusive teaching methods or adequate resources tailored to their needs. Many children experience challenges with reading, writing, attention, or memory—common issues associated with learning disabilities. Additionally, physical inaccessibility in schools, public spaces, or transportation systems can further limit their participation in everyday activities.

Social exclusion and stigma.These experiences can lead to emotional challenges, including a heightened risk of depression, frustration, and social anxiety. Furthermore, many children become heavily dependent on caregivers for both basic daily needs and academic support, which can limit their sense of independence. Another critical issue is the shortage of trained support staff, such as specialized teachers and therapists, who are essential in providing the tailored assistance these children require. Finally, inadequate early diagnosis can delay interventions that are crucial for managing disabilities effectively and supporting the child's long-term growth.

In India, children in need of safety often include those with neurodevelopmental disorders such as autism, attention-deficit/hyperactivity disorder (ADHD), and intellectual disabilities, as well as those with physical impairments. These children are particularly vulnerable due to limited mobility, communication challenges, or cognitive delays, necessitating tailored safety mechanisms and continuous monitoring.

Problem Statement

Ensuring child safety in today's dynamic and unpredictable environment requires much more than just GPS tracking or basic location monitoring. Existing child safety mechanisms are largely reactive and focused primarily on physical tracking, offering little to no insight into the child's emotional or social well-being. Children are vulnerable not only to physical threats such as environmental hazards, getting lost, or abduction, but also to emotional challenges like stress, fear, social withdrawal, and emotional instability. Despite advances in technology, there is a critical gap in solutions that proactively integrate environmental safety, emotional intelligence monitoring, and social adaptability evaluation into a unified, intelligent framework. Therefore, there is an urgent need for a comprehensive solution that not only tracks and alerts about physical risks but also monitors the child's behavioral and emotional patterns, ensuring holistic child safety and development through continuous analysis and intelligent intervention.

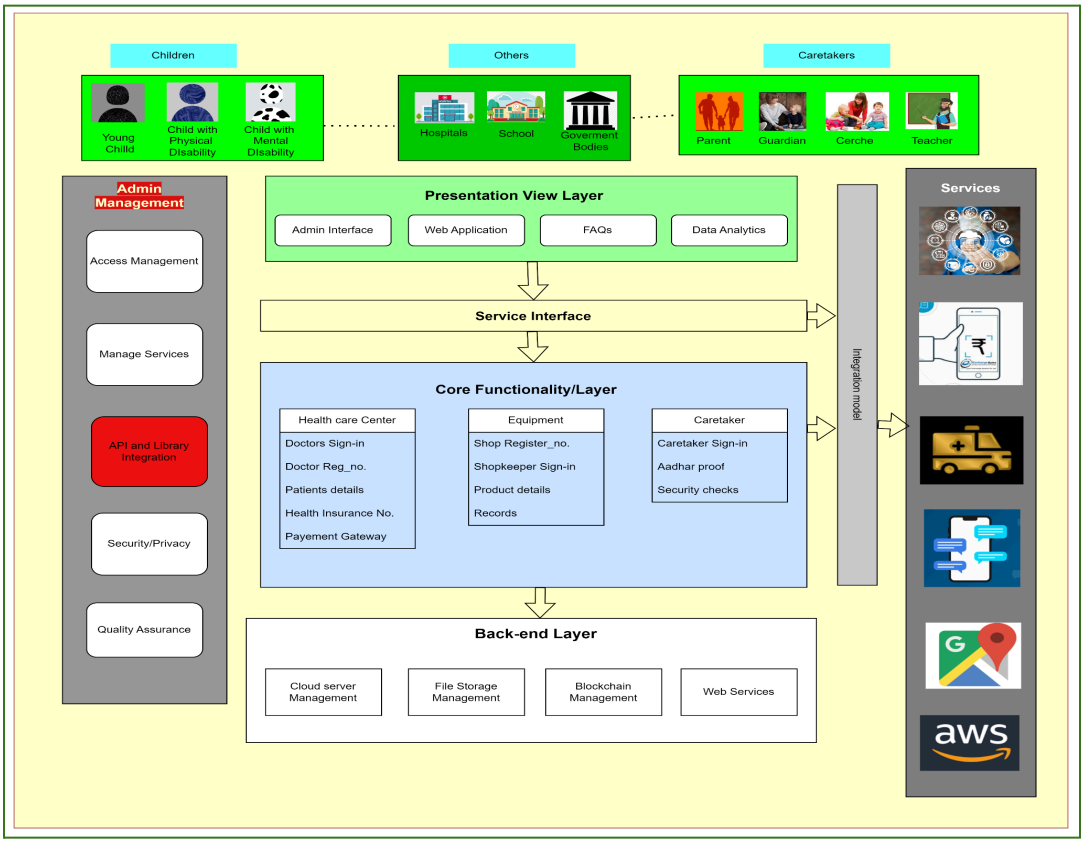
Proposed Solution

The SafeGuard system offers a revolutionary AI-driven, real-time child safety platform that combines three major pillars: **physical safety monitoring**, **Social Quotient (SQ) evaluation**, and **Emotional Quotient (EQ) analysis**. At its core, SafeGuard uses an IoT-enabled wearable device embedded discreetly into the child's clothing, equipped with sensors to monitor biometric and environmental parameters such as temperature, oxygen levels, humidity, and real-time GPS location.

Parallelly, the system assesses the child's Social Quotient by engaging them through carefully designed interactive activities such as games, story narration, and comprehension tasks. Simultaneously, the Emotional Quotient module captures the child's emotional expressions through video and speech analysis, applying deep learning, NLP, and sentiment analysis techniques to detect behavioral anomalies, stress levels, and emotional states.

The SafeGuard platform transmits all monitored data to a secure cloud infrastructure, where AI and machine learning algorithms continuously analyze it. In case of detected threats, emotional distress, or social anomalies, instant alerts are triggered to parents, caregivers, or authorities, allowing proactive intervention. Moreover, the system suggests tailored support strategies based on the child's assessed SQ and EQ, ensuring comprehensive and real-time child safety, social nurturing, and emotional resilience.

Methodology / Block Diagram



The methodology behind SafeGuard is structured around three interconnected modules:

1. **Safety Monitoring Module**:
   This module uses the IoT-based wearable device equipped with environmental and biometric sensors, including temperature, oxygen, air quality sensors, and GPS modules. The device constantly transmits data to the cloud where real-time analysis is performed. If abnormal patterns such as deviation from predefined routes, exposure to extreme temperatures, or low oxygen levels are detected, immediate emergency alerts are generated and communicated to registered guardians.

2. **Social Quotient (SQ) Assessment Module**:
   The SQ evaluation is conducted through an array of AI-driven, gamified, and NLP-based activities including "Memory Match," "Create Your Story," "Think Sphere (comprehension games)," "Self-Help Game," and "Dream Role Play." These activities are designed to map and evaluate the child's abilities across key parameters like communication, cooperation, responsibility, empathy, self-control, and socialisation. Based on the responses, a social age is calculated, and using a predefined formula, the SQ score is determined and categorized into Low, Average, or High.

3. **Emotional Quotient (EQ) Assessment Module**:
   For EQ analysis, recorded emotional responses in specific real-life simulated scenarios are processed. Videos are converted into frames using OpenCV, and audio is transcribed through speech-to-text processing. NLP techniques, including sentiment analysis and tone detection, are then applied to the text data. The model evaluates emotional states like empathy, emotional stability, prosocial behavior, aggression, and withdrawal. These insights are combined into a scoring system that provides a quantitative measure of the child's emotional intelligence.

All three modules are integrated into a centralized web platform where authorized users (parents, teachers, psychologists) can monitor reports, track real-time updates, and receive personalized recommendations for the child's growth.

Hardware , Software and tools Requirements

- **Hardware Components**:
  The SafeGuard wearable device includes a Raspberry Pi 4 microcontroller acting as the processing unit, BME680 sensors for monitoring environmental parameters such as temperature, humidity, and air quality, MIX8410 sensor for oxygen concentration, GPS HAT module for real-time location tracking, and WiFi

modules for cloud communication. The device is lightweight, discreet, and designed for continuous use by children.

- **Software Tools**:
  The system backend is developed using Python, integrating libraries such as Pandas and NumPy for data preprocessing, Scikit-learn for implementing machine learning models, and TensorFlow/Keras for deep learning applications like sentiment and tone analysis. OpenCV is used for video frame extraction in the EQ module, while NLTK and other NLP tools handle text-based emotional analysis. Flask is used to create web API endpoints, Firebase for user authentication and real-time database management, and Google Cloud services for hosting the web dashboard, data storage, and advanced AI model deployment. Visualization tools like Matplotlib and Seaborn are employed for data reporting and analysis.
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Tools Required

1. Development Tools:
   - Visual Studio Code: A powerful, lightweight code editor used for writing and debugging code.
   - SSH Client (PuTTY): For remote access and control of the Raspberry Pi.
   - Git: A version control system used to manage the project's source code.
2. Training and Fine-Tuning Tools:
   - GPU-equipped Laptop or Workstation: Required for training the ML model. Specifications should include a high-end GPU (e.g., NVIDIA GTX 1080 or higher), 16GB RAM, and an Intel i7 or equivalent CPU.
   - CUDA Toolkit: NVIDIA's parallel computing platform and application programming interface model used for leveraging GPU power in training ML models.
   - LabelImg: An open-source graphical image annotation tool for labeling images, which is essential for preparing training datasets.

Proposed Evaluation Measures

The performance and success of the SafeGuard system will be evaluated through multiple dimensions:

- **Model Performance Metrics**:
  The classification models for SQ and EQ will be evaluated based on accuracy, precision, recall, and F1-score to ensure the system effectively categorizes children into the correct social and emotional maturity levels.

- **Real-Time Responsiveness**:
  The effectiveness of emergency alert triggering and real-time environmental monitoring will be measured by response time (latency between event detection and alert generation).

- **System Stability and Reliability**:
  The uptime and stability of the wearable device's data transmission to the cloud and the responsiveness of the dashboard will be continuously monitored.

- **User Experience and Usability Testing**:
  Feedback from parents, educators, and healthcare professionals will be collected to assess the platform's usability, interpretability of reports, and practicality in real-life scenarios.

- **Intervention Success Rate**:
  Improvements in children's emotional and social behavior post-intervention will be monitored, providing a real-world measure of the effectiveness of the SafeGuard assessments and recommendations.

Conclusion

SafeGuard redefines the concept of child safety by introducing an intelligent, AI-powered framework that goes far beyond conventional GPS-based tracking. This system unifies real-time environmental monitoring, SQ and EQ assessments, and behavioral intelligence to offer a deeply responsive and multidimensional protective solution. At its core is an IoT-enabled wearable device, seamlessly integrated into the child's clothing, which monitors environmental parameters including temperature, oxygen levels, and precise geolocation and transmits this data securely to the cloud for continuous analysis and real-time tracking. These insights empower caregivers to intervene promptly, making child safety both preventive and personalized. In addition, the system will provide a curated dataset to medical practitioners for research, guidance and analysis of certain behaviours for specially abled children as well as analysing overall child psychology.

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