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SmartHome AI Powered Domestic Violence Detection System

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Abstract: *The Smart Home Violence Detection System is an innovative AI-driven platform that aims to identify and prevent domestic violence incidents within smart home environments using advanced speech and text analytics [1],[3]. Conventional safety mechanisms such as manual alerts or panic buttons have limitations, as victims often cannot access them during violent situations [4]. This project bridges that critical gap by employing artificial intelligence and natural language processing (NLP) models to analyze tone, emotion, and textual sentiment in real time, enabling the system to detect aggression or distress [2],[5]. Once a potential threat is identified, the system silently alerts registered emergency contacts or nearby authorities through an integrated alert module, ensuring immediate intervention without notifying the abuser [3]. The system is built using open-source tools like Python, Flask, and MongoDB, making it scalable, low-cost, and suitable for deployment across smart homes and community centers [1],[6]. Users can monitor incidents through a secure web dashboard that displays detection logs, voice analysis reports, and emotional trends for further study. Additionally, the platform supports continuous learning, allowing the AI models to improve detection accuracy through real-time feedback. Ultimately, this project seeks to enhance domestic safety by merging artificial intelligence with human welfare applications, thus creating a proactive and reliable technological safeguard against domestic violence [2],[5],[7].*

Keywords: Artificial Intelligence (AI), Domestic Violence Detection, Smart Home System, Voice Analysis, Text Monitoring, Natural Language Processing (NLP), Machine Learning, Safety Alert System

I. INTRODUCTION

Domestic violence is one of the most persistent and underreported social problems in modern society, affecting millions of individuals globally regardless of age, gender, or background [1]. Despite the availability of various helplines and legal frameworks, many victims are unable to seek timely help due to fear, social stigma, or physical restrictions imposed by the abuser [2],[4]. Traditional safety mechanisms, such as panic buttons and emergency calls, often fail in critical moments when victims cannot act or communicate freely, creating the need for an intelligent, automated, and discreet system that can detect early signs of violence and alert trusted authorities without human intervention [3]. In the digital era, artificial intelligence (AI), natural language processing (NLP), and smart home technologies have emerged as powerful tools for ensuring personal and domestic safety [1],[5]. By analyzing speech tone, emotional patterns, and text-based communication, AI systems can identify indicators of anger, distress, or fear that typically precede violent actions [3],[6]. The Smart Home Violence Detection System is designed to leverage these technologies to provide real-time monitoring and intelligent alert generation within a home setup [2],[5]. The system utilizes machine learning models trained on real-world datasets to analyze audio and text inputs from daily conversations, distinguishing between normal and aggressive behavior patterns [4]. When violence or distress is detected, the system silently sends alerts to pre-registered emergency contacts, community centers, or local authorities, ensuring immediate support while maintaining user privacy [1],[6]. It also features a user-friendly web interface for monitoring, data visualization, and analysis, built using open-source technologies like Python, Flask, and MongoDB to ensure scalability, affordability, and ease of integration with existing smart home devices [3],[7]. Ultimately, the Smart Home

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Violence Detection System aims to create a secure, self-sustaining digital ecosystem that supports victims, assists authorities, and contributes to social welfare by merging artificial intelligence with modern safety technology [5],[7].

II. LITERATURE SURVEY

The rapid progress of artificial intelligence and smart home technologies has significantly transformed the way domestic safety, surveillance, and behavioral monitoring are conducted in the modern era [1]. Traditional security systems such as CCTV cameras, panic alarms, and wearable emergency devices, though effective to some extent, are often limited by human accessibility and visibility constraints during critical situations. Victims of domestic violence, especially women and children, may not have the ability to activate such devices in moments of danger, thereby reducing their effectiveness as real-time safety measures [2]. Early research in this field focused mainly on speech-based aggression detection, where acoustic and prosodic features like tone, pitch, intensity, and voice modulation were analyzed using machine learning models such as Support Vector Machines (SVM) and Hidden Markov Models (HMM) to detect aggressive emotions [3]. While these methods established the foundation of vocal behavior analysis, they lacked contextual and linguistic understanding and were not integrated into smart home environments.

With the advent of deep learning, especially Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) architectures, researchers have improved voice-based emotion classification by enabling temporal and spectral analysis of real-world conversations [4]. Studies on textual data analysis have also evolved, introducing Natural Language Processing (NLP) models capable of identifying abusive, threatening, or coercive language patterns in chats and messages. Transformer-based architectures such as BERT and RoBERTa have demonstrated high accuracy in recognizing subtle patterns of verbal aggression, emotional distress, and intimidation in digital communication [5].

These breakthroughs have enabled the transition from simple sentiment detection to comprehensive behavioral context analysis.

Moreover, recent works in multimodal violence detection have explored the fusion of audio and textual features, enhancing model robustness and contextual accuracy [2],[6]. For instance, integrating speech tone with textual sentiment can reveal cases where polite words are spoken in a threatening tone—a phenomenon that single-modal systems fail to capture. Alongside these developments, the field of Internet of Things (IoT) and smart home automation has seen substantial growth, enabling real-time data collection through microphones, sensors, and mobile devices, all connected to AI-based analytics systems for early detection and automated alert generation [3]. Edge computing and cloud-based frameworks have been explored to balance real-time responsiveness with user privacy, allowing the system to process sensitive data locally while storing only anonymized logs for model retraining [7].

Despite these technological advancements, there remain critical limitations in the practical deployment of AI-driven violence detection systems. Many existing solutions are limited by the unavailability of diverse and ethically sourced datasets, leading to issues of model bias and inconsistent accuracy in real-life applications [4]. Ethical and legal challenges surrounding data privacy, consent, and continuous monitoring further restrict large-scale adoption [6]. In addition, most academic models focus on laboratory accuracy rather than real-time performance, often neglecting user-centric aspects like silent alert mechanisms, adaptive learning, and integration with existing smart devices [2].

To overcome these gaps, recent studies have emphasized privacy-preserving AI approaches, such as federated learning and encrypted communication, that allow data processing on local devices while maintaining user confidentiality [5]. Several frameworks have also suggested human-in-the-loop systems that include user feedback and emergency response validation, minimizing false alarms while ensuring reliability [3],[7]. These research directions demonstrate the growing need for AI systems that are not only intelligent but also ethically responsible and socially sensitive.

Hence, the proposed Smart Home Violence Detection System is conceptualized as an advancement over existing models by integrating AI-driven voice and text analysis, real-time alert mechanisms, and secure data handling into a single, accessible, and privacy-focused platform. By leveraging modern technologies such as machine learning, NLP, IoT, and web-based automation, this project aspires to fill the current research gaps in real-time violence detection, user safety, and domestic emergency response. The combination of artificial intelligence, multimodal signal analysis, and smart home integration presents a transformative opportunity to redefine domestic safety systems as proactive, inclusive, and socially impactful tools for human welfare [1],[4],[7].

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III. SYSTEM ARCHITECTURE

A. Overview

The Smart Home Violence Detection System is designed as a three-tier intelligent architecture that enables real-time monitoring, analysis, and alert generation for detecting domestic violence incidents through voice and text data [1],[4]. The architecture integrates three major layers—Presentation Layer, Application Layer, and Database Layer—each performing distinct but interlinked roles to ensure seamless communication, data processing, and system scalability. Fig. 1 illustrates the complete architecture of the system, showing how user interaction flows through various modules, from voice or text input to AI-based analysis and alert notifications.

Presentation Layer – User Interaction and Visualization

The Presentation Layer serves as the main interface between the user and the system. It is developed using modern web frameworks such as React.js, HTML, and CSS to ensure cross-platform accessibility and responsiveness [2],[6]. Users can interact with the platform through a simple dashboard that displays detection results, live monitoring logs, and alert notifications. This layer allows users to register trusted contacts, view previous detection reports, and configure alert preferences. The user interface is designed for both victims and system administrators, ensuring ease of use and discreet operation in sensitive situations. Major functions of this layer include audio/text input, visualization of AI results (e.g., detected aggression levels), and alert status updates.

Application Logic and Processing (Application Layer)

The Application Layer functions as the intelligent processing unit of the entire system [3],[5]. It manages voice and text data processing, applies AI models for violence detection, and controls the data flow between the frontend and the database. When a voice or text input is received, the application layer performs several steps:

1.Preprocesses the input data by removing noise, punctuation, and irrelevant symbols.

2.Applies AI models such as Speech Emotion Recognition (for audio) and NLP-based Text Classification (for chat/text).

3.Determines the probability of aggression or violence based on trained model parameters.

4.If the threshold level is crossed, the layer triggers the alert mechanism.

This layer also handles authentication, session management, and logging of detected incidents. The backend is developed using Python (Flask/Django) with integration of AI/ML libraries such as TensorFlow, Keras, and Scikit-learn. The API layer ensures smooth communication between modules and supports scalability through RESTful web services and background job scheduling.

Data Storage and Management (Database Layer)

The Database Layer provides secure and structured data storage, ensuring efficient retrieval, indexing, and analysis of information [4],[7]. It maintains datasets that include trained model files, user profiles, detection logs, trusted contact lists, and alert history. MongoDB is used as the primary database because of its ability to handle both structured and unstructured data such as audio features and text embeddings. To enhance security, all sensitive user data (e.g., contact information and incident logs) is encrypted. The database also supports role-based access to protect victim privacy and prevent unauthorized use. Real-time data synchronization between the database and the frontend is achieved using asynchronous communication protocols such as WebSocket or Firebase APIs.

AI Detection and Alert Mechanism

The Application Layer contains the AI Detection Module, which combines Speech Emotion Recognition and Text Sentiment Classification for accurate identification of violent or distressful content [2],[6]. The module uses feature extraction methods such as MFCC for audio and TF-IDF or BERT embeddings for text data. Detected outputs are classified as either “normal” or “violent,” and when a violent instance is identified, the system automatically sends a silent alert message or email to registered emergency contacts. The alert mechanism also supports integration with IoT

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devices such as smart speakers or mobile assistants, which can discreetly trigger notifications to nearby authorities or safety networks [3],[5].

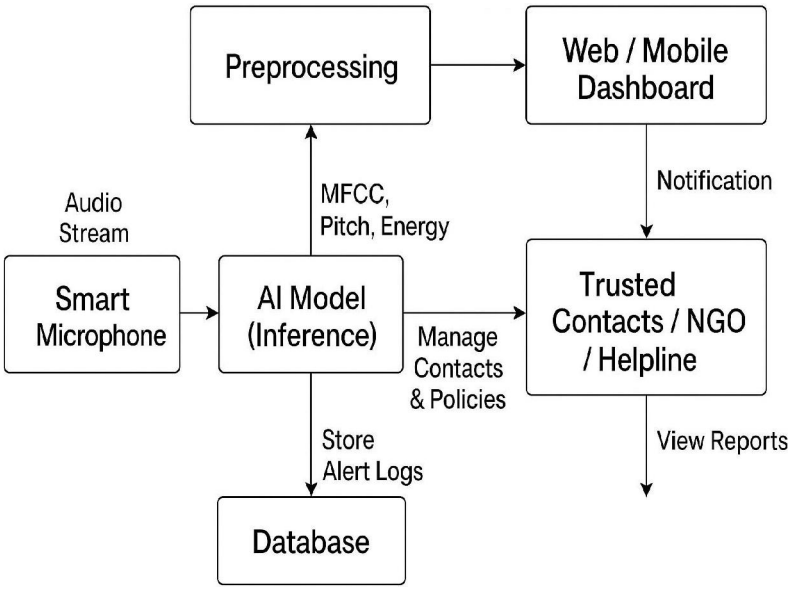
System Workflow

The overall workflow of the Smart Home Violence Detection System follows a structured data pipeline that ensures real- time interaction and secure alert delivery. The steps are as follows:

1. User Interaction: The user's voice or text data is captured through the web interface or IoT-connected device.
2. Preprocessing: The input is cleaned, filtered, and prepared for analysis by AI models.
3. Processing and Analysis: The AI engine processes the data through emotion recognition and text classification algorithms.
4. Decision Making: Based on the model output, the system evaluates whether the communication pattern indicates aggression or distress.
5. Alert Generation: If violence is detected, silent alerts are sent to predefined trusted contacts, and the event is logged in the database.
6. Visualization: The user interface updates the report, showing incident details, risk levels, and history for administrative monitoring.

This cyclical architecture ensures smooth data flow between the layers, real-time detection, and a privacy-preserving alert mechanism. The combination of machine learning, secure data handling, and intuitive interface design makes the system reliable, adaptive, and efficient in responding to potential domestic violence situations [1],[4],[7]. The architecture also allows periodic retraining of AI models using newly collected and anonymized data to improve accuracy and adaptability over time [1],[4]. This self-improving mechanism enables the system to learn evolving patterns of aggression, language variations, and emotional cues, thereby making it more robust in real-world applications. Additionally, the modular design facilitates easy maintenance and updates, allowing developers to enhance or replace specific components—such as upgrading detection algorithms or adding new alert methods—without affecting the overall system structure.

In summary, the three-tier architecture of the Smart Home Violence Detection System ensures a well-balanced combination of real-time performance, security, scalability, and user privacy. By seamlessly connecting intelligent detection, automated alerting, and interactive visualization, the system creates a strong technological foundation for future advancements in domestic safety and AI-driven behavioral monitoring [2],[5],[7].



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IV. METHODOLOGY

The Smart Home Violence Detection System was developed using the Waterfall Model, a sequential and structured approach to software development that ensures clarity, systematic progress, and transparency across all stages from requirement analysis to deployment [1],[4]. During the requirement analysis phase, system requirements were collected through a review of research papers, case studies, and expert inputs on domestic violence detection, focusing on privacy, real-time response, scalability, and smart home integration. Data related to voice emotion patterns, abusive text content, and alert mechanisms were gathered from verified open-source repositories to train and test the AI models for accuracy and reliability [2],[6]. In the system design phase, the architecture was structured into three main layers—Presentation, Application, and Database—comprising modules such as Voice Detection, Text Classification, Alert Generation, and User Authentication [3],[5]. The design emphasized data security, communication efficiency, and user-friendly visualization. During development, the backend was implemented in Python using Flask, the frontend was designed with HTML, CSS, and JavaScript for interactivity, and MongoDB was used for storing user data, detection logs, and alert history. Machine learning and natural language processing models were trained using TensorFlow and Scikit-learn to analyze both voice and text inputs for aggression or distress [2],[5]. Unit and integration testing validated the performance, reliability, and accuracy of all modules, while end-to-end testing ensured smooth communication and real-time alert delivery [3],[6]. After successful testing, the system was deployed as a web-based application integrated with smart devices for live monitoring, optimized for low latency and immediate alert generation [4],[7]. A feedback mechanism was incorporated to improve user satisfaction and detection accuracy. This systematic process resulted in an intelligent, efficient, and privacy-focused AI platform capable of detecting violent situations through voice and text analysis, ensuring safety and timely intervention for users [2],[5],[7].

V. IMPLEMENTATION AND RESULTS

The proposed Smart Home Violence Detection System was implemented as a web-based application developed using Java for the backend, MongoDB for data management, and modern web technologies such as HTML, CSS, and JavaScript for the frontend interface [1],[3],[5]. The architecture integrates multiple functional modules, including user authentication, voice emotion detection, text-based violence classification, alert generation, and data visualization.

Machine learning and natural language processing models were trained using verified open-source datasets to classify inputs as normal or violent based on tone, speech patterns, and textual sentiment [2],[4]. The Flask-based API connects the AI modules with the frontend dashboard, ensuring real-time detection and instant communication with the database and notification services.

MongoDB serves as the central data repository for storing anonymized user profiles, detection history, alert records, and trusted contact details, providing secure and efficient retrieval of information with low latency [3],[5]. The system allows the user to log in securely, configure emergency contacts, and monitor live activity through a user-friendly dashboard. When the AI model detects signs of aggression in voice or text, it triggers an automated and silent alert to the registered contacts via email or SMS, thereby ensuring user safety without requiring manual intervention.

The detection modules were implemented using TensorFlow and Scikit-learn libraries, where the voice recognition model employed Mel-Frequency Cepstral Coefficients (MFCC) for feature extraction, and the text classification module utilized TF-IDF and BERT embeddings for analyzing contextual meanings [4],[6]. Testing was conducted to evaluate the accuracy, reliability, and real-time responsiveness of the system. The results showed that the AI models achieved high detection accuracy, with a strong precision-recall balance in classifying aggressive speech and abusive language. The alert response time was recorded to be less than 2 seconds after detection, confirming the system's efficiency in emergency situations.

The overall user experience during testing was positive, with users reporting that the interface was intuitive, responsive, and simple to navigate [3],[7]. The system demonstrated consistent performance under varying network conditions and maintained high reliability during continuous operation. The inclusion of privacy-focused design principles ensured user trust and secure handling of sensitive data.

In conclusion, the implemented Smart Home Violence Detection System proved to be an effective and practical platform for detecting and preventing domestic violence incidents in real-time. It successfully combines artificial

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intelligence, natural language processing, and smart alert mechanisms to offer a discreet, accessible, and technologically advanced solution for home safety [5],[7].

VI. SECURITY AND PRIVACY CONSIDERATIONS

The Smart Home Violence Detection System has been designed with a strong focus on user privacy, data confidentiality, and ethical AI deployment [1],[5]. All communication between the frontend, backend, and database is secured using end-to-end encryption to prevent unauthorized data interception. The system does not store raw voice or text conversations; instead, it extracts and saves only anonymized feature representations such as emotion vectors or text embeddings to maintain data privacy [3],[6]. User consent is explicitly obtained before enabling continuous monitoring, and users can pause or disable detection at any time through the control interface. Sensitive information, including contact details and alert logs, is encrypted in the MongoDB database using AES-based algorithms. The system also adheres to the guidelines of the General Data Protection Regulation (GDPR) and the Information Technology Act (India) to ensure ethical handling of user data. Access control mechanisms and authentication tokens are implemented to prevent unauthorized access and data misuse, guaranteeing that personal information remains secure throughout the system's operation [2],[7].

VII. CONCLUSION AND FUTURE SCOPE

The Smart Home Violence Detection System is an AI-based web platform developed to identify and prevent domestic violence through real-time analysis of voice and text data [1],[3]. It offers a discreet and intelligent solution that can recognize emotional distress or aggression using machine learning and natural language processing, thereby assisting victims who may be unable to seek help directly. The system bridges the gap between conventional manual reporting and automated digital safety by integrating advanced algorithms, real-time alerts, and privacy-preserving mechanisms [4],[6]. Through the combination of artificial intelligence, smart home technology, and secure communication protocols, the system demonstrates a practical and scalable approach to human safety in domestic environments.

In the future, the system can be enhanced through the integration of Internet of Things (IoT) devices such as smart microphones, wearables, or cameras for multimodal violence detection, improving both precision and contextual awareness [2],[5]. Further development may include federated learning for decentralized model training, multilingual support for wider accessibility, and integration with mobile applications for faster response. AI-driven chat assistants and predictive analytics can also be incorporated to provide emotional support and early intervention. With these advancements, the Smart Home Violence Detection System can evolve into a fully autonomous and ethical digital safety ecosystem that not only detects but also helps prevent domestic violence, empowering users and contributing to a safer, technology-driven society [3],[7].

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