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# Empowering Women Safety with Hand Sign-Based Communication and AI

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**ABSTRACT:** Ensuring women's safety in public spaces remains a significant concern, particularly during nighttime. This project proposes a real-time women safety system using MediaPipe for hand and sign language gesture recognition combined with machine learning algorithms, including Random Forest, Support Vector Machine (SVM), k-Nearest Neighbors (k-NN), and hybrid models. The system employs a webcam to capture live video, with MediaPipe facilitating hand tracking and key point detection to accurately identify predefined safety gestures. These gestures serve as emergency signals, which, upon recognition, trigger alert mechanisms. Specifically, the system sends an immediate email alert with a screenshot of the incident to designated authorities, enabling swift response. Additionally, an alarm system activates to draw attention nearby. The integration of advanced gesture recognition with machine learning enhances the accuracy and responsiveness of the system, making it effective for real-world deployment. Rigorous testing on different datasets evaluates performance based on precision, recall, and F1-score, selecting the optimal model for deployment. This automated safety solution offers a cost-effective, non-intrusive method of protecting women by providing timely alerts, thereby contributing significantly to safety in public environments.

**KEYWORDS:** Women's Safety, Sign Language Recognition, MediaPipe, Machine Learning, Real-time Alerts, Emergency Response.

## I. INTRODUCTION

Women's safety remains a pressing concern, particularly in public spaces where distress signals need to be communicated quickly. Existing self-defense devices often require manual operation, which can be challenging during emergencies when a woman's mental state is compromised. To address this, gesture-based systems, especially sign language recognition, offer a contactless, secure, and efficient communication method. Sign language uses hand gestures, facial expressions, and body movements to convey messages, making it ideal for emergency scenarios involving deaf, speech-impaired, or threatened individuals. This system leverages computer vision and machine learning algorithms to detect and interpret hand gestures in real-time, enabling rapid transmission of distress signals. When integrated with IoT devices and cloud platforms, such as Firebase or Google Sheets, these gestures can trigger immediate alerts to guardians, authorities, or emergency services. This approach not only enhances communication speed and reliability but also provides an intuitive interface for women in danger, ensuring swift assistance. The adoption of gesture recognition technology combines advanced web and AI techniques to create a cost-effective, user-friendly safety solution capable of deploying in various public and private environments.

## II. LITERATURE SURVEY

Previous research in women's safety has largely concentrated on standalone safety devices and manual monitoring systems. Early works, such as wearable panic buttons connected via Bluetooth or RFID, provided basic emergency alert features but lacked real-time location tracking and integration with cloud services. For example, "Wearable Safety Devices Using Bluetooth Modules" focuses on simple alarm systems, but they are limited in range and scalability. More recent approaches incorporate IoT technologies, such as GPS-enabled wristbands with GSM modules for real-time tracking and alerts, exemplified by "IoT-based Women's Safety System Using GPS and GSM," which improves response times but involves hardware complexities and higher costs.

Some studies have explored social media analysis to detect harassment or unsafe situations, but these lack direct intervention capabilities. The integration of sensor networks with cloud platforms, like IoT devices transmitting data to cloud services for instant alerts, is emerging as a more effective solution. For instance, "Cloud-Connected Wearables

for Women Safety” combines wearable sensors and cloud computing for immediate response, emphasizing scalability and remote monitoring. Overall, contemporary systems aim to blend sensor technology, cloud integration, and user friendly interfaces to enhance women safety effectively and affordably.

### III. METHODOLOGY

The proposed system includes:

#### Module 1: Data Collection

Hand gesture images were captured using a webcam, and MediaPipe was utilized to extract 21 hand landmarks per frame. Each detected gesture was numerically represented as 28 features (unit-0 to unit-27), encompassing spatial coordinates and derived attributes. These were labeled under an emergency\_sign column to identify the gesture type.

#### Module 2: Data Preprocessing

The dataset underwent cleaning to remove missing or inconsistent values. Features and labels were separated, and the data was split into training and testing sets (typically 80:20). Feature normalization was applied to ensure uniform scaling, enhancing model convergence during training.

#### Module 3: Model Training

Four models were developed to learn gesture patterns:

- Random Forest Classifier: Utilized 30 decision trees; robust against noise and useful for feature importance ranking.
- Support Vector Machine (SVM): Found optimal hyperplanes for separating classes; effective in both linear and non-linear scenarios.
- K-Nearest Neighbors (KNN): Classified gestures based on the majority label among the K closest samples.
- Stacking Ensemble: Combined the predictions from RF, SVM, and KNN using a meta-model (e.g., Logistic Regression) to improve overall generalization.

#### Module 4: Testing & Evaluation

- Model performance was evaluated using:
- Accuracy: Overall correctness.
- Precision & Recall: Evaluated false positives/negatives.
- F1 Score: Balanced measure of precision and recall.
- Confusion Matrix: Analyzed misclassifications—critical for emergency gesture detection.

#### Module 5: Output Prediction

In deployment, real-time hand gestures are captured via webcam. MediaPipe extracts keypoints, which are fed to the trained models. The stacking meta-model then predicts the final gesture class (e.g., “Emergency Call”) and triggers appropriate alerts or safety actions based on the outcome.

### IV. EXPERIMENTAL RESULTS

The frame-based event classification system was evaluated using a dataset containing 28-feature vectors per frame (unit-0 to unit-27) from sensor inputs. The key findings are as follows:

Data Collection: Sensor data was collected across 13 frame-based classes, including various vehicle states and emergency scenarios. Each frame was represented by 28 numerical features reflecting sensor conditions.

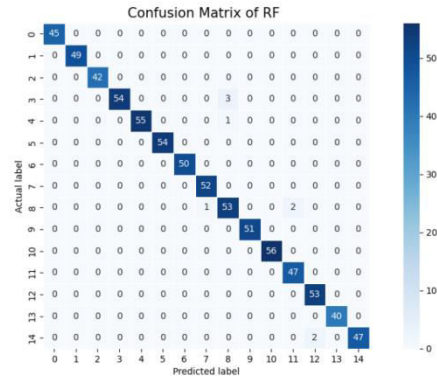
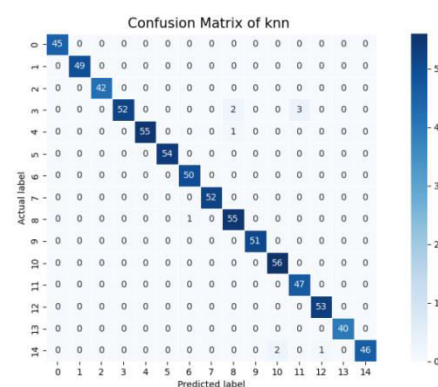
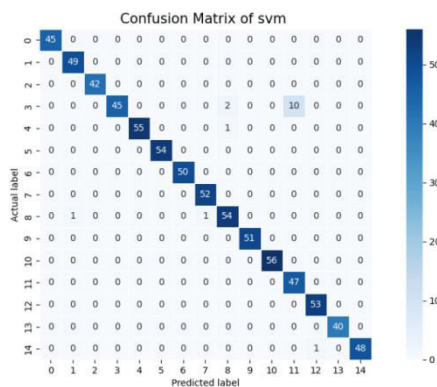
Preprocessing: The dataset underwent cleaning and normalization. It was then split into training and testing subsets to prepare for supervised model training.

Model Training and Testing: Two machine learning classifiers—Random Forest (RF) and K-Nearest Neighbors (KNN)—were trained and evaluated. Both models were tested on the same dataset for consistent comparison.



#### Performance Evaluation:

- Random Forest achieved 98.81% accuracy and a macro average F1-score of 0.99, with some misclassifications between similar frames (e.g., FRAME11 and FRAME3).
- K-Nearest Neighbors achieved 99.07% accuracy, slightly outperforming RF with fewer misclassifications and stronger class distinction.



The results confirm that both RF and KNN are highly effective for frame classification based on sensor features, with KNN showing superior performance in this context. The system demonstrates strong potential for reliable real-world application in vehicle state monitoring and safety detection.

#### V. CONCLUSION

This project demonstrates an effective sign language recognition system utilizing advanced web-based technologies and machine learning algorithms to enhance women's safety. By leveraging MediaPipe for hand tracking and implementing models such as Random Forest, Support Vector Machine, hybrid ensembles, and KNN, the system provides real-time recognition of emergency gestures. Its ability to trigger alarms and send notifications ensures prompt response to safety threats, making it a reliable and responsive security tool. The integration of sign language recognition further increases its accessibility. Overall, the system offers a practical, scalable, and impactful solution for addressing safety concerns public spaces, with promising potential for further enhancements and wider deployment.

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