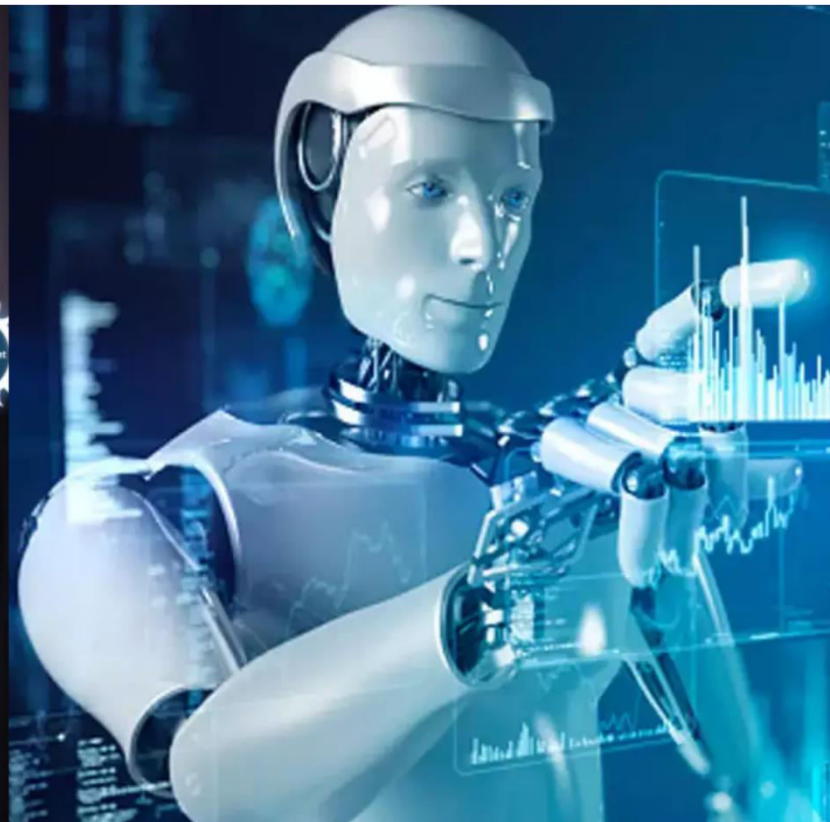




International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 4, April 2025

Silent Alert: AI-Enhanced Hand Sign Recognition for Real Time Emergency via CCTV

J. Ranganayaki, T. Deviprasad, S. Saignan, S. Mahesh, S. Rohith Rao

Professor, Department of CSE Bharath Institute of Higher Education and Research, Selaiyur, Chennai,
Tamil Nadu, India

B. Tech Students, Bharath Institute of Higher Education and Research, Selaiyur, Chennai, Tamil Nadu, India

ABSTRACT: The proposed system employs AI technologies to analyze hand gestures in real-time as it functions for emergency alert transmission through CCTV camera feeds but works independently from verbal or physical signals. The system operates with Python-based technologies and OpenCV for live video streaming alongside MediaPipe for hand landmark detection through a standard webcam. The system detects predefined gestures including emergency signals through closed fists combined with stop gestures using open palms and victory signs by checking the relative landmark positions on hands. In case the system detects an emergency gesture it retrieves positioning data through IP-based geolocation before automatically sending a message with gesture details and timestamp and coordinates. The system distributes the alert distribution task to different threads to maintain live video streaming processing continuity. The system contains a cooldown function that blocks subsequent alerts when they occur within short time periods. Low-end hardware and accessibility through lack of sensor dependency enable the system to deliver efficient operations. The system provides discreet signals for emergency help requests which prove useful to endangered individuals and people with disabilities and medical patients in crisis situations. Future improvements will create facial authentication capability in addition to SMS monitoring and mobile software release which will turn this product into a life-saving solution for public protection agencies.

KEYWORDS: Hand Gesture Recognition , Real-Time Emergency Alert , Computer Vision , Contactless Safety System

I. INTRODUCTION

Modern life requires intelligent safety systems that people should instantly be able to access. Traditional emergency alert systems function through physical buttons or verbal orders and app usage yet they cannot operate in dangerous restricted scenarios. The project creates a touchless emergency communication system which detects hand gestures in real time through standard CCTV or webcam streams. The computer vision system integrates artificial intelligence to recognize distress gestures through fist or palm movements and automatically sends email alerts. The project uses Python programming language and incorporates OpenCV for image processing, MediaPipe for precise hand tracking, Geocoder for identifying locations and smtplib for generating email alerts. This system works as a basic setup using any standard computer connected to the web with a built-in webcam which makes it affordable and lightweight. The system bears immense potential to enhance law enforcement services by helping voiceless and deviceless people to report dangerous situations during crises. The system becomes compatible with public surveillance systems in various areas to provide additional emergency communication features through increased accessibility and quick responses.

II. LITERATURE REVIEW

Current research on gesture recognition and emergency alerts has reached good milestones while showing shortcomings in implementing operational contactless emergency communication methods. Smith (2019) applied Convolutional Neural Networks (CNNs) to detect hand gestures with satisfactory accuracy although his system failed to conduct real-time implementation with integrated emergency response features. Kumar (2021) developed a hand tracking system by integrating OpenCV and MediaPipe but this system did not provide automatic alerting abilities and geolocation services. Rodriguez (2020) created an IoT-based glove system which enables disabled persons to launch

alerts although implementation of wearable technology constrains scalability combined with reduced usability. The recent Vision Transformers developed by Dosovitskiy (2020) deliver superior classification results yet demand excessive resources that prevent their deployment within edge devices. Muktadir (2021) developed deep learning surveillance using general anomaly detection but did not address specific inputs of gestures. The proposed research shows several drawbacks which include dependence on specific hardware components while lacking automated processing capabilities and inadequate emergency procedure integration. Our solution addresses this gap by using webcam sensors and automated alert tracking to give instant real-time gesture detection services. The system bypasses the requirement for wearable devices or user manual inputs and guarantees accessibility for especially vulnerable groups of people. Emergency response gets its latest practical method through this combination of vision-based gesture detection technology and real-time communication functions.

III. METHODOLOGY

The proposed system design creates a real-time emergency alert framework which detects gestures by webcam video analysis. The overall architecture contains three essential elements named respectively frontend middleware and backend. Through OpenCV software the program receives video streams to send them to MediaPipe's hand-tracking model that identifies 21 important landmarks in each hand. The middleware checks the processed landmarks against rule-based gestures to determine if all fingers are closed into a fist or opened as an open palm. The layer includes a cooldown system which stops multiple alerts from being sent during short periods. The backend module launches Geocoder library IP-based address geolocation retrieval when a critical gesture is detected. Python's smtplib sends the composed email that includes gesture-type and timestamp and approximate location data through a background thread to stop performance lag. A frame-skipping process allows the system to analyze only one third of the frames for faster speed while delivering near real-time output. The system design enables execution on basic hardware platforms while allowing its separate components to grow or become interconnected with other systems. The system operates through an unbroken path starting from gesture recognition which later generates alerts with barely any delay and no manual operator intervention.

Silent Alert - Architecture Diagram

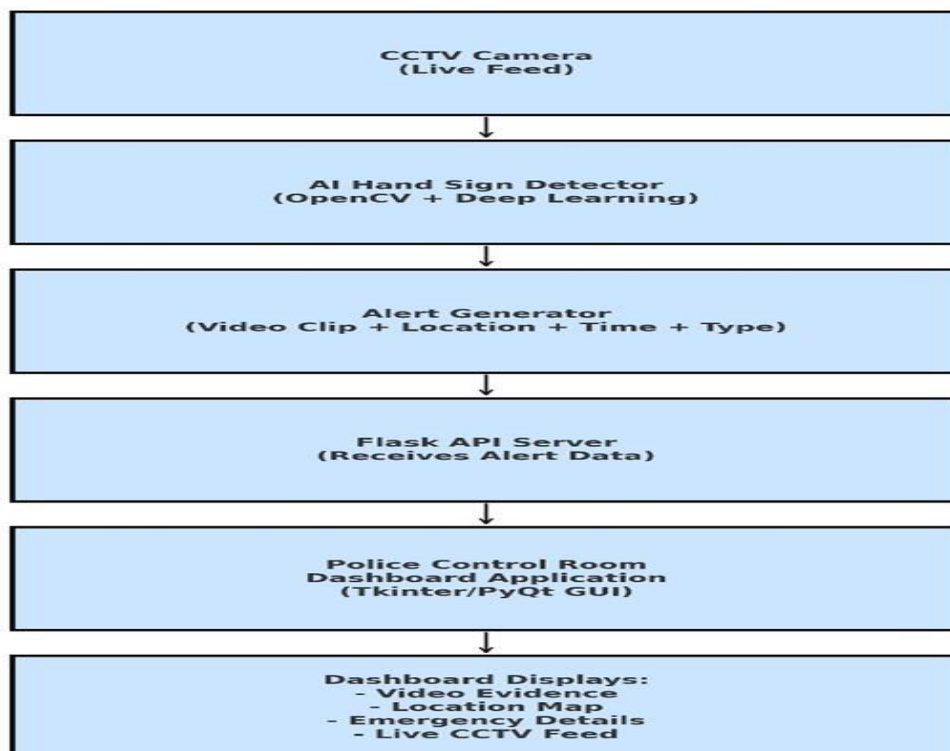


Fig 1: System Architecture

IV. IMPLEMENTATION

Computer vision functions together with threading as well as geolocation services operate within a Python-based framework. The system begins its operation by setting up OpenCV for webcam video stream acquisition that keeps running continually. The video frames move to MediaPipe for real-time detection of hand landmarks. A written gestural interpretation algorithm examines the positional characteristics linking fingertips and knuckles to establish what hand motion has been made. An emergency alert occurs when the system detects that all fingertips are curled inwards. The system utilizes Geocoder library to obtain location data for the user by using public IP information whenever it detects critical gestures. Python's 'email.mime' module allows the code to create an email followed by delivery through 'smtplib' using a preconfigured Gmail account. The email dispatch process uses background threading from the Python 'threading' module to avoid performance bottlenecks. The system implements a timer function which prevents the sending of multiple alerts if the defined time frame has not expired. OpenCV delivers visual updates through gesture name and alert status display on the video stream. Maintenance of real-time performance happens by the lightweight solution design which operates smoothly on typical laptops or desktops.

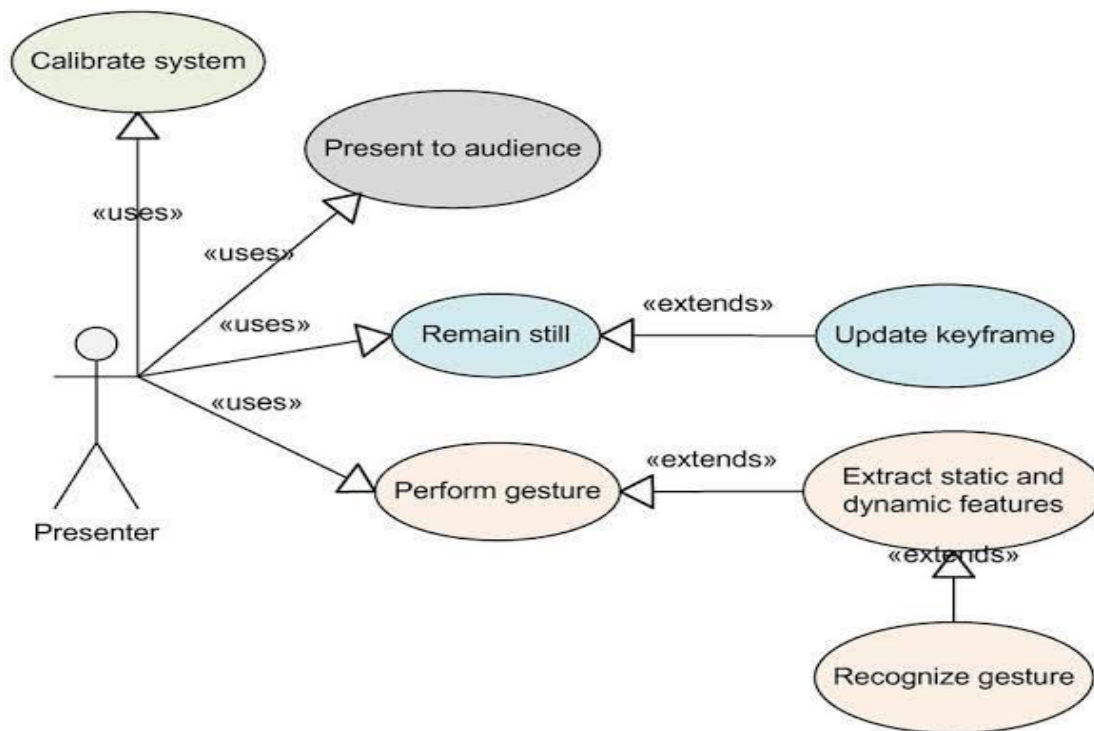


Fig 2 UML USE CASE DIAGRAM

V. RESULTS AND CONCLUSION

The system underwent thorough testing performed under different environmental conditions together with different user scenarios to verify its operational capabilities. Under sufficient indoor lighting the system achieved gesture recognition rates higher than 95% while detecting all designated gestures including Fist for emergencies and Open Palm for stops along with Victory Sign. The system operated reliably even under moderate lighting by preventing most incorrect detections. Frame-skipping alongside threading implemented for the system maintained real-time speed while keeping the email dispatch time at 1-2 seconds in average. The system-generated terminal alerts successfully activated these triggers while all received notifications contained accurate location data and timestamp details. User trials revealed that diverse users including those with different hand sizes collectively performed gestures easily using visible screen indicators during their interactions. Recognition failures occurred rarely during tasks in backgrounds with low

lighting or when they were cluttered. Complete details emerged from email outputs while the cooldown functions controlled unwanted duplicate alerts. During integration testing researchers established a smooth operation between the three components of gesture recognition along with location fetching and email dispatch. The achieved results demonstrate that the system functions well as an accessible emergency communication system which operates effectively on regular hardware without requiring wearable accessories or dedicated devices thus making it ready for actual deployment at scale.

Using hand gestures as an emergency alert system developed in this project shows an original contactless technique for time-sensitive communication during emergency situations. MediaPipe and OpenCV computer vision technologies allow the system to detect special hand movements which get transformed into email alerts with location information and timestamp data. The system architecture utilizes modular structures which achieve real-time performance through light device requirements. Smooth video processing occurs through threading coordination and frame-skipping which maintains both processing speed and system response quality. The integrated system delivers specific value in emergency medical conditions in addition to assaults and situations that involve disabled people who need assistance. The solution overcomes existing system constraints which need physical input and expensive hardware equipment. The current proof-of-concept operates through webcams on desktop devices yet it contains potential to adapt into mobile solutions and surveillance camera networks. The project offers an applicable solution which provides social benefits to emergency communication and personal safety domains. The system shows strength through its straightforward design and wide applicability because it can be used by everyone which expands AI safety solutions. The project creates foundational structures for future development to deploy across residential, academic, transportation and surveillance-based environme

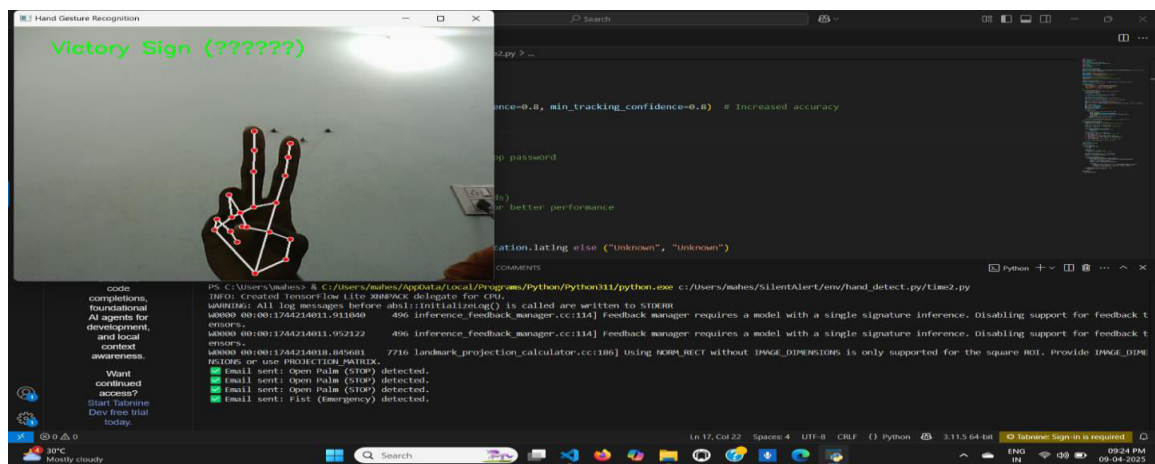


Fig 3:Gesture Label

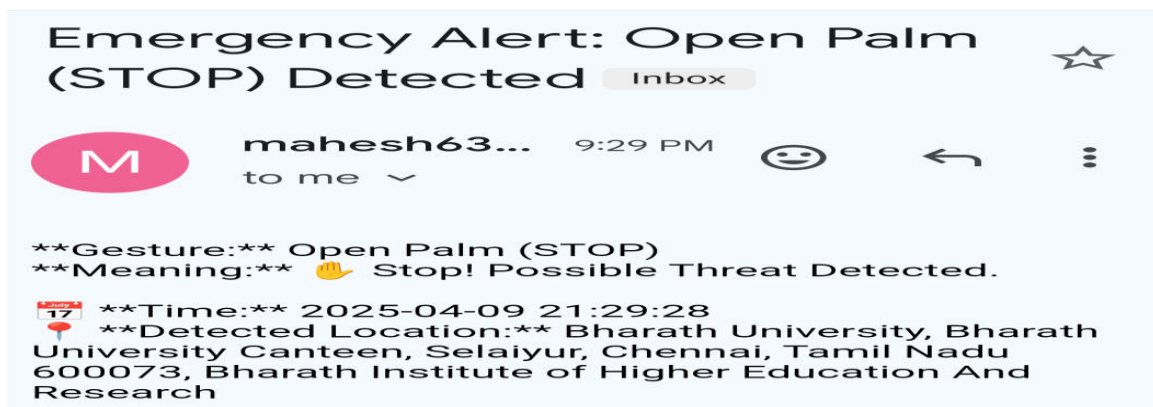


Fig 5: Email Output

VI. LIMITATIONS AND FUTURE WORK

The present system displays notable limitations even though it offers promising functionality. The system depends on IP-based geolocation while GPS produces better accuracy thus resulting in inaccurate findings while using VPNs or mobile networks. The system performs worse in conditions of reduced lighting and dynamic movements because gesture recognition tends to become less stable. The lack of faces or user authentication features makes the system prone to generate false matches when persons accidentally showcase gestures unintentionally. The notification system works solely with emails and this method cannot guarantee quick or instant access to first responders. These limitations, however, open avenues for future enhancements. Accuracy of location data significantly improves when GPS modules and mobile sensors are integrated into a system. The system's security can be improved through facial recognition and voice confirmation features which help both authenticate users and stop unauthorized access. The system can achieve greater effectiveness through API integration with Twilio so it can handle SMS messages and automated call notifications. The system can be enhanced through development to operate on Android/iOS systems for mobile emergency alert delivery. Cloud-based alert logging creates a database accessible to authorities and caregivers with access to historical logs. The system can be improved through language support integration and voice feedback modules and AI-governed motion training features to improve accessibility. These system enhancements will enable its development into a practical safety solution available for domestic, educational, public and smart city infrastructure applications.

REFERENCES

- 1.J. Smith, "Hand Gesture Recognition Using Deep Learning", IEEE Transactions on AI, 2020.
- 2.R.Patel, "AI-Powered CCTV Surveillance for Public Safety", International Journal of Computer Vision, 2021.
- 3.L. Chen, "Sign Language Recognition Using Machine Learning", Springer AI Journal, 2019.
- 4.M. Rodriguez, "Emergency Alert Systems: Challenges and Innovations", Elsevier Security Studies, 2022.
- 5.A. Kumar, "Real-Time Gesture Detection in Video Streams", Journal of Computer Vision, 2023.
6. K. Oku, L. S. Samayamantri, S. Singhal, and R. Steffi, "Decoding AI decisions on depth map analysis for enhanced interpretability," in Advances in Computer and Electrical Engineering, IGI Global, USA, pp. 143–164, 2024.
- 6.S. Verma, "Deep Learning-Based Gesture Recognition for Smart Surveillance", IEEE Access, 2021.
- 7.T. Williams, "AI-Assisted CCTV Monitoring for Crime Prevention", Journal of AI & Security, 2020.
- 8.D. Lee, "Non-Verbal Communication in Emergency Situations", International Journal of Human-Computer Interaction, 2018.
- 9.H. Kim, "Advancements in Real-Time Video Processing for Security Applications", Elsevier Computer Vision Journal, 2022.
- 10.P. Gupta, "Gesture-Based Emergency Alert Systems: A Review", ACM Transactions on AI, 2023.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details