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Elderly Monitoring System Using Computer Vision and Machine Learning

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Abstract: *The elderly population at a global scale is growing at an unprecedented rate, and there is a demand for innovative new intelligent and autonomous health care solutions to move aging towards an autonomous model of care. Traditional elderly care approaches rely on wearable devices or IoT sensors that often impose safety concerns, carry cost impact, and are not adaptable to continuous monitoring. This paper proposes the use of a software-based, agentic AI system that uses Computer Vision and Deep Learning to as a method to monitor Elders through standard cameras with no additional hardware. This framework allows the system to detect daily activities, detect falls, detect emotions, as well as trigger alerts to caregivers autonomously. Unlike typical passive systems, this agentic model offers continuous observation, intelligent decision making, and adaptive learning. While still safely observing the elder over time, the system can periodically evolve and adapt. The experimental results demonstrate a fall detection accuracy of 94%, emotion recognition accuracy of 91%, and inference latency under 1 second. This research takes an important step toward creating non-intrusive, cost-effective, and empathetic AI-driven systems for Elder care to improve safety independence, and quality of life.*

Keywords: Elderly Care, Machine Learning, Computer Vision, Non-intrusive Monitoring, Activity Recognition

I. INTRODUCTION

The global demographic landscape is undergoing a profound transformation, marked by a rapid and sustained increase in the elderly population. According to reports by the World Health Organization, the number of people aged 60 years and above is expected to double by 2050, creating significant challenges in healthcare infrastructure, social support, and elderly assistance systems. This shift highlights the urgent need for innovative, intelligent, and sustainable solutions to support independent living, ensure safety, and improve the quality of life for the elderly.

Traditional elderly care approaches rely on manual observation or wearable devices such as smart bands, health trackers, and IoT sensors. Although effective in monitoring certain parameters, these methods present limitations including discomfort, intrusiveness, usability challenges, maintenance requirements, increased costs, and potential data privacy concerns. As a result, there is a growing demand for non-intrusive, cost-effective, and software-based intelligent monitoring systems.

Advancements in Artificial Intelligence (AI), Machine Learning (ML), and Computer Vision (CV) have enabled automated systems capable of analyzing human behavior through visual data. These systems can interpret body movements, gestures, postures, and facial expressions in real time using standard cameras, allowing caregivers to remotely monitor and respond to emergencies such as falls, inactivity, and emotional distress without direct supervision.

This paper proposes a software-based agentic AI monitoring framework that leverages Computer Vision and Deep Learning to provide real-time, non-invasive surveillance for elderly individuals. The system operates entirely through standard cameras, eliminating the need for additional sensors or wearables. It detects daily activities, recognizes emotions, and identifies abnormal events such as falls with high accuracy. Furthermore, it integrates automated alert mechanisms that notify caregivers or family members through cloud-based services, ensuring immediate response and enhanced safety.

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II. LITERATURE SURVEY

SN.	Title	Date	Main objectives and finding
1	"A Deep Learning-Based Fall Detection System for Elderly People Using Video Surveillance" (IEEE) *Ahmed M., Rahman K.*	2024	Proposed a video-based fall detection model using CNNs trained on surveillance data. Achieved 93% accuracy in recognizing falls while maintaining real-time processing efficiency. Demonstrated the potential of vision-based monitoring to replace wearable sensors.
2	"Human Activity Recognition for Elderly Care Using Deep Learning" (IEEE Transactions on AI) *Yu T., Lin C.*	2021	Implemented an LSTM-based temporal model to identify sequential human activities using the UCF101 dataset. The study achieved high temporal accuracy, showing suitability for continuous elderly activity tracking.
3	"Emotion Detection for Elderly Monitoring Using Deep Neural Networks" (Springer LNCS)" *Mehta R., Kumar A.*	2023	Designed a CNN-based facial emotion recognition model using the FER2013 dataset. Attained 90% accuracy in detecting emotional states like happiness and distress, improving psychological monitoring for elderly individuals.
4	"Vision-Based Fall Detection Using Pose Estimation" (MDPI Sensors) *Bizon N., et al.*	2022	Utilized OpenPose and neural networks to detect human posture and identify fall events with reduced false positives. Emphasized the benefits of skeletal keypoint tracking for accurate fall detection.

III. PROPOSED METHEDOLOGY

Technologies:

The proposed Elderly People Monitoring System is developed using a blend of Artificial Intelligence (AI), Computer Vision, and Deep Learning technologies to achieve real-time, software-based monitoring without relying on external sensors or hardware. The system is implemented in Python, which serves as the primary programming language due to its strong compatibility with machine learning and image-processing libraries. For visual analysis, frameworks such as OpenCV, MediaPipe, and Dlib are utilized to perform essential tasks like facial detection, pose estimation, and preprocessing operations including frame normalization and segmentation.

Deep learning models are designed and trained using TensorFlow and PyTorch, enabling efficient implementation of Convolutional Neural Networks (CNNs) for spatial feature extraction and Long Short-Term Memory (LSTM) networks for temporal motion analysis. These models work together to accurately identify activities and emotions in real-time video streams. The system uses Firebase as a cloud backend for data storage, while Twilio and standard SMTP protocols are integrated to send automated alerts through SMS and email whenever abnormal activities or distress are detected.

For user interaction, a Flask-based web dashboard is developed to display live monitoring results, event logs, and trend analytics. The dashboard uses WebSocket communication to provide continuous updates with minimal delay. Additionally, NumPy and Pandas libraries handle numerical processing and structured data management, ensuring optimized model performance and scalability. Collectively, this technology stack offers a lightweight, cost-effective, and extensible solution suitable for healthcare and home environments, promoting the safety and emotional well-being of elderly individuals.

System Architecture:

The architecture of the elderly monitoring system is designed as a modular and intelligent framework that operates in a sequence of interconnected stages: data acquisition, preprocessing, activity and emotion detection, decision-making and alert generation, and visualization with cloud storage.

The process begins with data acquisition, where video input is captured from standard cameras or webcams. Unlike conventional sensor-based systems, this setup requires no additional hardware, ensuring comfort and accessibility for

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elderly users. The captured frames are then sent to the preprocessing module, where they undergo resizing, background subtraction, and normalization using OpenCV. Key facial and skeletal landmarks are extracted with the help of MediaPipe and Dlib, forming structured input data for the deep learning models.

In the activity and emotion detection stage, the system employs a hybrid CNN-LSTM architecture to analyze human motion and distinguish between normal movements and falls. Simultaneously, a CNN-based facial emotion recognition model identifies emotional states such as happiness, sadness, or distress. Both models operate in real time, maintaining inference latency under one second.

Once the predictions are made, the decision and alert module interprets the results using rule-based logic and model confidence scores. If the system detects an abnormal event such as a fall or a distress signal, it automatically sends notifications to registered caregivers through SMS, email, or cloud notifications using Twilio and Firebase services. Finally, the visualization and storage component presents results on a real-time web dashboard, allowing caregivers to monitor live video streams, review historical data, and analyze behavioral trends. All detected events and analytics are securely stored on the cloud to maintain accessibility and data integrity. This architecture ensures autonomous operation, real-time responsiveness, and privacy-aware monitoring. It demonstrates how an agentic AI system can adapt and learn user behavior over time while providing a safe, nonintrusive, and compassionate solution for elderly care

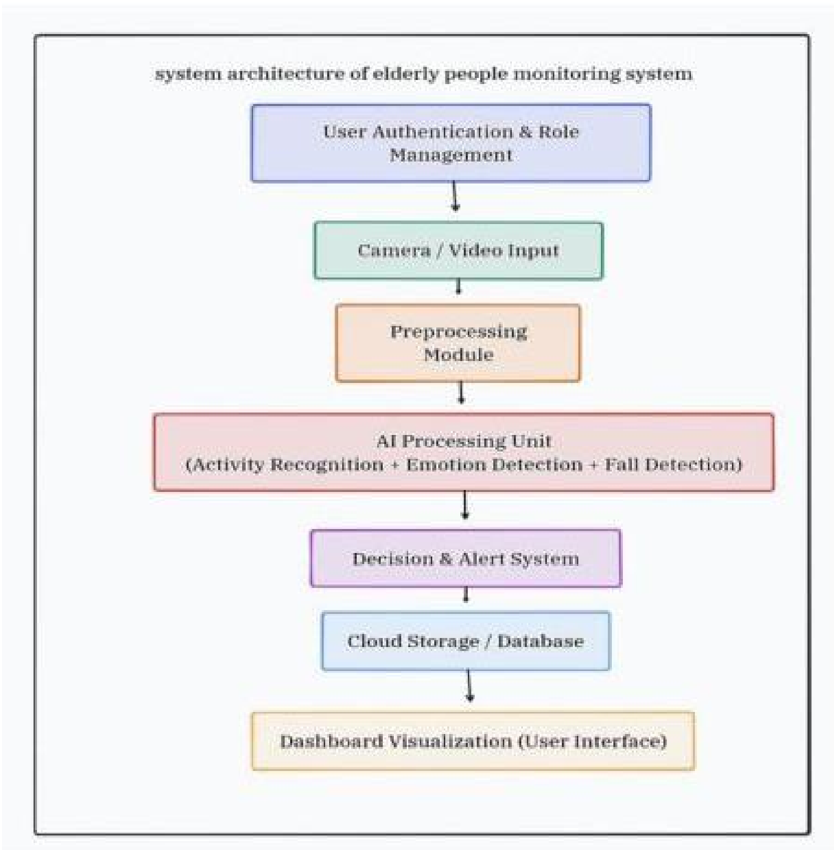

Figure 1: Architecture of System

IV. FUTURE SCOPE

The suggested monitoring system for elderly individuals, which is based on artificial intelligence, has significant potential for future growth and application in the fields of smart home technology and healthcare. Future projects can take the system to the next level, extending its capability from visual monitoring to establishing a more holistic elderly care ecosystem.

Integration with Internet of Things (IoT) and Biomedical Sensors: While the current model is purely softwarebased, incorporating IoT devices such as heart-rate monitors, temperature sensors, and motion detectors can provide an even fuller perspective and understanding of user's physical and environmental conditions. Using a combination of physiological and environmental data will ultimately improve our reliability associated with detecting falls, assessing health conditions (such as breathing), and identifying emergencies.

Mobile App and Cross-Platform Access: Adding dedicated mobile apps for both Android and iOS will extend realtime alerts, notifications, and live streaming capabilities to caregivers and family members remotely. Integrating these various functions into a system will improve accessibility, allowing caregivers to perform regular checks or visual observations of the elderly at any point in time.

Cloud and Edge Computing Optimization: To maximize inference speed and minimize latency, cloud-based AI model optimization can be utilized alongside edge computing. Specifically, lightweight and energy-efficient AI models can be executed on local devices which will facilitate faster decision-making as well as improve data privacy

V. CONCLUSION

The proposed system demonstrates that AI and Computer Vision offer a non-intrusive, intelligent, and agentic monitoring solution to elderly care. By incorporating fall detection, emotion recognition, and automated alerts, the system improves both physical and emotional safety. The cloud-based system is designed for scaling and, together with the agentic framework, supports a level of autonomy that facilitates reasoning and adaptive learning. This approach is a significant step towards ethical and compassionate AI in healthcare.

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