REAL-TIME PATIENT SAFETY SYSTEM USING DEEP LEARNING

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ABSTRACT

Patient safety, particularly for individuals under anesthesia or needing constant supervision, remains critical in healthcare settings. Such patients risk incidents like falling from hospital beds. Conventional monitoring methods, including wearable sensors, alarms, and direct supervision, present challenges like invasiveness, scalability limits, high costs, and privacy issues. To overcome these limitations, this study proposes a real-time, non-intrusive monitoring system utilizing MediaPipe and OpenCV for precise human posture detection and tracking.

The system processes live video feeds, extracting 33 anatomical landmarks to monitor patient posture and movements minimally intrusively. Clinicians establish a Region of Interest (RoI) indicating safe mobility boundaries. Real-time analysis within this RoI quickly identifies deviations, prompting alerts for immediate medical response.

Key contributions include three novel metrics: (1) Activity Level, measuring body movement frequency and intensity; (2) Agitation Level, detecting rapid or erratic distress-associated movements; and (3) Distance from RoI, assessing deviation from the safe area. Rigorous training used a custom dataset of over one million annotated landmark records from video footage, categorically labeled by posture type. K-means clustering (optimal k=7 via elbow method) identified inherent spatial joint configurations.

Designed with patient privacy paramount, the system stores numerical landmark data rather than raw video footage. Healthcare professional validation confirms its efficacy in fall prevention, addressing significant patient safety and operational cost concerns. Ultimately, this research advances autonomous, efficient patient monitoring, enhancing healthcare safety and predictive posture analytics.

INTRODUCTION

Patient safety, particularly for individuals under anesthesia or requiring continuous clinical supervision, remains a critical and persistent challenge in healthcare environments [1]. Falls among such vulnerable patients, especially in high-risk areas like Intensive Care Units (ICUs) or post-operative recovery rooms can lead to severe complications, increased hospital stays, and substantial operational costs [1]. Conventional monitoring solutions such as wearable sensors, bedside alarms, and direct supervision present notable limitations, including intrusiveness, high labor demands, privacy concerns, and limited scalability [2].

Recent advancements in computer vision and AI-powered pose estimation frameworks offer promising, non-intrusive alternatives for patient posture monitoring. In particular, MediaPipe an efficient, real-time pose tracking library combined with OpenCV, enables the continuous