

EMBEDDED SYSTEM-BASED FALL DETECTION FOR THE ELDERLY USING K-NEAREST NEIGHBOR (KNN)

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ABSTRACT

As age increases, the decline in motor functions among the elderly significantly heightens the risk of fall incidents. These incidents can be fatal if the victim does not receive immediate medical attention due to a lack of supervision. This research aims to design and implement a fall detection system based on an embedded system using the MPU6050 Inertial Measurement Unit (IMU) sensor and the ESP32 microcontroller. The K-Nearest Neighbor (KNN) machine learning classification algorithm is embedded directly into the device to recognize movement patterns in real-time. The data pre-processing involves the Low-Pass Filter (LPF) method to reduce transitional movement noise, followed by Signal Vector Magnitude (SVM) feature extraction to detect impact force spikes, and Min-Max normalization. The KNN model ($K=11$) was trained using 120 primary data points simulated through a mannequin. Based on 40 real-time testing observations covering Standing, Sitting, Lying down, and Falling activity classes, the system demonstrated highly reliable performance. Evaluation using the Confusion Matrix showed an Accuracy rate of 97,5%, Sensitivity of 100% (zero false negative), and Specificity of 96,67%. This proves that the device can precisely detect all fall scenarios without omission, while effectively distinguishing them from normal daily activities with minimal false alarms.

Keywords: Fall Detection, K-Nearest Neighbor, Elderly, MPU6050, Embedded System.