

ABSTRACT

The elderly population in Indonesia continues to increase, with West Java reaching 15.61% of the total population in 2021. Falls are the leading cause of disability and death among the elderly, especially in high-risk areas such as slippery bathrooms with minimal direct supervision. This study aims to design an inertial sensor-based fall detection system that can detect falls among the elderly in bathrooms with 90% accuracy and send automatic alerts to caregivers. The limitations of this study include simulation testing on elderly subjects in a safe open space, not directly on elderly individuals in bathrooms.

The proposed system integrates an Arduino Nano RP2040-based IMU sensor with a Random Forest Machine Learning algorithm deployed embedded on a microcontroller. The system combines accelerometer and gyroscope data to classify normal movement patterns and fall events in real-time. When a fall is detected, the system automatically sends a signal via BLE to an alarm device that activates a buzzer as a warning to the caregiver.

Test results show that the system successfully distinguishes between normal activity and falling movements through signal analysis, where the Acc_Z axis shows a range of 1.5-2.5 m/s² during normal activity and experiences an extreme spike during a fall. The buzzer produces a sound intensity of 71.7 dB at a distance of 2 meters and remains audible up to 56.6 dB at 10 meters. Bluetooth connectivity remains stable up to 10 meters with a latency of 0.4–0.6 seconds under various environmental conditions. User comfort evaluation achieved a MOS score of 4.2, indicating the device is comfortable to use. Although the battery life only reaches 1.1 hours, failing to meet the 2-hour target, the system successfully implements real-time fall detection with automatic alerts to enhance elderly safety.

Keywords: *fall detection, inertial sensor, elderly, machine learning, Arduino RP2040, IMU, Bluetooth Low Energy, bathroom.*