PROJECT ABSTRACT

TinyML Fall Detection Wearable for Elderly Safety

Project ID: k-1691 | projectech.in/projects/tinyml-fall-detection-wearable/

Falls are the leading cause of injury for the elderly living alone, and the critical minutes after a fall are when the person may be unable to reach a phone. This project builds a waist-worn ESP32 wearable that reads its 6-axis IMU at 100 Hz and classifies every 2-second motion window as fall vs activity of daily living — entirely on the microcontroller, with no phone, cloud or network in the loop. A tiny quantized 1D-CNN in TensorFlow Lite Micro makes the decision; a confirmed fall sounds the buzzer, opens a 15-second cancel window, then alerts the caregiver over BLE. Training follows the public SisFall benchmark (4,505 labeled fall/ADL recordings from 38 subjects).

Suitable for B.E./B.Tech final-year projects in AI & Machine Learning and Electronics.

Project type: Hardware

Availability: Built to order

Suitable branches: AI & Machine Learning and Electronics

Technologies: ESP32, TensorFlow Lite Micro, MPU6050 IMU, 1D-CNN, SisFall dataset, BLE caregiver app, SSD1306 OLED, Python training pipeline

Price: Request a quotation

Prepared by Projectech · projectech.in — for academic project reference.

1. Title

TinyML Fall Detection Wearable for Elderly Safety — a built-to-order hardware project delivered with the assembled wearable, complete firmware, training pipeline, caregiver phone app, project report, presentation and viva preparation kit.

2. Introduction / Background

Camera monitoring invades privacy and cloud-connected pendants die with the Wi-Fi. Moving the intelligence onto the body solves both: an ESP32-class microcontroller can now run a real neural network on a 2-second IMU window, so detection-to-alert latency stays under a second even with no network at all — and nothing is recorded or streamed, only event counts and timestamps.

3. Problem Statement

Elderly people living alone face the highest risk from falls, yet existing aids either watch them with cameras or depend on a network that may not exist when it matters. A wearable must distinguish real falls from sitting, bending and lying down — with a false-alarm rate low enough that the wearer keeps wearing it — while running for a full day on a small battery.

4. Objectives

- Build a waist-worn ESP32 + MPU6050 wearable classifying 2-second IMU windows on-device.
- Combine a physics-based fall signature (free-fall dip, impact spike, post-fall stillness) with a quantized 1D-CNN.
- Train on the SisFall benchmark with elderly-subject data included.
- Add a 15-second audible cancel window before the BLE caregiver alert fires.
- Ship firmware, training pipeline, caregiver phone app and the full viva kit.

5. Proposed Methodology

SisFall recordings (4,505 labeled fall/ADL samples, 200 Hz, downsampled to 100 Hz) are windowed into 2-second frames; signal-magnitude-vector plus statistical and spectral features are computed. A 1D-CNN is trained for fall-vs-ADL classification, INT8-quantized to ~24 KB and deployed in TensorFlow Lite Micro. A rule-based signature prefilter (weightlessness < 0.5 g, impact > 2.5 g, post-event stillness) gates the network to cut false alarms. The buyer-run cushioned drop-test procedure measures achieved sensitivity and false-alarm rate for the report.

6. System Architecture / Working

- Input: MPU6050 3-axis accel + gyroscope at 100 Hz, waist-worn.
- Firmware: sliding 2-second window; SMV and spectral features computed on-chip.
- Stage 1: fall-signature rules (free-fall dip → impact spike → stillness).
- Stage 2: INT8 1D-CNN outputs the fall probability for signature-passing windows.
- Alerting: buzzer + 15-second cancel window, then BLE alert with timestamp to the caregiver app; event log on the OLED.

7. Hardware / Software Requirements

- ESP32 (240 MHz dual-core, 520 KB SRAM); MPU6050 6-axis IMU at 100 Hz.
- 0.96" SSD1306 OLED, buzzer, 3.7 V LiPo, 3D-printed waist case.
- TensorFlow Lite Micro; SisFall dataset (Sucerquia et al., 2017) via PhysioNet.
- Python training pipeline (NumPy, TensorFlow); BLE caregiver phone app source.

8. Expected Outcomes

- A working waist-worn fall detector meeting the design sensitivity/specificity targets.
- On-device inference with sub-second detection-to-alert latency and no network dependency.
- A measured drop-test report from the buyer-run procedure.

- Documented false-alarm behavior on scripted daily activities.

9. Applications

- Academic final-year project in AI & Machine Learning or Electronics programs.
- Teaching aid for TinyML: sensor interfacing, signal processing, quantization, on-device inference.
- Prototype safety aid for elderly care at home (with the stated non-medical limits).

10. Future Scope

- Detection of slow, controlled collapses with weak impact signatures.
- Multi-day battery via duty cycling and lower-power IMU modes.
- Fall-direction estimation from gyroscope data.
- Integration with home emergency-response services.