Minor in AI

TinyML

Edge AI Bootcamp : Part 2

June 09, 2025

1 Introduction

Edge Impulse is a powerful platform for developing machine learning applications specifically optimized for edge devices such as microcontrollers and smartphones. It bridges the gap between ML developers and embedded systems by providing a graphical and intuitive pipeline to collect data, engineer features, build models, and deploy them on constrained hardware environments.

This document summarizes a hands-on session that explored how to use Edge Impulse to implement a real-world TinyML application: fall detection using mobile phone sensors. The process involved data acquisition, feature extraction, model training, and finally deployment either via microcontrollers like the ESP32 or directly on mobile devices.

2 Edge Impulse Platform Overview

Edge Impulse is designed to handle the full ML pipeline in an embedded-friendly manner. It includes:

- **Data Collection and Labeling:** Connect mobile or embedded devices and stream sensor data in real time.
- **Feature Extraction:** Built-in signal processing blocks allow efficient preprocessing of raw signals.
- **Model Training and Evaluation:** Offers built-in classifiers like decision trees and neural networks with real-time evaluation.
- **Deployment:** Generates C++ libraries, TensorFlow Lite models, and WebAssembly code for hardware integration.

The platform is highly modular, supports 40+ sensors, and integrates well with Arduino, Raspberry Pi, and mobile devices.

3 Case Study: Fall Detection System Using Smartphones

3.1 Objective

The goal of the project is to distinguish between safe movement (e.g., walking, standing) and dangerous movement (simulated falls). The model is expected to be lightweight and efficient for deployment on mobile phones or embedded hardware.

3.2 Step-by-Step Implementation

1. Project Setup Users begin by logging in at `studio.edgeimpulse.com`. After creating a new project, the device (typically a smartphone) is connected via QR code scanned through Google Lens.

2. Data Collection Sensor data is recorded in real-time using the mobile phone's IMU, which includes an accelerometer and gyroscope. Activities are labeled as `Safe` or `Fall`. A balanced dataset is important for model performance. It is advised to collect a minimum of 30–40 samples for each category.

Tip: Simulating Fall Data

Place the mobile phone in a soft environment (e.g., a mattress) and simulate jerky, abrupt motions to create realistic fall data without damaging the device.

3. Impulse Design and Feature Engineering Once data is labeled, users create an **Impulse**. This is a chain that defines:

- How to process the incoming signal (e.g., spectral analysis or raw data)
- What kind of ML model to apply (e.g., Decision Tree, Neural Network)

The signal processing block extracts statistical features from the raw IMU data, converting it into a form suitable for the classifier.

4. Training and Validation The data is split into an 80-20 training-testing set. Edge Impulse also allows manual adjustments to ensure proper class distribution. After training, the model's accuracy, confusion matrix, and F1-score are evaluated to validate performance.

5. Live Testing and Classification In the `Live Classification` tab, new data can be collected on the spot and tested against the model. The system provides probabilities for each class, allowing confidence assessment in predictions.

4 Deployment Options and Hardware Integration

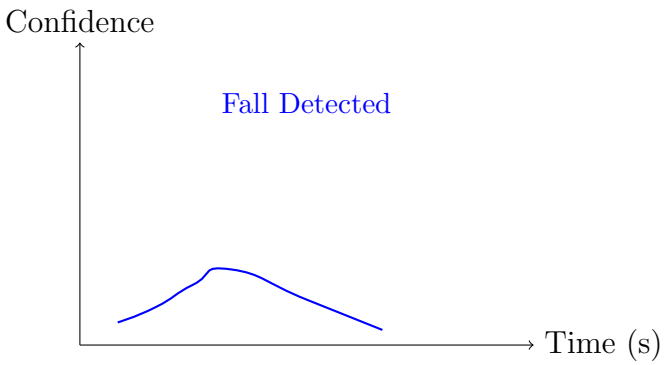
Edge Impulse offers various deployment formats:

- **C++ Library:** Ideal for deployment on microcontrollers like Arduino Nano 33 BLE and ESP32.
- **WebAssembly:** Allows running inference directly in a browser.
- **Python SDK:** Suitable for Raspberry Pi and similar SBCs.

Once the desired format is selected, users can download the complete model bundle and integrate it with their embedded application code. The model can also be deployed on mobile apps or tested directly in the browser using data forwarders.

5 Simulation and Visualization

For debugging or demonstration, the Edge Impulse studio offers a simple visual interface. A graph of confidence scores over time can be viewed while simulating safe and fall activities.



Key Takeaways

1. Edge Impulse makes it easy to build and deploy edge ML models through a complete, no-code platform.
2. Real-time data collection and labeling on smartphones can be effectively used for prototyping.
3. Impulses enable customization of feature processing and model choice tailored to hardware constraints.
4. Deployment options cater to multiple platforms, including MCUs, Raspberry Pi, and web browsers.
5. A fall detection system can be implemented end-to-end without writing any model code, making TinyML more accessible than ever.