

Hackathon Proposal for ELCIA Tech Summit 2025

Team Details:

Team Name	HardWearEd		
Institution	IIT Bombay		
Team Members	Email	ROLE	Contact No.
Dikshit Singla	dikshit131105@gmail.com	Team Lead	8699300395
Ravindra Sidda	ravindrasidda0s@gmail.com	Hardware Integration Specialist	9515525646
Ankur Gupta	ankur2115gupta29@gmail.com	Software & Testing Engineer	8808558045

Project Title:

Pulse Track: AI-Enhanced Multi-Modal Vitals Monitoring System with Edge Intelligence

Target Application Area:

Remote Patient Monitoring—Comprehensive Vitals Analysis with Predictive Health Analytics

Overview of Proposed Solution:

Our solution addresses the critical need for continuous, accurate, and intelligent health monitoring in remote settings. The system combines photoplethysmography (PPG), temperature sensing, and motion detection with advanced AI/ML algorithms running on edge computing platforms.

Problem Addressed: Traditional vital monitoring systems suffer from motion artifacts, inconsistent readings, and lack of predictive capabilities. Healthcare providers need real-time, accurate vitals data with early warning systems for patients with cardiovascular conditions, respiratory issues, or post-operative recovery.

Innovation Highlights:

- Edge AI Implementation: TinyML models running on ESP32 for real-time signal processing
- Multi-sensor Fusion: Advanced algorithms combining PPG, temperature, and IMU data for artifact reduction
- Predictive Analytics: Early detection of arrhythmias, hypoxemia, and cardiovascular anomalies
- Adaptive Learning: Personalised baselines that adapt to individual physiological patterns

Sensors and Compute Board:

Component Type	Part Name/Number	Estimated Cost (INR)	Purpose
PPG/SpO2 Sensor	MAX30102	320	Heart rate, SpO2 monitoring
Non-contact Temperature	MLX90614	1000	Body temperature measurement
IMU/Accelerometer	ADXL335	1280	Motion detection, artifact removal
Microcontroller	ESP32-WROOM-32	800	Edge AI processing, WiFi connectivity
Display	0.96" OLED SSD1306	200	Real-time data visualisation
Power Management	LiPo Battery + Charging	300	Portable operation
Miscellaneous	PCB, Resistors, Capacitors	100	Circuit implementation
Total Cost		4000	

Circuit Connection & Pinout Table:

Sensor/Module	ESP32 Pin	Function	Protocol
MAX30102 SDA	GPIO 21	I2C Data	I2C
MAX30102 SCL	GPIO 22	I2C Clock	I2C
MAX30102 INT	GPIO 4	Interrupt	Digital
MLX90614 SDA	GPIO 21	I2C Data (shared)	I2C
MLX90614 SCL	GPIO 22	I2C Clock (shared)	I2C
ADXL335 X-axis	GPIO 36 (ADC)	X-axis motion	Analog
ADXL335 Y-axis	GPIO 39 (ADC)	Y-axis motion	Analog
ADXL335 Z-axis	GPIO 34 (ADC)	Z-axis motion	Analog
OLED SDA	GPIO 21	Display Data	I2C
OLED SCL	GPIO 22	Display Clock	I2C

Testing Plan (TRL-8 Readiness):

- **Accuracy Validation:** Compare heart rate measurements against commercial pulse oximeters (± 3 BPM accuracy target)
- **Motion Artifact Testing:** Validate signal quality during various activities (walking, typing, resting)
- **Temperature Calibration:** Cross-validation with medical-grade thermometers ($\pm 0.3^{\circ}\text{C}$ accuracy)
- **24-Hour Continuous Operation:** Battery life and data consistency testing with 99% uptime target
- **Environmental Testing:** Temperature drift analysis (-10°C to 50°C), humidity resistance testing
- **AI Model Validation:** Arrhythmia detection accuracy testing with synthetic and real ECG data
- **Field Testing:** 48-hour real-world deployment with multiple subjects for system validation

Indian Sensor Substitution Plan:

Current Strategy: Design modular sensor interfaces with standardised I2C/SPI protocols.

Future Adaptation:

- Implement software abstraction layers for easy sensor swapping
- Develop calibration algorithms adaptable to different sensor characteristics
- Create open-source hardware design compatible with Indian sensor form factors
- Establish partnerships with emerging Indian sensor manufacturers
- Maintain backward compatibility through firmware updates

AI/ML Innovation Components:

Edge AI Architecture:

- **TensorFlow Lite Micro:** Optimised neural networks for real-time processing
- **Signal Processing:** FFT-based noise reduction and artifact elimination
- **Fusion Algorithms:** Kalman filtering for multi-sensor data integration
- **Anomaly Detection:** Isolation Forest algorithms for outlier identification
- **Predictive Modeling:** LSTM networks for trend analysis and early warning

Machine Learning Features:

- **Personalised Baselines:** Adaptive learning of individual physiological patterns
- **Motion Compensation:** AI-driven artifact removal using IMU data correlation
- **Context Awareness:** Activity recognition to adjust measurement sensitivity
- **Health Scoring:** Multi-parameter risk assessment algorithms

Declaration:

We understand and agree to comply with cost constraints, TRL-8 goals, and sharing policies

Name: Dikshit Singla

Signatures: 