Internet of Medical Things

–Team Zzz

Problem Motivation

Traditional Care is Reactive

Patient data is only collected during episodic doctor visits. This leads to data gaps, delayed diagnoses, and late intervention *after* an event has occurred.

Our Solution is Proactive

Our system provides **continuous, remote monitoring** and uses AI to predict adverse events (like fever or falls) *before* they become critical, enabling early intervention.

Introduction

This project presents an end-to-end Internet of Medical Things (IoMT) system for proactive health monitoring. By integrating a custom PCB with five core sensors, we capture real-time physiological data, which is processed by a suite of AI models to predict fever, estimate non-invasive blood pressure, detect falls, and identify coughs. This system shifts the paradigm from reactive to predictive healthcare, enabling early intervention and continuous monitoring.

Project Objectives

Predictive Fever

Forecast fever onset 15 minutes in advance using multi-sensor fusion.

Instant Fall Alert

Deliver immediate fall detection alerts to caregivers for rapid response.

Cough Detection

Identify cough events from audio data for respiratory analysis.

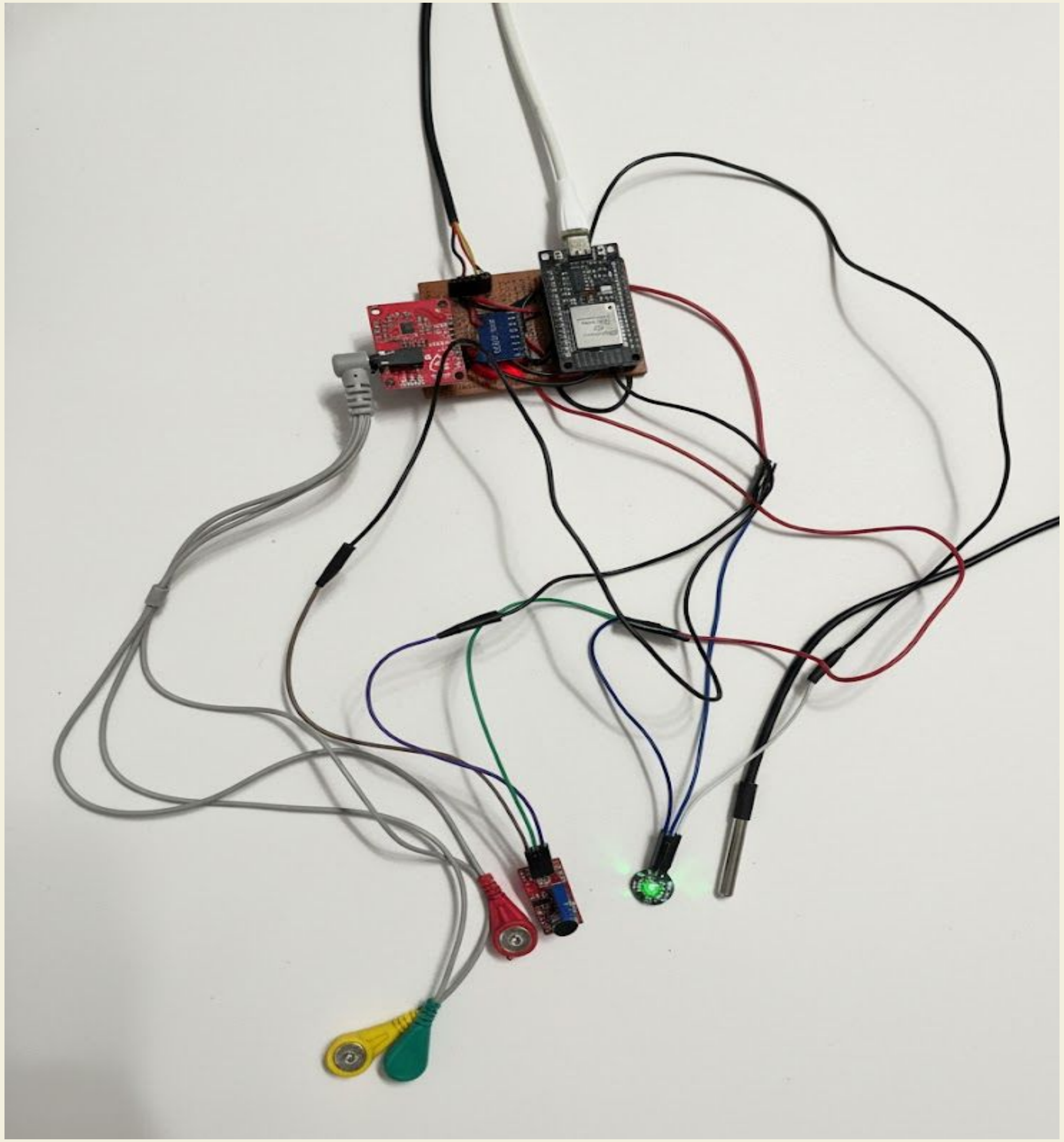
Methodology & Architecture

The hardware, data flow, and software stack powering our predictive health system.

Hardware: The Sensor Hub

Custom IoMT Device - Prototype

- **Microcontroller:** ESP32 for robust Wi-Fi and processing.
- **Sensor Suite:**
  - HW-827 (PPG)
  - KY-038 (Sound)
  - MPU6050 (Gyro)
  - DS18B20 (Temperature)
- **Form Factor:** Compact, wearable device for continuous, non-intrusive monitoring.



Core Sensor Modalities

Temp & Ambient

Skin-surface and ambient sensors provide data for core temperature analysis.

MPU-6050

A 6-axis gyro/accelerometer detects sudden G-force changes to identify falls.

Audio (KY-038)

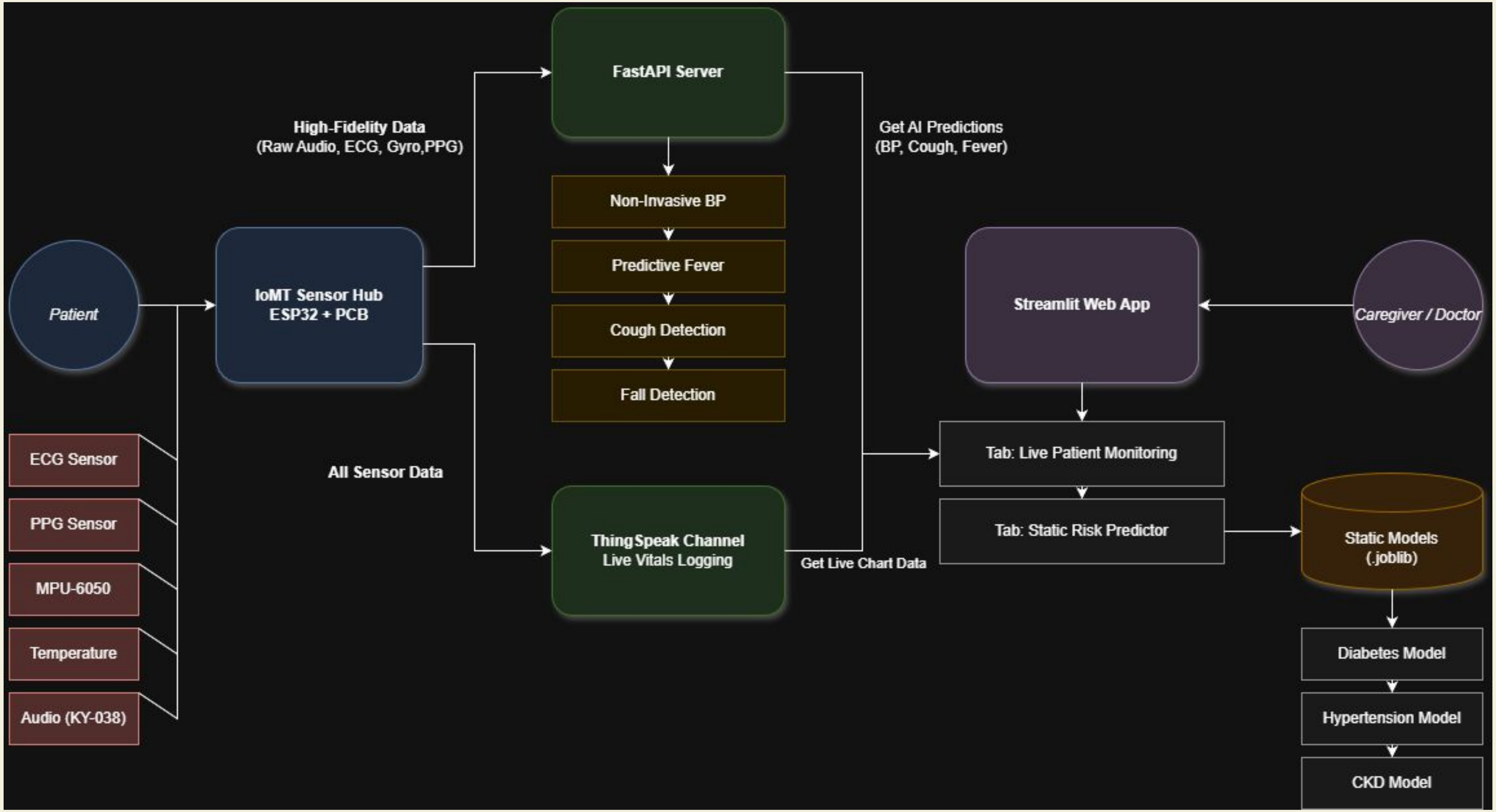
A high-sensitivity microphone captures buffered audio clips for cough analysis.

Sensor Calibration

From Raw Data to Medical Insight

- **Why?** Raw sensor values are arbitrary. Calibration converts them into accurate, standardized medical units (e.g., mmHg, °C).
- **Non-Invasive BP:** Requires a baseline calibration against a traditional cuff. The model learns the patient's unique PTT-to-BP relationship.
- **Temperature:** Calibrated against a medical-grade thermometer to find the offset between skin temperature and core temperature.
- **MPU-6050:** Placed on a flat, stable surface to calibrate the "at rest" state and remove gyro drift.
- **Audio:** A "DC Offset" calibration finds the silent midpoint of the microphone, centering the audio waveform for the AI model.

System Architecture



Our IoMT Dashboard: Two Modes

Tab 2: Live Patient Monitoring

- Provides a unified view of all incoming data and predictions.
- **Live Vitals:** Pulls from ThingSpeak to show real-time charts (Temp, HR, Gyro).
- **Live Predictions:** Polls the FastAPI server to display the Fall detection along with latest AI results:
  - Predictive Fever Alert
  - Cough Detected Alert

Tab 1: Static Risk Predictor

- Analyzes long-term health risks using static data.
- **Models:** Uses local `.joblib` models (e.g., Gradient Boosting).
- **Input:** Manual patient EHR data (Age, BMI, Smoking Status, etc.).
- **Output:** Long-term risk scores for:
  - Type-2 Diabetes
  - Hypertension
  - Chronic Kidney Disease (CKD)

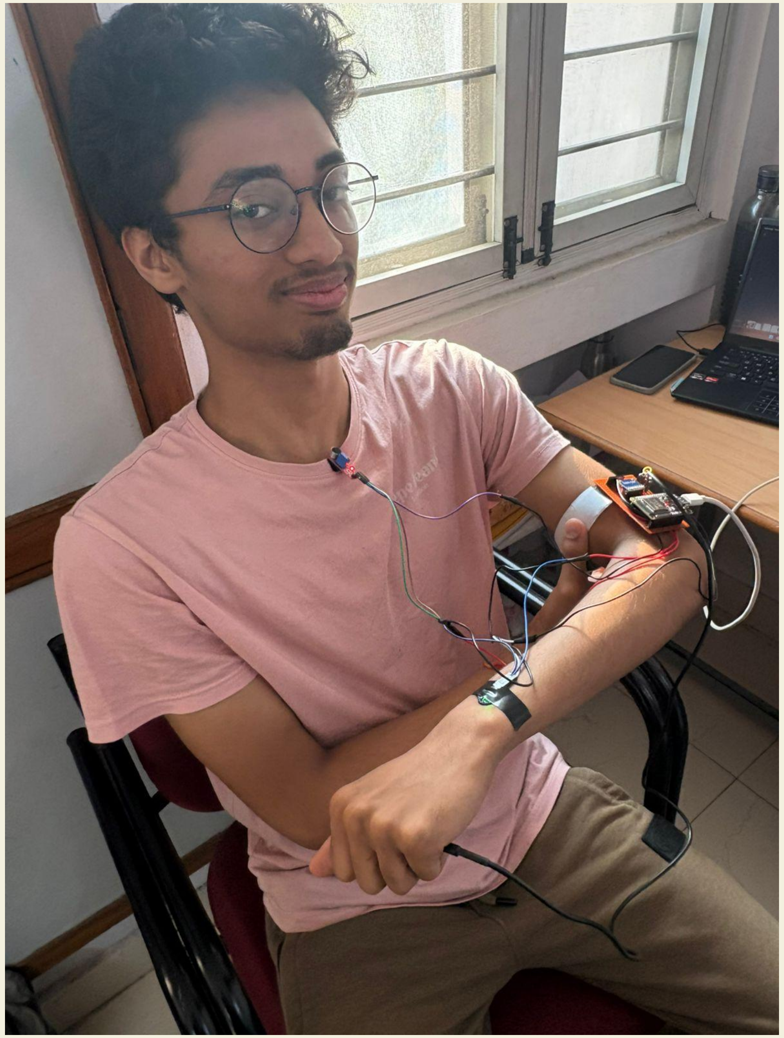
Real-Time Dashboard

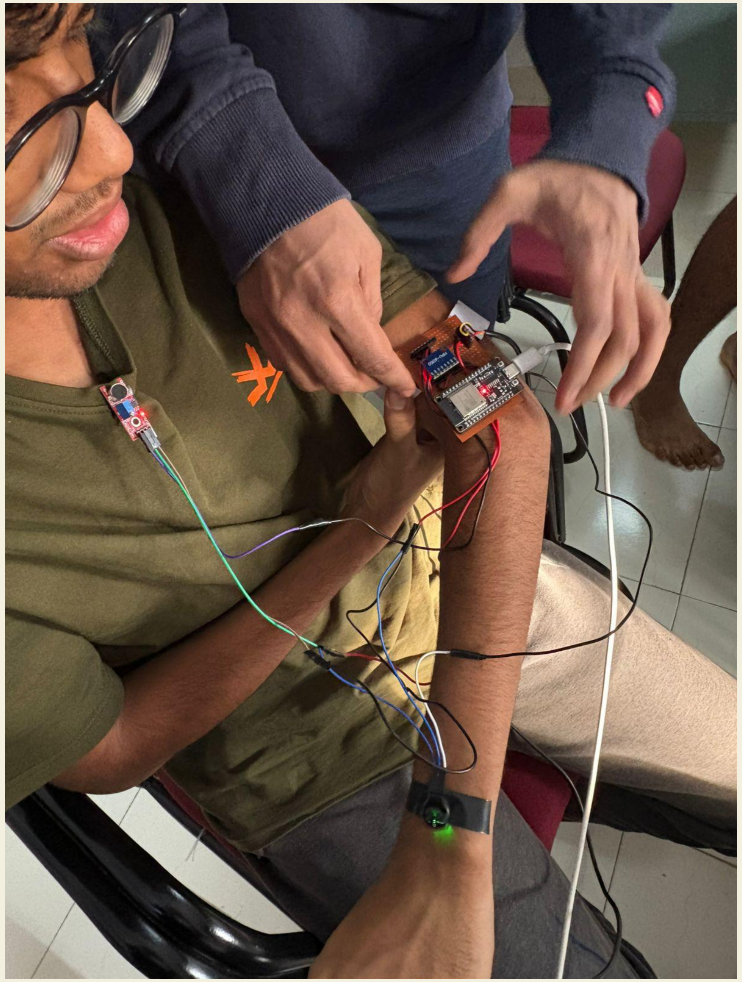
Monitoring & Alerts

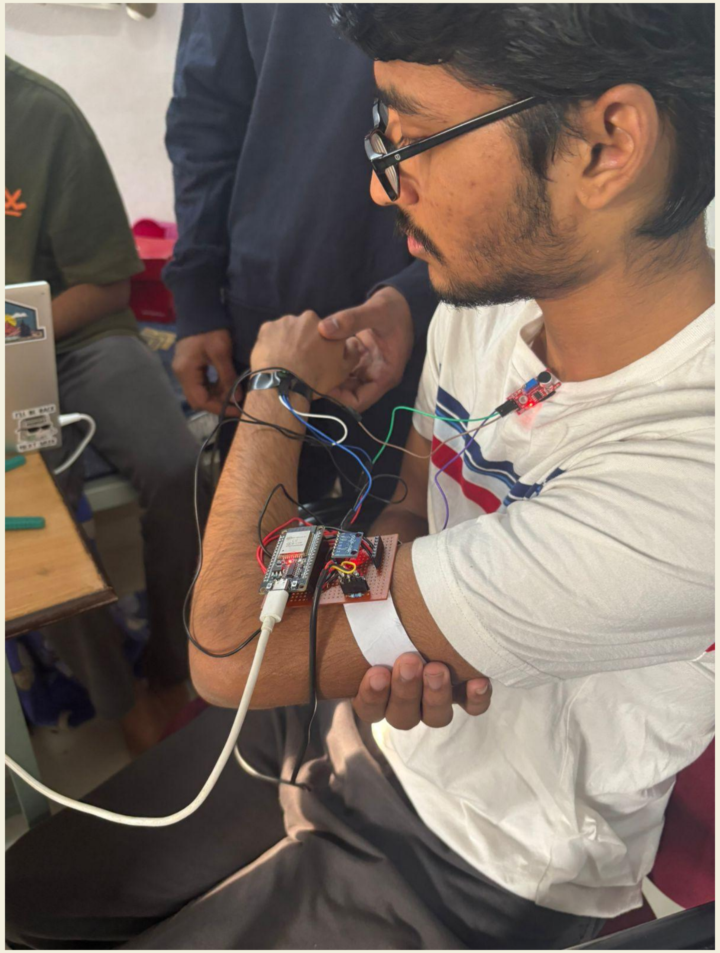
- **Live Vitals:** Real-time visualization of all incoming sensor data via Chart.js.
- **Predictive Alerts:** Clear notifications for positive fall, cough, or fever predictions.
- **Caregiver Portal:** Streamlit app provides a central hub for caregivers to monitor patient status.
- **Historical Data:** Allows for analysis of health trends over time.

7:14 a.m.
7:19 a.m.
7:24 a.m.
Temperature
38
36
34
32
30
28
26
7:04 a.m.
7:09 a.m.
7:14 a.m.
7:19 a.m.
7:24 a.m.
Activity Level
1.030
1.025
1.020
1.015
1.010
1.005
1.000
0.995
0.990
7:04 a.m.
7:09 a.m.
7:14 a.m.
7:19 a.m.
7:24 a.m.
Sound Level
4,500
4,000
3,500
3,000
2,500
2,000
7:04 a.m.
7:09 a.m.

Data Collection With Peers







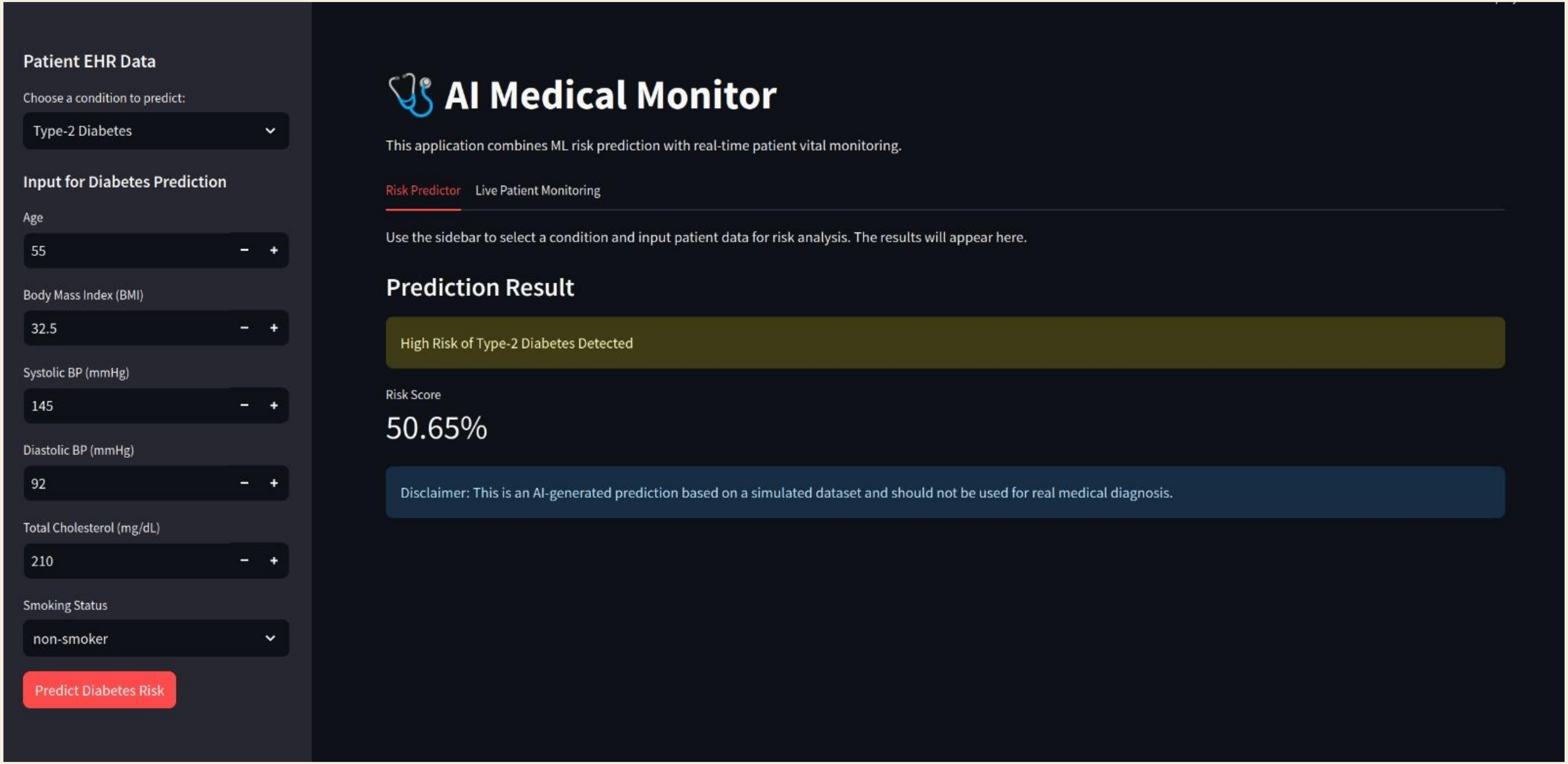
Data Collection With Peers

Dual-Mode: Static Risk Prediction

EHR "What-If" Analysis

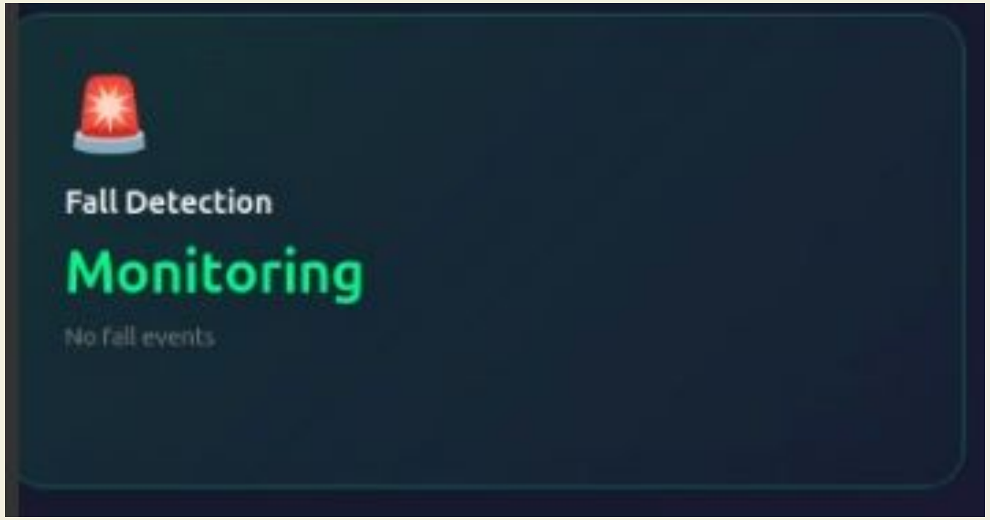
- Beyond real-time data, the platform includes a static "Risk Predictor" tab.
- Uses ML models (`joblib`) trained on EHR data to predict long-term risk for:
  - Type-2 Diabetes
  - Hypertension
  - Chronic Kidney Disease (CKD)
- Provides "what-if" analysis to model how lifestyle changes (e.g., smoking cessation) can impact a patient's risk score.

Dual-Mode: Static Risk Prediction



Fall Detection

- **Method:** Threshold-based algorithm on MPU-6050 data.
- **Logic:** Monitors for a high G-force impact followed by a period of inactivity.
- **Action:** Triggers an immediate alert to the device and caregiver dashboard.



AI-Powered Features

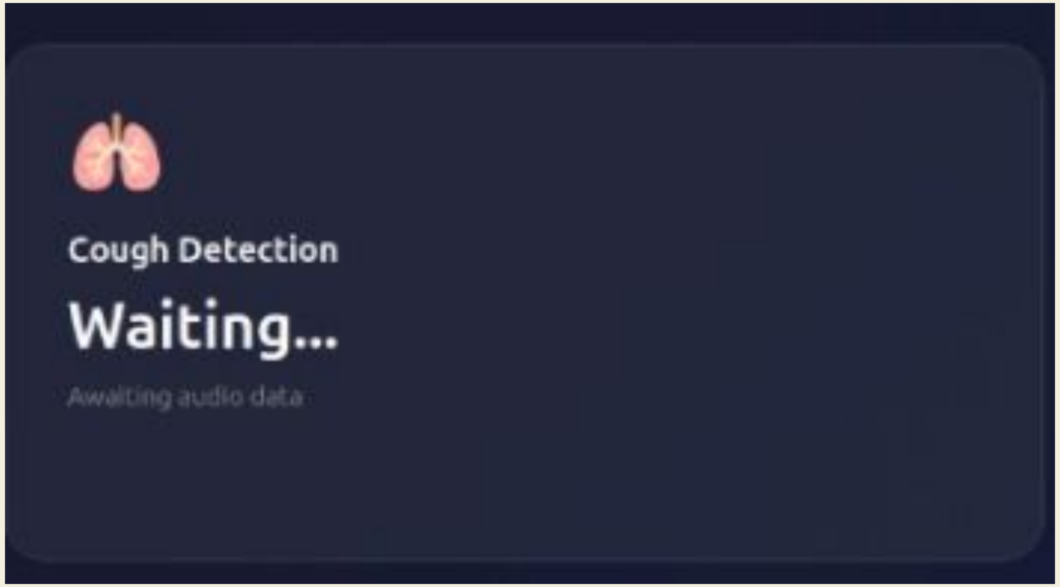
Turning raw sensor data into actionable, predictive insights.

Feature 1: Predictive Fever

- **Model:** A **Gradient Boosting Classifier**.
- **Inputs:** Uses a fusion of **PPG** (for Heart Rate), **MPU-6050** (for activity level), and **Temperature** sensor data.
- **Output:** Binary classification of a fever event within 15 minutes.
- **Training:** Model was trained on online datasets and validated against 1500-2000+ custom-collected test samples.

Feature 2: AI Cough Detection

- **Method:** Real-time audio analysis of **KY-038** sensor data.
- **Data Flow:**
 1. ESP32 captures and buffers a 2-second WAV audio clip.
 2. The raw audio clip is POSTed directly to the FastAPI server.
- **Models:** We use an ensemble of **Logistic Regression** and a **Gradient Boosting Classifier**.
- **Training:** Models were trained on online audio datasets and validated against 1500-2000+ custom-collected test samples.



Future Scope & Enhancements

Edge AI Processing

Migrate AI models from the cloud to a Raspberry Pi paired with the ESP32. This enables offline predictions, enhances patient privacy, and reduces latency.

Model Personalization

Develop longitudinal models that continuously learn from a single patient's data, adapting and re-calibrating to improve personal accuracy over time.

Hardware Miniaturization

Integrate the custom PCB, sensors, and power supply into a single, compact wearable enclosure (e.g., a 3D-printed chest patch or wristband).

Clinical Validation

Conduct formal clinical trials to validate the system's accuracy against gold-standard medical devices on a larger, more diverse patient population.

Conclusion

Our system successfully integrates a multi-modal sensor hub with a robust software backend. It uniquely provides *both* real-time predictive insights (Fever, BP, Fall, Cough) and static, long-term risk analysis (Diabetes, CKD). This dual-mode platform bridges the gap between acute-care monitoring and chronic-disease prevention, creating a holistic and actionable view of patient health.

Thank You

Questions?