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Pragati

AI for Impact Hackathon

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Team Name : hydra

Team Leader Name : Vivek Kumar Soni

Which domain does your idea address? (Agriculture / Healthcare / Skilling / Education): Healthcare

What is the problem you are solving? (50 words max)

In rural and underserved regions, limited access to hospitals, medical tools, and specialists results in many illnesses going undiagnosed due to irregular health checkups. This project addresses the need for early disease detection through a low-cost, AI-powered health monitoring system integrated with IoT technology.

Describe your solution. How different is it from any of the other existing ideas? How will it be able to solve the problem? USP of the proposed solution? What is the intended impact of your solution (max 350 words).

The proposed solution is a **portable, AI-powered health monitoring system** developed to tackle the lack of accessible healthcare in rural and underserved areas. In many such regions, there is limited availability of hospitals, medical equipment, and specialized doctors. As a result, people often miss out on regular checkups, and many common diseases remain undiagnosed until they become serious. Our system aims to solve this problem by providing **on-the-spot, early detection** of diseases using a **compact, low-cost, and easy-to-use device**.

The device integrates several biomedical sensors to measure vital health parameters including **heart rate, ECG, blood pressure, blood oxygen levels, respiration rate, hemoglobin, glucose levels, body temperature, and hydration status**. These measurements are analyzed using **AI algorithms**, which instantly detect signs of conditions like **diabetes, hypertension, anemia, and lung diseases** such as COPD or pneumonia. The device can operate without constant internet access and can store or transmit data through IoT when connectivity is available.

What sets this solution apart is its **all-in-one functionality**. While existing systems often require multiple separate instruments or trained professionals, this device simplifies diagnostics into a single step. It's **affordable**, **battery-efficient**, and **suitable for low-resource environments**, making it ideal for use in remote villages by community health workers or even individuals themselves.

The **unique selling points (USP)** include:

- Multiple health tests in a single, portable device
- Real-time AI-powered analysis without specialist involvement
- Low production and operational cost
- IoT-based data sharing for remote consultation

The intended impact of this solution is to bring preventive healthcare closer to those who need it the most. By enabling regular monitoring and early detection, the system reduces the chances of severe illness, minimizes emergency hospital visits, and improves long-term health outcomes. It empowers communities with timely information and supports health workers with intelligent, actionable insights, ultimately **bridging the gap in rural healthcare delivery**.

Who is the primary user of your solution, and explain how your solution will leverage open-source AI to address the aspects mentioned in the Key Design Guidelines (max 200 words).

The primary users of our solution are **community health workers, rural clinics, and individuals in remote areas** who lack access to regular medical facilities. These users often cannot afford frequent hospital visits or do not have specialists nearby, making early diagnosis of common diseases difficult.

To solve this, our system uses **open-source AI technologies** to analyze real-time health data collected from sensors. By using platforms like **TensorFlow Lite** or **ONNX**, the AI can run directly on the device, even without internet access. This supports the **offline-first** requirement for rural environments.

Open-source AI offers **flexibility, transparency, and cost-efficiency**, helping us build a solution that meets the **Key Design Guidelines** such as **affordability**, **privacy**, **local adaptability**, and **scalability**. The AI models are trained on publicly available datasets and can be improved by local health experts to match regional health trends.

This approach empowers frontline health workers with instant, AI-powered insights and enables preventive healthcare, reducing the burden on distant hospitals and improving community well-being.

How is this solution scalable? (100 words max)

The solution is scalable due to its **modular design, low cost, and use of open-source AI tools**. The device can be mass-produced using affordable sensors and deployed in large numbers across rural regions. Since the AI runs on edge devices, there's no need for heavy infrastructure or constant internet, making it ideal for remote areas. Updates to the AI model can be distributed remotely or offline. Additionally, the system supports data integration with national health databases, allowing governments or NGOs to scale its use for **community-wide health monitoring and preventive care**.

List of features offered by the solution

It is always better to add a few visual representations (drawings/sketches/illustrations etc.) to your presentation, it adds to the power through which it reaches the audience.

List of Features Offered by the Solution

1. **Portable Multi-Sensor Device**
   Compact and easy to carry for use in rural and remote areas.
2. **Vital Sign Monitoring**
   Tracks heart rate, ECG, blood pressure, blood oxygen (SpO_2), and respiration rate.
3. **Disease Detection**
   AI-based analysis detects early signs of diabetes, hypertension, anemia, and lung diseases.
4. **Non-Invasive Readings**
   Uses sensors and NIR spectroscopy for painless, real-time health monitoring.
5. **AI-Powered Offline Diagnostics**
   AI models run on the device without needing internet access.
6. **IoT Connectivity**
   When available, syncs data to cloud or health databases for remote access.
7. **User-Friendly Interface**
   Simple display with color-coded alerts for health status.
8. **Rechargeble and Low Power Usage**
   Suitable for areas with limited electricity.
9. **Customizable & Open-Source AI Models**
   Easily adaptable to local health conditions.

What open-source AI tools and technologies will you use to design the solution? (Please list all.)

To design the solution, we will use a combination of **open-source AI tools, frameworks, and libraries** that support efficient, offline, and real-time health data analysis:

1. **TensorFlow Lite** – For running AI models directly on edge devices with low memory and power usage.
2. **PyTorch Mobile** – Lightweight version of PyTorch suitable for on-device inference.
3. **Scikit-learn** – For building and training machine learning models on health data like heart rate, blood pressure, and glucose levels.
4. **OpenCV** – Used for processing sensor signals or images (e.g., skin color analysis for anemia detection).
5. **Edge Impulse** – Platform for developing AI models specifically optimized for embedded and IoT devices.
6. **ONNX (Open Neural Network Exchange)** – Enables compatibility and conversion between different AI frameworks.
7. **Arduino IDE / PlatformIO** – For programming microcontrollers and integrating sensor data collection.
8. **Node-RED / MQTT** – For IoT-based communication and lightweight data transfer.
9. **Matplotlib / Seaborn** – For visualizing and debugging health data trends during development.

These tools help ensure the system remains **cost-effective, flexible, offline-capable, and scalable** for rural healthcare needs.

Why are these open-source technologies the most appropriate for your solution? (150 words max)

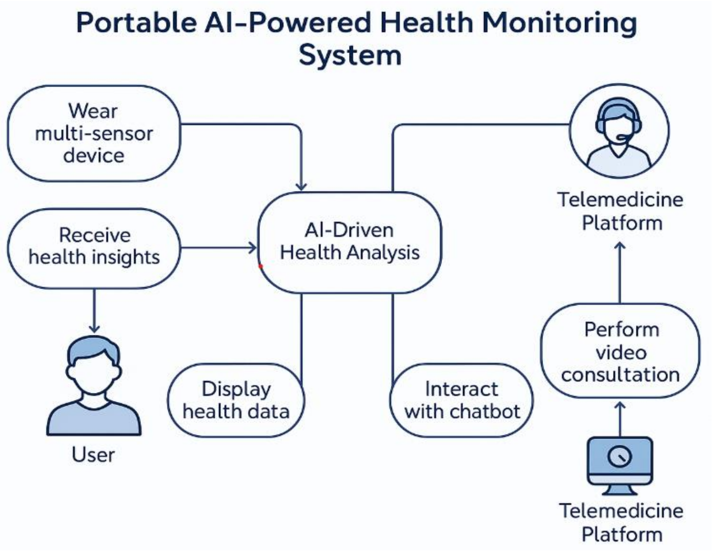
These open-source technologies are ideal for our solution because they offer **cost-efficiency, flexibility, and community support**—key requirements for building a healthcare system for underserved areas. **TensorFlow Lite** and **PyTorch Mobile** allow AI models to run directly on low-power devices without needing constant internet access, making them perfect for rural use. **Edge Impulse** and **ONNX** ensure the models are lightweight and compatible across platforms. Tools like **Scikit-learn** and **OpenCV** simplify data processing and disease prediction, while **Arduino IDE** supports easy integration of biomedical sensors. For IoT communication, **Node-RED** and **MQTT** offer lightweight, real-time data transfer. All these tools are well-documented, widely used, and continuously updated by global communities, which enhances reliability and future scalability. Their open-source nature ensures we can adapt and improve the solution based on local healthcare needs without high licensing costs. Together, they form a powerful, low-cost AI ecosystem for accessible healthcare.

Describe the Solutions Architecture (500 words)

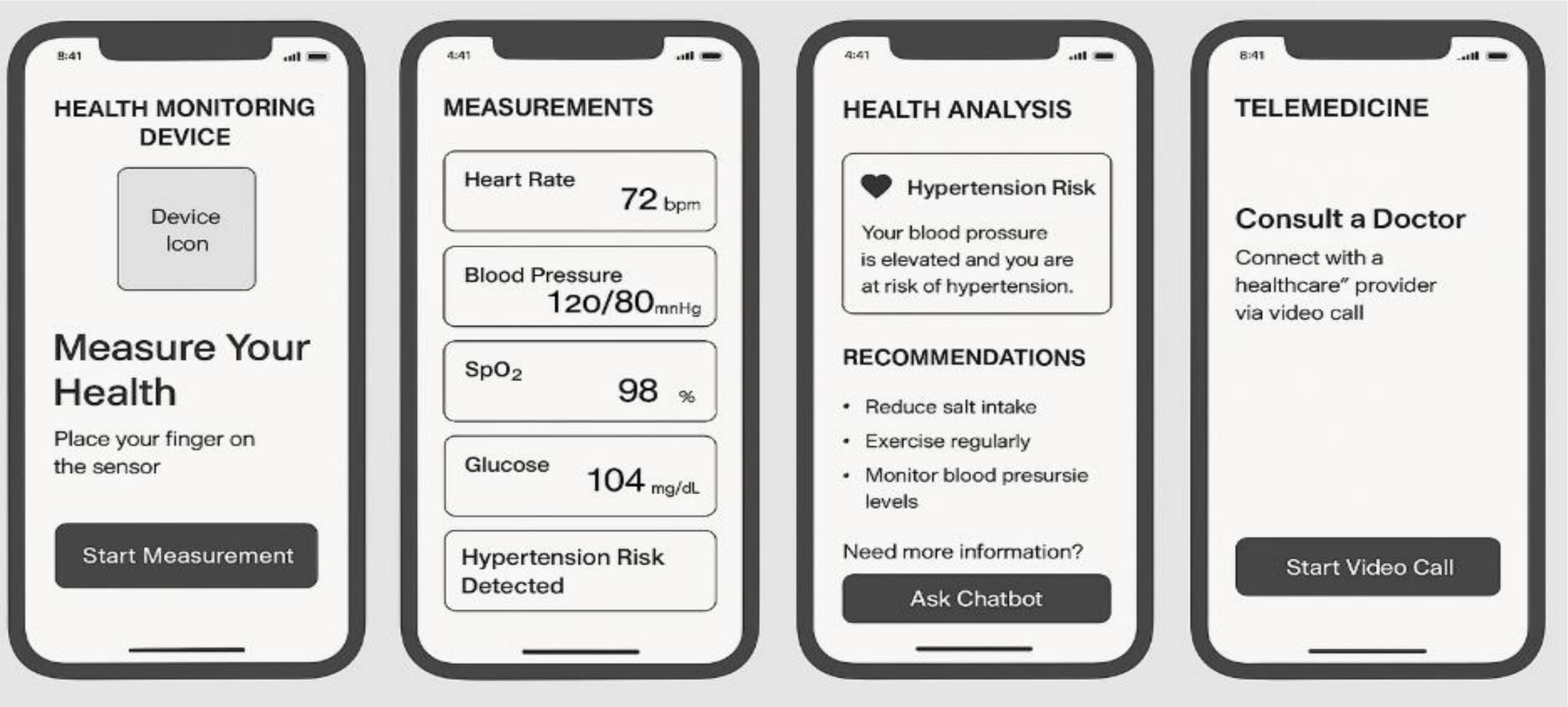
•The solution is a portable, low-cost health monitoring device designed to detect early signs of common diseases in rural and underserved areas
•It includes multiple biomedical sensors such as ECG, heart rate, blood pressure, SpO_2, respiratory rate, glucose level (via NIR), hemoglobin, temperature, and hydration sensors
•All sensors are connected to a microcontroller unit like Raspberry Pi, Arduino, or ESP32, which collects and manages real-time physiological data from users
•On-device AI processing is implemented using optimized machine learning models built with TensorFlow Lite, Edge Impulse, or Scikit-learn, which run efficiently on low-power devices
•The AI models analyze the sensor data locally to detect symptoms or risks of conditions like diabetes, hypertension, anemia, or lung diseases, even without an active internet connection
•The system includes a small display or can pair with a mobile app via Bluetooth or Wi-Fi to show the results and recommendations to users instantly
•Data transmission to the cloud is enabled when network access is available, using lightweight communication protocols like MQTT or HTTP for syncing health data
•The cloud component helps in long-term data storage, visualization, remote access by healthcare professionals, and future AI model updates or retraining
•All collected data is encrypted and access-controlled to ensure the privacy and security of the user's health information
•The entire device is built using low-cost, open-source hardware and software, making it affordable and easy to reproduce at scale for deployment in various regions
•The AI models are trained using diverse open datasets related to medical symptoms and vital signs, and the system is designed to be continuously improved through feedback and model updates
•The architecture allows full offline functionality, making it suitable for areas with little to no connectivity, while still supporting cloud features when online
•A modular design approach ensures that additional sensors or diagnostic capabilities can be added in future versions without changing the entire system
•The solution can be charged via USB or solar power, adding to its usability in power-scarce environments
•The combination of local AI, cloud connectivity, data security, and real-time feedback makes this solution a complete, scalable, and reliable healthcare companion
•By using open-source technologies, the solution remains flexible, adaptable, and community-driven, which enables rapid improvement, bug fixing, and collaboration from global contributors
•The solution supports large-scale deployment in public health missions, camps, rural clinics, and home-based self-assessments, creating a major impact on early diagnosis and preventive healthcare

Provide a high-level architecture diagram or a use-case diagram of your proposed solution

```
graph TD
    A[Portable Multi-Sensor Device] -->|Biometric Data| B(Data Acquisition & Preprocessing);
    B --> C{Edge AI (TinyML)};
    C -- Local Analysis --> D[Real-time Results & Alerts];
    C -- Data for Cloud Sync --> E[Cloud Database (Firebase)];
    D --> F[Mobile App (React Native)];
    E --> G[AI Models (Cloud)];
    G --> H[Disease Prediction & Analysis];
    H --> E;
    F --> I[User Interface & Health Insights];
    F --> J[Telemedicine (Twilio API)];
    J --> K[Doctors/Healthcare Providers];
    I --> L[AI Chatbot (LLM)];
    L --> I;
    E --> M[Data Analytics & Reporting];
    M --> N[Healthcare Organizations/Researchers];
    D --> F;
```



Please share the wireframes/Mock diagrams of the proposed solution (optional)



What datasets will your solution use? Are they publicly available, synthetic, or user-generated?

•The solution will use a combination of **publicly available medical datasets**, **synthetic datasets**, and **user-generated data**
•**Public datasets** help train initial AI models and include:
- **MIT-BIH Arrhythmia Dataset** for ECG and heart disease detection
- **MIMIC-III Database** for patient vitals like BP, SpO_2, temperature, etc.
- **PIMA Indian Diabetes Dataset** for diabetes risk prediction
- **Anemia Dataset from Kaggle** for hemoglobin level prediction

•**Synthetic datasets** are generated using data augmentation tools to improve model training where real data is limited
•**User-generated data** is collected from the device in real-time, used for personalized monitoring, and (if permitted) to improve model performance over time
•All datasets used ensure **privacy, anonymization, and ethical standards**
•This mixed approach ensures accurate predictions, better generalization, and adaptability for different user groups

Does your solution require cloud-based computation, or can it work with on-device processing? If cloud-based, how do you plan to address connectivity challenges and cost constraints?

On-Device Processing (Primary Mode)

- The solution is designed to work effectively even in **offline or low-connectivity environments**
- A lightweight AI model, trained using public health datasets, is deployed on microcontrollers like **Raspberry Pi** or **ESP32**
- Tools like **TensorFlow Lite** or **Edge Impulse** are used to compress and optimize the models for real-time inference
- The device processes sensor data locally to predict conditions like:
    - **Arrhythmia or heart diseases** (from ECG, heart rate)
    - **Hypertension risk** (from blood pressure)
    - **Anemia & diabetes** (from hemoglobin and glucose levels)
    - **Lung diseases** (from SpO_2 and respiratory rate)
- This ensures **instant diagnosis** without relying on internet access
- The results are shown on a small screen or sent to a mobile app using **Bluetooth or Wi-Fi**

Cloud-Based Computation (Secondary Mode)

•When internet is available, the system syncs data to a **secure cloud platform**
•This enables:
- **Remote access for doctors and health workers**
- **Visualization dashboards**
- **Long-term patient monitoring**
- **Periodic retraining and updates** of AI models using collective user data

•Cloud usage is optional and lightweight to **reduce dependency and cost**

Addressing Connectivity Challenges

•The device uses an **offline-first approach**: data is stored locally and only uploaded when a network is available
•**Automatic sync feature** ensures background uploads without user effort
•This makes the system suitable for **rural areas with intermittent connectivity**

Addressing Cost Constraints

•Cloud services are used in a **minimal way**, focusing only on:
- Data backups
- Model updates
- Remote diagnostics

•**Open-source cloud platforms** or low-tier services (e.g., Firebase, AWS Free Tier) help reduce operational costs
•Since most computation is handled on-device, the **cloud cost remains very low**, making the system **affordable and scalable**

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THANK YOU