SMART INDIA HACKATHON 2024

TITLE PAGE

- **Problem Statement ID** – **SIH1547**
- **Problem Statement Title-** Development of an alternative technology to check blockage of blood vessels *(an alternative to conventional angiography)*.
- **Theme-** MedTech / BioTech / HealthTech
- **PS Category-** Hardware
- **Department:** Department of Science & Technology (DST)
- **Team ID - FIXME**
- **Team Name** – **CardioSonic**
- **Team Leader** – Komal Agarwal
- **Institute Name** – Silicon University, Odisha

IDEA TITLE

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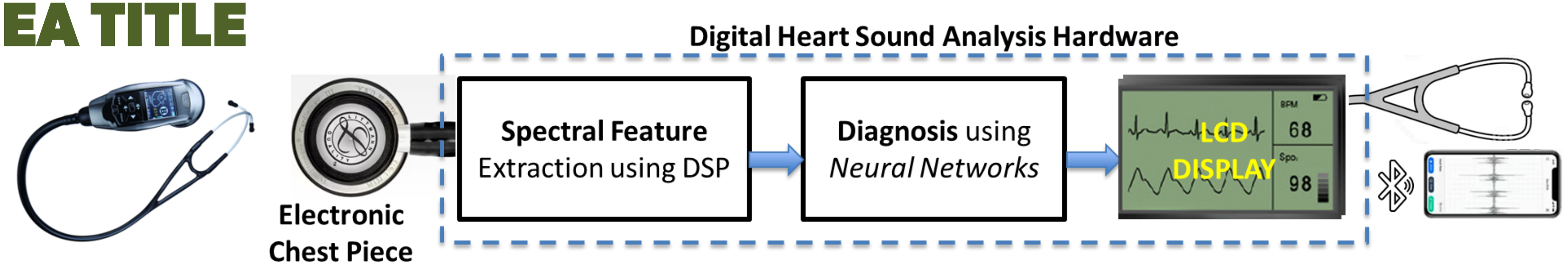

Detailed Explanation of the Proposed Solution:

- The proposed solution is an **electronic stethoscope** that is capable of **detecting blockages in blood vessels**.
- This solution leverages **heart sound analysis** *research* to detect blockages in blood vessels.
- It uses **signal processing** and **machine learning (ML)** to extract *unique spectral features* from an e-stethoscope

The proposed method involves:

- An *electronic chest piece* that converts **heart vibrations** to **digitally encoded signal** using transducers.
- A **Digital Signal Processing (DSP)** hardware to extract *unique spectral features* from patient heart sounds.
- A *trained* **Neural Network** hardware is used to *detect blockages* by recognizing the unique spectral signatures.
- The result is locally displayed and transmitted using wireless technology such as **Bluetooth, WiFi, etc**.

Innovation and Uniqueness:

- A **cost-effective** and **non-invasive** alternative to conventional ***angiography.***
- Applying **audio processing techniques** as a cost-effective and non-invasive alternative to angiogram.
- Currently there are numerous e-stethoscopes in the market but without any diagnosis capability.

TECHNICAL APPROACH

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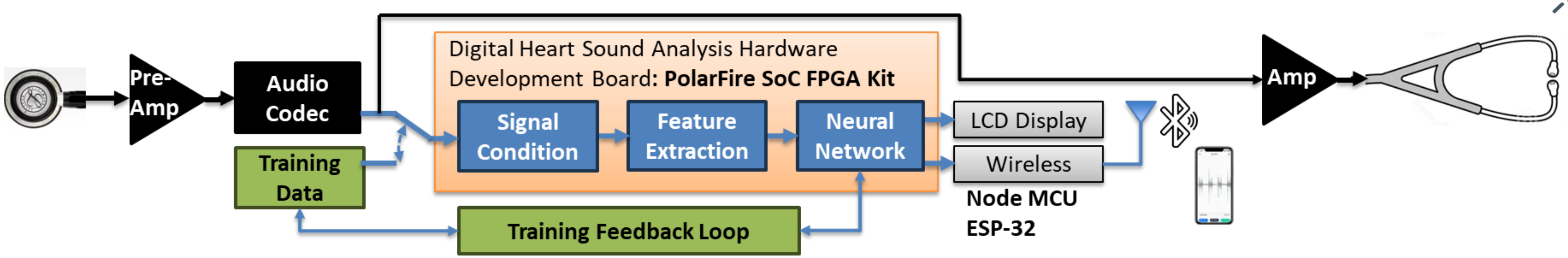

Technologies to be used:

- **Python**, **ML and audio libraries** (`librosa, tensorflow, sklearn`) for system modeling and training.
- Microchip's **PolarFire SoC FPGA** Icicle kit for implementing the hardware using **C/++/Python** and Verilog HDL
- **Node MCU ESP32** to implement the wireless communication (**WiFi and Bluetooth**)
- **Electronic chest piece** with transducer (mic) and audio codec to convert the heart sound to digital stream.

Methodology and Implementation Process:

- A **Python model** of the digital hardware: **Signal conditioning** (filter, windowing), **feature extraction** (Fast Fourier Transform (FFT), Mel-Frequency Cepstral Coeff (MFCC)), **Convolution Neural Network** (CNN).
- Using the popular **dataset** from the [2016 PhysioNet/CinC Challenge]() the **CNN is trained to detect blockages**.
- The Python model is implemented in hardware on the **PolarFire SoC FPGA EV Kit.** In addition to RISCV processors, this kit allows you to implement high performance hardware (eg. CNN) on the **FPGA using Verilog**.
- The **diagnosis result** is displayed locally on an **LCD display** and transmitted **wirelessly** using a **node MCU ESP32** microcontroller development board.

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FEASIBILITY AND VIABILITY

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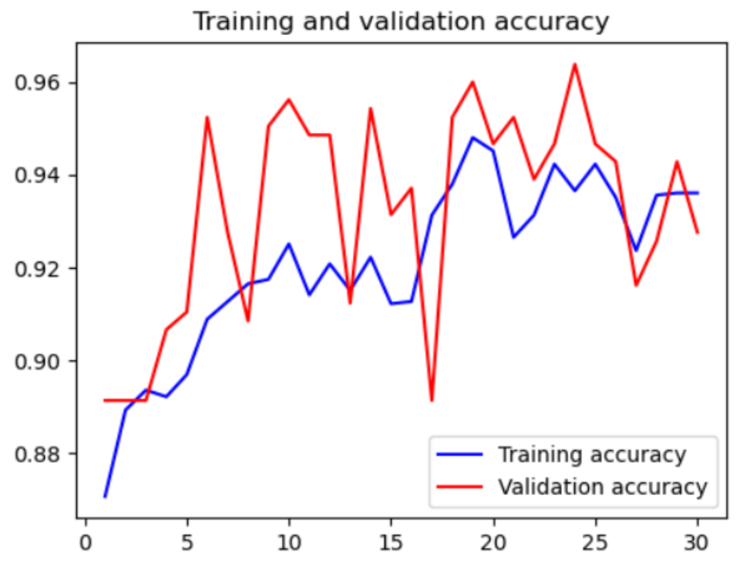
Feasibility Analysis

- **Large dataset** available at the 2016 PhysioNet/CinC Challenge
- This allowed us to **train the neural network** with great accuracy.
- A **30 Epoch training** of the CNN resulted in better than **92% accuracy**
- This *result* **proves the feasibility and viability** of the solution.
- Wide variety of hardware option to implement on, which increases viability.



Potential Challenges & Risks:

- **Clinical trial** with diversified patient is a **big challenge**.
- Any **peculiarities related to Indian** patient will result in classification error.
- **Real-world noise**, which are not part of training data, will **decrease the accuracy** of diagnosis.
- Adoption by doctors in urban areas will be a challenge due to resistance to new technology.

Strategies for Overcoming the Risks:

- Creating **mobile medical camps in rural areas** and proving the technology **will give confidence to the doctors** in urban areas to adopt the technology. This will also allow creating datasets for the local area.
- Add **noise-resistant layers** (e.g., attention mechanisms) for noise robustness.
- Generate **synthetic heart sounds** to diversify the dataset and address class imbalance (more normal sounds than abnormal) as data augmentation technique.

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IMPACT & BENEFITS

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Potential Impact on the Target Audience

- **Improved Accuracy:** High *diagnostic precision*, even for less experienced clinicians.
- **Increased Access:** Enables remote and home-based monitoring, democratizing care.
- **Cost Savings:** Reduces the need for costly diagnostic tools, making health monitoring affordable.
- **Reduced Physician Burden:** Automates routine tasks, freeing up professionals for complex cases.
- **Prevention of Disease Progression:** Early detection allows for timely treatment and lifestyle changes.
- **Potential for Advanced Accuracy:** Could serve as a pre-test to traditional angiograms.

Benefits of the Solution:

- **Enhanced Diagnostic Capability:** Improves accuracy for general physicians, reducing reliance on specialists.
- **Cost-Effective:** Minimal hardware costs relative to the value of service provided.
- **Non-Invasive:** Safe for patients, reducing risk and discomfort.
- **Reduced Healthcare Costs:** Affordable, specialized solution lowers overall expenses.
- **Accessible Quality Care:** Benefits rural and underserved populations.
- **Versatile Application:** Potential for use in other healthcare areas.

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RESEARCH & REFERENCES

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Team Members

Name	Branch(Stream)	Year
Komal Agarwal (Lead)	B.Tech. (ECE)	3rd (III)
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B Donald Mclan	B.Tech. (ECE)	2nd (II)
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Abhijit Padhi	B.Tech. (CSE)	2nd (II)

Mentors

Name	Expertise	Experience (Yrs)
Dr. Saroj Rout	Embedded/VLSI/DSP	26
Dr. Santunu Sarangi	VLSI/FPGA	10