NEW YORK UNIVERSITY

TANDON SCHOOL OF ENGINEERING

NeuroCardiac Shield

An Integrated Brain-Heart Monitoring System
for Early Heart Attack Detection

ADVANCED PROJECT ECE-GY 9953 BK05 (3)
Proposal

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Abstract

Cardiovascular diseases continue to be a leading cause of global mortality, with heart attacks presenting a particularly challenging medical emergency. The NeuroCardiac Shield project introduces an innovative approach to early heart attack detection by integrating neural and cardiac monitoring technologies. By leveraging the intricate connection between brain activity and cardiac events through the autonomic nervous system, our solution combines advanced EEG and ECG monitoring with artificial intelligence-powered cloud computing.

The project aims to detect subtle physiological warning signs hours before a potential cardiac event, providing a groundbreaking platform for preventive healthcare. Our integrated system represents a significant leap forward in medical monitoring technology, offering the potential to save lives through early intervention and personalized risk assessment.

1 Introduction

1.1 Problem Statement

Heart attacks remain a critical public health challenge, characterized by their sudden and often fatal nature. Existing monitoring systems predominantly focus on direct cardiac parameters, overlooking crucial neural indicators that could provide critical early warning signs. The NeuroCardiac Shield project seeks to bridge this diagnostic gap by developing a comprehensive neural-cardiac monitoring system that captures and analyzes complex physiological interactions.

1.2 Project Significance

Emerging medical research has revealed that neurological changes can precede cardiac events by several hours. The NeuroCardiac Shield leverages these insights, creating a multidisciplinary approach that combines neuroscience, cardiology, and advanced computing. By simultaneously monitoring neural and cardiac parameters, the project offers a novel pathway for early detection, potentially transforming cardiovascular disease management.

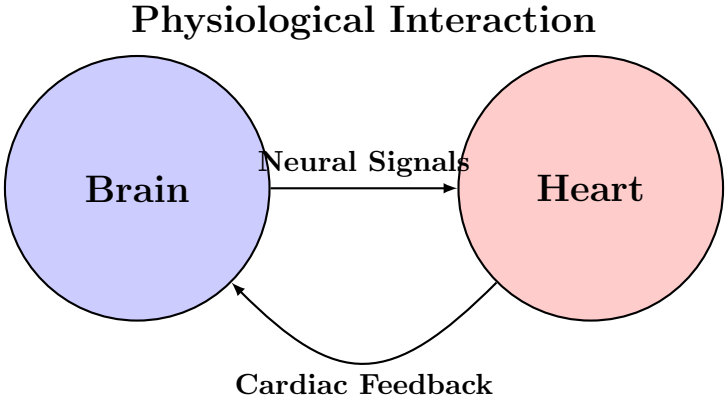

Figure 1: Neural-Cardiac Physiological Interaction

2 System Architecture

2.1 Device Layer

2.1.1 Hardware Components

The NeuroCardiac Shield utilizes a sophisticated hardware architecture:

- **Microcontroller:** STM32L4+ Series
  - Optimized for ultra-low power consumption
  - Integrated hardware-level encryption
  - 32GB secure onboard storage
- **Sensor Suite:**
  - Advanced 16-channel EEG Frontend
  - High-precision ADS1293 ECG front-end
  - Complementary sensors:
    - SpO2 monitoring
    - Precision body temperature sensor
    - 3-axis motion tracking accelerometer
- **Communication Infrastructure:**
  - Primary LTE-M/NB-IoT communication
  - Secondary Bluetooth Low Energy (BLE) 5.2 backup
  - Secure 32GB local data storage

2.2 Signal Acquisition Strategy

The project employs a nuanced approach to physiological data collection:

- **Neural Signal Processing:**
  - High-resolution autonomic nervous system monitoring
  - Advanced electrode configuration for precise neural capture
- **Cardiac Signal Processing:**
  - Comprehensive cardiac parameter tracking
  - Real-time heart rate variability analysis
  - Machine learning-enhanced anomaly detection

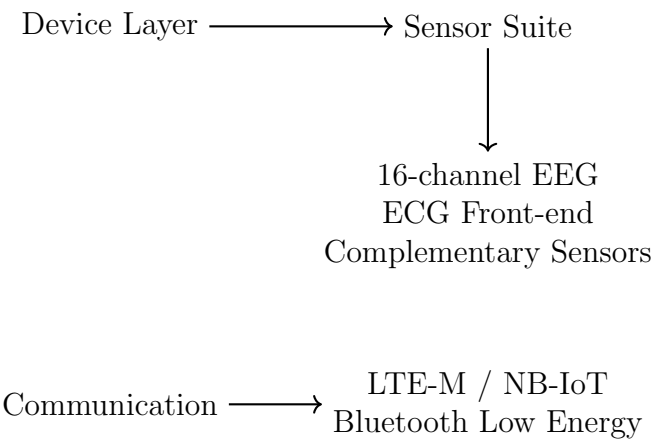

Figure 2: NeuroCardiac Shield System Architecture

3 Methodology

3.1 Data Processing Pipeline

The project implements a rigorous data analysis workflow:

1. Neural signal preprocessing
2. Multidimensional feature extraction
3. Cross-modal correlation analysis
4. Machine learning-driven classification
5. Predictive risk stratification

3.2 Machine Learning Approach

A hybrid neural network architecture powers the project's predictive capabilities:

- Long Short-Term Memory networks for temporal pattern recognition
- Convolutional Neural Networks for sophisticated feature extraction
- Gradient Boosting algorithms for precise risk classification

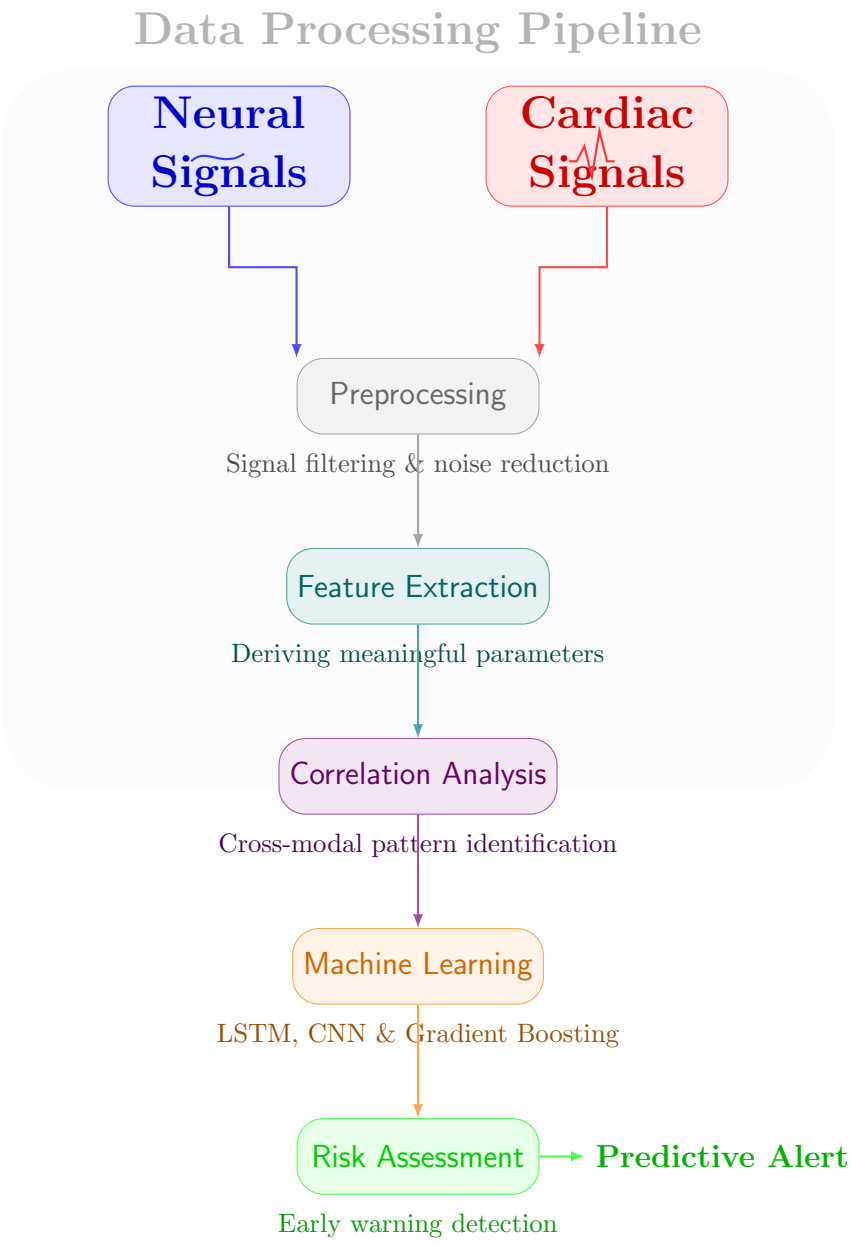

Figure 3: Neural-Cardiac Data Processing and Machine Learning Workflow

4 Challenges and Mitigation

Technical Challenge	Comprehensive Mitigation Strategy
Signal Noise Reduction	• Advanced multi-modal filtering techniques • Machine learning noise cancellation algorithms • Cross-sensor validation mechanisms
Data Accuracy	• Continuous algorithmic retraining • Extensive medical dataset cross-validation • Collaborative research with clinical partners • Dynamic baseline recalibration
Privacy Protection	• End-to-end encryption protocols • Rigorous patient data anonymization • Strict HIPAA regulatory compliance • Periodic comprehensive security audits

5 Conclusion

The NeuroCardiac Shield represents a transformative approach to cardiovascular monitoring. By integrating advanced neural and cardiac sensing technologies with sophisticated machine learning algorithms, the project offers unprecedented potential for early heart attack detection and prevention.

Our innovative solution bridges critical gaps in current medical monitoring technologies, providing a powerful platform for personalized, proactive healthcare interventions.