Exhaustive Cost Analysis of a Neurofeedback System: A Modular Breakdown for Educational and Clinical Implementation

KODE RUPA RASAGNA
BL.EN.U4AIE23114
Department of Artificial Intelligence and Engineering
AMRITA SCHOOL OF COMPUTING

Email: [bl.en.u4aie23114@bl.students.amrita.edu]

***Abstract*—Neurofeedback systems are emerging as a non-invasive and adaptive means of regulating brain activity through real-time analysis of EEG signals. These systems find use in medical therapy, sports enhancement, attention training, and human-computer interfacing. This report presents an exhaustive cost analysis of every major component required to implement a neurofeedback system. The cost assessment spans multiple system tiers: DIY student setups, mid-range research platforms, and high-end clinical solutions. Emphasis is placed on real-world pricing, component interdependencies, and the rationale behind cost variations.**

I. Introduction

Neurofeedback, a type of EEG-based biofeedback, provides individuals with real-time information about their brain states. Through this process, users can modulate specific brainwave activities to improve mental health, cognitive performance, and neurological balance. Building a functional neurofeedback system requires hardware, software, machine learning frameworks, and user feedback interfaces. Understanding the detailed cost of each module is crucial for budget-conscious users and institutions.

II. Detailed Component-wise Cost Analysis

A. 1. EEG Signal Acquisition Unit

Function: Captures real-time electrical signals generated by neural activity through the scalp.

Subcomponents and Cost Range:

- **EEG Headset (8 to 32+ channels)**:
  - Emotiv Insight (5 channels): INR 30,000–40,000
  - OpenBCI Cyton Board (8 channels): INR 50,000–90,000
  - NeuroScan or g.tec research-grade headsets: INR 2,50,000–3,50,000
- **Electrodes and Cap**:
  - Wet electrodes (silver/silver chloride): INR 3,000–10,000 for a set
  - Dry electrodes: INR 5,000–15,000 depending on quality
  - EEG cap (10-20 system): INR 10,000–25,000
- **Amplifiers (if required)**:
  - Low-noise analog amplifiers: INR 10,000–1,00,000
- **Consumables**:
  - Conductive gel, alcohol wipes, syringes: INR 500–3,000/year
- **Shielded Cables and Connectors**:
  - Gold-plated or shielded wires: INR 2,000–10,000

Total Estimated Subtotal: INR 50,000 to INR 4,00,000

B. 2. Signal Preprocessing Unit

Function: Cleans EEG data by filtering noise and artifacts for accurate analysis.

Subcomponents and Cost Range:

- **Software:**
  - MATLAB with Signal Processing Toolbox: INR 90,000–1,50,000
  - EEGLAB (MATLAB plugin): Free (open-source)
  - Python (MNE, SciPy, NumPy): Free
- **Algorithms Used:**
  - Band-pass filters (1–40 Hz), notch filters (50/60 Hz), ICA for artifact rejection
- **Computer Hardware:**
  - Laptop/Desktop (Intel i7/Ryzen 7, 16–32 GB RAM): INR 60,000–1,20,000
  - GPU-enabled systems for real-time analysis (NVIDIA RTX series): Additional INR 50,000–1,00,000

Total Estimated Subtotal: INR 60,000 to INR 2,50,000

C. 3. Feature Extraction Module

Function: Extracts relevant brainwave features (Delta, Theta, Alpha, Beta, Gamma) for classification.

Subcomponents and Cost Range:

- **Algorithm Libraries:**
  - Fast Fourier Transform (FFT), Power Spectral Density (PSD): Built into EEGLAB, Python
- **Development Time Cost:**
  - DIY scripting or hiring a developer: INR 0 (self-built) – INR 20,000 (outsourced)

Total Estimated Subtotal: INR 0 to INR 20,000

D. 4. Machine Learning Unit

Function: Classifies EEG patterns to detect cognitive states like attention, relaxation, stress.

Subcomponents and Cost Range:

- **ML Frameworks:**
  - TensorFlow, PyTorch, scikit-learn: Free
- **Training Datasets:**
  - PhysioNet, OpenBCI Datasets: Free
  - Custom labeled datasets (commercial): INR 10,000–50,000
- **Training Hardware or Cloud:**
  - Cloud GPU rental (AWS, Colab Pro): INR 5,000–1,00,000 depending on hours

Total Estimated Subtotal: INR 5,000 to INR 1,50,000

E. 5. Real-Time Feedback Interface

Function: Provides visual/audio feedback to guide the user in real-time.

Subcomponents and Cost Range:

- **Display Devices:**
  - Monitor/Tablet (1080p+): INR 10,000–30,000
  - VR Headset (optional): INR 30,000–80,000
- **Feedback Platform:**
  - Unity3D, Unreal Engine: Free
  - Custom game/app interface: INR 0–20,000
- **External Devices:**
  - Light/sound systems, haptic motors: INR 2,000–15,000

Total Estimated Subtotal: INR 12,000 to INR 1,00,000

F. 6. Training and Operation Loop

Function: Facilitates repeated feedback training and system usage.

Subcomponents and Cost Range:

- **Session Supervision:**
  - Psychologist/Trainer fees (if clinical): INR 500–1,000/session
- **Progress Dashboard and Logs:**
  - Custom interface: INR 0–10,000
- **Consumables and Maintenance:**
  - Electrodes, gel, battery replacements: INR 2,000–5,000/year

Total Estimated Subtotal: INR 2,000 to INR 30,000/year

III. Summary of Cost by Use Case

TABLE I
Overall System Cost Summary by Application

System Type	Estimated Total Cost (INR)
DIY Student-Level	1,00,000 – 1,50,000
Academic Research Platform	2,00,000 – 5,00,000
Clinical/Professional Use	5,00,000 – 10,00,000+

IV. Conclusion

This cost analysis dissects the financial requirements of building a neurofeedback system by examining each component with depth and real-world pricing. From low-budget setups to full-scale clinical deployments, this modular breakdown empowers stakeholders to choose configurations that suit their technical goals and budget constraints. With open-source software and affordable hardware now available, neurofeedback systems are more accessible than ever before.

References

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