Brain-Computer Interface for Wheelchair Control (JQ3b-16)

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INTRODUCTION

OVERVIEW

Being able to move independently is essential to participate in daily human life.

Niche
Many people rely on motorized wheelchairs to perform their everyday tasks

Problem
Traditional motorized wheelchairs are unsuitable for tetraplegic patients

Solution
Use of biological signals, mainly brain waves to develop a control system for wheelchairs

As such, an alternative wheelchair control system stands to benefit many users.

OBJECTIVE

In this project, we propose a new **BCI design for wheelchairs.**

- Make use of **biological signals**, particularly from the brain to improve mobility for patients with physical impairments
- Design a **non-invasive method to detect EEG signals** from the brain
- Develop a **navigation control system** for wheelchairs.

Extract brain wave data using EEG headset
Signal processing and noise removal
Identify concentration level/clenching
Identify signals from the motor region
Feature classification using Deep Learning
Wheelchair integration

SOLUTION

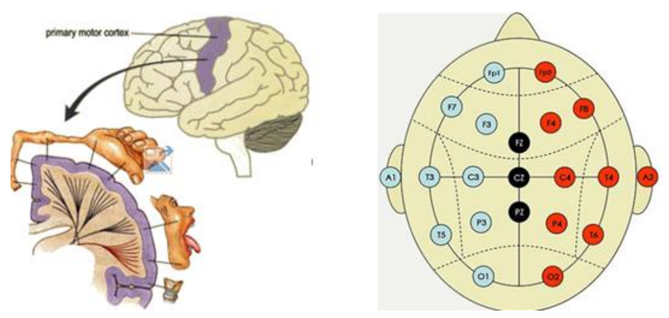
The solution involves the use of a non-invasive EEG headset

- **Monitors brain activity** through surface-mounted scalp electrodes and detect trigger features.
- Classify features using **deep-learning with feed-forward neural networks**.

→ This allows users to **control the wheelchair's navigation, simply with their brain,** restoring mobility for the physically impaired.

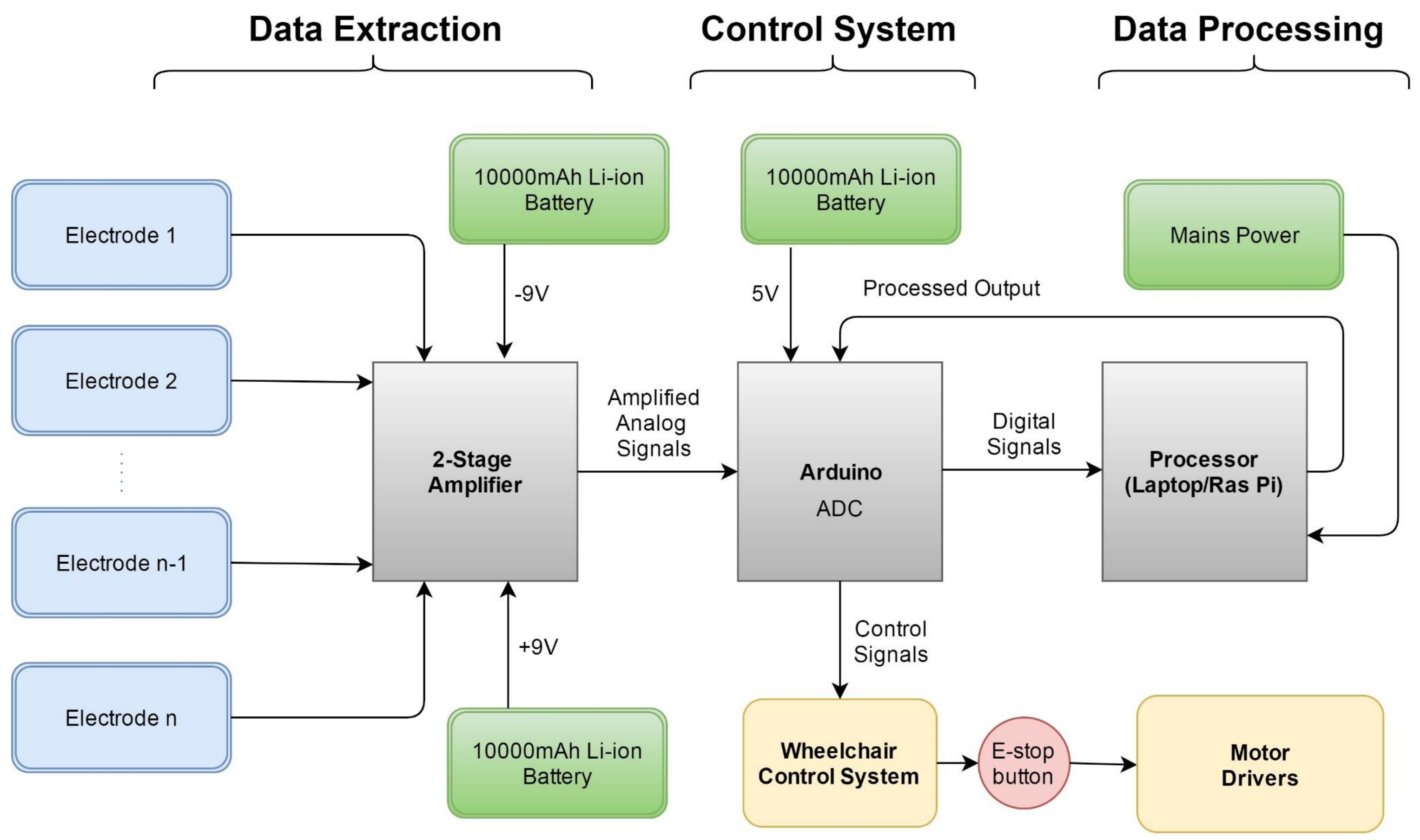
ELECTRODE PLACEMENT

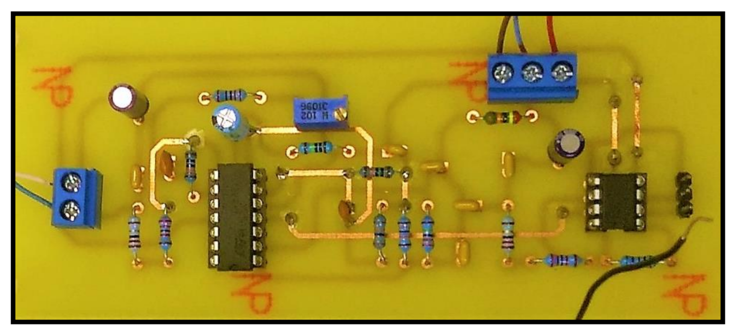
Our system requires only **7 electrodes**, namely **C3, C4, CZ, FP1, O1, A1 and A2**, based on a 10/20 placement map. The **motor region was crucial** to our work, and it's largest portion is responsible for finger and arm motion.



IMPLEMENTATION

HARDWARE DESIGN

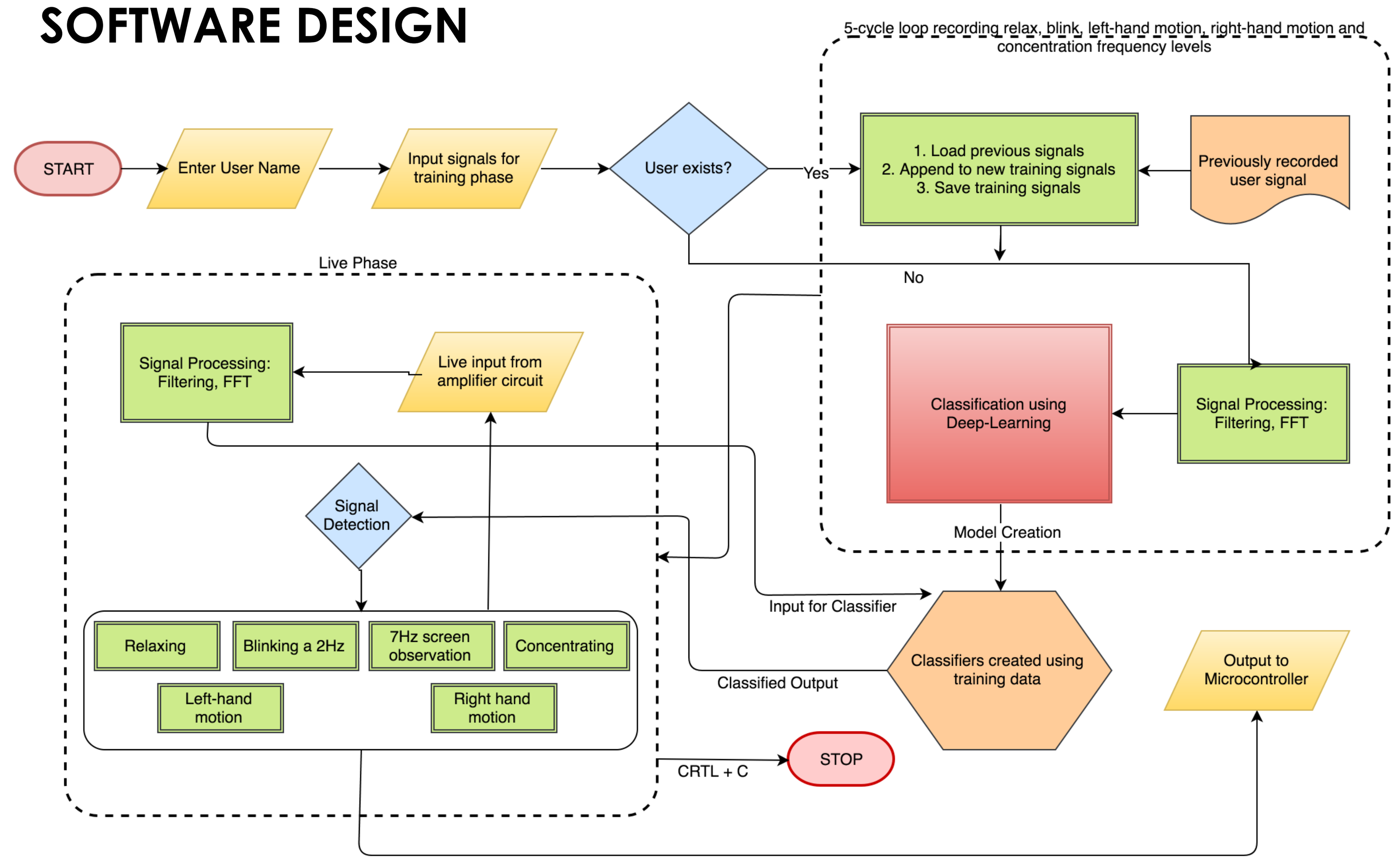




AMPLIFIER CIRCUIT DESIGN

A **two-stage amplifier topology** was implemented to detect the brainwave signals. At the end of each stage, analog filters **attenuate the 50Hz noise. The overall gain is 8,500 V/V.** In our system, we use three circuit boards to detect the intended signals, with the overall set-up costing **less than US$50.**

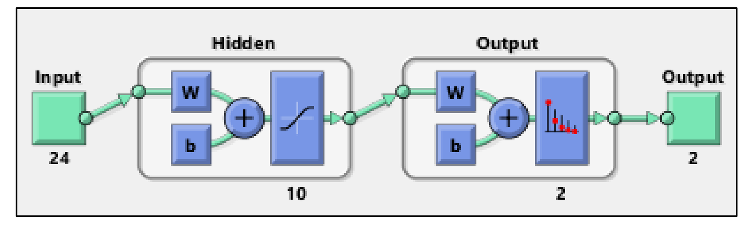
SOFTWARE DESIGN



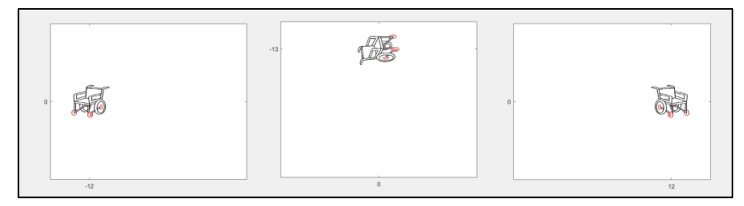
RESULTS & EVALUATION

TESTING PROCEDURES

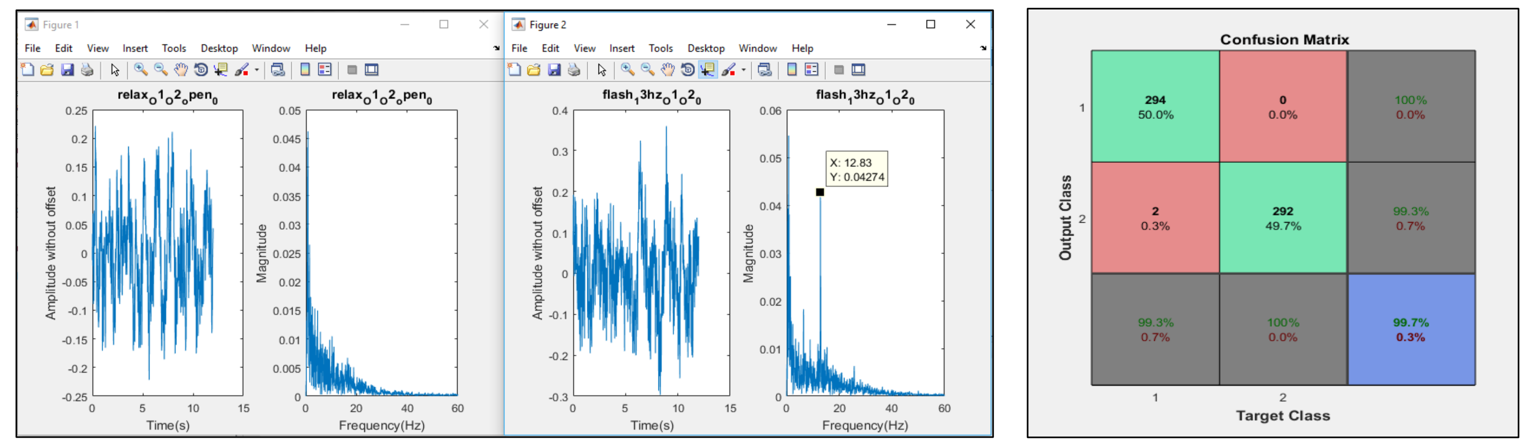
A series of **short recordings are taken** from the user in different states. The data is prepared and used to train a deep learning model with **two-layer feed-forward neural networks.**



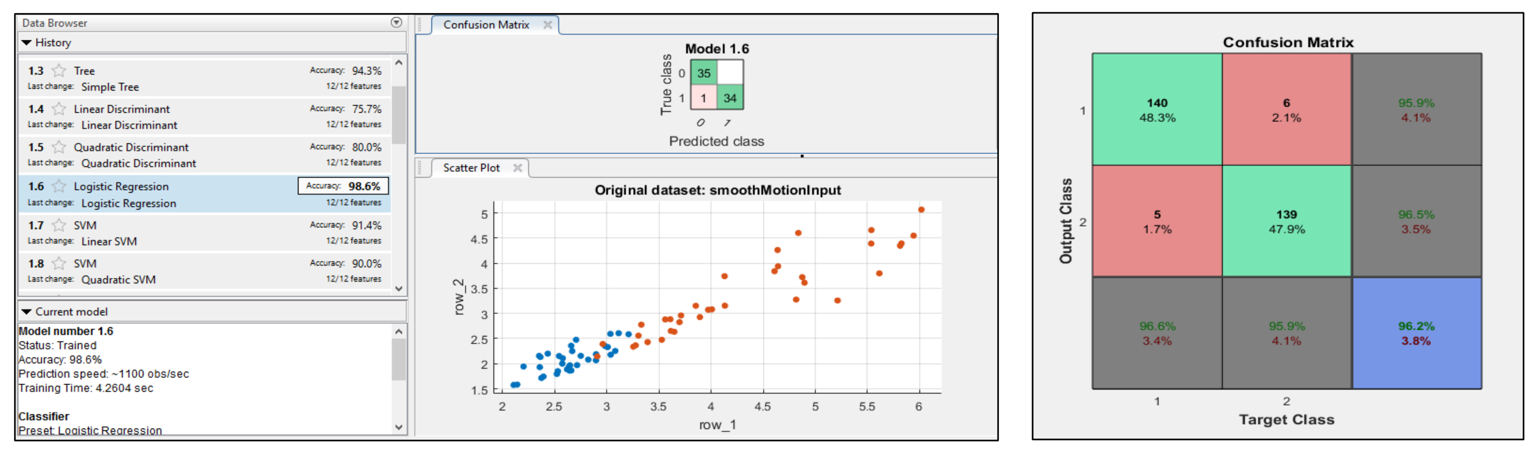
A GUI was implemented to **simplify the training and testing process.** by **recording training data**, and providing helpful prompts.



Blinking at 1-2Hz	*7Hz Flashing Screen*	*Clenching*
Training accuracy: 100% Delay: 1-2 seconds	Training accuracy: 100% Delay: 1-2 seconds	Training accuracy: 100% Delay: None



Concentration Level	*Relaxed vs. Hand Motion*	*Left vs Right Hand Motion*
Training accuracy: > 98% Delay: ~1 second	Training accuracy: > 98% Delay: 1-2 seconds	Training accuracy: >95% Delay: < 1 seconds



CONCLUSION

The main purpose of this project was to develop a **fully integrated electric wheelchair, designed for tetraplegic patients**. Our approach to this problem was to use a BCI and control the wheelchair motion through EEG waves. We opted to control the steering of the wheelchair, using right and left hand motions. We used concentration and beta waves to go forward, and clenching for emergency stop. On the whole, we have **achieved good results**, and the system can be **operated with high accuracy**, considering only a small amount of training data.

The system is **smart and capable of learning**, and therefore can be improved through continued use over a longer period of time. Furthermore, the headset could, eventually, **assist the user in their everyday activities**, from helping them open a door to enabling them to switch their lights on and off, remotely, for example. This opens the possibility for a **multi-purpose IoT device** that would essentially aid people with disabilities to accomplish everyday tasks with greater ease and comfort.