EEG-BASED EMOTION & DISCOMFORT DETECTION SYSTEM FOR NON-VERBAL PATIENTS

Subject: Machine Learning

Instructor : Ehsan Elhamifar

Team members:
Pavanchytanya Dharmapuri (002037438)
Deepashree Srinivasa Rao Rannore (002026701)
Vishal Kumar (002033054)

Introduction

Problem Statement:

Non-verbal patients suffering from conditions such as locked-in syndrome, coma, or severe paralysis are unable to communicate their emotional state or physical discomfort, making their care challenging for healthcare professionals and family members. The proposed system addresses these limitations by improving upon traditional behavioral observation methods, to identify emotions and if faced discomfort the specific location of discomfort in the body using EEG brain signals.

Available Data -

- EEG (Electro-encephalo-gram) Brain Signals
- Brain electrical activity recorded from scalp electrodes
- Captures emotional states and motor cortex activation
- Two public datasets: DEAP (emotion) and BCI Competition IV-2a (motor imagery).

Deliverables:
Emotion and Discomfort Detection System helps to:

- Stage 1: Detect if patient emotions is positive or negetive
- Stage 2: If negetive, identify specific body part (Hand/Feet/Tongue) and that is considered as discomfort
- If positive: Report patient's emotion

Targeted Population (Application) -

- Locked-in Syndrome patients
- Patients in Minimally Conscious State
- Severe stroke patients with complete paralysis
- Late-stage ALS(Amyotrophic Lateral Sclerosis) patients
- Clinical settings: ICU, long-term care, rehabilitation centers

Datasets and structure

Dataset 1: DEAP (Emotion Detection)

- **Basic Information**

Property	Value
Subjects	32
Trials per subject	40
EEG Channels	32
Peripheral Channels	8
Sampling Rate	128 Hz
Trial Duration	63 seconds

**Each subject watched 40 videos, 32 EEG + 8 peripheral sensors , 63 seconds at 128 Hz

Dimension	Size
Trials	40
Channels	40
Time Points	8,064 (-100 to +100 µV)

**One rating per video: Valence, Arousal, Dominance, Liking

Dimension	Size
Trials	40
Emotions	4(rating out of 9)

Datasets and structure

- **Dataset 2: BCI Competition IV-2a (Motor Detection)**
- **Basic Information**

Property	Value
Subjects	9
Sessions per subject	2 (Training + Evaluation)
Trials per session	288
EEG Channels	22
EOG Channels	3
Sampling Rate	250 Hz
Trial Duration	6 seconds
Property	Value

**Each subject watched 40 videos, 32 EEG + 8 peripheral sensors , 63 seconds at 128 Hz

Dimension	Size
Trials	288
Channels	25
Time Points	1500(-100 to +100 µV)

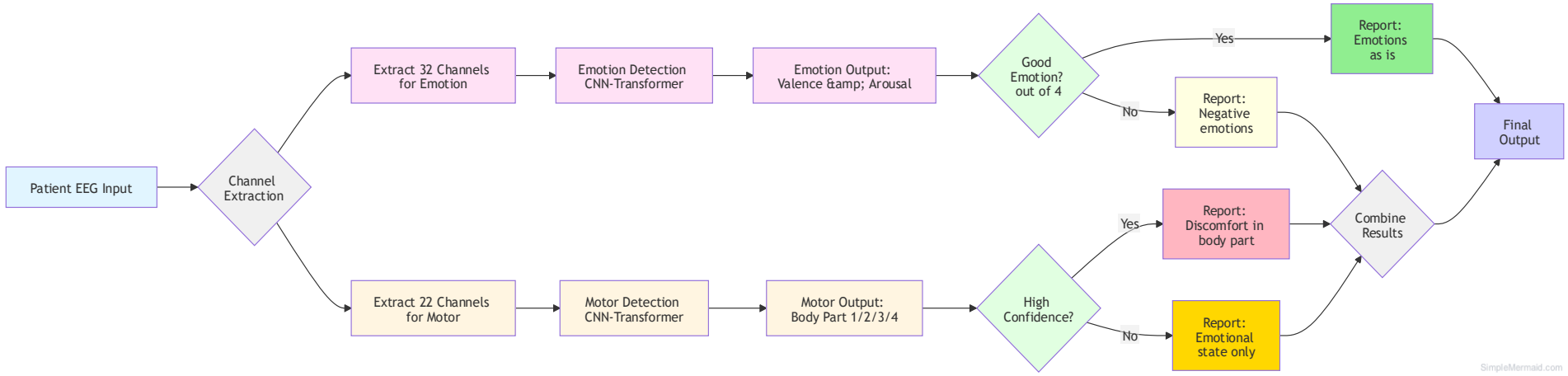
**Label Data : 288x1

Dimension	Size
Trials	288
Body parts	Left Hand,Right Hand , Both Feet, Tongue

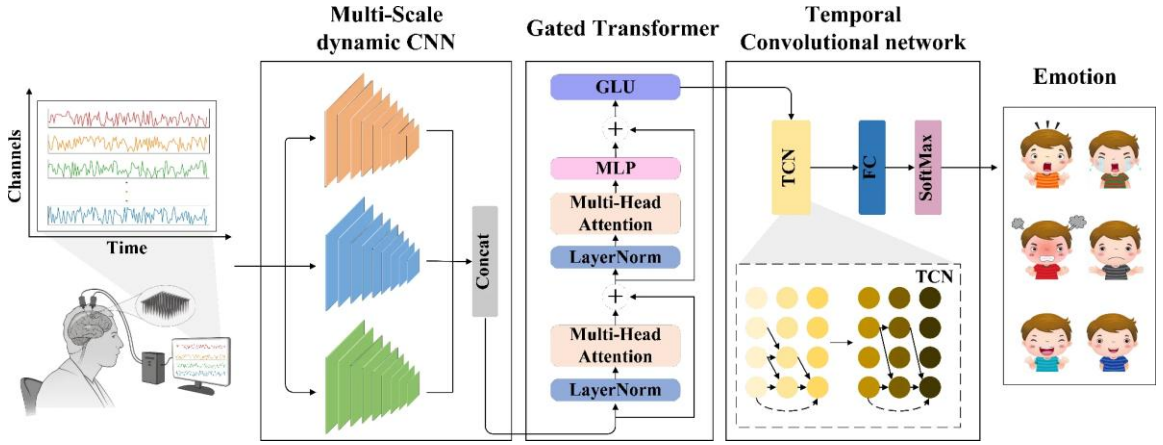
Methods and Architecture

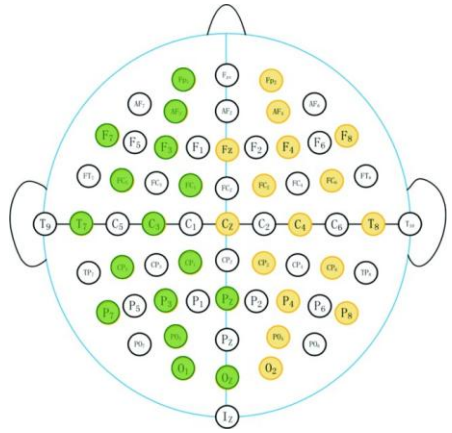
Branch 1: Emotion Detection (40 channels from DEAP)

Branch 2: Motor Detection (22 channels from BCI-IV 2a)



Model Used: Multi-scale dynamic CNN + Gated Transformer + Temporal convolution network





Expected Results:

Scenario	System Response
Patient in positive emotional state	"Report the positive state"
Patient in negative state + hand area active	"Discomfort in hand area"
Patient in negative state + feet area active	"Discomfort in feet area"
Patient in negative state + tongue area active	"Discomfort in mouth/throat area"

Emotion Detection Model (DEAP)

Expected Capabilities:

- Accurately classify positive vs negative emotional states
- Distinguish between comfortable and uncomfortable brain patterns
- Generalize across different subjects

Motor Area Detection Model (BCI-IV 2a)

Expected Capabilities:

- Identify which motor cortex area is active
- Distinguish between Hand, Feet, and Tongue regions
- Detect body part activation patterns

System Integration Results: Combined Two-Stage System

Performance Analysis:

- Subject-dependent validation
- Subject-independent validation
- Cross-validation across both datasets

Evaluation Metrics:

- Accuracy
- Precision
- Recall
- F1-Score

Thank You