A Spectro-Statistical Approach for Emotion Identification from EEG Signals*

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Introduction

- Emotion classification using EEG signals.
- EEG signals captures brain activity reflecting the neural activities of distinct emotions.

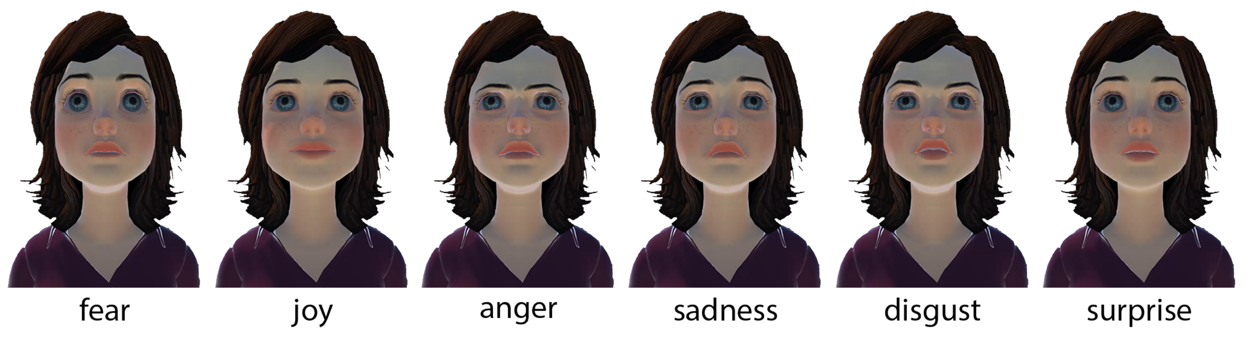

Fig. 1: Emotion classes[2]

Contributions

- We investigate the fusion of topographic plots with statistical descriptors to enhance data interpretation.
- We demonstrate that combining output probabilities computed from both CNN and ML classifiers results in robust emotion class predictions.

Dataset

- EmoNeuroDB[2] dataset comprises EEG recordings of 40 users during emotion perception task in virtual reality.
- 40 participants, ages 19-57.
- 6 emotion classes: *Fear, Joy, Anger, Sadness, Disgust, Surprise*
- EEG recordings: 15s long, sampled at 300 Hz across 21 channels.
- Dataset comprises:
  - 360 training samples.
  - 180 validation samples.
  - 180 test samples.

Problem Formulation

- **Raw Data:** Given 15s of EEG signal of a person mimicking emotion displayed by a virtual avatar.
- **Output:** Corresponding emotion class probabilities for each of the emotional states: *Fear, Joy, Anger, Sadness, Disgust, Surprise.*

Conclusion

- Integrating statistical indicators with spectro-temporal representations from topographic plots improves emotion recognition.
- A significant amount of the *Surprise* signals have been misclassified as *Fear*.
- Individual statistical encoders tend to favour a particular emotion.
- The proposed method outperforms the test set results of the EmoNeuroDB baseline [2] by an absolute margin of **5.5%**.
- We propose using synthetic EEG data from generative algorithms for data augmentation to enhance robustness and generalization for future works.

References

[1] Agnieszka Dubiel et al. "Brain Responses to Emotional Avatars Challenge: Dataset and Results". In: *2024 IEEE 18th International Conference on Automatic Face and Gesture Recognition (FG)*. 2024, pp. 1–8. DOI: 10.1109/FG59268.2024.10581914.

[2] EmoNeuroDB. *18th IEEE International Conference on Automatic Face and Gesture Recognition (FG 2024)*. https://voxellab.pl/EmoNeuroDB/. 2024.

Proposed Architecture

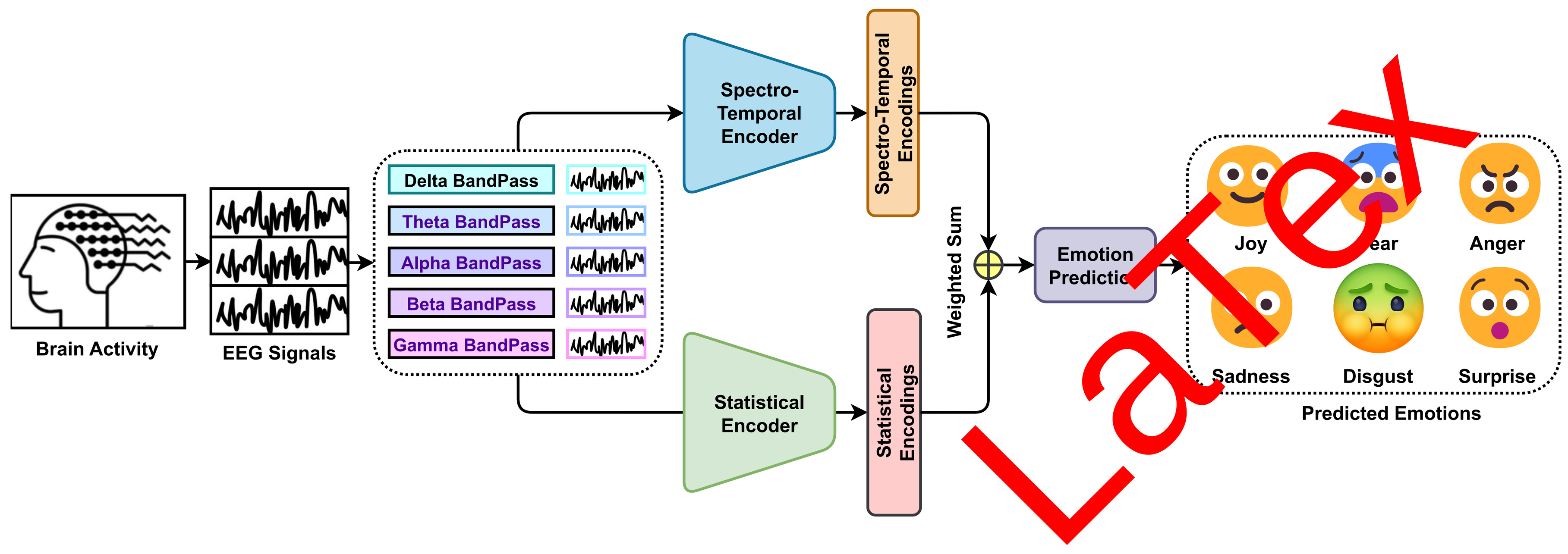

Fig. 2: Spectro-Statistical Fusion Model

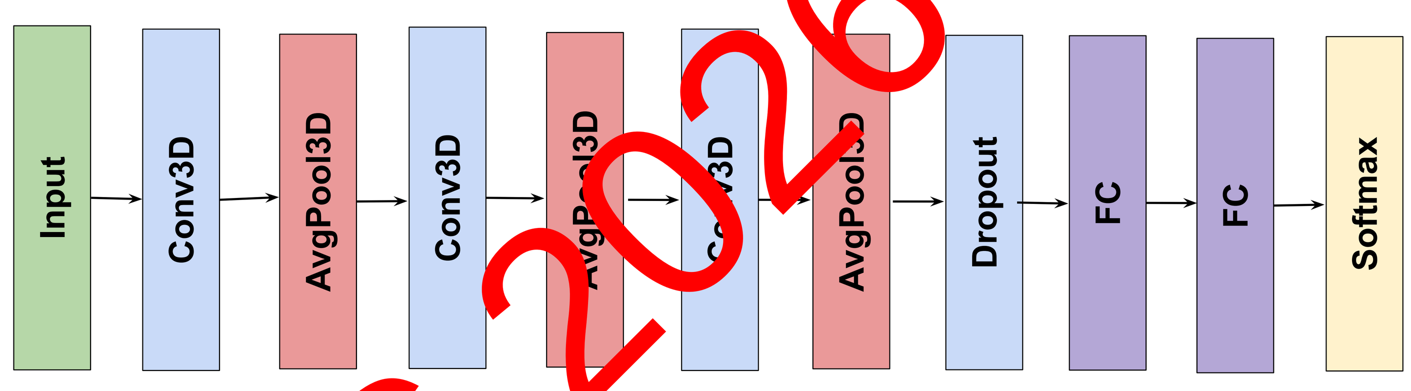

Fig. 3: Spectro-Temporal Encoder Architecture

Ablation Studies

Methods	Mean Accuracy
Baseline Method[1]	0.19
Spectro-temporal Encoder	0.18
SVM based Statistical Encoder	0.20
LDA based Statistical Encoder	0.26
RF based Statistical Encoder	0.24
RF based Statistical Encoder (Top 50% features)	0.26
Proposed Method	**0.27**

Tab. 1: Comparison of different encoders

Results

Emotion Class	Validation Set	Test Set
Fear	0.33	0.33
Joy	0.43	0.3
Anger	0.23	0.2
Sadness	0.2	0.3
Disgust	0.33	0.03
Surprise	0.1	0.3
Avg Accuracy	**0.27**	**0.24**

Tab. 2: Class-wise on EmoNeuroDB dataset

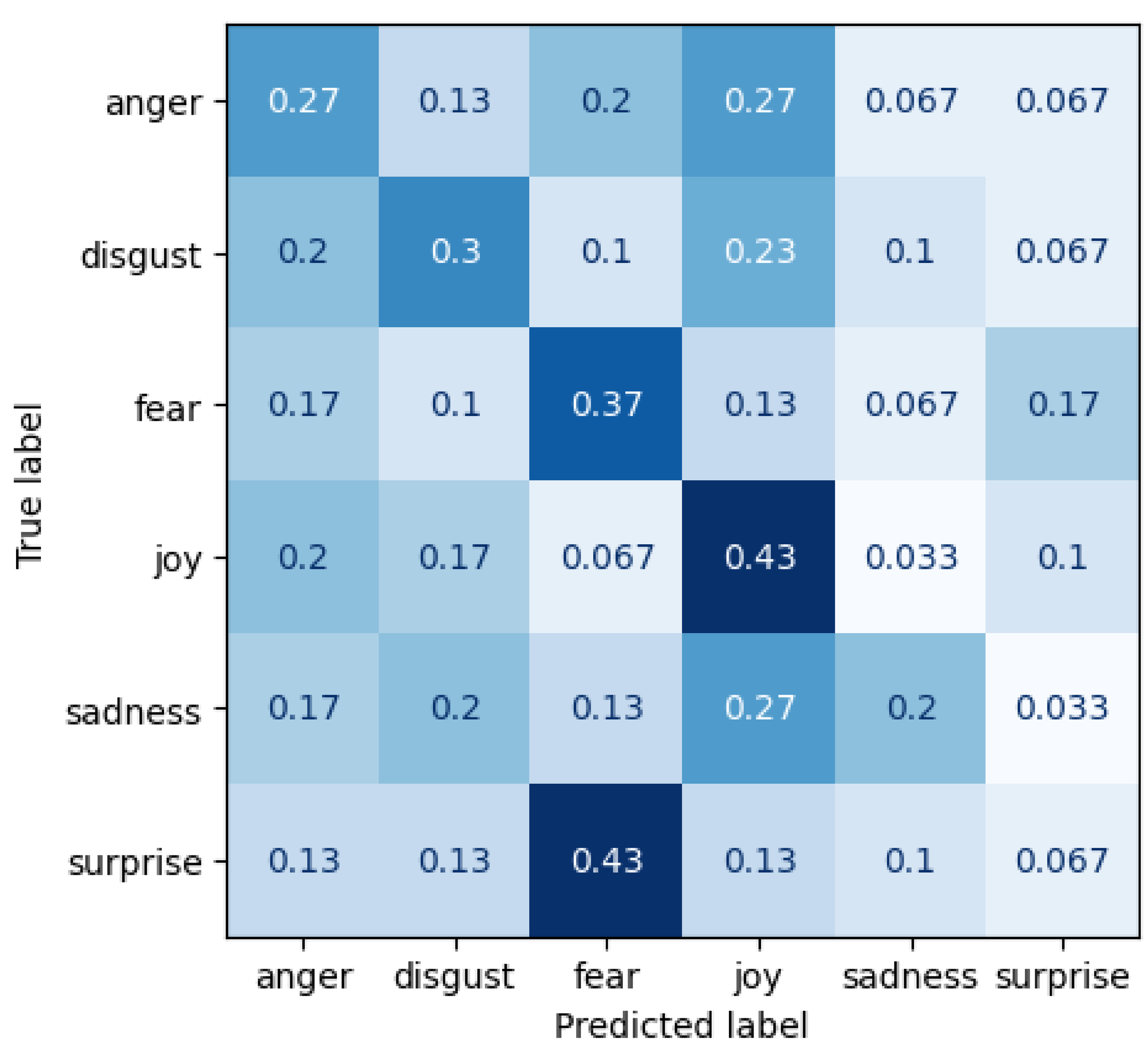

Fig. 4: Confusion matrix for Proposed Method (Validation Data)