The University of Texas Rio Grande Valley

Center for Multidisciplinary Research Excellence in Cyber-Physical Infrastructure Systems (MECIS)

Affective Autonomous Mobility through Human Computer Interaction: Facial and EEG Emotion Recognition in a CARLA Environment

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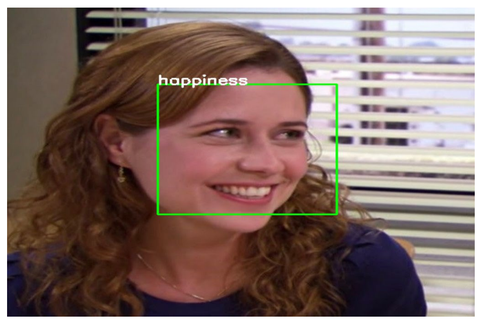
Abstract

Emotion recognition is essential for enhancing safety in autonomous vehicles by identifying driver states and emotional responses. This research combines facial and EEG-based methods for emotion detection using CARLA, an open-source simulator for autonomous driving research. Facial recognition leverages computer vision to analyze expressions, while EEG analysis classifies emotions based on brain wave patterns. This multimodal approach seeks to advance emotion detection, paving the way for smarter, safer, and more adaptive autonomous systems.

Introduction & Background

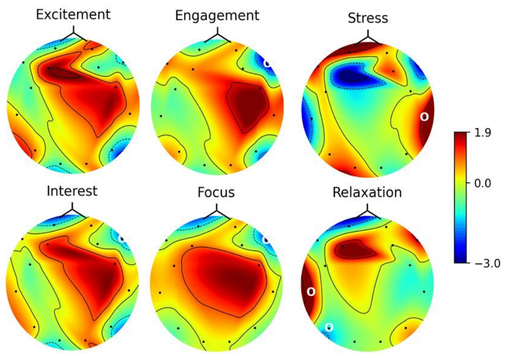
What is Facial Emotion Recognition?

- Facial emotion recognition (FER) identifies and categorize human emotions based on facial expressions.
  - ✓ Achieved by analyzing facial features such as eyes, eyebrows and mouth to determine the expressed emotion.



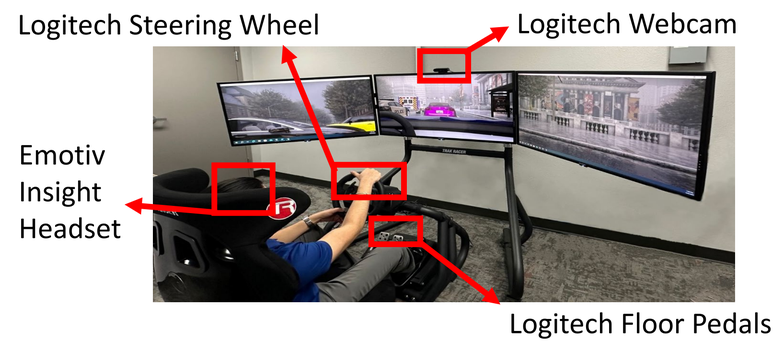
What is EEG Emotion Recognition?

- EEG emotion recognition identifies human emotions from neural activity recorded via electroencephalography (EEG).
  - ✓ Features like power spectral density (PSD) are extracted from brain signals to predict emotional states.



Methodology

Setup



Model Frameworks

- A trained convolutional neural network (CNN) is used to map features to emotions. This model is then evaluated using the CARLA Simulator, an open-source autonomous driving simulator that provides a realistic environment.
- EEG signals are preprocessed followed by feature extraction across five frequency bands to generate input data for a CNN model. The data is then split into 80% testing, 10% training, 10% validation sets, allowing for model training, hyperparameter tuning, and performance evaluation with a focus on minimizing overfitting.

Data and Results

AffectNet Dataset

- ~ 280 Thousand Images
- 8 different emotions

SEED Dataset

- 45 EEG recordings
- Positive, neutral, & negative emotion categories

FER Model

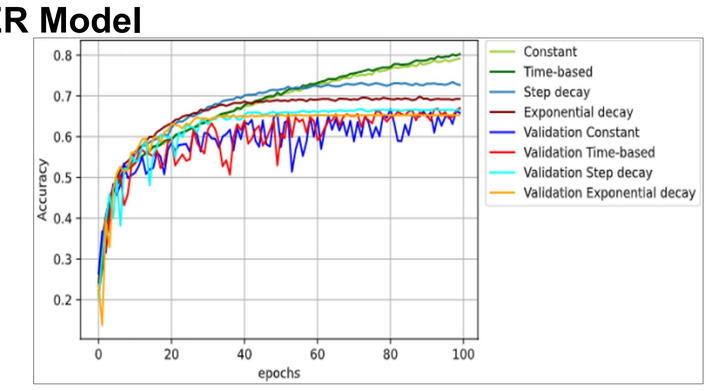


Figure 1: Accuracy rate of FER model

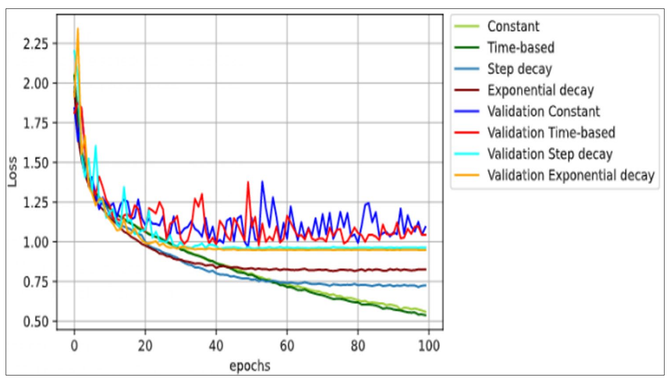


Figure 2: Loss rate of FER model

EEG Model

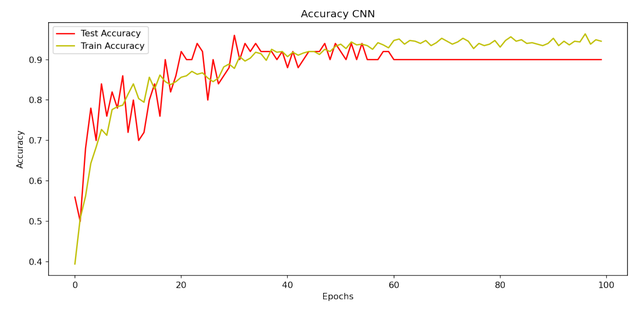


Figure 3: Accuracy rate of EEG model

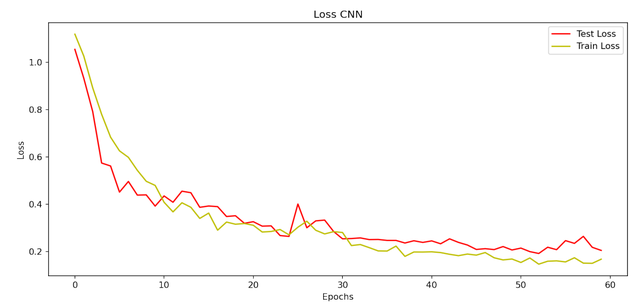


Figure 4: Loss rate of EEG model

Conclusions & Future Work

This study aims to develop a facial and EEG-based emotion recognition model to categorize human emotions by analyzing facial expressions and neural activity. Using the CARLA Simulator, the study assesses user responses to driving scenarios to inform adaptive vehicle behavior. Findings could enhance natural human-computer interactions. Future work will focus on implementing emotion recognition with autonomous vehicles, explore RNN models for EEG data to improve accuracy with sequential information, and test the model in real-world autonomous driving contexts.

Acknowledgments

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References

[1] Li, W., Tan, R., Xing, Y. et al. “A multimodal psychological, physiological and behavioural dataset for human emotions in driving tasks.” *Sci Data* 9, 481 (2022)

[2] MahmoudSabra1. Facial-Emotion-Recognition. GitHub. Last modified October 18, 2020.

[3] Antoinetlc. Emonet. GitHub. Last modified August 24, 2024