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

Leonel Ramirez, Leonardo Flores, Fatemeh (Noosheen) Nazari, Mohamadhossein Noruzoliaee

The University of Texas Rio Grande Valley
Center for Multidisciplinary Research Excellence in Cyber-Physical Infrastructure Systems (MECIS)

NSF

Award No 2112650

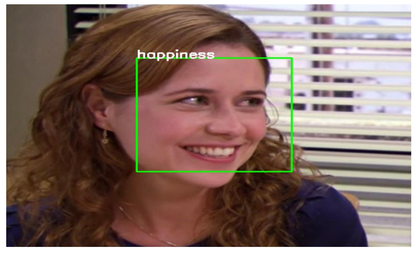
Introduction

Motivation:

- **The motivation behind facial emotion recognition is to provide a more natural and intuitive way for vehicles to interact with their human drivers by understanding their emotions. By recognizing human emotions based on facial expressions, cars can respond in real-time to the driver's state of mind, providing a more personalized and safer driving experience.**

What is Facial Emotion Recognition?

- Facial emotion recognition (FER) is a technology that uses computer algorithms to identify and categorize human emotions based on facial expressions.
  - ✓ This is done by analyzing various features of a person's face such as the shape of their eyes, eyebrows, mouth, and other parts, to determine what emotions they are expressing.



What is the CARLA Simulator?

- A software that allows a user to interact with a Carla map and spawn several agents into this map.
- Agents can include pedestrians, vehicles, and cameras.
- Agents' behavior in the environment can be adjusted, e.g., making a vehicle aggressive, spawning a pedestrian near a moving vehicle, or attaching a camera to a vehicle at a 90° angle.

Methodology

✓ **The objective of this study is to develop a system for recognizing human emotions based on facial expressions and to evaluate the system using the CARLA Simulator**

How is this done?

- **Model training:** A machine learning model, such as a Convolutional Neural Network (CNN), will be trained on the extracted features and the corresponding emotions. The goal of the training process is to learn a mapping from the features to the emotions.
- **Evaluation using the CARLA Simulator:** The trained model will be evaluated using the CARLA Simulator, which is an open-source autonomous driving simulator. The CARLA Simulator will provide a realistic environment for the subjects, and the model will be used to categorize the emotions of the subjects based on their facial expressions.

Data

✓ **AffectNet Dataset**

- ~ 280 Thousand Images

✓ **CARLA Environment**

- ~ Different Maps / Scenarios

Scenarios can include change in weather, environment, vehicle speed and behavior

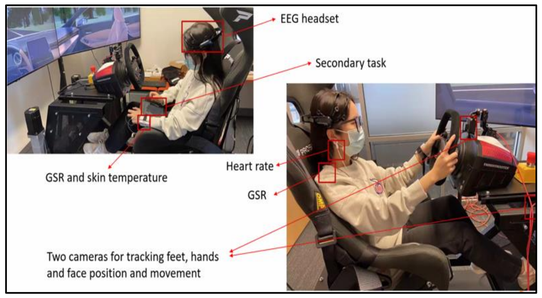
How will user react when the person in front of me is driving too cautiously or too slowly?

How will the user react when the person behind me or next to me is driving very aggressively?

How should the vehicle respond to these outside variables and the user's reaction?

✓ **Experiment Design**

- Data Collection



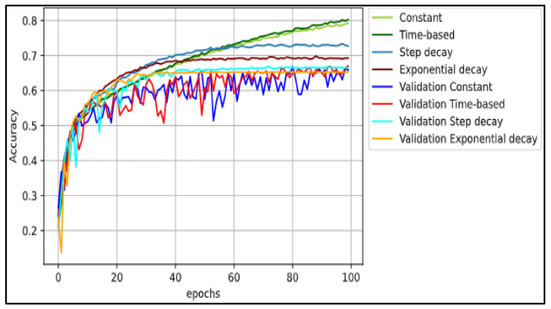
- Car seat and steering wheel to give user a realistic feel.
- In the simulation the user has a 270° field of view (FOV).
- A 4K camera to capture subjects in the simulation.

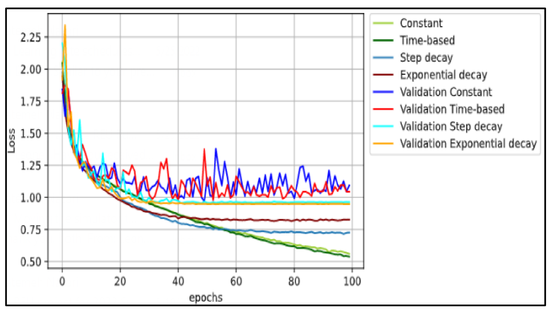
- Evaluation of Image with Facial Landmarks
  - ✓ Facial expression prediction
  - ✓ Valence and arousal estimation

Results

✓ **How well does the FER model perform?**

- Evaluation of FER model with different learning rates
- **Goals:**
  - ✓ Maximize accuracy
  - ✓ Minimize loss function





Conclusions

This study aims to develop a facial emotion recognition model that can categorize human emotions based on facial expressions. Using the CARLA Simulator, the user's reaction to different driving scenarios and aimed to understand how the vehicle should respond to these variables and the user's reaction. The findings of this study can contribute to the development of more natural and intuitive human-computer interactions in the future.

https://github.com/MahmoudSabra1/Facial-emotion-recognition

https://github.com/face-analysis/emonet

https://www.unrealengine.com/en-US/spotlights/carla-democratizes-autonomous-vehicle-r-d-with-free-open-source-simulator