

Towards Empathic Vehicles: Simulator-Based Induction of Affective States for Emotion Recognition

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Motivation & Goal

- Emotions influence driving behaviour, reaction times, and risk-taking, making them an important factor in driver models and safety research [1].
- However, provoking strong emotions in real traffic is unsafe - virtual driving simulators provide a safe and controllable alternative while eliciting comparable emotional responses in participants [2].
- This work aims to build a virtual driving simulator and a library of emotion-inducing scenarios for future multimodal emotion recognition studies.
- A screen-based setup is chosen instead of HMDs/CAVEs to ensure clear capture of facial and upper-body expressions for multimodal analysis.
- CARLA [3] was selected among open-source simulators (e.g., AirSim, DeepDrive) due to its modifiability, visual realism, and active maintenance.
- The primary goal is to conduct controlled user studies on emotion elicitation, while the secondary goal is to generate a dataset for machine learning (ML) training and future real-vehicle data collection.

Simulator & Hardware Setup

- **Cabin and Hardware:** The cabin is modelled on a Volkswagen Polo V layout with realistic dimensions and driver positioning. The setup includes a Logitech G29 steering wheel, pedals, gear shifter, adjustable seat, and mirrors, as well as an integrated infrared camera to document and analyse driver behaviour.
- **Software:** The simulation is implemented in CARLA, which allows for custom scenario scripting and precise control over environmental events.
- **Supervision:** A researcher observes the participant on a separate screen and can manually trigger events or intervene as needed.



simulator setup based on the Polo V

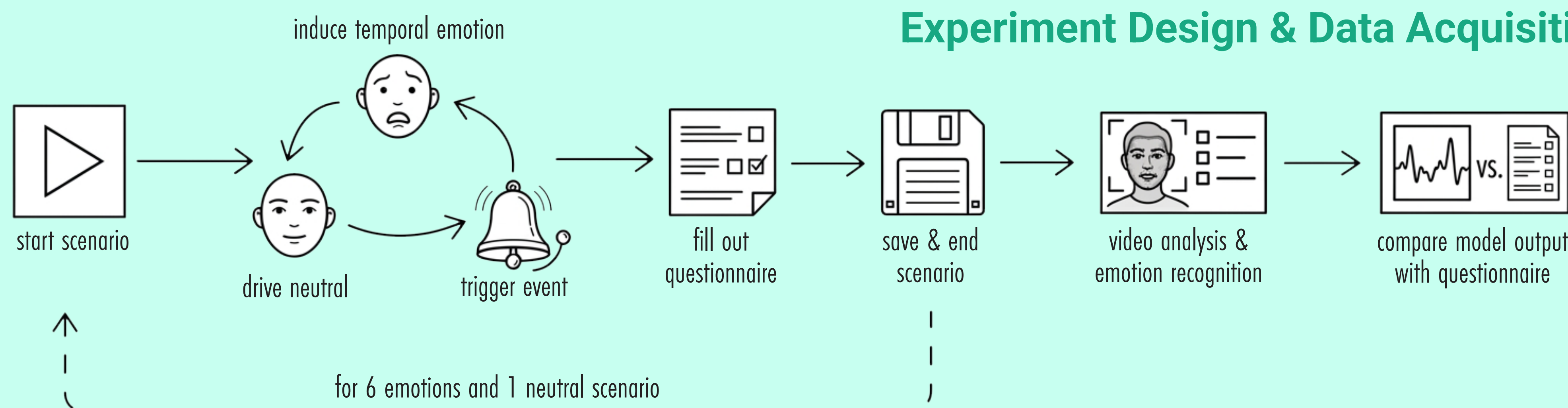


real-time emotion detection with software by emotion3D



active simulation scenario

Experiment Design & Data Acquisition



cut-in maneuver scenario implemented in the CARLA simulator (target emotion: Anger)

Emotion-Inducing Scenarios

- Emotion selection follows Ekman's [4] six basic emotions.
- Stimuli and events are derived from an extensive literature review.
- Driving-related emotional triggers are primarily based on Li et al. [5] and Dargahi Nobari et al. [6].
- Auditory stimuli (music) are informed by Strauss et al. [7] to induce specific emotions.

Emotion	Stimuli / Event
Neutral	country road limited traffic music: Fast Car (Chapman) time of day: daytime weather: sunny
Anger	road blocking event (e.g., traffic jam / bicycle / prolonged red light) vehicle cutting in from left maliciously driving vehicle in front (e.g., slalom driving, sudden stops, running a red light) music: Master of Puppets (Metallica) time of day: daytime weather: sunny
Disgust	garbage on the road (side) (waste containers & bags, animal carcass, discarded furniture) driver in front throws garbage poor road conditions time of day: evening weather: cloudy, dust storm
Fear	no other vehicles / pedestrians animal suddenly crossing the road large truck (honks from behind, drives next to the main vehicle) low fuel warning break failure (fog machine) music: Fear&Sickness (Neurosis) time of day: nighttime weather: foggy
Happiness	highway adjacent to lake / natural landscape interesting things near the road (e.g., waving people, street performers) music: Uptown Funk (Bruno Mars) time of day: daytime weather: sunny
Sadness	limited traffic, few pedestrians encountering a crash site distressing radio content music: Mad World (Gary Jules) time of day: daytime weather: dark, cloudy, rainy
Surprise	pedestrian walking on highway small animal suddenly crossing the street sudden disappearance of a bus (e.g., behind a building) music: Little Numbers (BOY) time of day: daytime weather: cloudy, sudden snowfall

Challenges & Open Questions

- Evoking authentic, high-intensity emotions in a simulated environment remains a significant challenge compared to real-world driving.
- Relying on participant self-reports as a ground truth for ML training introduces subjective bias, as felt emotions often diverge from expressed behaviour.
- Multimodal recognition must address significant individual differences in how emotions are expressed and manifested.

References

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