MASTER'S DEGREE IN COMPUTER ENGINEERING

INDUSTRIAL APPLICATIONS

PROJECT DISCUSSION

MoodPilot

PROTOTYPE
PRESENTATION

PROFESSORS

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STUDENTS

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ABSTRACT

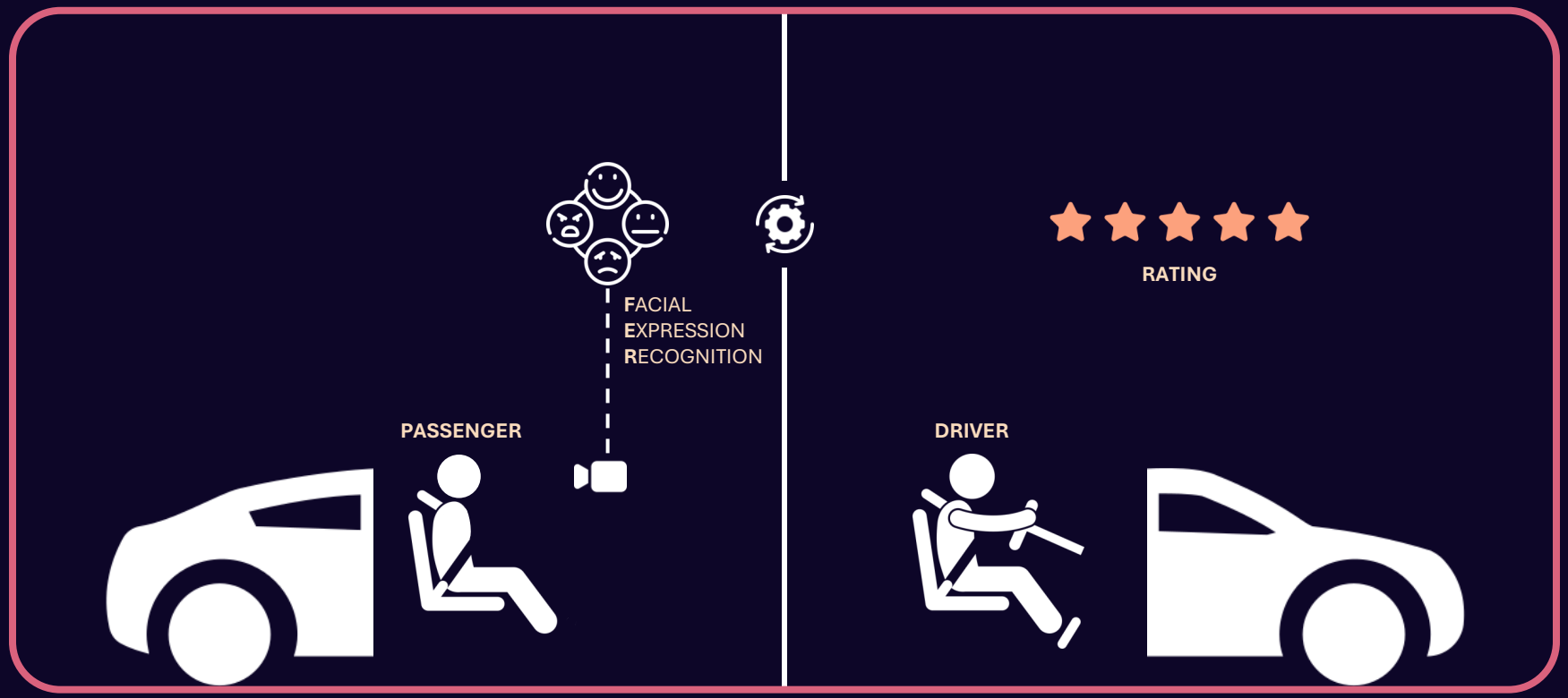
In this study, we present a system for evaluating user satisfaction with autonomous and manual driving experiences through Facial Expression Recognition (FER). A detailed analysis was conducted to identify and benchmark state-of-the-art FER models, including **DeepFace**, **EmoNet**, **HSEmotionONNX**, **RMN**, and **Vision Transformer** (ViT), with additional tests performed on a Raspberry Pi 3B+ as a reference for potential car controller deployment. Alongside this analysis, we developed a frontend and backend system to facilitate **data collection** for future training of a predictive model. The system allows users to manually respond to a form and undergo video-based analysis of their driving experience. The ultimate goal is to train a model that can autonomously infer user responses based on collected data, paving the way for an adaptive system to evaluate driving satisfaction efficiently.

INTRODUCTION

Facial Expression Recognition in Automotive Applications

- **Role of Emotions:** Fundamental in shaping human behavior, cognition, and decision-making.
- **Relevance in Driving:** Key to evaluating passenger satisfaction in autonomous and manual driving modes.
- **System Overview:** Automates emotion-based passenger experience analysis for ride-hailing and driving services, enhancing service quality and user trust.
- **Key Technology:** Facial Expression Recognition (FER) for real-time emotional state assessment.
- **Challenges:** Addressing in-car constraints like limited resources, environmental variability, and privacy.

MoodPilot



FACIAL EXPRESSION RECOGNITION
INTEGRATION

AUTO-FILLED FEEDBACK FORMS
EMOTION-BASED

TWO-WAY RATING SYSTEMS FOR DRIVER EVALUATION

EFFECTIVENESS IN ASSESSING DRIVER PERFORMANCE

STATE OF THE **ART**

[1] PLATFORM-MEDIATED REPUTATION SYSTEMS IN THE SHARING ECONOMY (2020)

Analyzes how platform-driven reputation systems impact service quality in ride-sharing, highlighting benefits and limitations in maintaining consistent quality.

[2] A SYSTEMATIC LITERATURE REVIEW OF RIDE-SHARING PLATFORMS, USER FACTORS, AND BARRIERS (2021)

Provides a systematic review of ride-sharing platforms, focusing on user adoption factors and barriers, including the effectiveness of rating systems.

[3] UNDERSTANDING RIDE-SHARING SYSTEMS IN URBAN AREAS: LOCATION, USERS, AND BARRIERS (2020)

Explores ride-sharing in urban areas, examining the role of location, user types, and system barriers with specific reference to two-way rating mechanisms.

FACIAL EXPRESSION RECOGNITION IN **AUTOMOTIVE** CONTEXTS

ENHANCEMENT OF PASSENGER SAFETY AND EXPERIENCE

STATE OF THE **ART**

[4] DRIVER EMOTION RECOGNITION FOR INTELLIGENT VEHICLES: A SURVEY (2020)

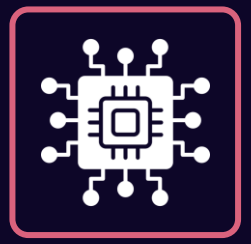
Provides a comprehensive literature survey of work addressing the problem of human emotion recognition in an automotive context.

[5] AUDIOVISUAL AFFECT RECOGNITION FOR AUTONOMOUS VEHICLES: APPLICATIONS, CHALLENGES, AND OPPORTUNITIES (2023)

Examines the use of audiovisual emotion recognition in autonomous vehicles, highlighting technical challenges and opportunities for improving human-machine interaction.

[6] REVIEW AND PERSPECTIVES ON HUMAN EMOTION FOR CONNECTED AUTOMATED VEHICLES (2023)

Discusses the importance of recognizing human emotions in connected automated vehicles, focusing on implications for passenger safety and experience.



FACIAL EXPRESSION RECOGNITION ON EDGE DEVICES

PRIVACY-PRESERVING AND REAL-TIME EMOTION DETECTION

STATE OF THE ART

[7] USING EMOTION RECOGNITION AND TEMPORARY MOBILE SOCIAL NETWORK IN ON-BOARD SERVICES FOR CAR PASSENGERS (2023)

- Deployment of FER Systems on Edge Devices Using Raspberry Pi: Evaluates the performance of lightweight FER systems on resource-constrained edge devices, emphasizing their potential for privacy-sensitive and real-time applications.
- Lightweight Models for FER: Highlights the efficiency of lightweight FD and FER models like Yoloface-500k v2 and DeepFace for achieving real-time emotion detection on edge devices.
- Accelerated FER Using Neural Compute Stick 2: Discusses how NCS2 accelerators significantly enhance FER processing speeds, enabling efficient deployments for in-car systems in constrained environments.

DATABASE

BACK-END

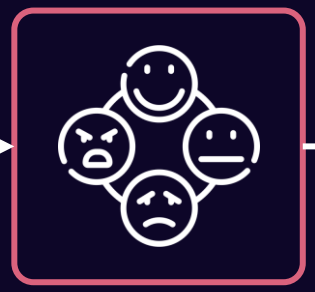
CAR CONTROLLER

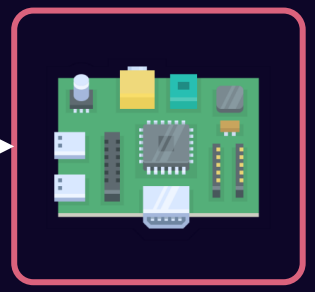
MoodPilot

FRONT-END
MOBILE **APP**

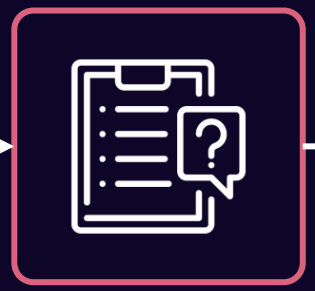
SYSTEM **ARCHITECTURE**

THE **PROTOTYPE**





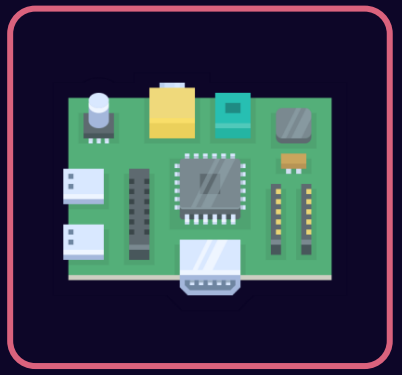
FER DEPLOYMENT ON AN EDGE DEVICE



DATA **COLLECTION** SYSTEM

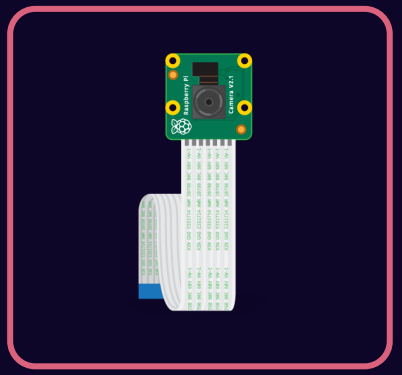
HARDWARE SETUP

RASPBERRY PI 3 MODEL B+



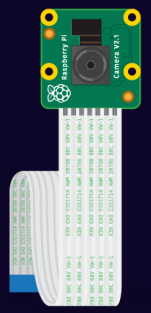
- **Processor**: 1.4GHz 64-bit quad-core Broadcom BCM2837B0, Cortex-A53 (ARMv8) SoC.
- **Memory**: 1GB LPDDR2 SDRAM.
- **Wireless Connectivity**: Dual-band 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2/BLE.
- **GPIO**: Extended 40-pin GPIO header.
- **Camera Support**: CSI camera port for connecting a Raspberry Pi camera.
- **Power Input**: 5V/2.5A DC power input.

RASPBERRY PI CAMERA MODULE (V2.1)



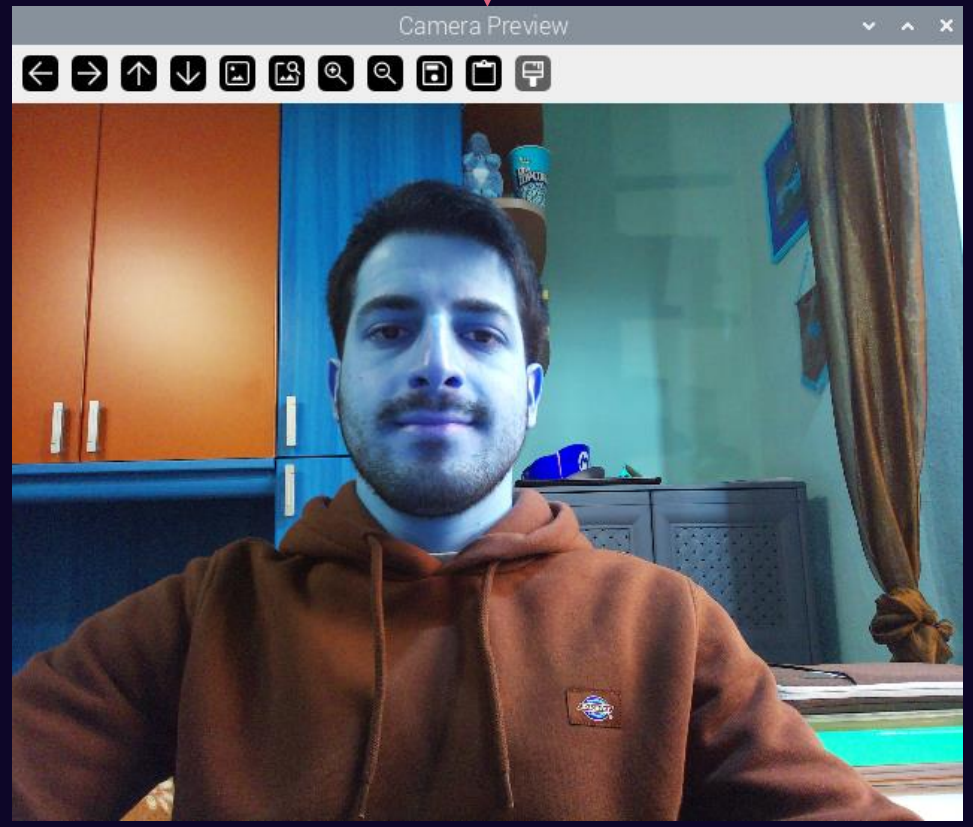
- **Sensor**: Sony IMX219, 8-megapixel sensor.
- **Capabilities**:
  - High-definition video recording: 1080p30, 720p60, VGA90 video modes.
  - Still image capture.
- **Connection**: Attaches via a 15cm ribbon cable to the CSI port on the Raspberry Pi.
- **Software Support**: Numerous third-party libraries are available, including the Picamera Python library.

RASPBERRY PI CAMERA INTEGRATION



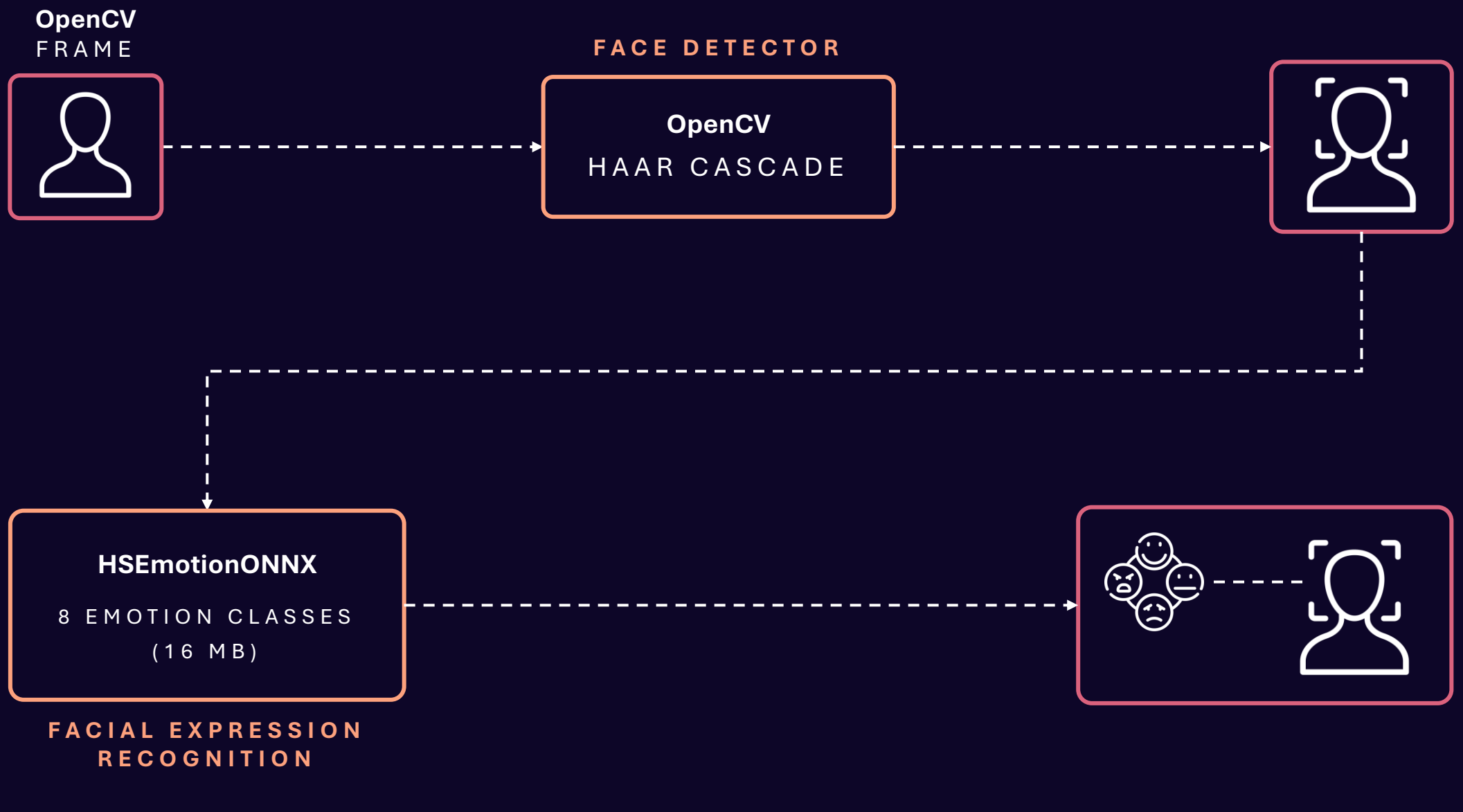
picamera2

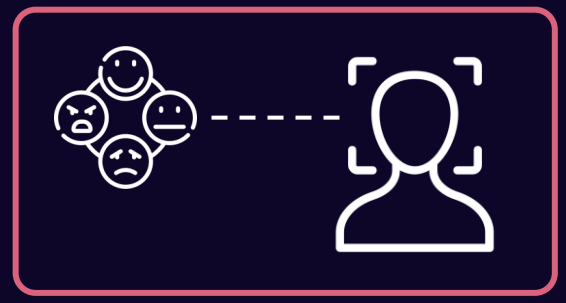
OpenCV



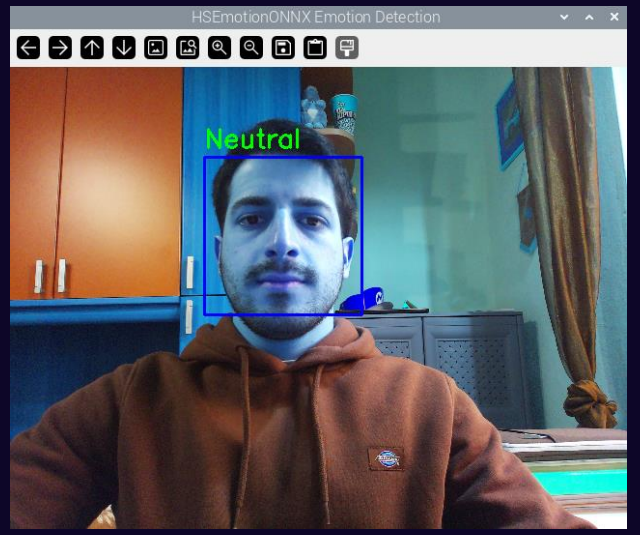
pi@raspberrypi: ~/Progetto_IndustrialApplications **$** python3 Prototype/FER/camera.py

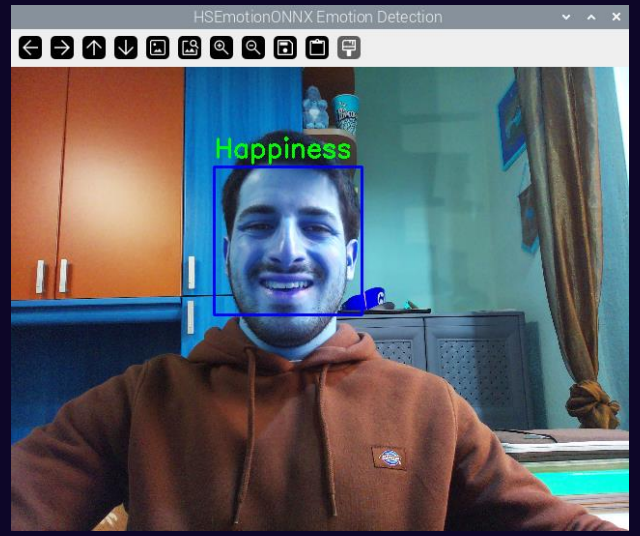
EMOTION DETECTION **DEPLOYMENT**

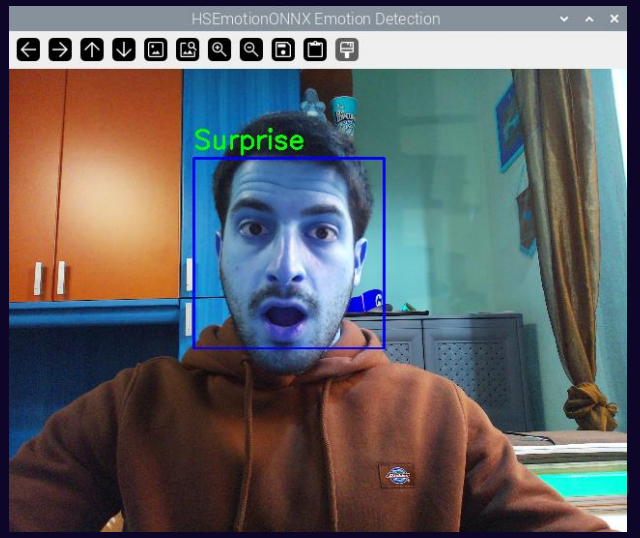


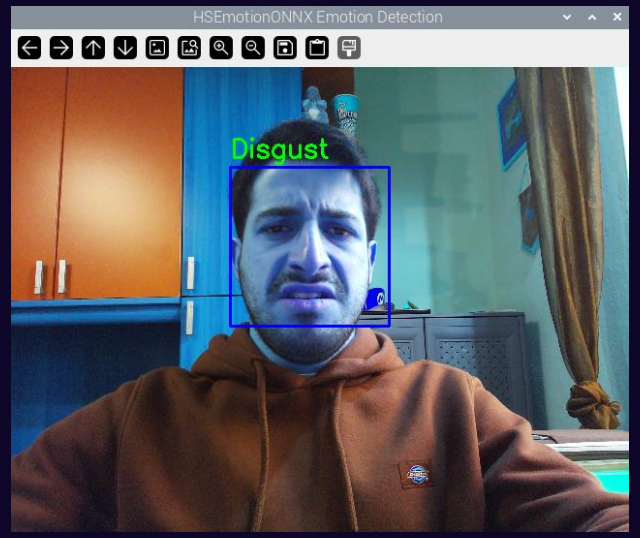


REAL-TIME EMOTION DETECTION









pi@raspberrypi: ~/Progetto_IndustrialApplications/Prototype/FER/Models/HSEmotionONNX **$** python3 hsemotion_onnx.py

WHAT ABOUT **PERFORMANCE?**

~0.50
FPS
WITH PREVIEW

~0.90
FPS
WITHOUT PREVIEW

HSEmotionONNX + RASPBERRY PI 3B+ + RASPBERRY PI OS (DEBIAN 12 – 64 BIT) =

THE **DATA COLLECTION** SYSTEM

CAPTURING EMOTIONS AND USER FEEDBACK FOR MODEL TRAINING

The system was designed to capture passengers' emotional states and feedback during rides, creating a robust dataset for analysis. It integrates:

- **Frontend** module for user interaction.
- **Backend** module for data processing and storage.

FUTURE DEVELOPMENT

The collected dataset will enable training of predictive models capable of **autonomously** answering feedback form questions based on passengers' inferred emotions. This feature bridges the gap between user feedback and adaptive driving systems, enabling **real-time** evaluations and adjustments to improve ride quality.

BACKEND MODULE

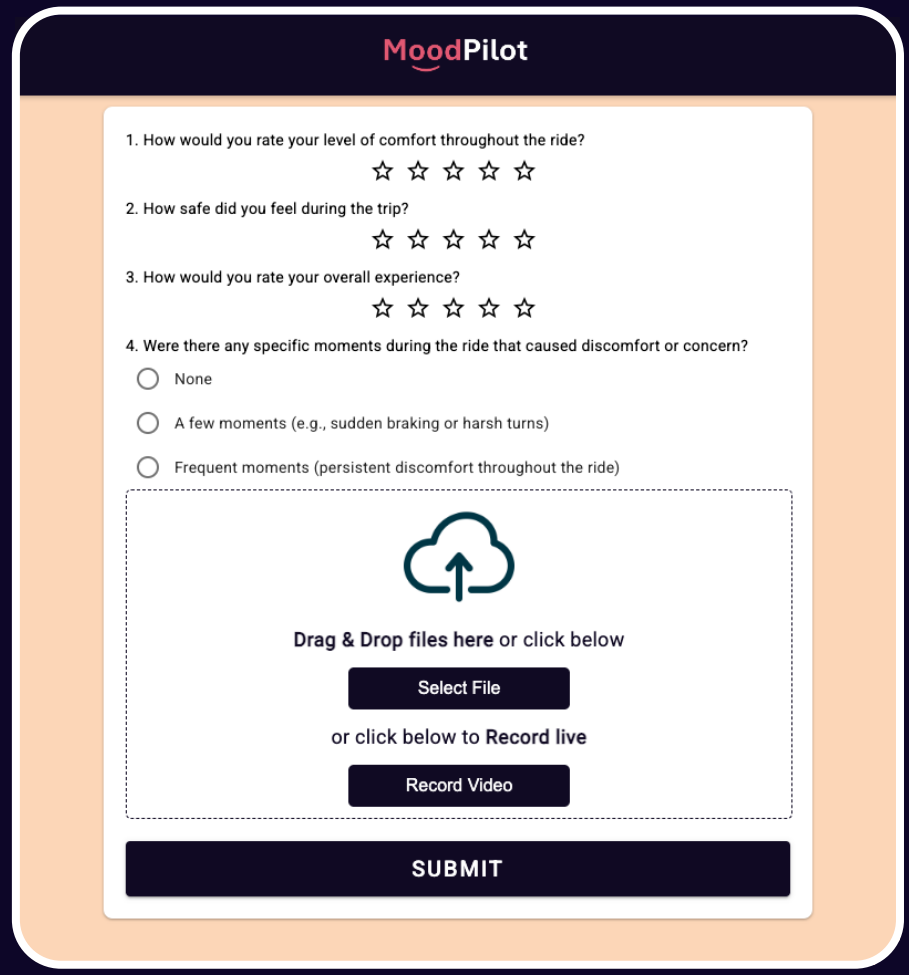
- Processes video inputs using AI-based **emotion detection models**.
- Stores emotional data and feedback securely in a **structured database**.
- Includes a robust API layer for efficient data exchange and future model integration.

FRONTEND MODULE

Passengers complete a **feedback form** about their driving experience after their facial expressions are recorded in real-time during the ride. This data provides insights into user emotions and overall satisfaction.

FRONT-END

ANGULAR



WEB APP

DATA COLLECTION SYSTEM

DATABASE
MONGODB

BACK-END
FLASK

CAR CONTROLLER
RASPBERRY PI 3B+

FER DEPLOYMENT ON AN EDGE DEVICE

MoodPilot

FRONT-END
WEB APP

MODULES
ALLOCATION

REFERENCES

[1] PLATFORM-MEDIATED REPUTATION SYSTEMS IN THE SHARING ECONOMY (2020)

https://www.academia.edu/77030822/Platform_mediated_reputation_systems_in_the_sharing_economy_and_incentives_to_provide_service_quality_the_case_of_ridesharing_services

[2] A SYSTEMATIC LITERATURE REVIEW OF RIDE-SHARING PLATFORMS, USER FACTORS, AND BARRIERS (2021)

https://etrr.springeropen.com/articles/10.1186/s12544-021-00522-1

[3] UNDERSTANDING RIDE-SHARING SYSTEMS IN URBAN AREAS: LOCATION, USERS, AND BARRIERS (2020)

https://www.academia.edu/76607239/Understanding_Ride_Sharing_Systems_in_Urban_Areas_The_Role_of_Location_Users_and_Barriers

[4] DRIVER EMOTION RECOGNITION FOR INTELLIGENT VEHICLES: A SURVEY (2020)

https://www.media.mit.edu/publications/driver-emotion-recognition-for-intelligent-vehicles-a-survey/

REFERENCES

[5] AUDIOVISUAL AFFECT RECOGNITION FOR AUTONOMOUS VEHICLES: APPLICATIONS, CHALLENGES, AND OPPORTUNITIES (2023)

https://ieeexplore.ieee.org/document/10337780

[6] REVIEW AND PERSPECTIVES ON HUMAN EMOTION FOR CONNECTED AUTOMATED VEHICLES (2023)

https://link.springer.com/article/10.1007/s42154-023-00270-z

[7] USING EMOTION RECOGNITION AND TEMPORARY MOBILE SOCIAL NETWORK IN ON-BOARD SERVICES FOR CAR PASSENGERS (2023)

https://link.springer.com/chapter/10.1007/978-3-031-37470-8_7

TOOLS

coolors.co/palette/f9dbbd-fca17d-da627d-9a348e-0d0628

www.flaticon.com

THANKS

FOR YOUR ATTENTION