Title
Biometric Advanced Driver Assistance System (ADAS)

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Biometric Advanced Driver Assistance System (ADAS)

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Project Repo

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Abstract

- Did you know:
  - Stressed drivers are 6 times more likely to suddenly accelerate and invade lanes [1]?
  - Drowsy drivers pose an 11-fold increase in crash-related injury [2]?
- Drivers show one of three behaviors:
  - Aggressive
  - Assertive
  - Defensive [3]
- How do we improve driver safety?
  - Use machine learning to customize warnings based on the driver's physical state and driving behavior

Objectives

- Collect driver biometrics
  - Track breathing rate (BR), heart rate (HR) and galvanic skin response (GSR)
  - Display on CARLA in real-time
  - Send to machine learning models to detect physical state:
    - Stress
    - Drowsiness
- Send physical states and vehicle controls to be analyzed and display a warning to the driver based on this result

Materials and Methods

- Medtronic Zephyr BioHarness 3.0: Biometric Belt
- CARLA Simulator: Car Simulation Software
- Unreal Engine: Environment Simulation
- Python: Software Interface
  - Scikit-learn: Machine learning models
  - PyHRV: ECG feature analysis
  - NumPy/Pandas: Data analysis
  - MNE: Raw data extraction
- Next Level Racing GT Track: Vehicle Testbed
- Logitech G920 Steering Wheels: Vehicle Control
- Logitech G PRO Racing Pedals: Vehicle Control

Diagrams/Figures/Experiments

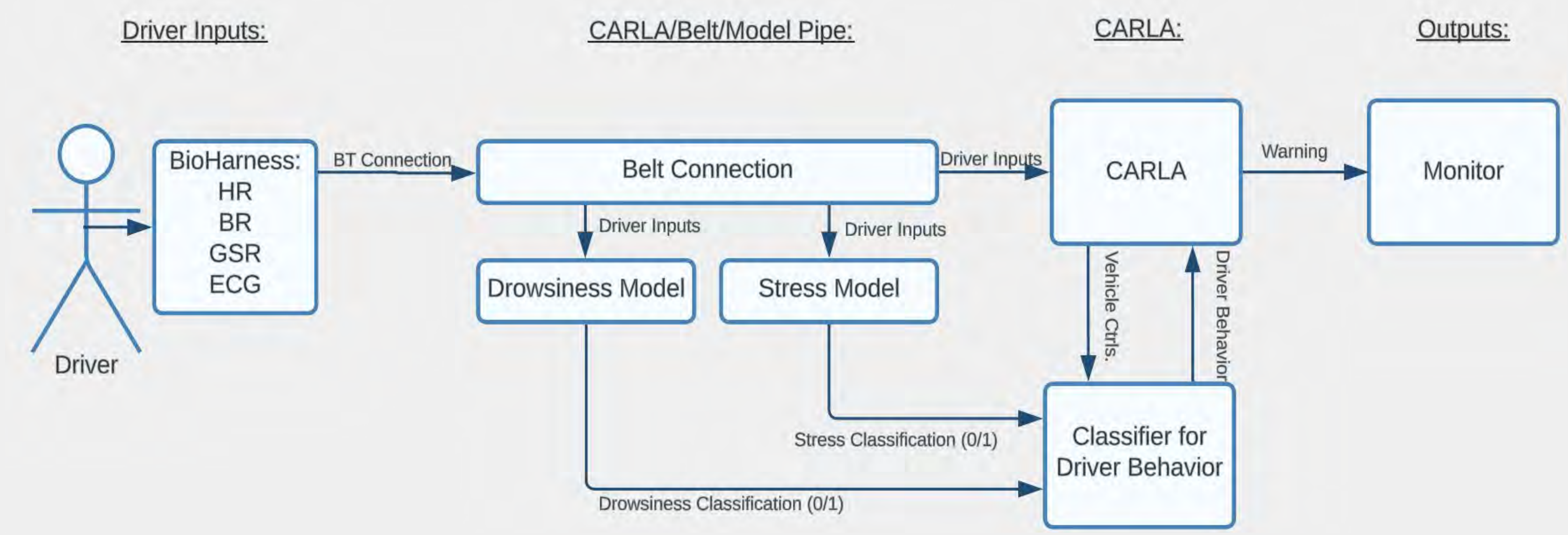

Fig. 1: Project diagram.

Fig. 2: CARLA displaying driver's biometrics, vehicle controls and model confidence values.

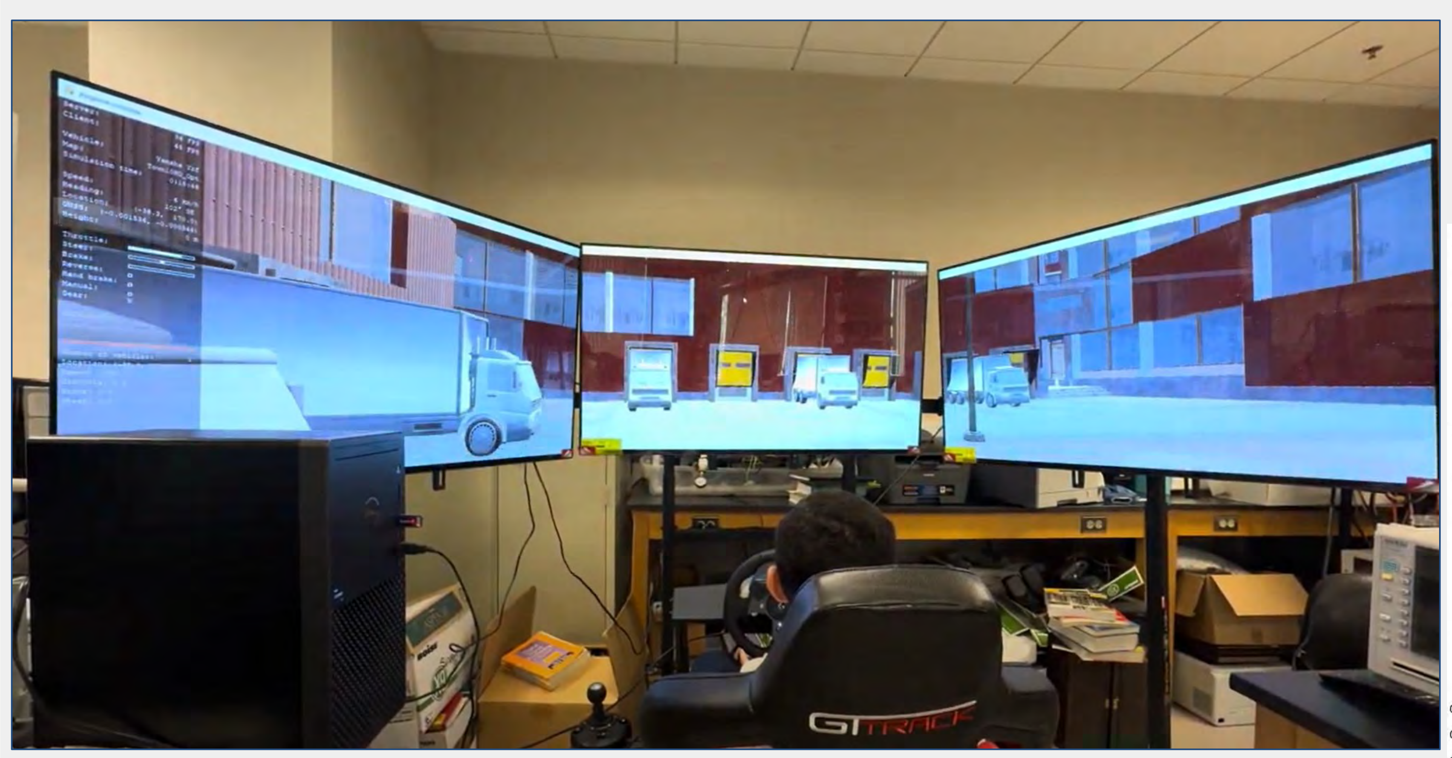

Fig. 3: Driver in vehicle testbed while wearing the Zephyr BioHarness belt.

Model Results:

Stress Model:

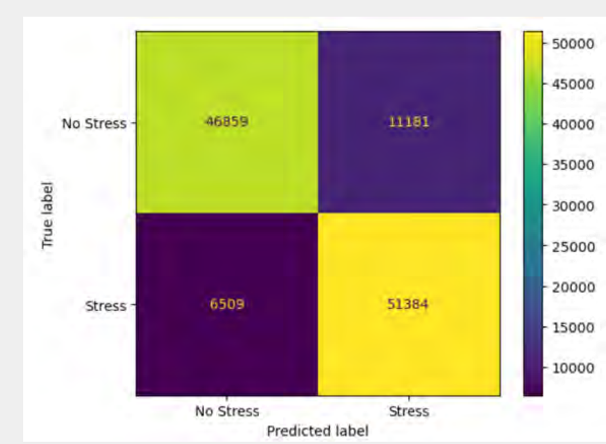

Fig. 4: Confusion matrix for Random Forest stress model with an F-score of 0.85.

Drowsiness Model:

Fig. 6: Confusion matrix for NN model with F-score of 0.812.

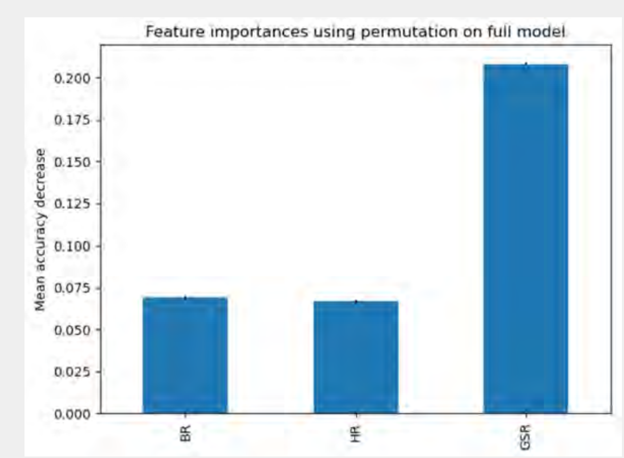

Fig. 5: Stress model feature importance according to Random Forest.

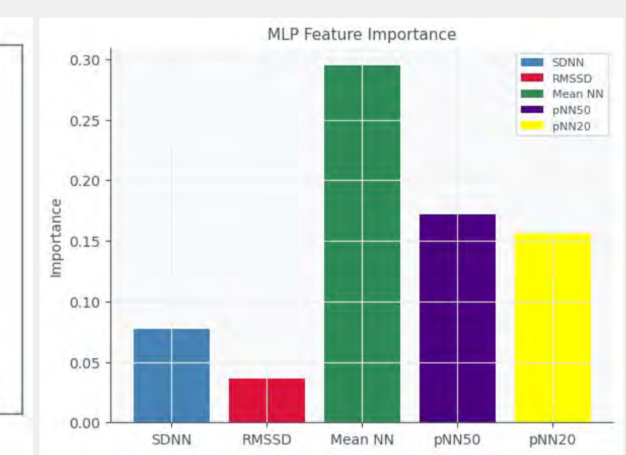

Fig. 7: Drowsiness feature importance according to NN model.

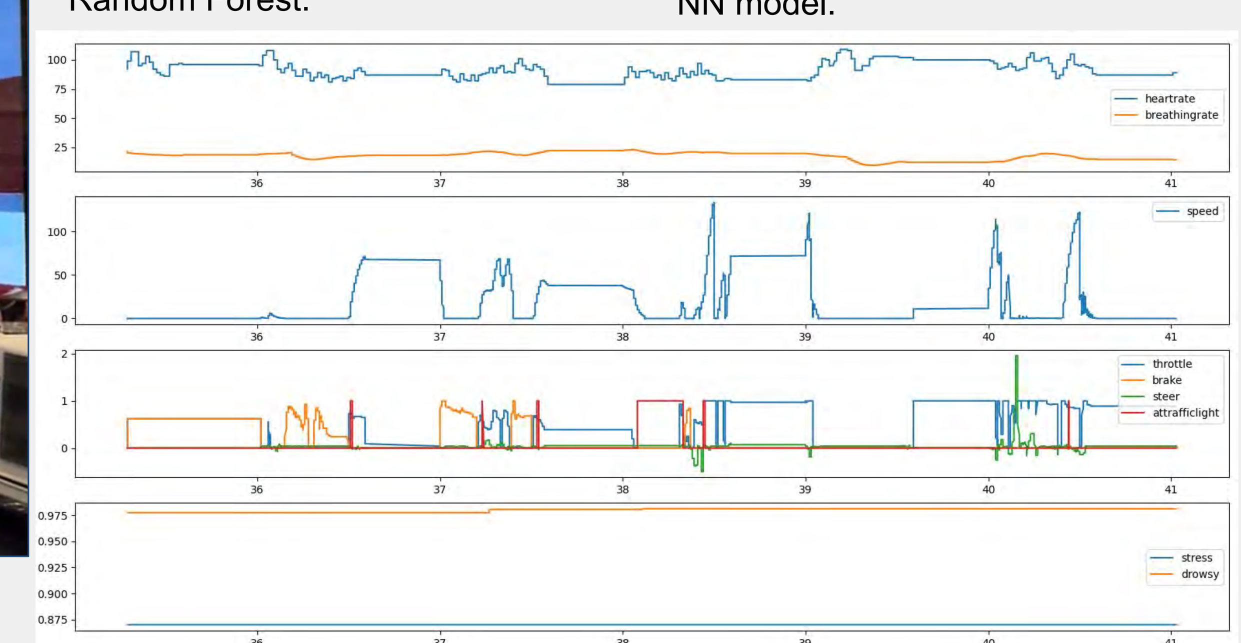

Fig. 8: Sample plot of data from an experiment. Includes biometrics, vehicle controls and model classifications.

Results

- Driver biometrics and CARLA simulation integration:
  - Viewing the belt biometrics of the driver in the CARLA simulation while controlling the vehicle
- Stress Model:
  - Detects stress with 84% accuracy using a Random Forest model with BR, HR, and hand GSR features
- Drowsiness Model:
  - Detects drowsiness with 99.6% accuracy on testing data using a Random Forest model with heart rate variability features (i.e. SDNN, RMSSD, mean NN, PNN50, PNN20)
- Model/CARLA Integration:
  - Model results successfully sent and displayed in CARLA

Standards

- IEEE USB Standard: Used to connect the biometric belt sensor module to a computer for configuration and charging
- IEEE 802.15.1 Bluetooth Standard: Used for communication between the belt and a computer to transmit the biometric data of the user

References

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[2] J. Connor, "Driver sleepiness and risk of serious injury to car occupants: population based case control study," *BMJ*, vol. 324, no. 7346, pp. 1125-1125, May 2002, doi: https://doi.org/10.1136/bmj.324.7346.1125.

[3] Salma Elmalaki, H.-R. Tsai, and M. Srivastava, "Sentio," *International Conference on Embedded Networked Sensor Systems*, Nov. 2018, doi: https://doi.org/10.1145/3274783.3274843