AutoConduct: a novel dataset for in-vehicle driver posture monitoring

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Outline

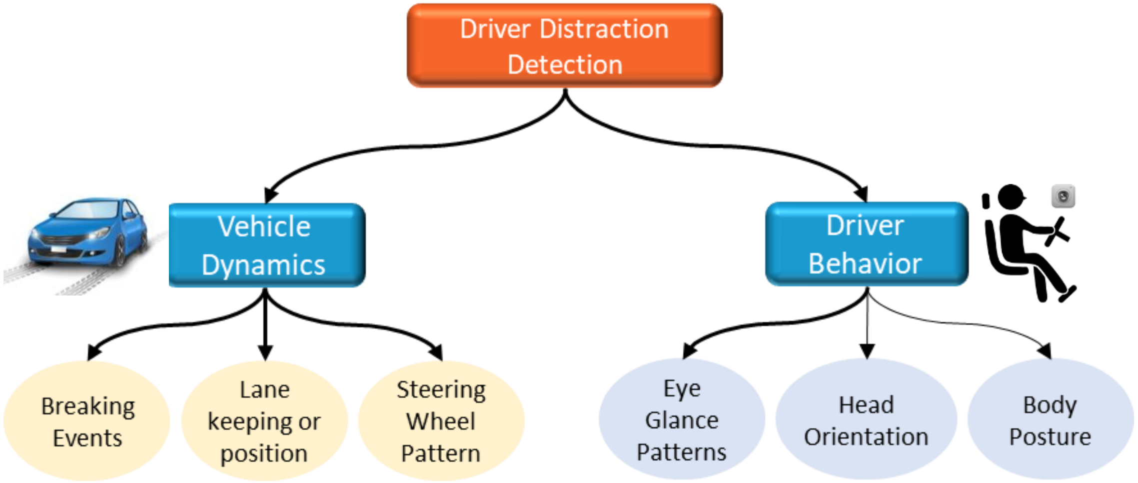
- Introduction
- Objectives
- AutoConduct dataset
- Posture estimation
- Future work

Introduction

Driver distraction and road traffic safety

❖ **Fact:** 10 - 16 % of fatal traffic accidents are caused by distracted driving (Née et al., 2019)
❖ **Ironies of automation:** driver distraction increases with automation level (Lu et al., 2016)

Detection of driver distraction



Alkinani et al. 2020; Kashevnik et al. 2021

➢ Research on driver posture monitoring is falling behind

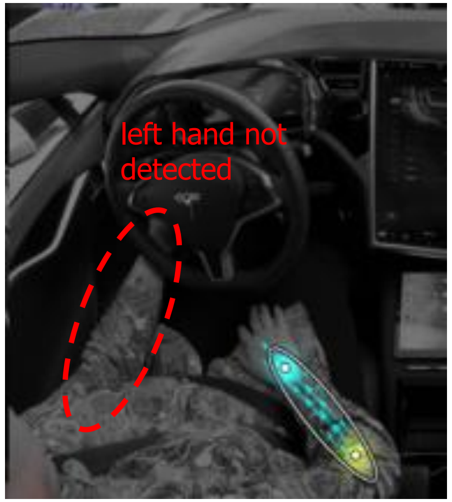
Introduction

In-vehicle driver posture monitoring

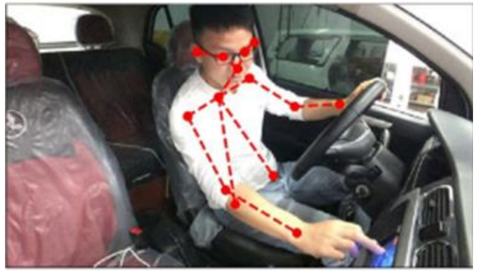
A challenging task due to
- Body close to vehicle interior
- Suboptimal camera placement
- Illumination, occlusions
- Accuracy requirement

Limitations of existing systems
- Incomplete body coverage (head or hands)
- 3D pose estimation rarely investigated
- Insufficient investigations of supplementary methods
- Limited validation

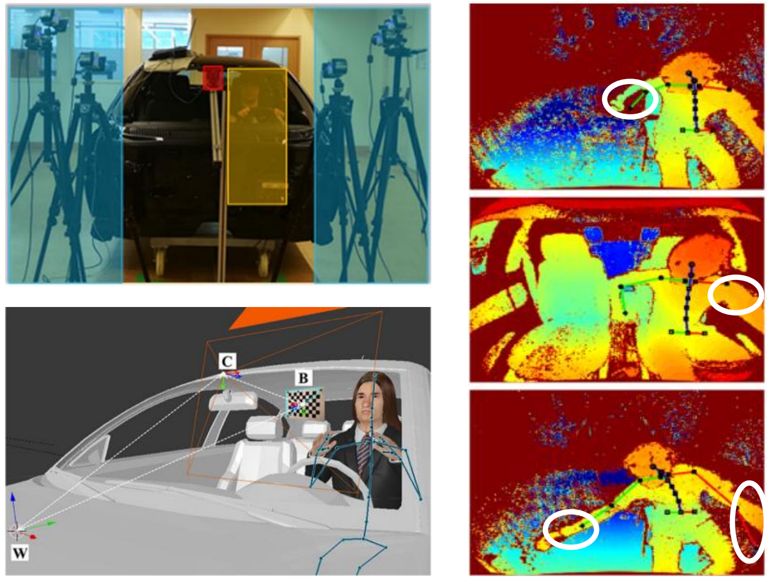
A critical issue
- Lack of in-vehicle driver posture datasets
  - Measurement: images, etc
  - Annotations: segmentations, joint centers, etc



Yuen and Trivedi. (2018)



Pan et al. (2021)



InCar (Borges et al. 2021)

Researchers are still struggling to find more useful data and better algorithms for driver posture monitoring

Objectives

- **To create an in-vehicle driver posture dataset in order to facilitate the research on driver posture monitoring**
- **To propose more reliable driver posture estimation methods**

AutoConduct dataset

Data collection and data processing

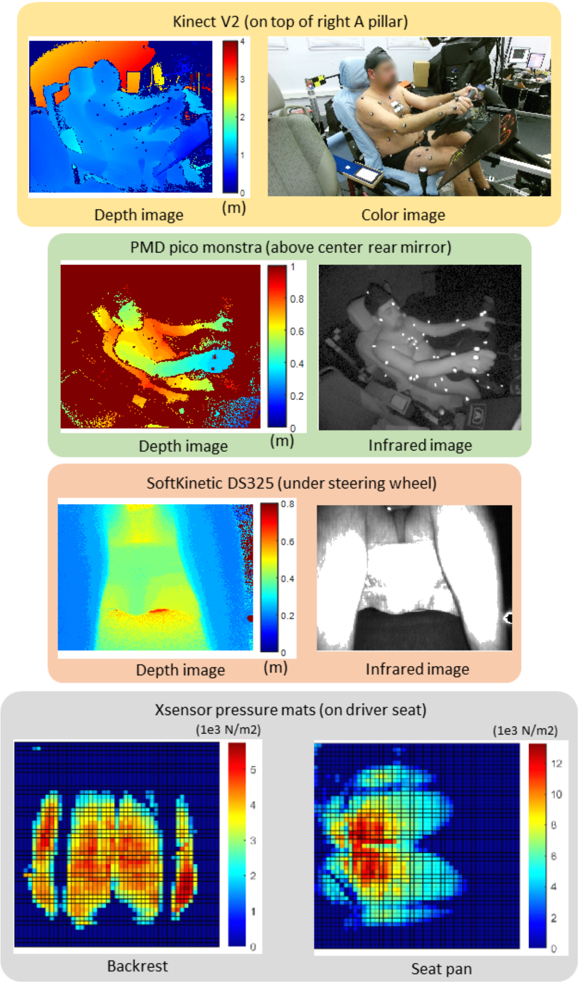
Twenty-three Drivers (11 females)
- Age: 22 – 65 years
- Height: 153 – 195 cm
- BMI: 18.2 – 43.4 kg/m^2

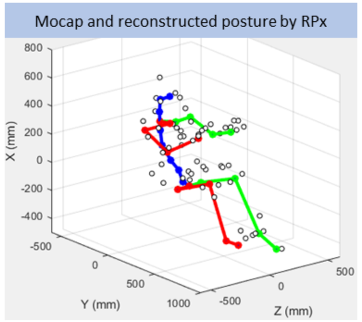
42 in-vehicle tasks
- Driving tasks
- Non-driving related tasks

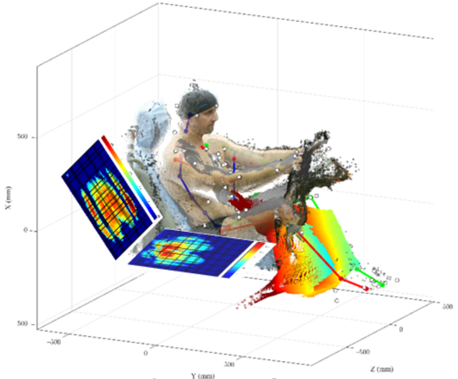
Motion capture system
- 14 VICON cameras
- 78 reflective markers

Monitoring system
- Kinect V2
- PMD pico monstra
- SoftKinetic DS325
- 2 Xsensor pressure mats

Nature of data content (~2 hours recording)
- Anthropometry measurement
- Motion capture data (50 fps)
- Depth image flow (25 fps)
- Color image flow (25 fps)
- Infrared image flow (25 fps)
- Pressure distribution (25 fps)



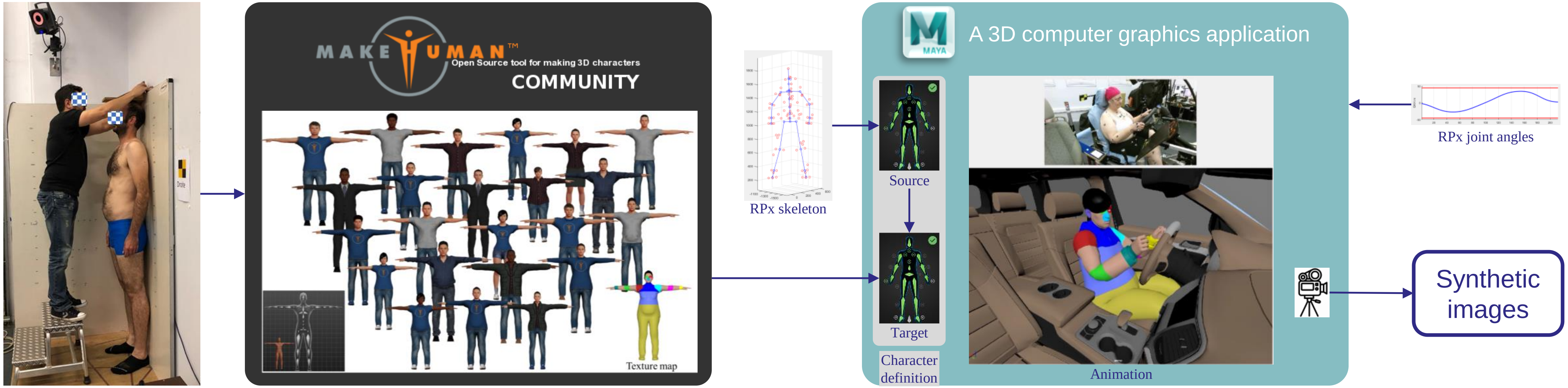


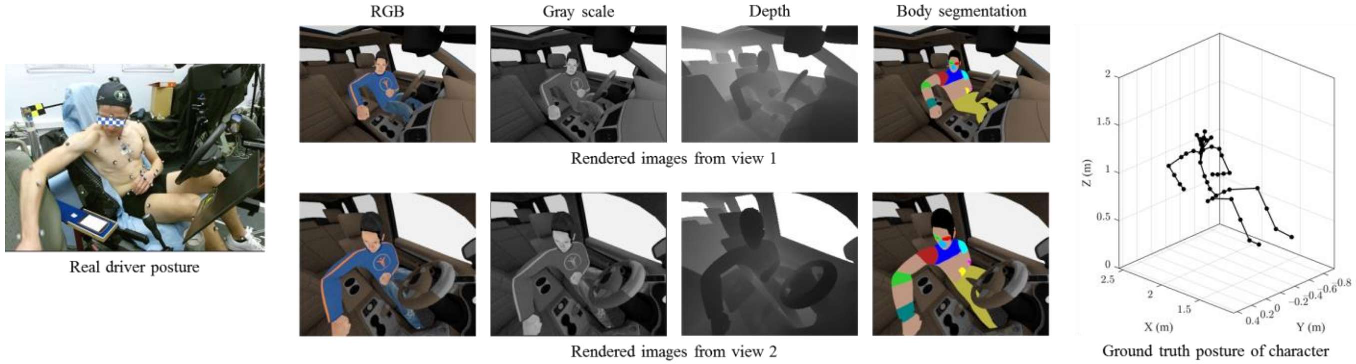


Data alignment after camera calibration and time synchronization

AutoConduct dataset

Data augmentation

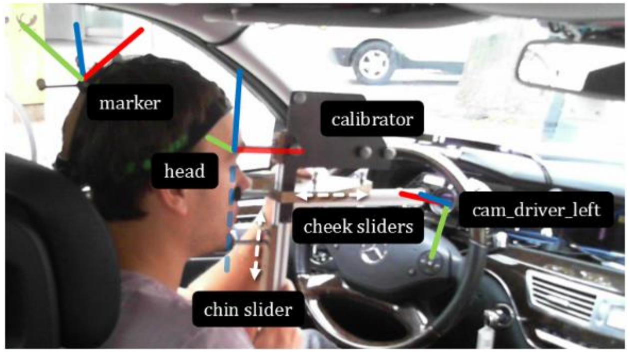




Synthetic data examples

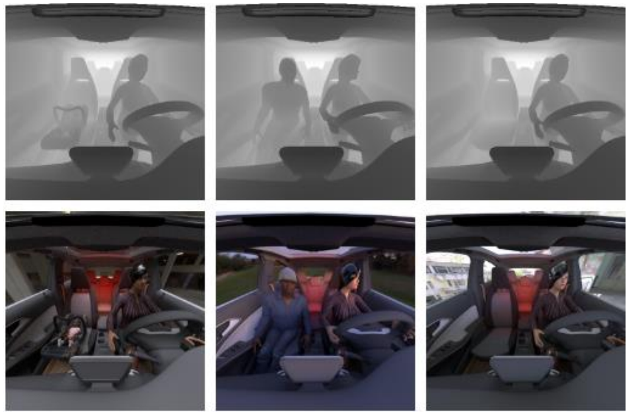
AutoConduct dataset

Comparison with state-of-the-art



DD-Pose (Roth and Gavrila 2019), optical mocap for ground truth of head pose

VS



TICam (Mirbach and El-sherif 2021), synthetic dataset

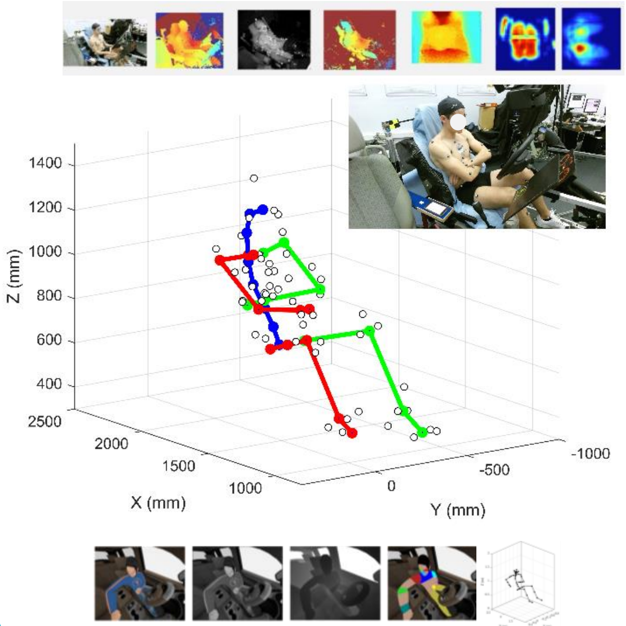
VS

Experiment data:

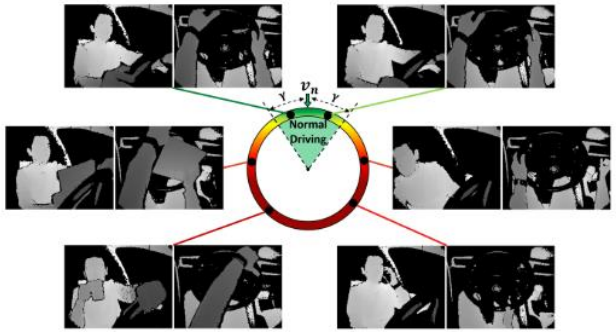
- ~130K frames of IR/RGB/Depth images, pressure data and 3D skeleton

Synthetic data:

- ~12M frames of images, body segmentations and 3D skeleton

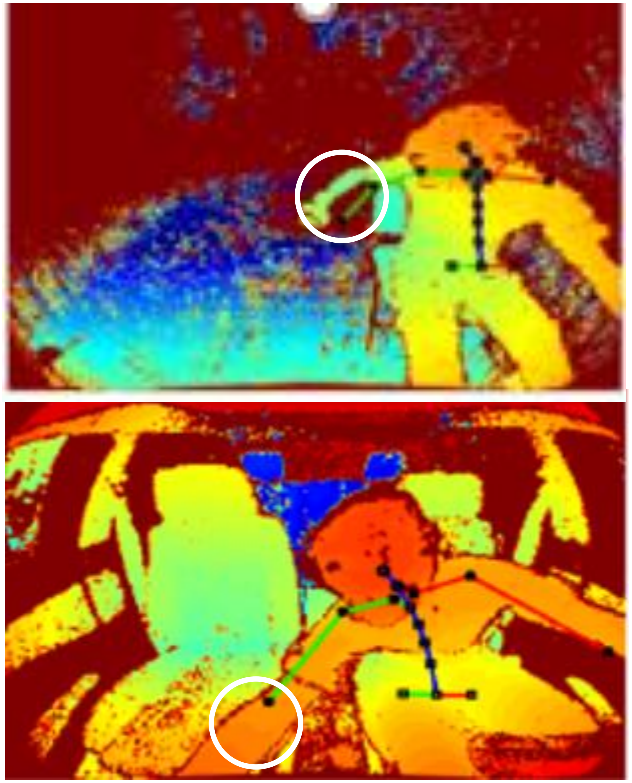


VS



Driver anomaly detection dataset (Köpülü et al. 2021), no posture annotations

VS



InCar (Borges et al. 2021), IMU for ground truth of upper-body pose

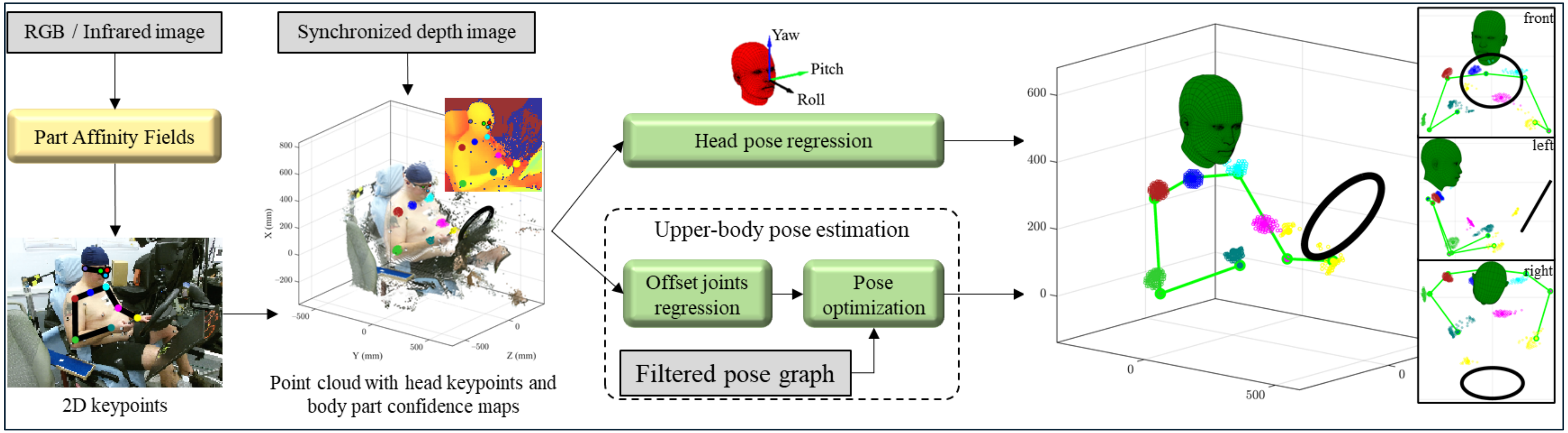
Posture estimation

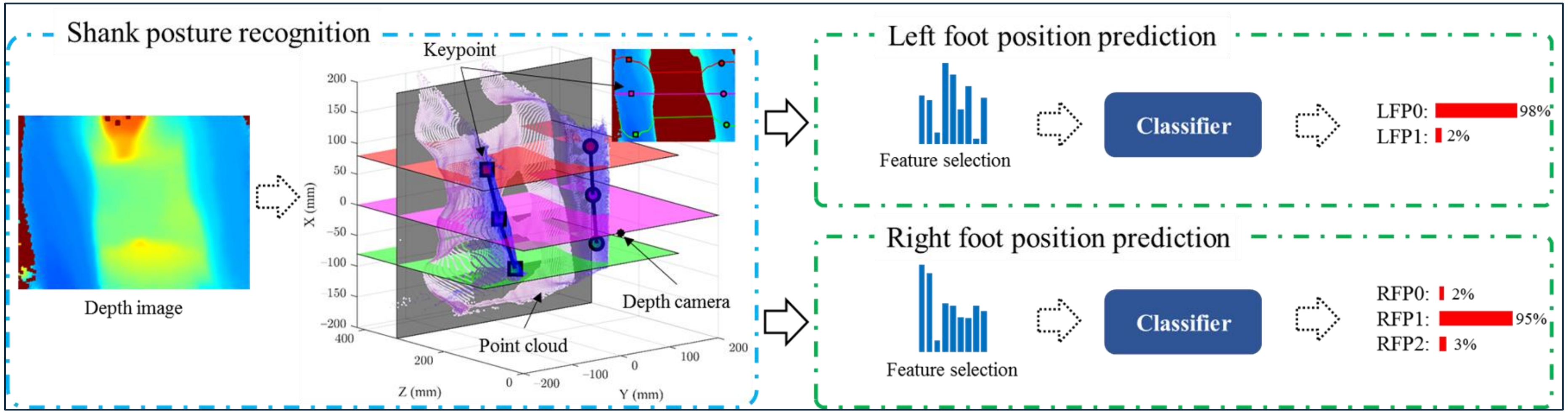
Vision-based monitoring

3D skeleton (N = 129282)
- Average accuracy across seven body joints: 91%

Head pose (N = 129282)
- Mean errors of head orientation and position less than 11 deg and 2 cm in 96.3 % of all data samples

Feet positions (N = 5216 / 8024)
- Average classification accuracy of left and right foot is 93 % and 88 %, respectively



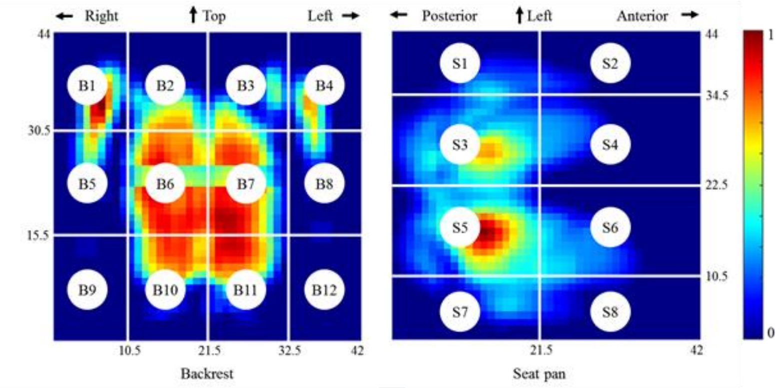


LFP0	Left foot on floor
LFP1	Left foot on clutch

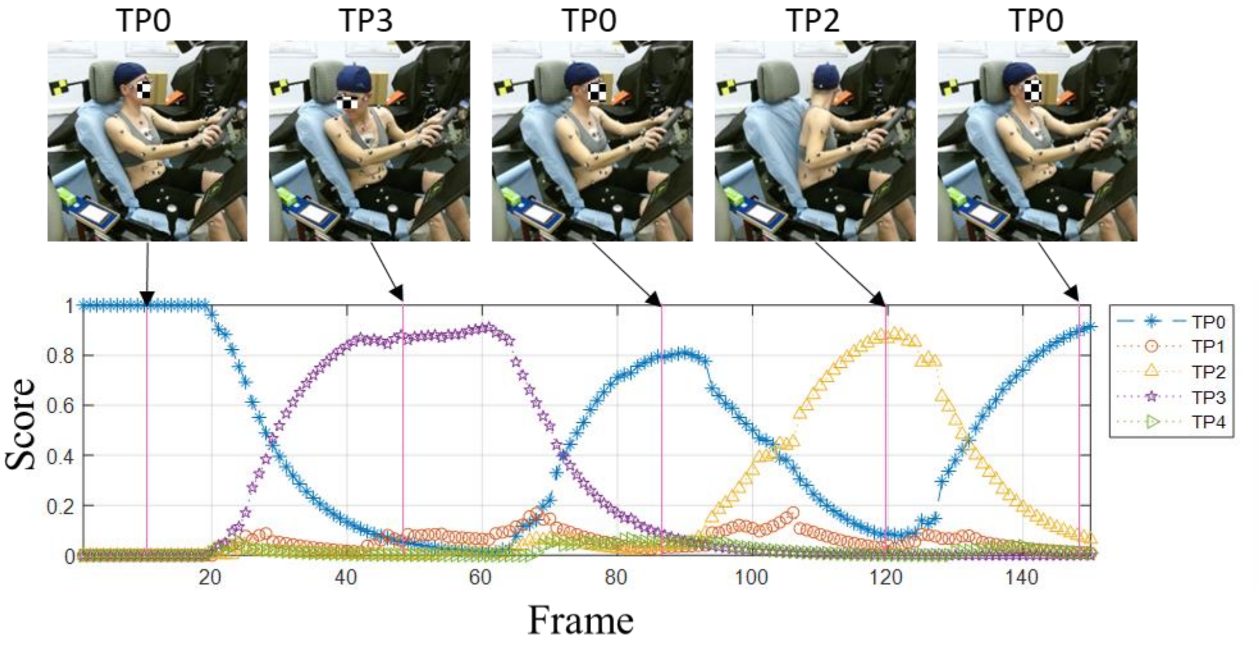
RFP0	Right foot on accelerator
RFP1	Right foot on brake pedal
RFP2	Right foot on floor

Posture estimation

Pressure measurement based monitoring



Random forest classifiers



Continuous prediction of trunk postures by Leave-one-out cross-validation

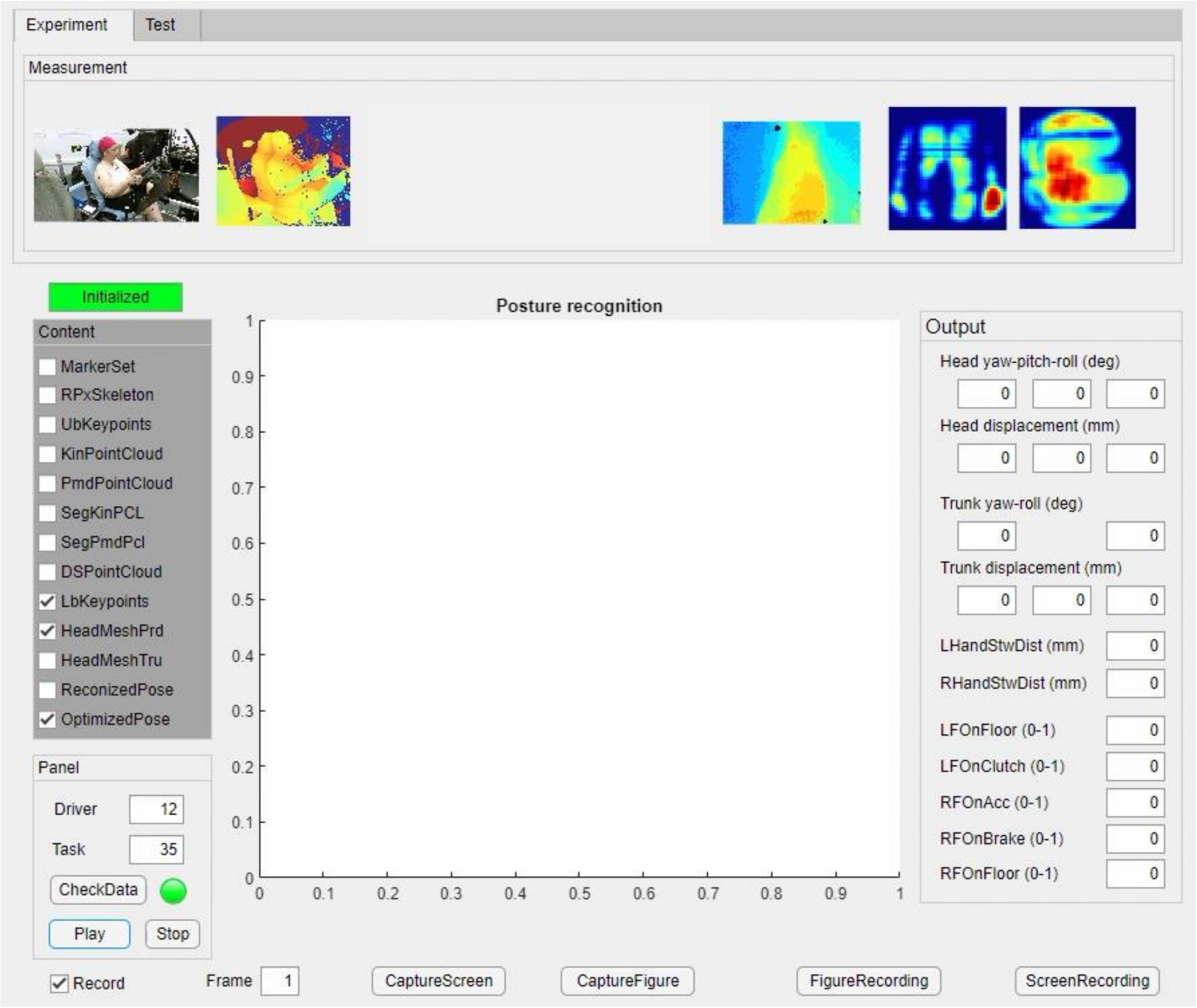
Trunk posture classification (N = 3999)

- Average accuracy of 91 % from leave-one-out tests

Feet position classifications (N = 5216 / 8024)

- Average classification accuracy of left/right foot positions: 93 % / 74 %

Overview of monitoring system



Publications:

- Zhao, M., Beurier, G., Wang, H., & Wang, X. (2021). Exploration of Driver Posture Monitoring Using Pressure Sensors with Lower Resolution. Sensors, 21(10), 3346.
- Zhao, M., Beurier, G., Wang, H., & Wang, X. (2021). Driver posture monitoring in highly automated vehicles using pressure measurement. Traffic injury prevention, 22(4), 278-283.
- Zhao, M., Beurier, G., Wang, H., & Wang, X. (2020, August). Extraction of pressure features for predicting driver posture. In Proceedings of the 2020 IRCOBI conference, Munich, Germany (pp. 398-409).
- Zhao, M., Beurier, G., Wang, H., & Wang, X. (2020, May). Driver Posture Prediction Using Pressure Measurement and Deep Learning, In Proceedings of the 2020 IRCOBI (ASIA) conference, Beijing, China (pp. 102-105).
- Zhao, M., Beurier, G., Wang, H., & Wang, X. (2020). A Pipeline for Creating In-Vehicle Posture Database for Developing Driver Posture Monitoring Systems. In Proceedings of DHM2020, August 31-September 2, 2020 (Vol. 11, p. 187). IOS Press.
- Zhao, M., Beurier, G., Wang, H., & Wang, X. (2019, September). Detection of Driver Posture Change by Seat Pressure Measurement. In Proceedings of the 2019 IRCOBI conference, Florence, Italy (pp. 84-85).
- Zhao, M., Beurier, G., Wang, H., & Wang, X. (2018). In vehicle diver postural monitoring using a depth camera kinect (No. 2018-01-0505). SAE world congress 2018.

Future work

- **Refinement of the proposed data augmentation pipeline**
  - Driver-object interaction, sensor noise, vehicle models
  - Real driver motions will be made open access
- **Improvement of proposed posture monitoring functions**
  - Adaptation of more advanced algorithms for posture estimation
- **Identification of critical postures based on posture monitoring & evaluation of their safety impact**

Thank you for your attention

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