Prediction of Driver's Stress Affection in Simulated Autonomous Driving Scenarios

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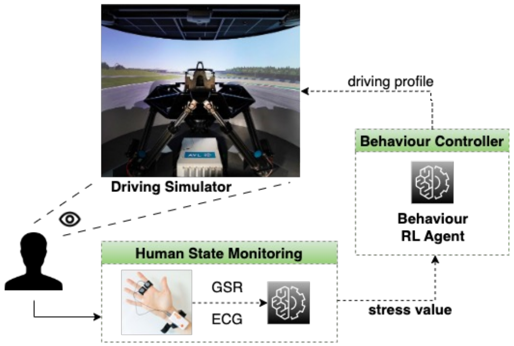
Highlights and Objectives

- The driver's cognitive state is a mean of implicit interaction between the driver and the AD vehicle
- Physiological data reflect the cognitive state of a human, and is effective to determine the *cognitive stress*
- **Objective 1**: determine the best proxy, among subjective and objective labels, to predict the driver's stress affection from physiological data
- **Objective 2:** obtain a model which is suitable for learning in a pervasive environment (i.e., good trade-off between performance and efficiency in training and inference)

Introduction and Study Description

- In Autonomous Driving, the mutual interaction between driven and vehicle loosens, and *more implicit means of interaction come into play*
- In the TEACHING project, we modelled such interaction by adapting the *driving profile* of the vehicle with respect to the cognitive state of the driver

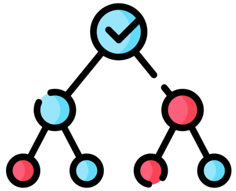


- In this paper, we investigated the stress affection prediction from the outcome of a pilot study
- The study included **40 participants**
- Each **participant experienced 6 simulations of autonomous driving** (~155s each), including different driving modes and environmental conditions
- During the simulations, the participant **worn devices to collect physiological data** (GSR, ECG)
- The **simulations present stress-inducing events**
- **After each simulation, the participants answer a questionnaire to provide subjective feedback on the experience**

Coarse-Grained Task

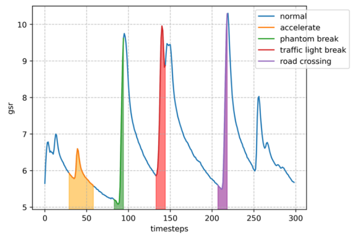
I found the automonous driving experience stressful.

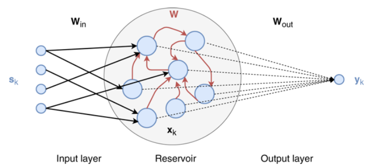
Answer: [Strongly disagree, Disagree, Neither disagree or agree, Agree, Strongly agree]



- We computed the mean and standard deviation of the physiological signals of each simulation (resulting in a single vector)
- We translated the response of the questionnaire to a binary label
- A **decision tree** learns to **classify the response of the participant** after a simulation, **given the statistics of their physiological signal**

Fine-Grained Task





- We equipped the sequences with a sequence of binary labels
- A label denotes whether a **potentially stress-inducing event is occurring**
- An **Echo State Network** (with untrained reservoir, or with reservoir adapted via Intrinsic Plasticity) learns to **predict whether the participant is experiencing a stress-inducing event**

Experimental Assessment

- **Simulation-wise split**: scenarios from 1 to 4 are for training, scenario 5 for validation and scenario 6 for test
- Evaluated 5000 configurations for each model (DT, ESN and IP-ESN)
- Assessed accuracy and F1-Score in training, validation and test, and measured training time

		Time (in s)	Accuracy (in %)		
			Train	Eval	Test
CG	DT	$\ll 1$	74.38 ± 2.20	66.25 ± 4.61	59.69 ± 4.28
FG	ESN	16.6 ± 3.8	60.64 ± 4.64	59.60 ± 4.10	60.61 ± 4.52
	IP-ESN	61.5 ± 12.9	88.71 ± 0.13	84.52 ± 0.67	84.05 ± 0.83

		F1		
		Train	Eval	Test
CG	DT	0.7091 ± 0.0250	0.6033 ± 0.0425	0.5257 ± 0.0531
FG	ESN	0.2604 ± 0.0127	0.2638 ± 0.0226	0.2715 ± 0.0191
	IP-ESN	0.6583 ± 0.0080	0.5680 ± 0.0037	0.5517 ± 0.0149

- On the *coarse-grained task*, the performance is poor on the test set due to
  - Diversity in correlation between physiological data and subjective measurement
  - The statistics collapsing useful input information
- On the *fine-grained task*, the ESN with reservoir adapted IP achieves a good performance in prediction
- **Local trends of the physiological signals are more representative of the driver's state** in presence of stress-inducing events
- Both models **attain to the efficiency constraint**, with a training time $\lesssim 1$ minute