

## MONITORING CHANGES IN HUMAN BEHAVIOR DYNAMICS DURING MONOTONOUS DRIVING CONDITIONS FOR DRIVER STATE ESTIMATION

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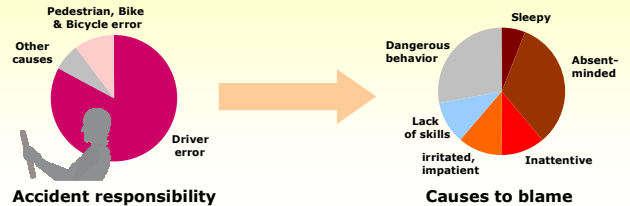
### Abstract

How does our bodily behavior relate to our internal states? Earlier studies have shown that factory workers tend to engage in unrelated movements due to monotony.<sup>[1]</sup>

Here, we show that during monotonous driving conditions, drivers exhibit recurrent subsidiary behaviors, which are indicative of an imminent decrease in their arousal level. We also propose an approach for automatic detection of the considered behavioral events using non-intrusive computer vision techniques.

### Motivations

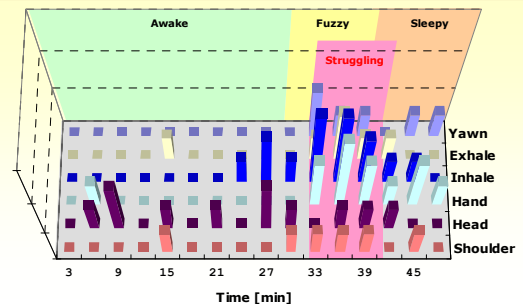
- Human error (driver's internal state) is the cause in many accidents



Source: ITARDA<sup>[2]</sup>

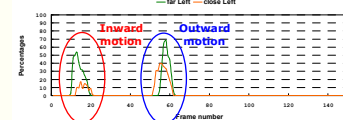
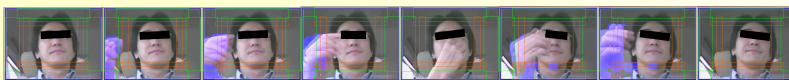
### Subsidiary Behavior (SB)

- Definition:** Subsidiary behavior is any action that is not related to the main task.<sup>[1]</sup>  
➢ In our case, any action of the driver that is unrelated to driving is considered SB.
- During monotonous driving, the analysis of the occurrence frequency of SB was found to be highly indicative of the driver's struggle to maintain his/her arousal state at a level adequate to the driving task.
- Among all considered SB actions, three of them (**Self-touching hand motion**, **Yawning**, **Head twisting motion**) represent a good combination that is relatively insensitive to individual differences, while being sufficiently indicative.

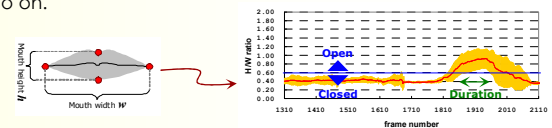


### Automatic detection

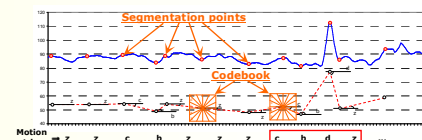
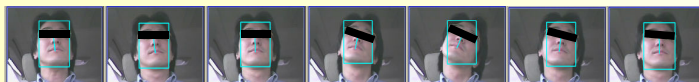
- Hand motion detection:** detect an inward motion followed by an outward motion using simple background subtraction



- Yawning detection:** measure mouth openness ratio to detect open mouth state, and measure its duration in time to select only yawning events and avoid detecting other mouth-related events, such as speaking, eating, ... and so on.



- Head motion detection:** measure head inclination angle and compare its value to pre-learned patterns using a string matching approach.



### Summary and Future work

- A behavior pattern was observed when drivers try to maintain an adequate arousal level during monotonous driving conditions.
- A detection approach of the considered behavioral events is proposed for early prediction of the decrease in arousal level.
- Future work:**
  - Handling of occlusions
  - Handling of illumination changes

### References

- [1]: Koya Kishida, "Temporal Change of Subsidiary Behavior in Monotonous Work", in Journal of Human Ergology, Vol.2, No.1, pp. 75-89, 1973.
- [2]: ITARDA, "Analysis of Human Factors during Intersection Collisions", Report of the Institute for Traffic Accident Research and Data Analysis, No.56, 2005. (in Japanese)

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