

Estimation of Wakefulness in Video-based Lecture based on Multimodal Data Fusion

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Motivation

Negative impact of drowsiness during e-learning

To help learners refocus their attention on the learning task, accurate estimation of wakefulness is required.

Related Work

Facial expressions for internal state estimation

- Whitehill et al. [1] built models to estimate engagement, frustration, and so on.

Body posture for engagement estimation

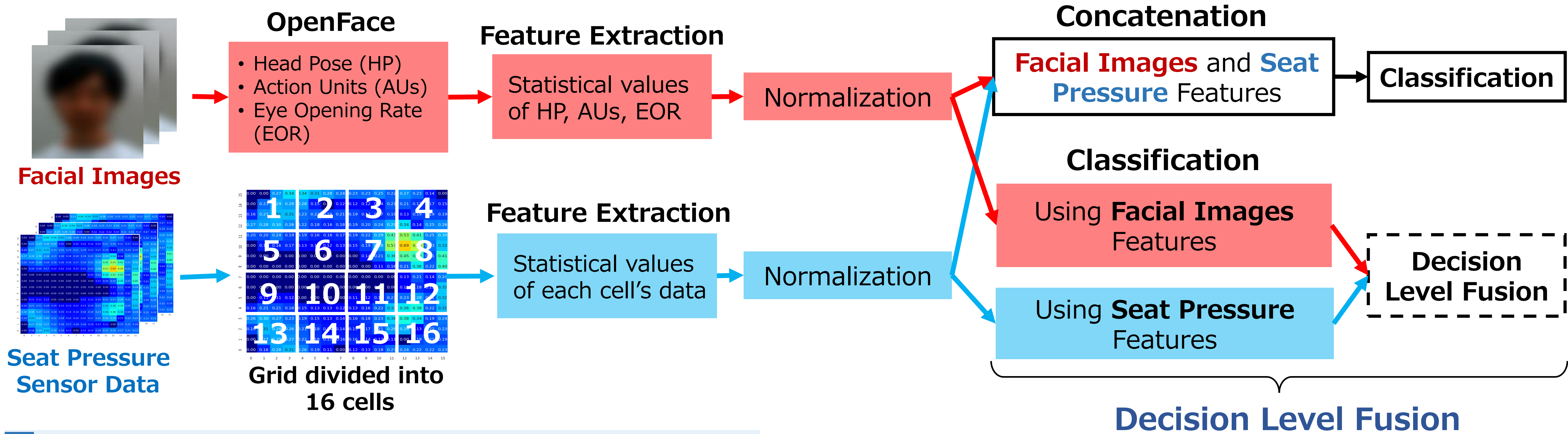
- D'Mello et al. [2] and Nomura et al. [3] show the relationship between body movements and internal states in e-learning

Our Approach

Multimodal data fusion for wakefulness estimation

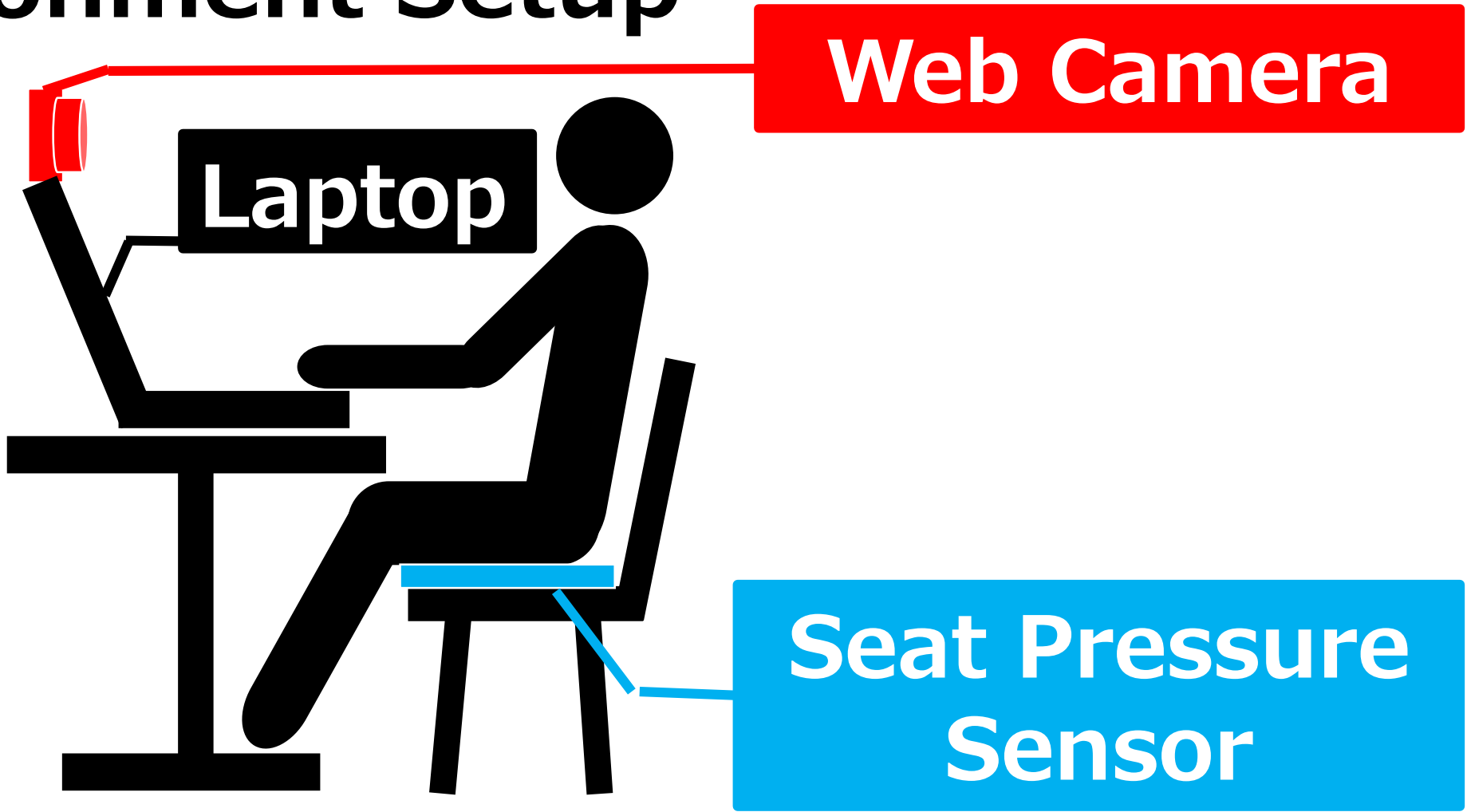
- Both facial expressions and body posture are related to internal states.**
- Employ web-cameras and seat pressure sensors to obtain facial expression and upper-body posture information.

Steps in Multimodal Fusion



Experiment

Environment Setup



Data collection

Task	Take lectures of informatics (10 min x 3-5 lectures)
Subjects	53 (4 are selected for analysis)
Annotation	<ul style="list-style-type: none">Three observers3 levels (Awake, Drowsy, Asleep)Duration: one second

Evaluation and Results

Evaluation of Wakefulness Estimation

Classification Condition	3 levels, Awake vs Others, Asleep vs Others
Classifier	Catboost classifier
Cross Validation	Leave One-Out CV
Evaluation Index	Macro F1-score

Results

- Multimodal data fusion outperformed single mode method (Face, Seat pressure)
- Multimodal fusion can improve the performance of wakefulness estimation**

Macro F1-scores of unimodal and multimodal features

Method	Awake vs Others	Asleep vs Others	3 levels
Chance rate	0.49	0.49	0.33
Face	0.88	0.64	0.67
Seat pressure	0.55	0.72	0.45
Early Fusion	0.88	0.71	0.70
Decision	0.89	0.72	0.69

[1] Jacob Whitehill et al. 2014. The faces of engagement: Automatic recognition of student engagement from facial expressions. *IEEE Trans. Affective Computing* 5, 1 (2014), 86–98.

[2] Sidney S D'Mello et al. 2007. Posture as a predictor of learner's affective engagement. In *Proceedings of the Annual Meeting of the Cognitive Science Society*, Vol. 29.

[3] Kazuaki Nomura et al. 2019. Estimation of student's engagement based on the posture. In *Adjunct Proceedings of the Ubicomp/ISWC 2019* 164-167.

[4] Tadas Baltrušaitis et al. 2018. Openface 2.0: Facial behavior analysis toolkit. In *IEEE International Conference on Automatic Face & Gesture Recognition (FG)*. IEEE, 59–66.