Tracking Sustained Attention with Webcam-Based Eye Gaze and Blink Pattern Tracking

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1. Introduction

- Maintaining sustained attention is important for learners in the remote learning context.
- Our research team used different types of sensors to find indicators of changes in attention.
- Novelty of this research is use of a commodity webcam for wide deployability, rather than expensive cameras.
- Main research question: **"How can webcam-based eye gaze and blink pattern tracking indicate changes in learners' sustained attention?"**

Sensor multimodality

2. Methodology

- Small user study with 3 research team members.
- Experiment 1 with short reading tasks to collect "attentive" gaze and blink data.
- Experiment 2b with long reading task to collect "inattentive" gaze and blink data. Uses "gradual blurring" ground truth annotation introduced by Huang et al. (2019) to annotate inattentive moments.

Schematic overview of experiments:
1 and 2b do sensor recording
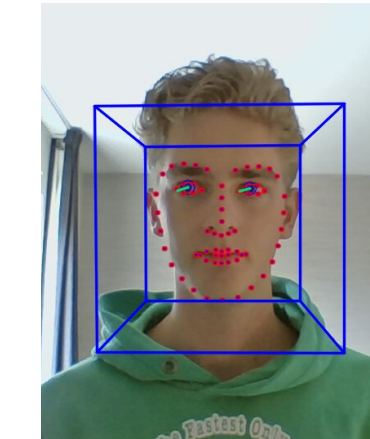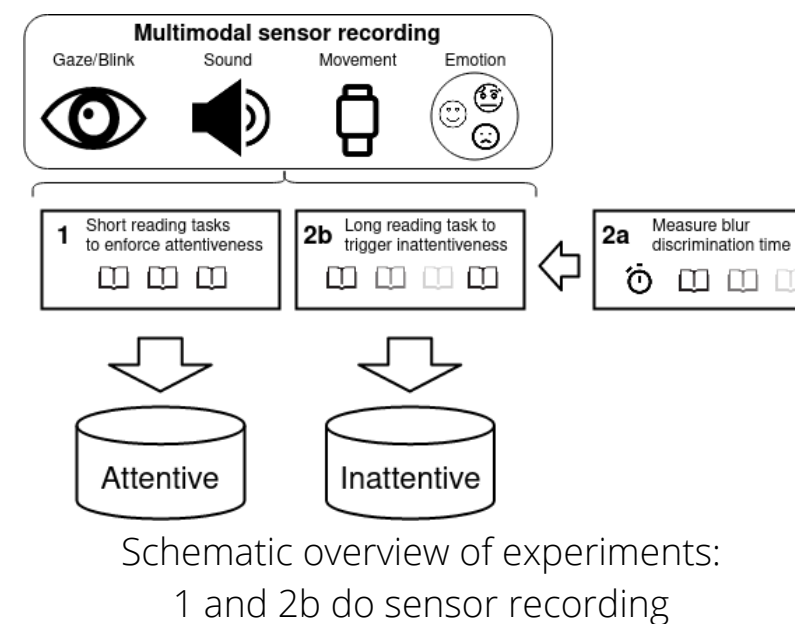
OpenFace gaze and blink tracking

Example of saccade and blink

- OpenFace library was used for gaze and blink tracking.
- 54 features were extracted from labeled time windows, mostly concerning saccades and blinks.
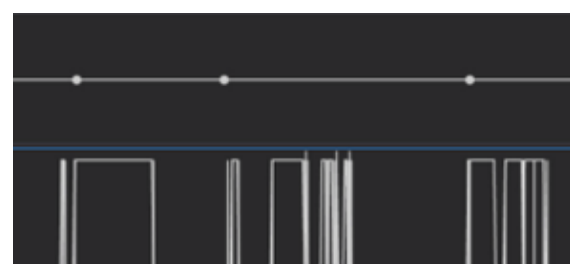
Alternative methodology

- Considered alternative methodology where only gaze/blink data from long reading task were used. This is disputed however, due to missing attention ground truth.

3. Experimental Setup and Results

- 27 classification models were trained varying in window size, algorithm and included labels.
- Best general model performed well on validation data with F1-score of 0.889.
- During validation model showed strong bias towards experimental setting rather than attention, making it unusable in practice.
- Model trained with alternative methodology performed better on testing data, but false positive rate differs highly per participant.

Alternative model: High false positive rate

Experimental setting participant
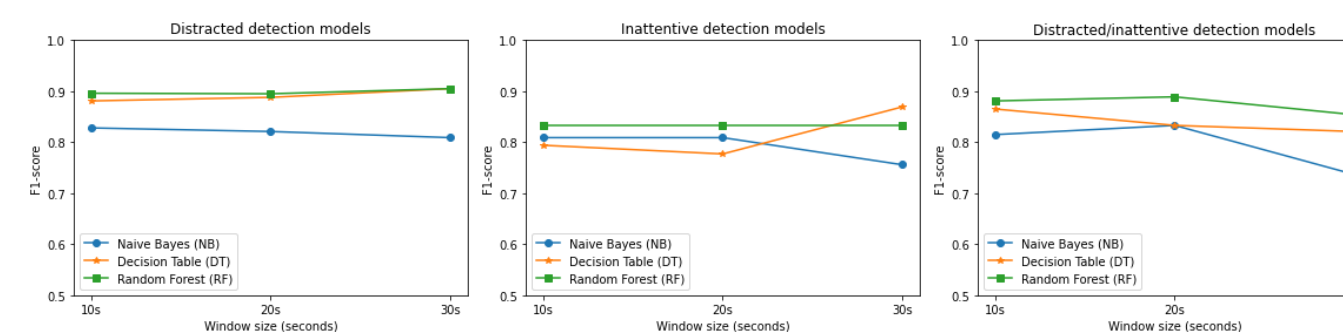
F1-scores classification models on validation data

4. Discussion and Conclusions

- Model likely overfitted due to small size user study. Could be overfitted on:
  - Long reading task vs short reading task
  - Head pose/webcam orientation
  - Lighting conditions
- Alternative methodology works better in practice, but makes invalid assumptions.
- Future work should focus on larger user studies and proper attention/inattention ground truth annotation. Finally, we also encourage sharing datasets of multimodal learning analytics experiments.

Main references

- Bixler, R., and D'Mello, S. (2016) Automatic gaze-based user-independent detection of mind wandering during computerized reading.
- Huang, M., Li, J., Ngai, G., Leong, H., and Bulling, A. (2019). Moment-to-Moment Detection of Internal Thought from Eye Vergence Behaviour
- Baltrušaitis, T., Zadeh, A., Lim, Y.C., and e Morency, L. (2018). OpenFace 2.0: Facial Behavior Analysis Toolkit. IEEE International Conference on Automatic Face and Gesture Recognition