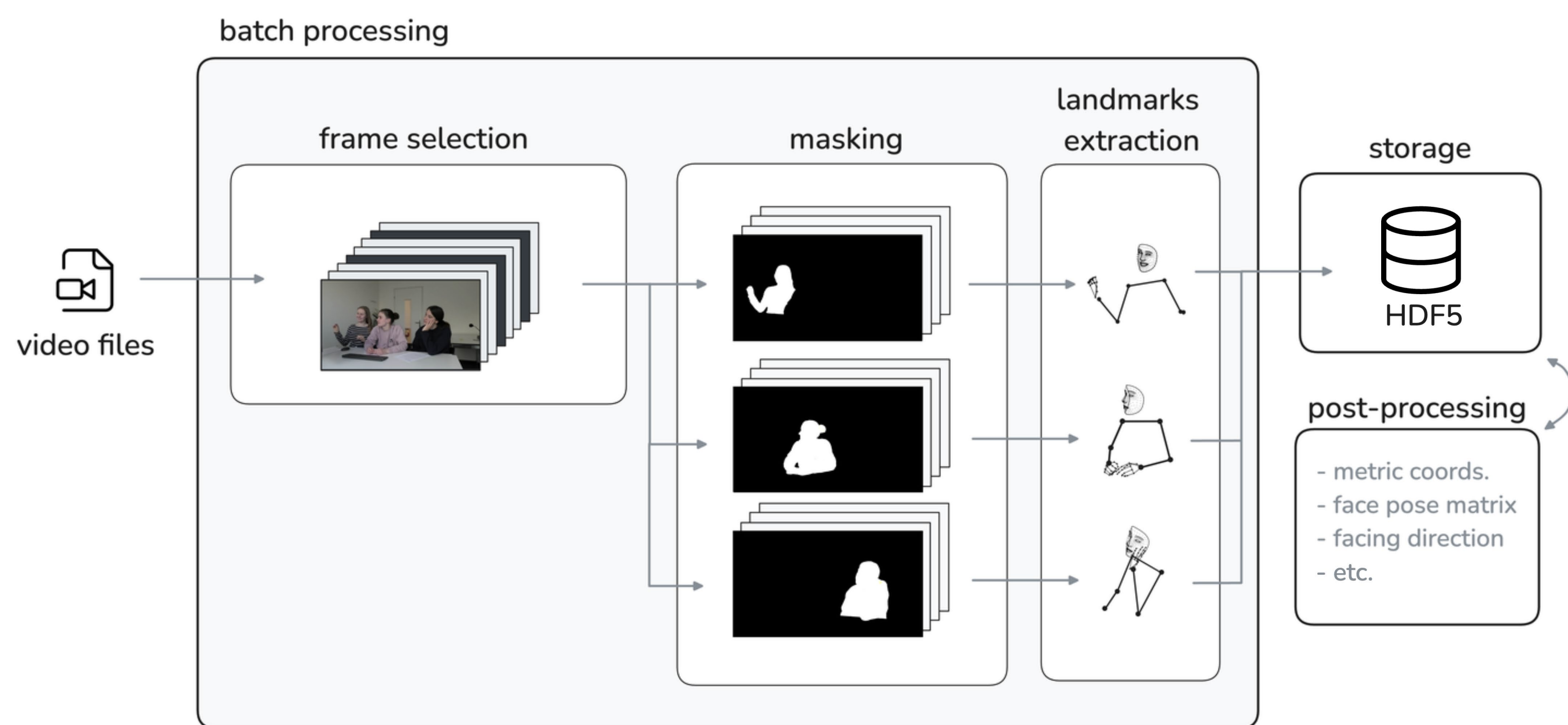


Visual Analytics of Nonverbal Behavior to Evaluate Collaborative Group Engagement

Analyzing nonverbal behavior (NVB) in collaborative groups is complex. We present a Visual Analytics approach that processes video-based facial, hand, and body landmarks into interpretable NVB signals. Aggregation of these signals at different temporal granularities enables interactive visualization and exploration of group dynamics, as expressed by head orientation and movement, to be interpreted by domain experts.

Processing group videos to nonverbal behaviour signals



The videos of collaborative group work [2] were batch-processed by masking the people per frame and extracting body landmarks for each person using MediaPipe Holistic library [1]. The high-resolution multidimensional data, including facial meshes and body joint positions as well as timestamps and anonymized metadata, was stored in the hierarchical HDF5 file format. Further, 3D coordinates were calculated and information, such as the Mutual Orientation Index (MOI), derived. The raw body landmark data provided high temporal resolution, but it was too dense for meaningful pattern analysis. It was aggregated at different temporal granularity using regular intervals as well as event-based segmentation (Fig. 1). However, only regular segmentation was acceptable to the domain specialists, which lead to the implementation of different regular aggregations (Fig. 3).

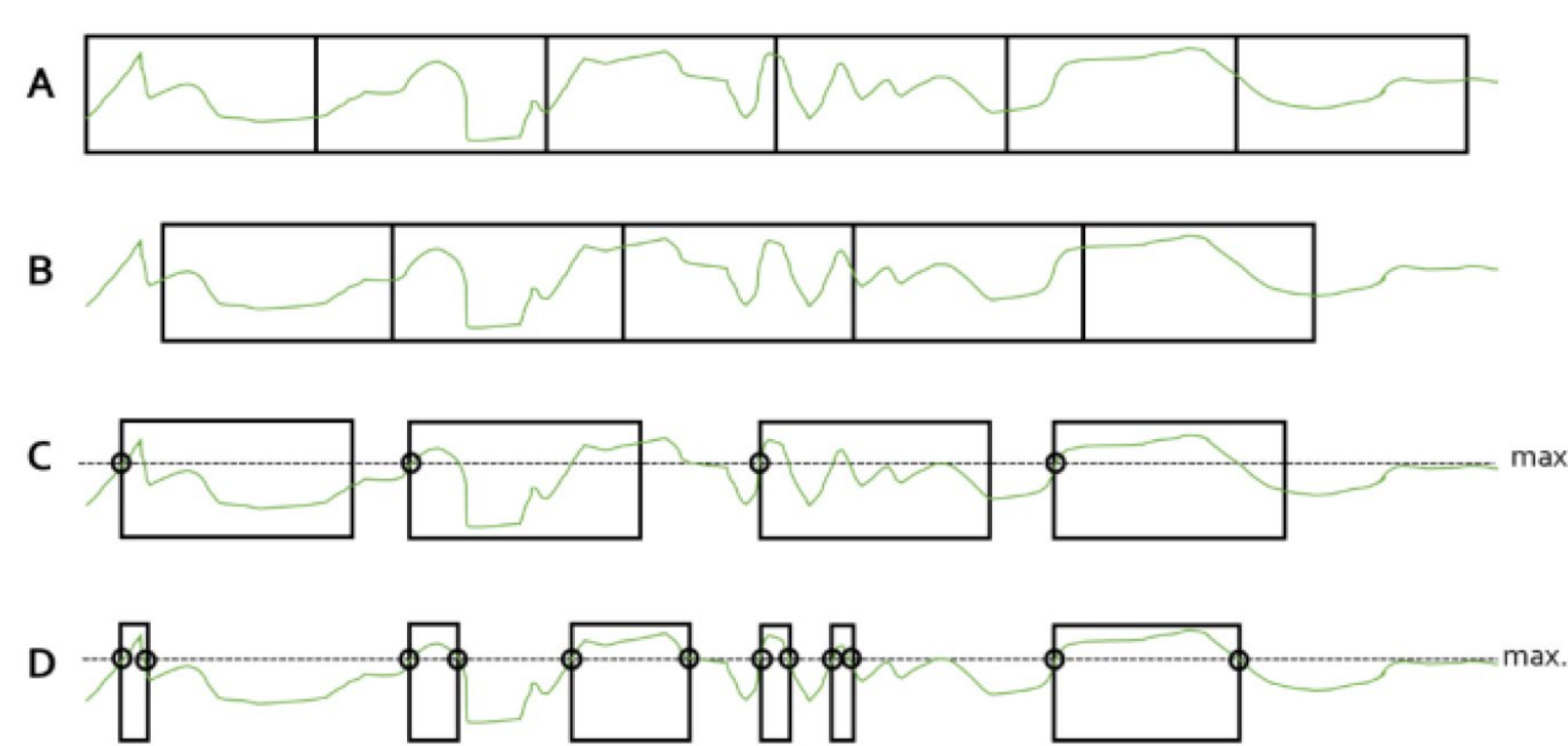


Figure 1
A: regular temporal aggregation
B: regular temporal aggregation with an offset
C: temporal aggregation triggered by an event (value exceeding threshold)
D: irregular event-based temporal aggregation

Representing nonverbal signals at different temporal granularity

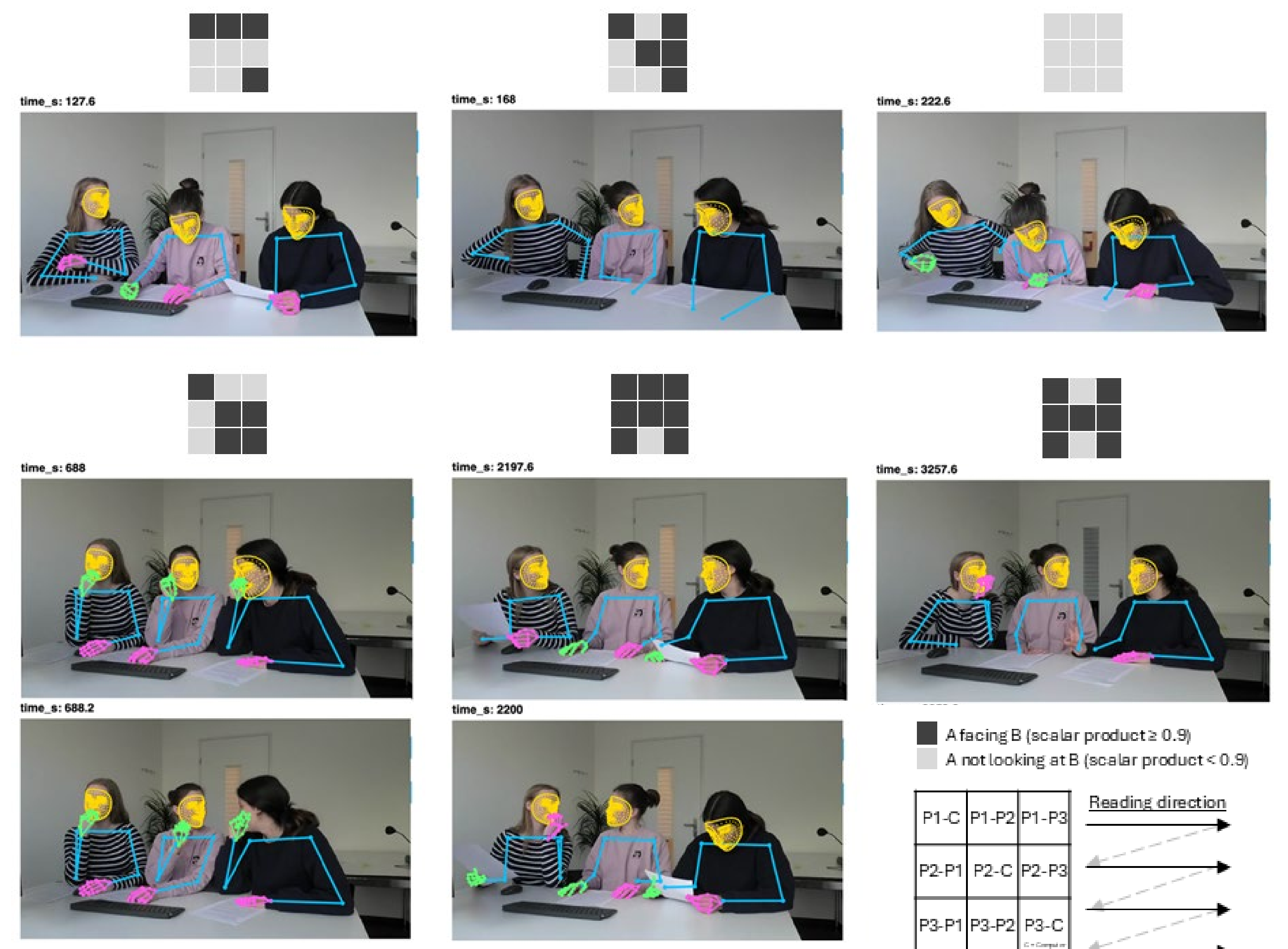


Figure 2: Examples of the 3x3 glyph arrays showing the binarized maximum MOIs during a 5-second segment, along with one (top row of figures) or two (two bottom rows of figures) characteristic frames from this period that illustrate the pattern of the 3x3 glyph array. The example frames are overlaid with the extracted body landmarks (colored lines and points).

Different glyph-based encodings (e.g., glyph arrays in Fig 2 and multi-dimensional area-based glyphs in Fig 3) were used to represent aggregated time-series data in compact visual formats to allow interactive exploration of both individual and dyadic NVB patterns. Exploring the data at different temporal granularities (Fig. 3) seems to provide insight into persistent and temporary group activities and the domain experts may be able to provide the context required to make sense of the visible patterns. Independent of the common understanding that existing behavioral constructs need to be extended from what is possible with manual encoding of group interactions, this project was not able to fully exploit the domain specific knowledge for the interpretation of the visualizations.

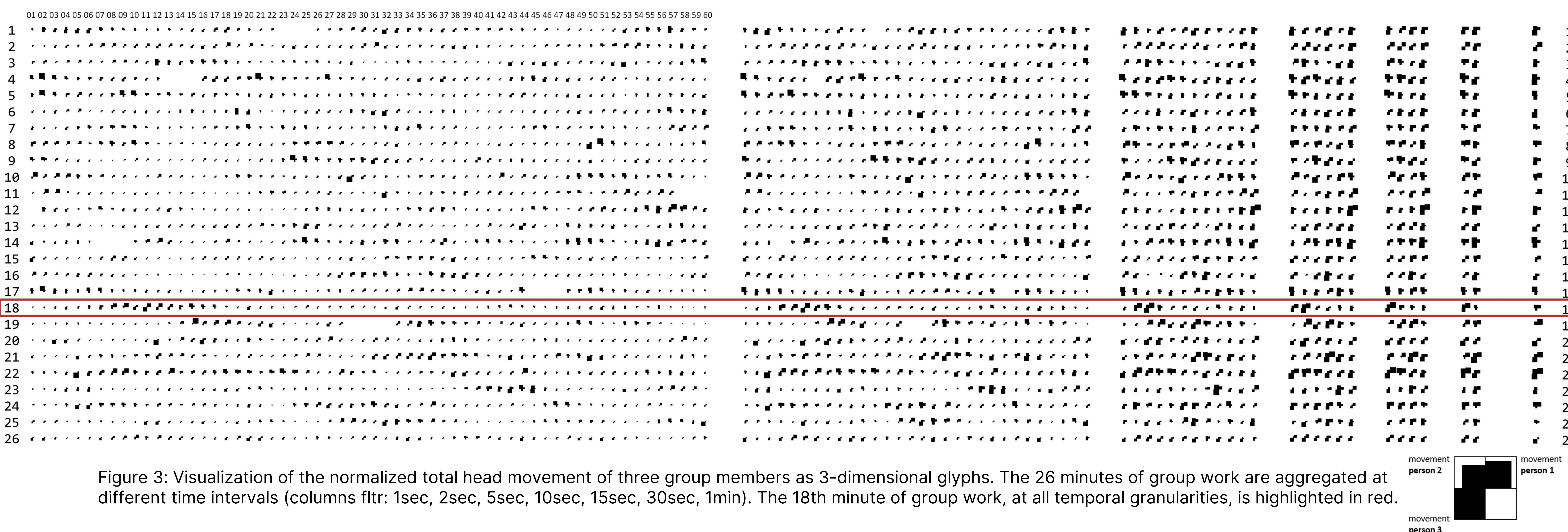


Figure 3: Visualization of the normalized total head movement of three group members as 3-dimensional glyphs. The 26 minutes of group work are aggregated at different time intervals (columns fltr: 1sec, 2sec, 5sec, 10sec, 15sec, 30sec, 1min). The 18th minute of group work, at all temporal granularities, is highlighted in red.

Authors
Matus Gasparik, Carolin Bronowicz, Susanne Bleisch
matus.gasparik@fhnw.ch
carolin.bronowicz@fhnw.ch
susanne.bleisch@fhnw.ch

References
[1] C. Lugaresi, J. Tang, H. Nash, C. McClanahan, E. Ubowaja, M. Hays, F. Zhang, C.-L. Chang, M. Yong, J. Lee, and others. Mediapipe: A framework for perceiving and processing reality. In Third Workshop on Computer Vision for AR/VR at IEEE Computer Vision and Pattern Recognition (CVPR), vol. 2019, 2019. doi: 10.48550/arXiv.1906.08172 1
[2] L. Paneth, L. T. Jeitziner, O. Rack, K. Opwis, and C. Zahn. Zooming in: The role of nonverbal behavior in sensing the quality of collaborative group engagement. International Journal of Computer-Supported Collaborative Learning, 19(2):187–229, jun 2024. doi: 10.1007/s11412-024-09422-7 1

Acknowledgements
This work has been funded by the Swiss National Science Foundation within the National Research Program NRP 77 (Project 407740 187258) Next generation learning: Investigating and enhancing collaborative group engagement quality to support learning groups. We thank all the study participants for their time and engagement. Without them, this work would not have been possible. All data is from participants who have given their informed consent about the use and publication of the collected data, including pictures.