Aalborg Universitet

AALBORG UNIVERSITY

CAVA360VR2: An Open-Source Tool for Collaborative Learning and Immersive Analysis in 360-Degree VR Environments

Paulsen, Lucas; Davidsen, Jacob Gorm

[Link to publication from Aalborg University](#)

CAVA360VR^2: An Open-Source Tool for Collaborative Learning and Immersive Analysis in 360-Degree VR Environments

Lucas Paulsen, Jacob Davidsen
lupa@ikp.aau.dk, jdavidsen@ikp.aau.dk
Aalborg University

Abstract: CAVA360VR^2 is a free, open-source multi-user Virtual Reality (VR) tool designed for collaborative learning, immersive analysis, and training. Developed by BigSoftVideo at Aalborg University, CAVA360VR^2 enables users to explore, annotate, and discuss synchronized 360-degree videos in real-time. The tool supports both VR and desktop modes, making it accessible for users with or without headsets. Key features include timeline navigation, a shared drawing tool, transcript integration, multiple video portals, and real-time collaborative playback. CAVA360VR^2 is ideal for applications in education, qualitative research, and cross-institutional collaboration, offering a democratic model where all users have equal access to tools. During the workshop, we will demonstrate CAVA360VR^2 in action and discuss its potential uses for teaching, research, and analysis. This session aims to foster dialogue, gather feedback, and explore partnerships for future development. Participants are encouraged to try the tool and share their insights.

Introduction

CAVA360VR^2 (Davidsen, McIlvenny, et al., 2024) is a free, open-source, multi-user Virtual Reality (VR) application designed to enable collaborative learning and joint research activities in an immersive environment. Developed by BigSoftVideo at Aalborg University, CAVA360VR^2 allows users to collaboratively explore, annotate, and analyze 360-degree video content in real-time virtual environments. The tool supports a unique model of democratic collaboration, making it particularly suited for research and educational contexts where the focus is on interaction, reflection, and analysis. A previous version of CAVA360VR^2 has been used in medical training (Davidsen et al., 2022; Davidsen et al., 2024), teacher mentoring (Paulsen & Davidsen, 2024) and collaborative research activities (McIlvenny, 2020; Vatanen et al., 2022).

CAVA360VR^2 is built using Unity and Photon Engine. It supports both VR and desktop modes, ensuring accessibility for users with and without VR headsets. The tool is compatible with most high-end VR headsets, including HTC VIVE PRO (1+2), Oculus Rift S, HP Reverb, Valve Index, Oculus Quest 2 (via link cable). For desktop users, CAVA360VR^2 runs on Windows 10/11. Participants will need a VR-ready PC or laptop and a stable internet connection to participate in a CAVA360VR^2 session. To use CAVA360VR^2, session hosts will have to create free photonengine account – this allows up to 20 simultaneous users. After this, users can use the CAVAbuilder to freely generate a 360VR session and distribute the build to trusted users (see Figure 1 for an illustration).

Figure 1
CAVA360VR^2 Flowchart
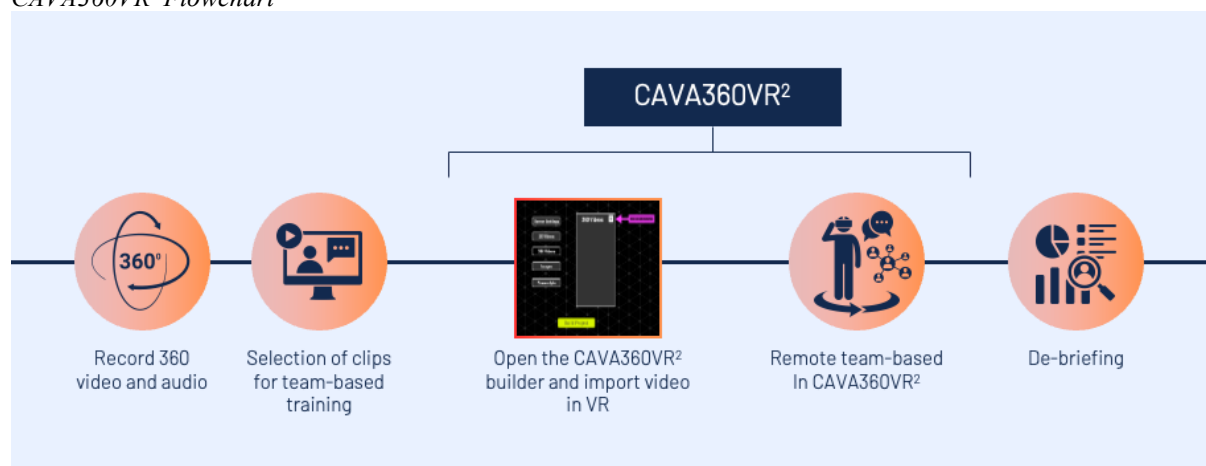
The workshop aims to showcase how CAVA360VR^2 can facilitate collaborative learning through innovative use of VR technology. Participants will have the opportunity to experience a live demo of the software, followed by an interactive discussion on its potential applications for learning, teaching, and research in various fields.

Background

CAVA360VR^2 emerges from the need to integrate collaborative and immersive capabilities in 360-degree VR environments, addressing the limitations of traditional VR platforms designed primarily for individual use. While existing research emphasizes the potential of VR for enhancing individual learning and skill acquisition, the social and collaborative dimensions of learning in immersive VR remain underexplored. Previous studies have demonstrated the effectiveness of shared viewing and mutual awareness in VR video platforms but often lack tools for fostering true collaborative interaction, such as shared annotations, dynamic movement, and synchronized engagement (Jin et al., 2023; Nguyen et al., 2017).

Grounded in participatory learning theories (Sfard, 1998) and interactional theories of embodiment (Streeck et al., 2011), CAVA360VR^2 is designed to facilitate mutual and embodied awareness, enabling users to engage in coordinated activities within shared 360-degree virtual spaces. By supporting features like synchronized timelines, laser pointers, and collaborative annotation tools, the platform enhances the co-construction of knowledge and shared problem-solving. This approach aligns with the theoretical frameworks emphasizing the importance of mutual awareness and embodied participation in creating meaningful and inclusive learning experiences.

CAVA360VR^2 builds upon prior work in immersive VR collaboration (Paulsen et al., 2024), integrating advanced networking capabilities and interactive tools to create a robust environment for team-based learning. Unlike conventional VR applications, which often replicate physical activities or rely on static interactions, CAVA360VR^2 provides dynamic and flexible solutions for immersive learning, fostering a sense of community and collaboration that mirrors traditional classroom dynamics.

Main features of CAVA360VR^2

CAVA360VR^2 is designed with features that enhance collaborative learning and interaction in virtual environments supporting various activities (see Figure 2 for an illustration of some of the tools inside CAVA360VR^2).

Figure 2
Inside CAVA360VR^2 – Each Image is the View of an Individual
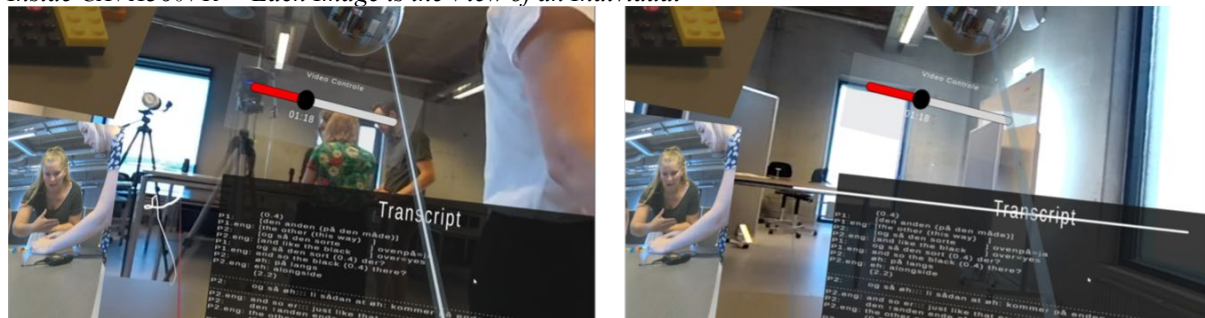
With the CAVABuilder users can create and configure immersive collaborative 360VR projects by adding synchronized 360-degree videos, 2D videos, images, 3D objects, and DOTE transcripts. Then you compile the project into a distributable folder containing media files, Photon App ID, and an executable file (.exe). For the VR mode, we wish to mark the following key features:

VR file browser

- Access and manage all imported media files (360-degree videos, 2D media, images) within the VR environment.
- Open media files can be repositioned and scaled in the VR application

Timeline navigation

- Navigate specific moments in videos using a shared timeline.
- Playback is synchronized across all participants (the butterfly effect).

Drawing tool
- Annotate directly on 360-degree videos with adjustable brush sizes.
- Erase and modify drawings that are visible to all participants.

Laser pointer with animated trail
- Visualize user focus and direction with the animated trail on the right controller.
- Ideal for guiding and highlighting points during discussions without leaving a permanent mark.

Teleport option
- Move dynamically within the 360VR space.
- Facilitate group formations and enhance spatial interaction.

Multiple video portals
- Switch between various 360-degree video perspectives depending on the number of cameras used.
- Communication and synchronization remain intact across portals.

Avatar customization
- Unique avatar colours for easy identification.
- Colours are reflected in pointers, drawings, and video portal indicators.

Transcript viewer
- Display and synchronize DOTE transcripts (McIlvenny et al., 2022) with video playback.
- Navigate videos using timestamped transcript entries.

Zoom and rotate
- Adjust the size and orientation of media objects.
- Enhance spatial alignment for collaborative focus.

Portal color indicators
- Coloured rings show participants in specific video portals.
- Dynamically update to reflect real-time user movement.

Mirror camera
- Activate the mirror cam to see what is behind you
- Lock the mirror cam and reposition the window in the 360VR space

Applications in learning and teaching

CAVA360VR^2 supports a wide range of applications in education and research, making it a versatile tool for various contexts. It facilitates collaborative analysis and discussion, allowing students and researchers to jointly analyze 360-degree video recordings of real-world environments, fostering rich discussions on topics such as classroom interactions, fieldwork documentation, and virtual simulations. Additionally, CAVA360VR^2 is well-suited for immersive training in fields like medical education, emergency response, and classroom management, where realistic virtual environments can significantly enhance learning outcomes. The tool is also highly valuable for qualitative research, particularly for projects that require detailed analysis of recorded interactions, including ethnographic studies, interaction analysis, and digital learning research. Furthermore, as an open-source tool, CAVA360VR^2 supports cross-institutional collaboration by enabling researchers to share and co-analyze video data in virtual spaces, fostering partnerships and innovative research across institutions.

Structure of the session

Participants in the demo will experience
- Hands-on demonstration of CAVA360VR^2: Attendees will experience a live demonstration, showcasing key features of the software, including timeline navigation, annotation tools, transcript viewer and portal switching.
- Interactive discussion on the potential of immersive technologies in CSCL design and research: participants will be invited to discuss how immersive technologies such as CAVA360VR^2 can be integrated in their teaching and research practices in order to support collaborative learning processes.

Conclusion

CAVA360VR^2 represents a significant step forward in collaborative learning technologies. By combining immersive VR environments with open-source accessibility, the tool offers new possibilities for teaching, research, and cross-institutional collaboration. We look forward to sharing CAVA360VR^2 with the learning sciences community and exploring its potential in various educational and research contexts.

References

Davidsen, J., Larsen, D. V., Paulsen, L., & Rasmussen, S. (2022). 360VR PBL: A New Format of Digital Cases in Clinical Medicine. *Journal of Problem Based Learning in Higher Education*, *10*(1), Article 1. https://doi.org/10.54337/ojs.jpblhe.v10i1.7097

Davidsen, J., Larsen, D. V., Rasmussen, S., & Paulsen, L. (2024). Collaborative 360° Virtual Reality training of medical students in clinical examinations. *Medical Education Online*. https://doi.org/10.1080/10872981.2024.2412398

Davidsen, J., McIlvenny, P., Paulsen, L., & Larsen, A. C. M. (2024, December 17). *CAVA360VR2.0*. https://github.com/BigSoftVideo/CAVA360VR2.0

Jin, Q., Liu, Y., Sun, R., Chen, C., Zhou, P., Han, B., Qian, F., & Yarosh, S. (2023). Collaborative Online Learning with VR Video: Roles of Collaborative Tools and Shared Video Control. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–18. https://doi.org/10.1145/3544548.3581395

McIlvenny, P. (2020). New Technology And Tools To Enhance Collaborative Video Analysis In Live 'Data Sessions. *QuiViRR: Qualitative Video Research Reports*, *1*, a0001–a0001. https://doi.org/10.5278/ojs.quivirr.v1.2020.a0001

McIlvenny, P., Davidsen, J., Kovács, A. B., & Stein, A. (2022). *DOTE: Distributed Open Transcription Environment* [Computer software]. Github. www.dote.aau.dk

Nguyen, C., DiVerdi, S., Hertzmann, A., & Liu, F. (2017). CollaVR: Collaborative In-Headset Review for VR Video. *Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology*, 267–277. https://doi.org/10.1145/3126594.3126659

Paulsen, L., Dau, S., & Davidsen, J. G. (2024). Designing for collaborative learning in immersive virtual reality: A systematic literature review. *Virtual Reality*, *28*(1). https://doi.org/10.1007/s10055-024-00975-4

Paulsen, L., & Davidsen, J. (2024). A Model for Collaborative Immersive Classroom Management Development Using Multi-user Virtual Realit. *23rd European Conference on E-Learning (ECEL 2024)*. European Conference on e-Learning (ECEL 2024), Porto.

Sfard, A. (1998). On Two Metaphors for Learning and the Dangers of Choosing Just One. *Educational Researcher*, *27*(2), 4–13.

Streeck, J., Goodwin, C., & LeBaron, C. D. (Eds.). (2011). *Embodied interaction: Language and body in the material world*. Cambridge University Press.

Vatanen, A., Spets, H., Siromaa, M., Rauniomaa, M., & Keisanen, T. (2022). *Experiences in Collecting 360° Video Data and Collaborating Remotely in Virtual Reality*. *3*. https://doi.org/10.5278/ojs.quivirr.v3.2022.a0005

Acknowledgements