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Technical Brief

AR / VR Design Considerations for Immersive Collaborative Data Analysis Platforms

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This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 883293. The content of this document represents the view of the authors only and is their sole responsibility. The European Commission does not accept any responsibilty for any use that may be made of the information it contains.

1. AR/VR Design Considerations for Immersive Collaborative Data Analysis Platforms[1]

Designing immersive collaborative data analysis platforms that utilise mixed reality technologies, which includes both virtual reality (VR) and augmented reality (AR), involves several key considerations. These considerations revolve around creating intuitive and efficient interfaces, facilitating effective collaboration, optimising data visualisation, ensuring user comfort and enhancing the level of immersion. This brief will discuss each of these key factors which should be considered when designing AR/VR immersive collaborative data analysis platforms.

2. User Interface Design

It is important to ensure that the User Interface (UI) is intuitive to reduce the amount of training required to use the platform. The use of natural gestures and movements for user input should be utilised where possible to enhance immersion and minimise the learning curve when new users are introduced to the platform. This also helps people who are unfamiliar with VR/AR headsets and controllers as they do not need to learn how the controller works to be able to interact with the platform.

All visual elements should be designed to be clear and all legible visual elements, such as text and icons, should ensure readability in the AR/VR environment.

Ergonomics should be considered, including whether the user is intended to sit or stand and adjustments to the interface should be possible to ensure that it is suitable for different user preferences and physical constraints.

3. Movement

For large areas, where is it not possible for users to physically walk around the environment, different forms of locomotion should be considered, that is to say, the method of allowing users to navigate around an environment e.g. teleportation. Virtual large spaces can be disorientating for users to navigate around, therefore visual anchors should be used to help with navigation around environments, these provide a frame of reference to users.

During the INFINITY project three room types were developed, each room served a different function. The rooms functions needed to be considered during the design of the prototype. Listed below are the different room types and a brief description of their function and how this impacted the design of these rooms:

Lobby: The Lobby was intended to act as an immersive homepage and provide a private and personal space for the user to familiarise themselves with the VR before entering a public environment. It was also used as a break-out space from the work environment. To achieve this the room was modelled on a living room to create a more relaxing atmosphere, this can be seen in figure 1.

Figure 1: Lobby

Lab: The Lab was required to be a large space where collaborative data analysis could take place. Not only did the room need to allow for numerous users in the same space, but also within this space users were able to place data analysis podiums, in a smaller environment that could have caused clutter and a feeling of claustrophobia. As mentioned previously, such a large space can be disorientating therefore different circular seats, marble columns and statues were used as a visual anchor to serve the purpose of making the environment look less empty whilst also acting as subtle frames of reference to improve the usability of the system as a whole. This can be seen in figure 2.

Figure 2: Lab

Meeting rooms: The meeting room is another area for collaborative work, with more of an emphasis encouraging discussions, and facilitating presentations of data to groups of people. To achieve these goals the meeting room houses a large round table to encourage users to gather around. There are 6 screens within the room to ensure that no-matter where the user stands they will have sight of the screens. A screenshot of the meeting room can be seen in figure 3.

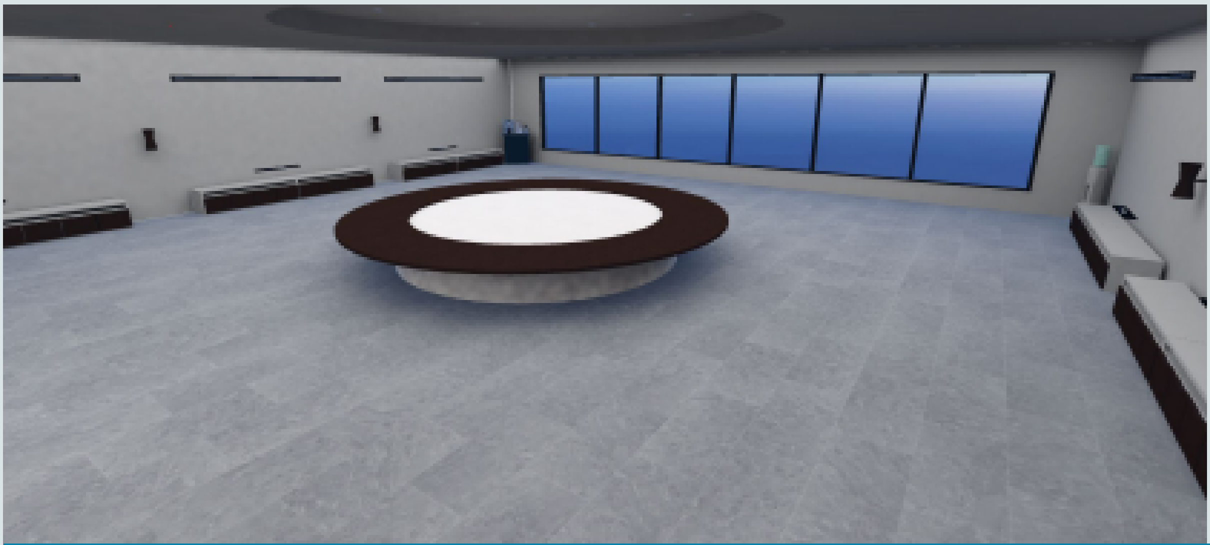

Figure 3: Meeting room

3. Collaboration

Real-time collaboration and communication between multiple users in the AR/VR environment is highly desirable. To achieve this, tools should be provided to allow for shared data exploration, annotation, and markup, to allow users to work together seamlessly. This can also be enhanced by integrating voice chat or text chat features to allow for real-time communication between users.

Users should be able to create a 3D representation of themselves, or an avatar, which will be visible to other users inside the mixed reality environment to enhance social presence and to create a sense of teamwork.[2]

4. Data Visualisation

In order to optimise data visualisations in mixed reality environments, factors such as depth perception and spatial understanding should be considered. The immersive nature of VR/AR should be utilised to represent data in three-dimensional space. Instead of traditional 2D charts or graphs, create interactive 3D visualisations where data points are positioned in space, allowing users to perceive depth and spatial relationships.

Depth cues should be used to enhance the perception of depth and spatial understanding in the visualisation. These cues include:

- Applying shading and lighting techniques to the data visualisations to convey depth information, using techniques such as ambient occlusion, shadows, and highlights to create a sense of depth and spatial relationships.
- Adjusting the size of visual elements based on their depth or importance in the data. Objects that are closer to the viewer can be rendered larger to emphasize their proximity and significance.
- Applying perspective projection to the data visualisation to replicate real-world depth perception. Objects that are further away should appear smaller and converge towards a vanishing point.

Users should be able to interact with the data visualisations, allowing them to move around and explore the data from different angles and perspectives. This active exploration enhances spatial understanding and provides an improved understanding of the data relationships. Users should also be able to use hand gestures or controllers to manipulate the data, rotate and scale visual elements, or navigate through different data dimensions using intuitive gestures or movements. This enhances the sense of engagement and control over the data. Options should also be provided to the user for scaling, filtering, and grouping data to manage complexity and improve the clarity of visual representations.

When developing AR applications, spatial cues or markers should be used to anchor data visualisations to real-world objects or environments. For example, overlay data visualisations onto physical objects or surfaces, allowing users to perceive the data within their immediate context. This contextualisation improves the understanding and relevance of the data.

Techniques such as opacity or transparency can be very effective to represent multiple data layers or complex relationships. Users can visualise and interact with different data sets simultaneously, enabling them to uncover hidden patterns or correlations.

Where possible, real-time data streams should be integrated into the VR/AR visualisation. This way, users can observe dynamic changes in the data and witness how it evolves over time. This live feedback enhances the understanding of data trends and facilitates informed decision-making.[3]

5. Comfort and Immersion

To enhance both comfort and the level of immersion for users when using VR/AR applications there are a number of factors which should be considered. All user interfaces should be designed to be intuitive and user-friendly so that they are easy to navigate and understand. Complex or convoluted interfaces can hinder immersion and frustrate users. Natural and intuitive interaction methods, such as hand gestures, voice commands, and gaze-based interactions, should be considered where appropriate to enhance the sense of presence and reduce the need for complex controllers.

Incorporating haptic feedback should be considered to provide users with a tactile sense of interaction and enhance immersion.

As mentioned previously, real-time collaboration and communication between users in the virtual or augmented environment, via voice chat, text chat, or spatial audio can help to enhance the feeling of teams working together, with user avatars or live video feeds of collaborators included to make users feel more connected and engaged with each other.

Attention should be paid to the visual aesthetics of the virtual or augmented environment. High-quality graphics and textures should be used to create a visually appealing and realistic experience.

The use of spatial audio should be considered to create an immersive soundscape that corresponds to the user's actions and the virtual environment. This can enhance the feeling of presence and immersion.

It is important to optimise the performance of the AR/VR application to maintain a high frame rate and minimise latency, as lag or stuttering can break immersion and cause discomfort for users. To help achieve this, techniques such as level of detail (LOD) rendering, culling, and occlusion should be considered to improve performance without compromising visual quality.

To ensure that the platform is accessible to a diverse range of users, including those with physical disabilities or limitations, options should be provided for customising the application, such as adjustable text size and colour schemes, to accommodate users with different visual preferences or impairments.

Considerations should be made for users who may experience motion sickness or discomfort in VR. This can be achieved by reducing the field of view while the user is in motion[4] or by using teleportation to change locations inside the virtual environment.[5]

By addressing these design considerations, immersive collaborative data analysis platforms can offer users a powerful and engaging environment for analysing and interpreting data, whilst enabling effective collaboration.

References

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