# Watch The Videos Whenever You Have Time

Asynchronously Involving Neurologists in VR Prototyping


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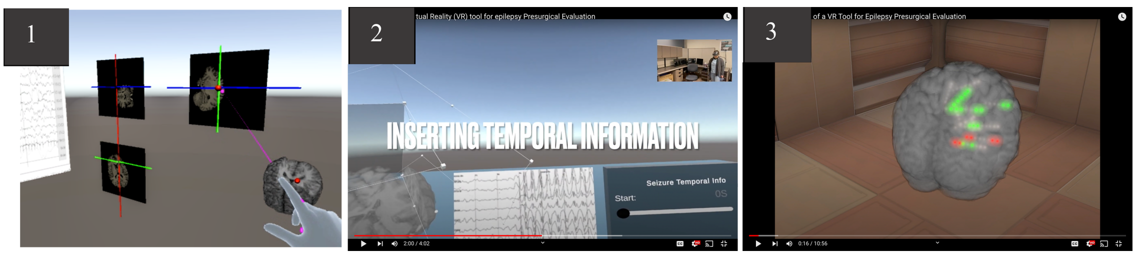


**Figure 1: Videos were a primary medium to update users and receive their feedback in three virtual reality (VR) prototyping iterations. Above, images from each of our three video iterations with neurologists highlight (1) our initial 2D, 3D, and chart components, (2) VR interactions with captions and a picture-in-picture video showing the presenter, and (3) our seizure propagation visualizations.**


## ABSTRACT

We present a video-based approach for collecting feedback on virtual reality (VR) prototypes. While developing a high-fidelity VR prototype to help neurologists analyze seizure propagation information for brain surgery planning, our neurologist collaborators' limited availability reduced opportunities for them to give feedback on critical design decisions. In response, we developed a remote feedback process in which developers created videos of the VR design process and used these to ground iterative input from neurologist collaborators. We describe our approach and detail opportunities and challenges for video-based feedback to play a role in future VR prototyping.


## CCS CONCEPTS

• **Human-centered computing** → Interaction design; Interaction design process and methods.


## KEYWORDS

Prototyping, Virtual reality, Video, Neuroscience

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## 1 INTRODUCTION AND RESEARCH BACKGROUND

The significant growth of virtual reality (VR) applications in domains such as neuroscience and neurosurgery [1, 4, 5] indicates a promising future of immersive solutions for non-gaming areas. Potential benefits of VR technologies—including accurate 3D shape perception, spatial judgment, depth perception [3], and fast changes of viewpoint through physical movement and direct interactions [5] — have also driven considerable interest from domain experts in areas like medical imaging. Engaging these kinds of domain experts in VR prototyping can help to progressively shape a product based on their feedback. However, translating domain knowledge into VR is a common challenge [2]. VR-beginner participants often require assistance with VR hardware and software to build the competencies to provide feedback in an early design stage [7]. Opportunities



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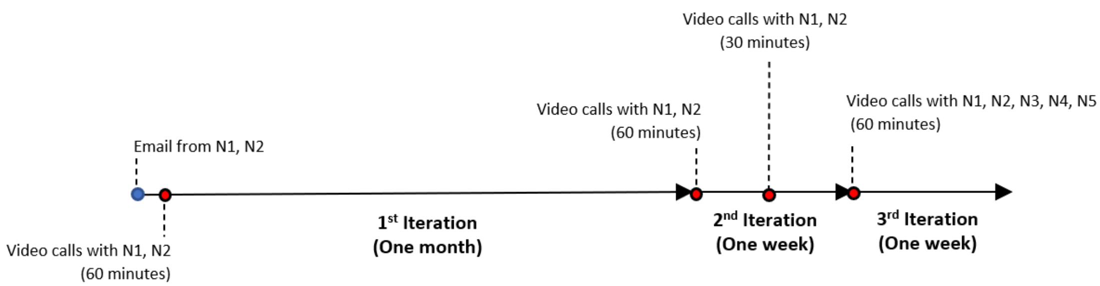


**Figure 2: A linear view of the prototyping with collected written or oral feedback from neurologists via email or video calls. The durations of online meetings were one hour or 30 minutes. We developed the initial VR prototype in one month (part-time) before the first iteration.**

for domain experts like neurologists to provide feedback can also be impacted by their extremely limited availability. In response, we developed a design approach that allows experts to iteratively provide feedback on a VR prototype via video documentation, without needing to interact with VR software or hardware.

Video recording is an effective approach for communicating the use of a system and receiving feedback from participants and is extensively used in the HCI [9, 11]. Videos are editable, accessible, and can help audiences to understand concepts step by step. Audiences can also control video playback, giving them freedom to skip or repeat slices as needed. In fact, videos have already proven to be useful for designers using sketched-based AR/VR prototyping [8, 10, 14]. However, there is a need for more investigation of video applications for VR prototyping with head-mounted displays (HMDs). In this paper, we discuss how a research team used video sharing to adapt a fast-paced HMD-based virtual reality prototyping process to the tight schedules of neurologist collaborators.

The medical users in our study are from a small medical community and are experts on epilepsy diagnosis and treatment. A part of their work is focused on epilepsy surgical planning. These neurologists collect intracranial EEG data by implanting electrodes into a patient's brain to support diagnosis. Traditionally, they analyze this data together with a 2D on-screen representation of a 3D MRI brain scan. This allows them to investigate seizure propagation during a diagnostic step called the "reading phase". Next, neurologists present their analysis results and make decisions regarding surgery with other physicians in clinical meeting rounds. Currently, no standard tool set exists to support seizure analysis in the reading phase or the presentation of data in epilepsy conference meeting rounds. Instead, each medical expert uses a personal approach to prepare and communicate their analyses, often relying on tools like PowerPoint.

Our HMD VR tool aims to help neurologists analyze and summarize epilepsy data by allowing them to visually examine the positions and responses of selected electrodes based on a patient MRI scan. We also sought to help neurologists understand spatiotemporal seizure propagation based on the implanted electrodes and EEG data (Figure 1right).

To better include neurologists in our development effort, we developed a process that used high-fidelity videos of our VR prototypes to support asynchronous collaboration and iteration. These short videos allowed us to receive feedback about visual design choices over the course of a short ten-week prototyping process with three design iterations (Figure 2) in which neurologists communicated design decisions via email and through short online meetings. These decisions included feedback about how to support the positioning of electrodes in the model brain and how to summarize the analysis of seizure propagation. In this paper, we reflect on lessons learned and highlight practical challenges for adopting this kind of asynchronous video-based approach during VR prototyping.

## 2 RELATED WORK

There are different approaches for prototyping in immersive environments, from low fidelity (lo-fi) sketching to high fidelity (hi-fi) digital prototyping [13]. Lo-fi methods, like sketching, are fast, but a final product needs to be developed separately from sketches [13]. Recent studies have focused on sketch-based video prototyping for mobile AR devices, for example in Rapido [10] and RealitySketch [14]. Also, researchers have presented concepts to VR users using videos, for example in TutoriVR [8]. These studies have primarily focused on providing users with the ability to sketch models [8, 10, 14] or test new behaviors [10]. However, these techniques are mostly constrained to mobile AR [10, 14], or focus on watching videos in VR [8].

Using prototyping approaches with high visual fidelities can result in a better understanding of 3D design concepts [13]. To support the creation of hi-fi prototypes, rapid prototyping platforms like Shapes XR[1] provide the ability to design a rapid 3D prototype in VR. These approaches are suitable for prototyping from scratch without any pre-existing designs. However, using these rapid prototyping platforms may not be possible when a prototype extends a previous design or if a design includes detailed concepts for domain-specific data. We built our prototype based on a previously-developed design within a programming framework [1]. This enabled us to progressively improve the prototype and

[1]https://www.shapesxr.com/

turn it into a final version instead of producing a prototype different from the final digital product in each prototyping iteration. In our approach, we could focus on details of medical visualization, like brain anatomy.

The engagement of VR novice end-users in the VR prototyping with high levels of fidelity often also requires the assistance of technical experts deploying the VR application or prototyping technologies on the available hardware [7]. Moreover, in-person VR prototyping requires the presence of all participants at the same time and place. Using a remote prototyping process can remove the restrictions of being present in the same place. For example, Irlitti et al. [6] connected remote participants to a virtual environment through a human surrogate with a shared VR viewpoint. However, this still has substantial time demands and can include communication overhead between facilitators and participants. Similarly, Mottelson et al. [12] conducted remote and unsupervised VR studies with VR-owning participants (mostly VR experts). However, this method required "over-recruitment" of participants to compensate a number of removed study samples due to including "aberrant responses" of some participants [12].

## 3 APPROACH

Understanding seizure propagation is inherently a 4D problem with 3D brain images and temporal information about seizure propagation. Early positive feedback from neurologists on the visualization of seizure propagation indicates that VR has the potential to support the planning of epilepsy brain surgeries [1]. This motivated us to develop a VR tool. Applying a remote VR approach in situations like ours with small populations of VR novices poses serious challenges. Instead, we asynchronously provided videos from our VR prototype so that participants could watch the videos whenever they wanted and provide written feedback or engage in short online meetings based on their availability.

**Participants.** Our study team consisted of an HCI practitioner with experience in the study area who is an expert in VR development and five neurologists (N1, N2, N3, N4 and N5). Two of these were neurology specialists (N1 and N2), while three were clinical fellows, who are in medical training to become specialists (N3, N4 and N5). N1 and N2 are co-authors of this paper.

**VR Prototype.** We chose to develop a hi-fi prototype to enable the neurologists to compare the design choices of 3D medical concepts in detail. However, preparing a design in a virtual environment has higher development costs compared to a lo-fi prototype, like sketching. Some main factors helped us iteratively develop the VR prototype with high resolution visuals and record videos for the presentation of the VR prototype in our 10-week design cycle. We built the VR prototype on top of our own existing Unity-based[2] VR application for the visualization of seizure propagation [1] and extended that prior work using Unity assets. VR interactions from the previous project [1] inspired the interactions in the new prototype. For example, we used the same approach for selection with the VR controllers.

**Videos.** The prototyping process included three iterations based on three recorded videos of the improved VR prototype. These videos were screen recorded using the Windows mixed reality portal[3] displaying the camera field of view (FOV) of the presenter inside the VR environment. The HCI practitioner added voice-overs to the videos and described details. Voice-overs included some questions about the visual design choices. A picture-in-picture mode in the second and third videos showed the VR interactions and the presenter's posture. The durations of the first, second, and third videos were 17, 4, and 11 minutes respectively.

**Feedback elicitation.** Before the start of the prototyping iteration, we conducted several kickoff meetings and interview sessions using a remote online approach with two neurologists (N1 and N2) for requirements elicitation. The VR prototyping process was spread over two months and two weeks (working part-time), including about a month for developing the initial VR prototype, a month for the first iteration, a week for the second iteration and a week for the third iteration (Figure 2). These iterations were based on the availability of neurologists. The number of iterations was based on reaching feedback saturation—we started to hear similar feedback from our participants instead of learning something new. Each iteration started by sending a recorded video to neurologists and continued with receiving feedback from them, improving the prototype, and preparing a video for the next iteration. The prototyping process included video calls and asynchronous written communications with neurologists. The two neurology specialists, N1 and N2, participated in all three online prototyping meetings, while the clinical fellows, N3, N4 and N5, took part in the last online meeting (Figure 2). We gathered feedback by presenting several design solutions, and correspondingly, we removed the alternative solutions from the design.

**Asynchronous Communications.** Three days before the scheduled remote meetings, we sent emails to participants. In the emails, we provided descriptions about the prototype and the videos as well as links to the videos via Google Drive or YouTube. All the participants were able to watch the videos before the meetings. As a backup, we had a plan to present videos in the meetings if any of participants could not watch videos beforehand. Most of the feedback from neurologists came during the video calls. However, we also received email feedback from neurologists before the online meeting during the first iteration which contributed to detailed discussions during the meeting itself.

**Online meetings.** The online meetings with neurologists started with the HCI practitioner showing a few frames of the video as a recap. We then raised initial questions about visual design choices and received free-form feedback about how to improve the VR prototype. We asked neurologists questions about potential improvements of the VR tool and how it could be more tailored to epilepsy presurgical evaluation. The remote discussions were not limited to design choices of visuals during the prototyping process, however we mainly focused on undetermined visual design choices. The final ten minutes of each online meeting in the first and second iterations focused on what neurologists liked about the videos and how to improve the video prototyping process.

## 4 TAKEAWAYS

After our meetings, we thematically coded feedback to identify high-priority improvements for the tool as well as opportunities

[2]https://assetstore.unity.com

[3]https://www.microsoft.com/en-ca/p/mixed-reality-portal/9ng1h8b3zc7m

for improving our video prototyping approach. At the end of the process, we collected and refined these observations to highlight three high-level takeaways for future VR video prototyping.

**Consider video when placing objects in the VR world.** Choosing the placement of objects, including the virtual camera, in a VR environment can have a major impact on the visibility of prototype details in the resulting video. In the first prototyping iteration of our study, both N1 and N2 noted that some visualization details, including the precise positions of some electrodes in a virtual brain, could not be seen. In subsequent videos, we adjusted the position of objects like brain models and make them big enough in the view while describing details. Based on these experiences, we recommend placing key virtual objects in the middle of the camera FOV when describing them in video.

**Avoid subtle changes in consecutive video frames.** Subtle movements in prototype videos (including those resulting from the natural movement of a presenter's head) can be distracting and disorienting to viewers. For instance, in the second iteration, N2 mentioned that in some video sections, some "jumping around" happened during the video, referring to the fast movements of the VR camera. In the third video, we reduced camera movement by relying on simulated inputs via the Mixed Reality ToolKit (MRTK)[3] rather than from a live headset. This made it possible to keep the camera still when simulating hand interactions and eliminate hand interactions while changing the camera transform. We also reduced VR headset rotation by reducing distances between virtual objects shown in consecutive video clips. While we found these approaches to be quite effective, wearing a VR headset while interacting with virtual objects using controllers or hand gestures can sometimes still be a better choice, since this makes it easier to synchronize hand interactions and camera movements.

**Use video storytelling to explain VR interactions.** Novice users are often confused about where to start in VR [2], in part because virtual environments often offer many opportunities for distraction. In contrast, video demonstrations can enable a more focused storytelling approach that emphasizes important aspects of the prototype where feedback is needed. We found that providing a descriptive introduction, presenting the final product outcome, including short video clips focusing on key features, and using consistent language through video recording helped make it easier for neurologists to follow the video and focus on the essential decisions. In particular, during the second iteration, N1 and N2 suggested that we also provide specific feedback elicitation prompts to encourage input from clinical fellows, who had not participated in previous design phases. N2 also mentioned that more "stepwise" presentations of the product could be helpful. In response, we added descriptive introductions that discussed how to work with a VR device and illustrated the envisioned end-product to help neurologists understand the expected benefits and potential use of the tool. This provided useful context for the rest of the video. Our experience with the first video (which at 17 minutes was quite long) also led us to focus subsequent videos around multiple short snippets based on the functionality of the VR application. We also added labels to interface elements to give the experts consistent language to reference. Finally, we added picture-in-picture views of the presenter in the second and third prototype to show postures and interactions from an outside view—a decision that was praised by the neurologists.

# 5 CONCLUSIONS

While the initial results from our video-based feedback approach are promising, they merit a few caveats. Our initial exploration reflects input from a small population of expert participants. We also focused on improving the design and interactions of our system, building on top of a previous design [1], rather than starting from scratch. Finally, because of the limited availability of our participants, we did not have the opportunity to compare the experience of giving feedback in response to the video to that of using the prototype directly. Going forward, we plan to provide opportunities for participants to test the VR tool directly, combining the prototyping videos with more immersive evaluation approaches—especially when refining interactions.

Ultimately, the practice of remote and online VR prototyping with neurologist participants allowed us to collect detailed feedback from difficult-to-reach experts in relatively short design cycles. Based on this experience, we expect that these kinds of video-based approaches are likely to be helpful in a wide variety of settings where target users have limited availability and/or limited access to or expertise with VR hardware and software. By iteratively refining a VR prototype based on successive rounds of feedback, we were able to develop a VR prototype with high levels of fidelity in just a few early iterations—setting the stage for richer prototyping and use while minimizing upfront costs, both to the researchers and collaborators.

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