2023 XR Access Symposium

June 15-16, 2023
New York City, NY

XR Access

Virtual, Augmented, & Mixed Reality for People with Disabilities

Contents

Introduction to the 2023 Symposium Report

Seizing Advancements for Access

In June 2023, XR Access convened thought leaders, innovators, and advocates for the XR Access Symposium, a hallmark event charting the frontier of accessible Extended Reality (XR). Held as a dynamic hybrid event, this symposium, themed “Seizing Advancements for Access,” resonated with a collective vision: to harness the momentum of rapid advancements in XR hardware and software, as well as breakthrough technologies like AI, for the benefit of disabled individuals.

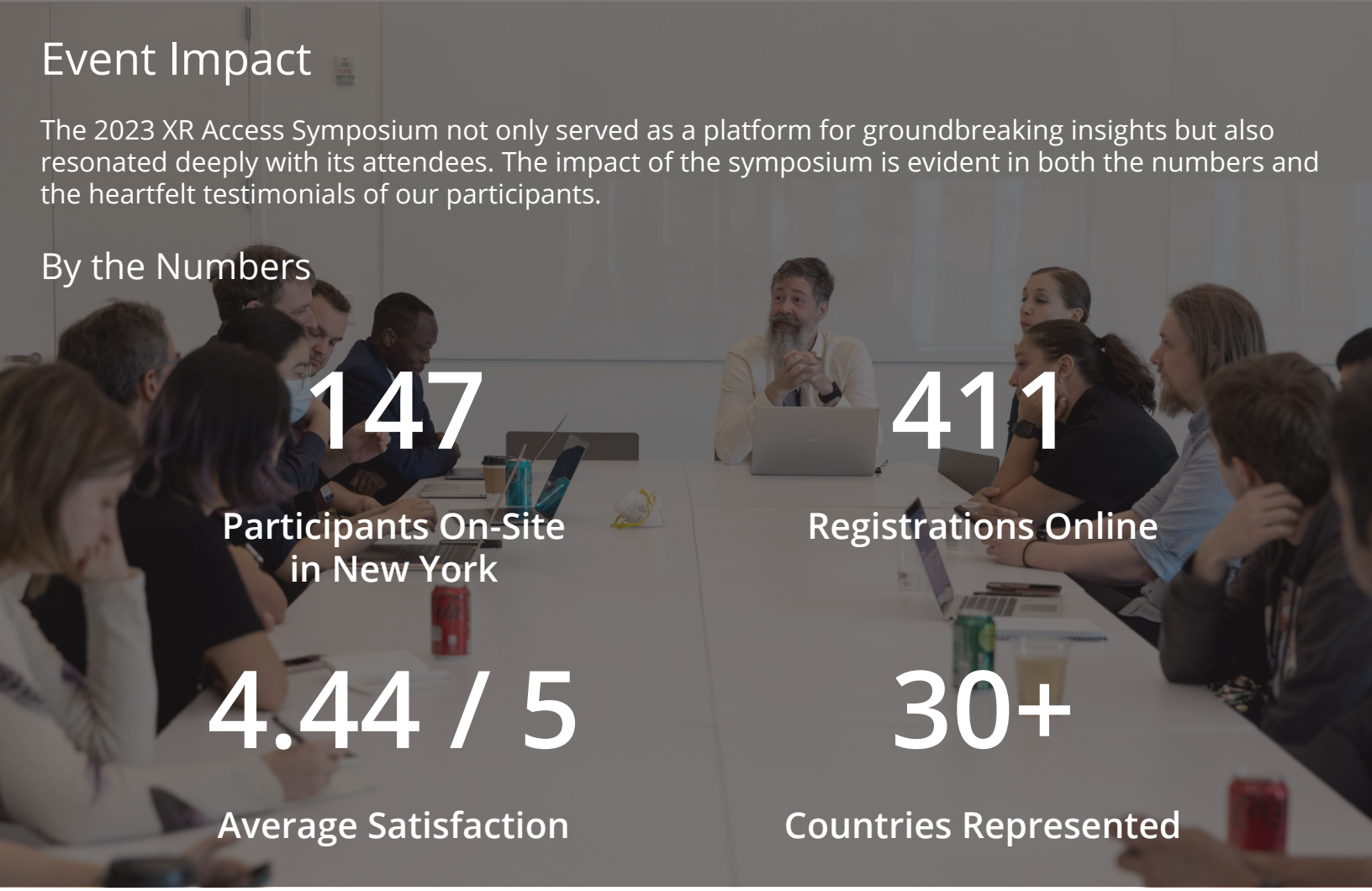
In a world where virtual and augmented realities are becoming an integral part of our daily experiences, ensuring inclusivity is not just a commendable endeavor—it’s an imperative. Our two-day symposium showcased cutting-edge demonstrations and featured trailblazing speakers who presented insights and solutions on how we can ensure that the immersive realms of XR are open and enriching for all.

As you delve into this report, you’ll discover highlights, revelations, and the pioneering strategies that were shared to capitalize on contemporary tech advancements for crafting a more inclusive XR ecosystem. Together, we’re poised at the precipice of a transformative era, ensuring that the virtual worlds we build echo the diverse, inclusive aspirations of the world we inhabit.

Event Impact

The 2023 XR Access Symposium not only served as a platform for groundbreaking insights but also resonated deeply with its attendees. The impact of the symposium is evident in both the numbers and the heartfelt testimonials of our participants.

By the Numbers



147

Participants On-Site in New York

411

Registrations Online

4.44 / 5

Average Satisfaction

30+

Countries Represented

Direct From Our Attendees

"I love that the presentations are engaging, insightful, and educational. Overall I learned a lot and discovered many resources that the presenters mentioned."

"Of the presentations I saw, I liked seeing visual examples of how developers and designers were going about improving accessibility and their explanations for the challenges they ran into in trying to achieve this."

"I was blown away by the quality of this conference and attendees, and that extended to the presentations. The passion everyone had was real. I wish I had better feedback on improvements, but this was really quite a great conference."

"I can say that I learned about the importance of research and how technologies can make a positive impact."

"I learned how ongoing research in the accessibility domain has been shaping and transforming the lives of people with disabilities [and] got inspired to do my Ph.D. research in accessibility."

The powerful synergy of data and direct feedback paints a vivid picture of a successful symposium. As we reflect and plan ahead, this feedback will be instrumental in shaping future XR Access endeavors.

Voices of VR
Covers the Symposium

The renowned “Voices of VR” podcast delved deep into the XR Access Symposium with a comprehensive 17-part series dedicated to accessibility. This series spotlighted key discussions, innovations, and insights, amplifying the event’s message to a broader audience passionate about the intersection of VR and accessibility.
Listen to Voices of VR

Public Access

All of the Symposium main stage talks are available on the XR Access YouTube channel, making these powerful presentations available and free for all to watch. They’ve already accrued over 1,000 views.
Watch the Symposium on XR Access’ YouTube

Supporting XR Access

As a Research Consortium based at Cornell University, XR Access is largely volunteer led. Our mission is to connect and engage stakeholders across the field of XR through events, resource sharing, and other programs. However, we can’t do it alone: support from our partners is critical to help us create accessible programming, remain sustainable, and achieve our vision of inclusion.

Industry and academic/non-profit partners who share our mission and goals can help keep XR Access by becoming a research partner or sponsoring next year’s Symposium. To learn about becoming a research partner, email info@xraccess.org.

Individuals and organizations can make a one-time or recurring monetary donation of any size to support XR Access’s work. Your donation supports XR Access’s programs, research, and overall sustainability. One-time or recurring donations can be made via the XR Access Website, and are processed by XR Access’s parent organization, Cornell University. We also welcome sustaining donations from industry partners.

Sponsors

The 2023 Symposium was generously sponsored by Yahoo! and grants from the National Science Foundation.

Acknowledgments

Organizations

We'd like to acknowledge the following organizations for their parts in making the Symposium a success:

- Oxygen Eventworks for providing audio/video support, photography, and video editing.
- Inclusive Communication Services and National Captioning Institute for providing accommodations.
- Constellation for catering the event.

Organizers

- Dr. Shiri Azenkot, Cornell University
- Dylan Fox, XR Access Director of Operations

Volunteers and Other Thanks

And thank you to our volunteers and everyone else who made this possible: Andres Gonzalez, Angelique Taylor, Anusha Kakileti, Ashley Fong, Ayushya Rao, Binyan Xu, Brennan Treadwell, Chloe Tedjo, Chuck Japely, Danielle Montour, Gemmechu Hassena, Helena Su, Jacky He, Jalynn Nicoly, Josh Bassin, Josiah Johnson, Maggie Tagoe, Melanie Royster, Ricardo Gonzalez, Richard Chuong, Ruchi Ukhade, Seunghyo Jang, Sophie Ana Paris, Tanisha Shende, Unaiza Nizami, Vennila Vilvanathan, Wei Wu, Xinyun Cao, Yanfei Wu, and Duong "Zach" Nguyen.

Panels & Presentations

The Guide Has Your Back: Exploring How Sighted Guides Can Enhance Accessibility in Social Virtual Reality for Blind and Low Vision People

Jazmin Collins
Cornell University

Crescentia Jung
Cornell University

The 2023 Symposium kicked off with a presentation from Jazmin Collins and Crescentia Jung of Cornell University about sighted guides in social VR. **Sighted guides** offer powerful advantages to blind or low vision (BLV) people in real life, including a physical connection, verbal information about their environment, and support in navigation and understanding of a new environment. But how should guides work in virtual reality? What accessibility needs can a guide address, and what design approaches can support these needs?

The authors developed a prototype VR application that could simulate physical guidance between a sighted guide and blind person. A core function unique to the study was **shared movement**: by approaching the guide's avatar and grabbing on, the participant could automatically travel along with the guide. They tested this system with 16 BLV participants, with one researcher running the study and introducing the participant to VR, and the other acting remotely as a guide, whether from the next room or across the country. Participants explored a virtual reality park filled with computer-controlled avatars, and participated in a scavenger hunt.

Overall, guides were found to be a **powerful aide** for the participants, enabling them to learn about both the visual and social aspects of their environment, and acting as a lifeline for learning the novel VR interface. Participants were split on treating the guide as an impersonal tool or as a companion, and while most felt that the guide was empowering, a few felt dependent on them and said they would have preferred an automatic tool instead. The preferred form factor for the guide was a matter of context, and varied from a human individual, to an accessory like a white cane or shoulder parrot, to being completely invisible to others.

Guides can address novel needs in VR such as embodied interaction, contextual information, and social support, both for blind and sighted users; and there are major opportunities in the near future to define guidance frameworks and training. In particular, **AI guides** represent a major potential step forward for the independence of BLV social VR users.

Read more about VR Sighted Guides at XR Access
Watch "The Guide Has Your Back" on YouTube

Empowering the Workforce Through Accessible XR

The second panel of the Symposium focused on the risks and opportunities regarding **accessible XR in the workforce.** Led by XR Association CEO Elizabeth Hyman, the panel featured Joel Ward, an emerging technology manager at Booz Allen Hamilton; Corinne Weible, the Co-Director of the Partnership on Employment and Accessible Technology (PEAT) at the Cadmus Group; and Christian Vogler, the Director of the Technology Access Program at Gallaudet University. Between Ward's experience in industry, Weible's in government, and Vogler's in academia as well as his lived experience as a Deaf person, the panel featured a variety of viewpoints.

With XR increasingly focused on productivity and workplace tools, it's more important than ever to consider accessibility. Section 508 guidelines in America mandate accessibility in government-backed purchases, but without formal guidelines in place defining how to achieve accessibility, there's little accountability as of yet. That said, PEAT and XRA collaborated to release a white paper titled Inclusive XR in the Workplace that details how accessible immersive technologies can **help employers upskill** and enable an increasingly diverse workforce, in addition to an Inclusive XR & Hybrid Work Toolkit that advises managers on how to procure and utilize accessible XR technology.

The potential accessibility uses for XR are incredible, but there are **many challenges in converting 2D best practices to 3D.** For example, deaf people using accessibility aids such as sign language interpretation or captions in 2D face the twin problems of split attention (whether to watch the subject or the aid) and localization (understanding what the aid is referring to), which could both be solved by localizing accessibility aids to the subject of a 3D presentation. However, captions used in 3D without regard to the immersive environment in which they appear can break immersion or even cause headaches by appearing to be in front of and behind other objects simultaneously. Additionally, the form factor of many modern headsets makes them very difficult to wear along with a cochlear implant, forcing some deaf users to choose between hearing and comfort. Vogler recommends customizable captions carefully placed with respect to the z-axis of a VR scene, a customizable headset that can accommodate cochlear implants, and the use of haptics as an alternative to audio cues.

Overall, XR presents major opportunities to enhance productivity in the workplace, but an equitable and inclusive rollout will require **both headset manufacturers and procuring companies** to carefully consider accessibility at all stages of technology creation and adoption.

Read Inclusive XR in the Workplace
Utilize the Inclusive XR & Hybrid Work Toolkit
Watch "Empowering the Workforce through Accessible XR" on YouTube

Elizabeth Hyman
XR Association

Joel Ward
Booz Allen Hamilton

Corinne Weible
PEAT, Cadmus Group

Christian Vogler
Gallaudet University

The Virtual Experience Research Accelerator (VERA)

Greg Welch
University of Central Florida

The Virtual Experience Research Accelerator (VERA) is a first-of-its kind effort to lay down infrastructure enabling researchers to conduct equitable testing in virtual reality. Similar to Mechanical Turk, it would create a **community of testers** able to try out VR experiments from the comfort of their homes, reducing the need to bring participants into a laboratory and vitally making VR data more scientifically and societally sound.

Science in general and VR science in particular suffers from a problem: most of its data is generated from samples of convenience made from those who can attend studies on college campuses. More often than not, this results in **bias towards M-WEIRD participants:** male, western, educated, industrialized, rich, and democratic. Because data leads to insights and insights lead to products and practices, this tends to result in VR that only works for this minority, excluding swaths of women, disabled people, and others who are not represented in the scientific process. The large, distributed testing base of VERA would enable researchers to avoid this bias, ensuring they could test with a representative sample of participants.

Christine Hemphill
Open Inclusion

Accessibility is a vital part of user research in VERA and beyond. Systems need to be built accessibly overall, and have a clear means for researchers to list requirements for individual studies, so that participants are not placed in studies that are impossible for them to complete. Additionally, **disabled people should not only be used to gather data, but also to support analysis and discussion** using their lived experience and contextual understanding. Ideally, we should move beyond participant pools to communities with shared values and trust.

Tabitha Peck
Davidson College

Data privacy and consent represent another important aspect of this project. Part of the goal of VERA is to create large datasets of VR activity that could be utilized in secondary research; this would be invaluable for advancing our understanding of human behavior and health outcomes in VR. However, much like health data, it can be hard to de-identify the distinctive patterns in biometric data, and very difficult to properly ask consent for participant's data to be used in studies that have yet to be defined, particularly if those may be for for-profit purposes. While few people are excited about their data being used to make others money, most do want products to be designed for them. Overall, **we will need to find the balance between participant control over their own data with the greater good** and larger learnings that comes from broader use of their data.

Jonathan Beever
University of Central Florida

Read about VERA on UCF's website
Read "DiVRsify: Break the Cycle and Develop VR for Everyone"
Watch "The Virtual Experience Research Accelerator" on YouTube

Loud and Clear: Improving Accessibility for Low Vision Players in Cosmonious High

Jazmin Cano
Owlchemy Labs

Peter Galbraith
Owlchemy Labs

Jazmin Cano and Peter Galbraith from Owlchemy Labs gave a talk about their groundbreaking work on **improving accessibility for low-vision players** in their VR game Cosmonious High. They started by asking the question of what the experience would be like for people with vision impairments, and then created a list of target features to address, including:

- Descriptions for every object in the game
- Settings for text-to-speech
- Environment descriptions
- Sound effects for stationary items
- Teleportation audio
- Descriptions for cinematic events
- Auto-orienting players to face significant objects

The importance of considering accessibility **early in the development process** cannot be overstated. Many of the features that they implemented in Cosmonious High were made possible by design choices that they had made from the beginning. For example, their game already used large text, bright colors, and clear silhouettes, which were all helpful for low-vision players. Owlchemy was able to test this themselves internally using a low-vision simulation tool, which enabled them to iterate rapidly before bringing builds to playtesters.

Another important takeaway was the **importance of testing with people with disabilities.** The disabled playtesters that Owlchemy Labs worked with, both internal and external, were able to identify a number of issues that the developers had not anticipated. For example, the initial design of the vision assistance mode would automatically play information about objects when the player scanned their hand over them. This quickly became apparent as a problem, because it was overwhelming to have two hands talking to the player simultaneously in a dense environment.

While VR is often thought of as a visual medium, there are many rich and varied ways that **immersive applications can be experienced by BLV players.** The features that Owlchemy Labs implemented in Cosmonious High are a good starting point for other developers who are interested in making their games more accessible.

Check out Cosmonius High on Owlchemy Lab's website
Watch "Loud and Clear: Improving Accessibility for Low Vision Players" on YouTube

SocialSense XR: Making the Invisible Visible

The first panel of day two centered around SocialSense XR, a combined project of Cornell, Benetech and LightHouse San Francisco aimed at making visual information in social VR accessible to blind and low vision (BLV) people. Social VR offers **new affordances for social interaction**, such as the ability to move around a virtual space, communicate with body motion and facial expressions, and use 3D environments and objects. Together, these offer a powerful new way to interact with others; however, many of the things that make VR powerful are currently inaccessible to BLV people.

The project, funded by the National Science Foundation Convergence Accelerator, seeks to convert purely visual information into sound and haptics so that **BLV people can participate fully in social VR.** The organizations each bring unique strengths to the table: LightHouse with their connection to the BLV community, Cornell with their expertise in accessible XR and XR Access, and Benetech with their background in document accessibility and marketing and development resources.

So far, the team has already conducted expert interviews with platform owners such as Mozilla, Meta, and Microsoft, and conducted 3 focus groups with 22 BLV participants to understand their needs and current views on communications technology. They've found that **people are often interested in who's paying attention to them** via indicators of attention such as eye gaze, head nodding, and smiling. Whether in a physical meeting or VR, a person should be able to identify another group, walk up to it, and understand if the group is paying attention to them.

With audio as an extremely precious resource and one often used simultaneously in meetings for tools like screen readers, **haptics becomes an important tool for communication**. The team is focused on the hardware that ships by default with modern headsets, but recognized the need for experimentation and customization. While initial solutions are focused on BLV users, the techniques identified via the project could also be applied to improve social VR experiences for everyone, including people with other disabilities such as deafness or neurodiversity.

See SocialSense XR on the XR Access Website
Watch SocialSense XR on YouTube

Dylan Fox
XR Access

Shiri Azenkot
Cornell University

Andrea Won
Cornell University

Charles LaPierre
Benetech

Sean Dougherty
LightHouse San Francisco

Building an Accessible and Inclusive Metaverse

Jamie Bykov-Brett
MetaHub

Jamie Bykov-Brett is a youth worker-turned digital strategy consultant who helps organizations improve ethically and strategically. In this talk, he covered the **emergence of the metaverse,** how it threatens to further inequality if we're not careful, and how we can incorporate accessibility into this new digital world.

A metaverse is an interconnected space of virtual words, assets, and places. There are multiple competing views for how this could come to be, including **closed vs open metaverses.** A closed metaverse is administered by a single entity, and siloed off from other spaces, whereas an open metaverse is community owned and governed and freely interoperable. While there are advantages to each, the open metaverse emulates the best qualities of the current world wide web that has led to an unprecedented sharing of information and creativity.

Accessibility in the metaverse is an imperative for both ethical and economical reasons. Economically, businesses that don't provide accessible services risk losing out on the billions of dollars in purchasing power that disabled people influence both directly and indirectly. Accommodate the extremes and you benefit the means; fail to do so, and you create poor customer service interactions that can drive consumers right out the door. Ethically, we risk shutting out wide swaths of the population (as many as one fifth of the population), as **inequities in human capital that we experience in the physical world are not just transferred but magnified in the digital world**. In the words of William Gibson, "The future is already here - it's just not evenly distributed."

It's also important to rethink how we model and talk about disability. Historically, our society has used the medical model of disability, which focuses on "fixing" disabled individuals. More recently, we've adopted elements of the social model, which says that disability lies not with an individual but due to barriers that prevent participation. However, even systems operating under the social model often place onus on an individual to prove their needs before distributing accommodations, and continue to discriminate against those who request them. Bykov-Brett suggests moving to the **"Celebration Model" of disability,** which celebrates that everyone has a unique set of skills, and designs from the beginning for those with a wide range of abilities. Additionally, rather than asking whether someone is disabled, we can ask whether they have experienced disablement.

Ultimately, it's up to us to eliminate the attitudinal, technological, financial, social, and policy barriers to enablement in order to establish a humane and inclusive technological paradigm.

Join Jamie's Distributed Republic community
Watch "Building an Accessible and Inclusive Metaverse" on YouTube

Annotated Lip Reading for Augmented Educational Systems

Hrishikesh Mulay
University College Dublin, Ireland

Mulay presented research on the implementation of **annotated lipreading in Extended Reality (XR) systems.** The primary aim of the study was to enhance the accuracy of lipreading algorithms in real-life scenarios. While these algorithms displayed commendable performance in controlled database settings, their accuracy significantly diminished in varied surroundings. To illustrate this, Hrishi shared two distinct experimental results. In a controlled setting, using a clip from the AV-HuBERT database, the word error rate stood at 34.5%. However, in a real-life setting, where Hrishi recorded himself reading a disclaimer in his dimly lit living room, the error rate surged to 82.1%. The algorithm's inaccuracies were evident in its nonsensical sentence predictions.

To address these challenges, Mulay outlined **future steps** including the development of an improved prototype, comprehensive evaluations using various criteria such as accuracy, time and space complexity, robustness, ethics, usability, and accessibility. Key design parameters for this endeavor encompass audio or video capture, advanced lipreading algorithms, real-time processing, customizable captions, user interaction, a rigorous testing phase, and accessibility guidelines.

Mulay proposed the **utility of lipreading in enhancing speech recognition,** especially in noisy environments, by integrating visual cues. An intriguing perspective was whether the algorithm would be effective when used with XR interactions, such as AR, where users might have glasses equipped with cameras capturing lip movements. Harnessing multiple data streams available in XR, including considering larger learning models in tandem with vision algorithms and additional sensors, could be used to improve accuracy yet further.

Emphasizing the diverse challenges in lipreading, Hrishi acknowledged that various speech patterns, like cultural variances in pronunciations, mumbling, and the animated way some people converse, can greatly influence error rates. **Applying lipreading to virtual avatars** could also be valuable, but is likely to perform better with avatars that maintain a consistent, front-facing orientation. Overall, there are many innovative possibilities and challenges to look forward to in the realm of automated lipreading in XR.

Read more about Annotated Lip Reading on D-Real
Watch "Annotated Lip Reading for Augmented Educational Systems" on YouTube

Multidimensional Computing Accessibility in the Age of XR and AI

Liv Erickson
Mozilla

Liv Erickson, the Innovation Ecosystem Development Lead at Mozilla, spoke to her dreams of a future where **spatial computing and AI combine to let individuals create custom-made interfaces** and even operating systems that suit their needs.

Erickson defined **"multidimensional computing"** as a combination of AI-powered machine learning and spatial computing. "Multidimensional" refers not only to physical dimensions, but to the capacity of humans and computers alike to understand dimensions of space, society, and more of the objects around us, and to derive meaning not only from individual aspects of these but also the relationship between them. It also means shifting away from binaries towards more continuous spectrums, and having people and systems that are more comfortable with ambiguity and context-dependent meanings. Identifying herself as autistic, Erickson described how she might prefer to experience content via computer science and written words or via artistic abstractions and music, depending on the context.

Central to the discussion was the notion of **accessibility in this new age**. Erickson described how the team at Mozilla Hubs has been experimenting with accessibility, including visualizing audio falloff, creating nonphysical options for moving around a space, and supporting the GLTF format to enable the development of user-generated metadata. The emphasis on open source movements means communities can develop their interfaces, ensuring inclusivity and accessibility. Erickson showcased an early prototype tool that combined a screenshot of a virtual space with the Microsoft cognitive services API to generate captions, highlighting the blend of human and machine understanding. At the same time, this showed the limitations of these services: while the AI was able to identify the image as being of a soft red chair, it couldn't identify the paper hidden beneath or the lack of people in the room, either of which could have been vital information depending on the context.

In the future, we may be able to simply **speak to computers to generate interfaces that suit us.** For example, someone could ask an AI to generate a gallery room with summarized research findings and digital assistants, all in a way that suited their needs and abilities. However, to ensure that generative AI is accessible, we'll need to create accessible methods, train AIs on accessible models, and rethink how to make the necessary data accessible without compromising privacy.

Read Equal Entry's article about "Building a More Accessible Social Virtual Reality World"
Watch "Multidimensional Computing Accessibility in the Age of XR and AI" on YouTube
View the Multidimensional Computing Accessibility in the Age of XR and AI slide deck

Vision Accessibility with AR+AI Tools

To round out the Symposium, Sean Dougherty and Jeffrey Colon of LightHouse San Francisco gave an informative overview of LightHouse's history, current augmented reality tools created to support blind and low vision (BLV) people, and how these tools are likely to change and grow in the future.

Sean Dougherty
LightHouse San Francisco

Jeffrey Colon
LightHouse San Francisco

LightHouse for the Blind and Visually Impaired is a 501(c)(3) nonprofit based in San Francisco, CA. Founded in 1902, it's one of the largest and most established blindness-focused organizations in North America. Its mission: to provide education, training, advocacy, and community for thousands of BLV individuals in California and around the world. Their Access Technology team supports the blind & low vision community by increasing their access to the world through learning how to use assistive and mainstream technologies.

Dougherty and Colon introduced **AI-based accessibility tools** such as Optical Character Recognition (OCR), which can use AI to process text, images, and environments. They demonstrated using Microsoft SeeingAI on a smartphone to read a business card and summarize the objects on a table. With integration into a glasses form factor using tech such as the NReal glasses, these technologies can vastly increase the degree to which BLV individuals can glean visual information from the world around them.

Next, they showcased how smart speakers and smart assistants can utilize AI to deliver audio output based on **user voice prompts**. These include Google Home and Google Nest, Amazon Echo devices with Alexa, and the Apple HomePod with Siri. These can be used for a variety of tasks; for example, using the Google Translate application to translate English and Spanish in real-time. Additionally, ChatGPT and other AI-based tools extend these capabilities further by enabling users to ask questions in simple language about visual information, or even generate and print tactile 3d models on command.

Finally, they discussed the **accessibility of AR devices,** starting with the accessibility showcase Apple released for their upcoming Vision Pro device. By tagging 3d objects with metadata describing their appearance and state, announcing meaningful events with voice or sounds, describing new rooms and items, and enabling both gesture and switch-based interaction, many AR experiences that may seem purely visual can be made accessible for BLV users as well.

Watch "Vision Accessibility with AR+AI Tools" on YouTube
View the "Vision Accessibility with AR+AI Tools" slide deck

Breakout Sessions

The breakout sessions enabled Symposium participants to contribute their specific expert knowledge and lived experience in order to collaboratively generate best practices and next steps for XR accessibility. Each breakout session was 50 minutes long; participants could choose to attend one in session A and one in session B.

Full breakout session information

A1 360° Video Descriptions

Moderator: Lucy Jiang, Cornell University
This breakout focused on best practices for 360° video descriptions, in order to make immersive video more accessible to blind and low vision viewers. Reviewing the research by moderator Lucy Jiang, discussion served to highlight several important components of a good video description:

- **Content**: what is happening onscreen? Which aspects are most important to user understanding?
- **Perspective**: from whose perspective is the video shot? Short, tall, flying, etc.
- **Mood**: is the video funny? Sad? Tense?

Other suggestions included highlighting key objects for those with some residual vision and avoiding repetitive audio cues that could grow cumbersome if looped.

A2 Captions

Moderator: Michael Cooper, W3C
When it comes to captions in XR, there are a number of new challenges to deal with, and a lot of nuance in how to do so. Participants discussed aspects of XR captions that don't work well, such as positioning out of view and rendering over close objects. Additionally, there are differences between captions generated in real time (for example, during social VR interaction) and scripted captions; realtime captions face big challenges in accurate language processing and questions over how to treat simultaneous conversations or those that take place further away.

To converge on design patterns, the W3C Immersive Captions Community Group will create a report, supported by the W3C Research Questions Task Force and informed by this and other discussions. They will also connect with people in industry and utilize existing guidelines from publishing platforms. While universal settings established by platforms and informed by this report would be valuable, this must be balanced against the risk of setting misinformed standards and establishing a rigid bad precedent.

A3 Spatial Computing & Data

Moderator: Liv Erickson, Mozilla
Anticipating moderator Liv Erickson's Multidimensional Computing Accessibility plenary on Day 2, this breakout group discussed the interaction of AI and XR, with particular focus on customization of computing environments, operating system vs application level accessibility, and how data and information can augment workflows. Spatial computing includes multiple concepts, including transforming data from occupying 2D screens to 3D space in and around a user's environment, as well as computing based on information about the physical world.

Some particular challenges include:

- **Training data**: considering that only 2.6% of websites are accessible, many web data sets are integrating inaccessible material into their models. How can we utilize training data that will lead to accessible generative code?
- **Privacy**: new forms of data lead to new concerns over privacy. Organizations may be able to harvest not only information about app usage and clicks, but also information about users' physical environments and biometrics, with few safeguards on usage. There's also a risk of advertisements cluttering the 3D environment.
- **Accessible interfaces:** some UIs have been relying on vision and fine motor control for interaction. With the additional complexity a third dimension brings, we need to establish accessible and customizable interfaces to confirm access for disabled users.

A4 Policy

Moderator: Elizabeth Hyman, XR Association
The Policy breakout group discussed how to educate and motivate policy makers in the US government to pass legislation creating responsible, accessible XR. This includes leveraging the 2022 CHIPS and Science Act, which authorized billions of dollars in spending on emerging technology, as well as the Americans With Disabilities Act and Section 508 that mandate accessibility in public products and services.

Some possible ways to influence policy include:

- **Demand accessibility:** set clear standards for accessibility, and hold vendors accountable via audits and, if necessary, lawsuits.
- **Highlight dangers and opportunities**: emphasize both the economic benefits of inclusive XR to disabled and nondisabled people alike, as well as the dangers that threats like cyberbullying and privacy breaches represent.
- **Focus on the local:** keep policy makers' focus with tangible examples that benefit their constituency. "All politics is local," after all.

A5 Customization

Moderator: Jamie Bykov-Brett, MetaHub
The Customization breakout focused on how XR can be customized to suit every individual's needs and preferences. This can remove not only technological barriers, but also attitudinal, financial, social, and policy barriers as well. Some examples of customization include:

- **Interfaces**: in addition to controllers or gestures, utilizing voice, eye movement, remotes, and other custom input and output devices to enable interaction. This includes enabling XR via multiple devices such as head-mounted displays, PCs, phones, and wearables, as well as customizable captions and other accessibility features.
- **Avatars**: offering a wide variety of avatars to enable users to represent themselves how they wish, including having fine-tuned control over disability disclosure.
- **Assistance**: different users may need different kinds of assistance based on their abilities and familiarity with XR technology. Offering tools like local co-piloting, remote help, and AI-based support can ensure everyone gets the help they need.

Developing a broadly enabling suite of customizations will require deep interaction with disabled users, as well as researchers, user interface designers, and other experts.

B1 User Research

Moderator: Greg Welch, University of Central Florida
The User Research breakout covered challenges in engaging in inclusive user research in XR. Both recruitment and the consenting process can be very challenging for "vulnerable populations" such as disabled people, children, and non-native language speakers. Researchers must overcome long travel times, lack of technology access, and more.

The group identified several means of mitigating these challenges:

- **Secondary research:** projects like the Virtual Experience Research Accelerator aim to enroll participants in multiple studies and/or reuse their data across multiple studies, though this comes with additional challenges in consenting and data privacy.
- **Diverse leadership**: having diverse leadership, including disabled people, makes it easier to identify and fix gaps in representation.
- **Safe, local testing environments**: find ways to enable people to test in safe, local environments, ideally within their own homes.

B2 Standards

Moderator: Will Schell, FCC

The Standards group focused on the creation and enforcement of standards for XR accessibility. In some cases, industry sets their own standards, such as ISO; however, when this isn't the case, the government may intervene. Often this comes in the form of broad requirements based on outcomes, not methods; for example, "can you operate this communication platform without hearing/vision?" These requirements often vary based on context such as industry, location, and usage.

There are risks to implementing standards. While standards can ensure access to accessibility features like captions, they also risk limiting the flexibility and innovation of creators, and poor standards can even prevent the implementation of emerging best practices. Creating standards for XR will require innovating on what works in 2D and creating a feedback cycle to allow complaints of inaccessibility to shape subsequent implementations.

B3 Exploring Accessible VR for Blind Users

Moderators: Sean Dougherty & Jeffrey Colon, LightHouse for the Blind and Visually Impaired

The Accessible VR for Blind Users breakout discussed considerations and best practices for blind and low vision (BLV) users, as well as areas of opportunity for improvements in accessibility. VR applications often rely on complex visual interfaces, with insufficient audio and haptic feedback for BLV users to understand the presence or shape of objects in the space. BLV users also face challenges in spatial orientation, accurate movement, and obstacle avoidance. Contrast issues are prevalent, and alternate text almost nonexistent.

Thankfully, there are many ways VR accessibility can be improved.

1. **Inclusion**: Bring BLV people onto teams and test with them from early stages.
2. **Text alternatives:** Integrate VR with assistive technologies like screen readers and optical character recognition (OCR) to create text alternatives for VR content.
3. **Alternate inputs**: Providing alternate input options beyond visual or gesture interactions, such as voice commands or tactile controllers.
4. **Audio cues and descriptions**: Use spatial audio cues and audio descriptions to represent the virtual environment, objects within it, and important nonverbal social cues.
5. **Haptic feedback:** Use haptics to provide tactile sensations, allowing BLV users to perceive virtual objects and interactions.
6. **Customization**: Allow users to customize their display settings, captions, and important UI elements to make them easier to see for their unique vision.

B4 Inclusive Avatars

Moderator: Ria Gualano, Cornell University

Building on moderator Ria Gualano's research on self-presentation for people with invisible disabilities, the Inclusive Avatars group discussed the challenges of creating a truly inclusive avatar generation process. Ideally, users should be able to make their avatars match their own appearance, but also control how they represent themselves and what elements of their identity they communicate to whom.

Avatars should include options for body differences (e.g. different limb configurations), cultural symbols, assistive technology, weights, heights, genders, hairstyles, and more. They should also be capable of changing moment to moment to dynamically express the user's state, such as absence (busy navigating menus or interacting with the physical world), level of desired social interaction or personal space, or even turning invisible.

B5 Accessible Career Development

Moderator: Mark Steelman, Transfr

The Accessible Career Development breakout focused on training applications of VR and their potential to improve disabled people's access to employment. VR training can be very helpful in learning skills for those who are disabled and/or neurodiverse compared to traditional methods of learning; for example, enabling accessibility tools like captions in environments like the factory floor where they would normally not be available, or enabling learners to slow down and replay instructions to suit their learning needs.

VR trainings and evaluations also offer a unique benefit: the opportunity to show, rather than tell, skills to hiring managers. Many people, particularly those who are neurodiverse, struggle in job interviews yet do great work onsite; VR evaluations can both demonstrate their skills directly, and possibly serve to anonymize the hiring process to avoid bias.

Demos & Posters

Our app demonstrations and poster sessions gave the Symposium audience a look at the latest and greatest in XR accessibility research and projects.

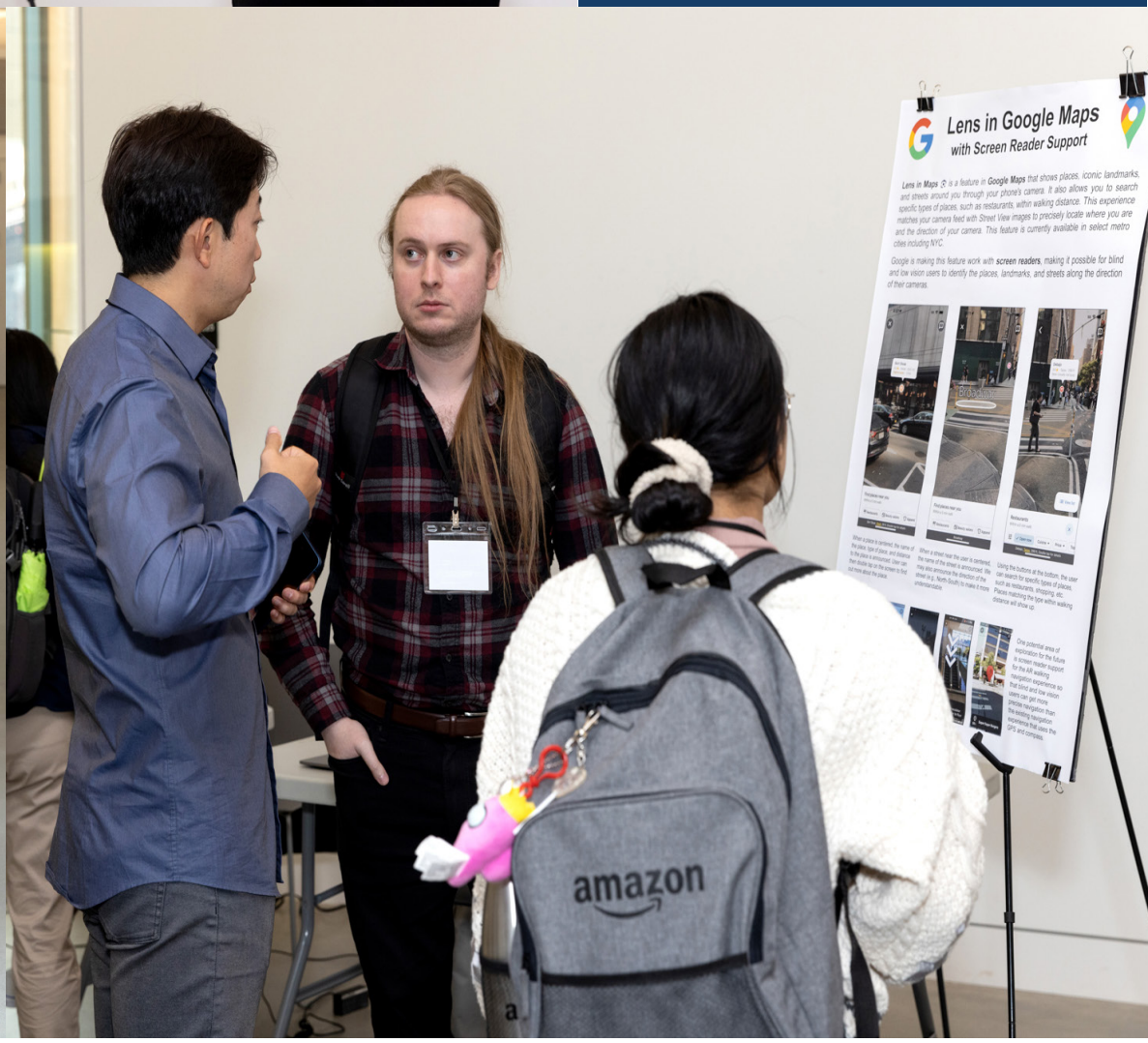
Display | Author

1. Accessible Nonverbal Cues in VR | Jazmin Collins, Crescentia Jung, Jonathan Segal
2. Beyond Audio Description: Exploring 360° Video Accessibility with Blind and Low Vision Users Through Collaborative Creation | Lucy Jiang, Mahika Phutane, Shiri Azenkot
3. AR Subtitle Glasses | Suchen Huang
4. Expanding Inclusive Avatar Design: Understanding Invisible Disability Representation and Disclosure on Social VR Platforms | Ria Gualano, Lucy Jiang, Kexin Zhang, Andrea Stevenson Won, Shiri Azenkot
5. KNOWHERE | Jamie Bykov-Brett
6. Accessible Live View in Google Maps | Ohan Oda
7. Future or Career Development With Transfr | Mark Steelman
8. Augmented Reality Art | Denise Coke
9. Extreme Personalisation, XR Digital Twins and the Future of Education - XR Accessibility Discussions for a Metaverse Campus Environment | Nicholas Waern
10. Hear the Shape! | Jialin Huang

Upper left: An attendee tries out accessible 360° audio descriptions, which enable blind and low vision people to fully experience immersive video.

Bottom left: Denise Coke shows off her Augmented Reality Art, which lets art come to life with movement in AR.

Bottom right: Ohan Oda explains Lens in Google Maps with Screen Reader Support, enabling screen reader users to get information about their surroundings using Google Maps' passthrough AR.

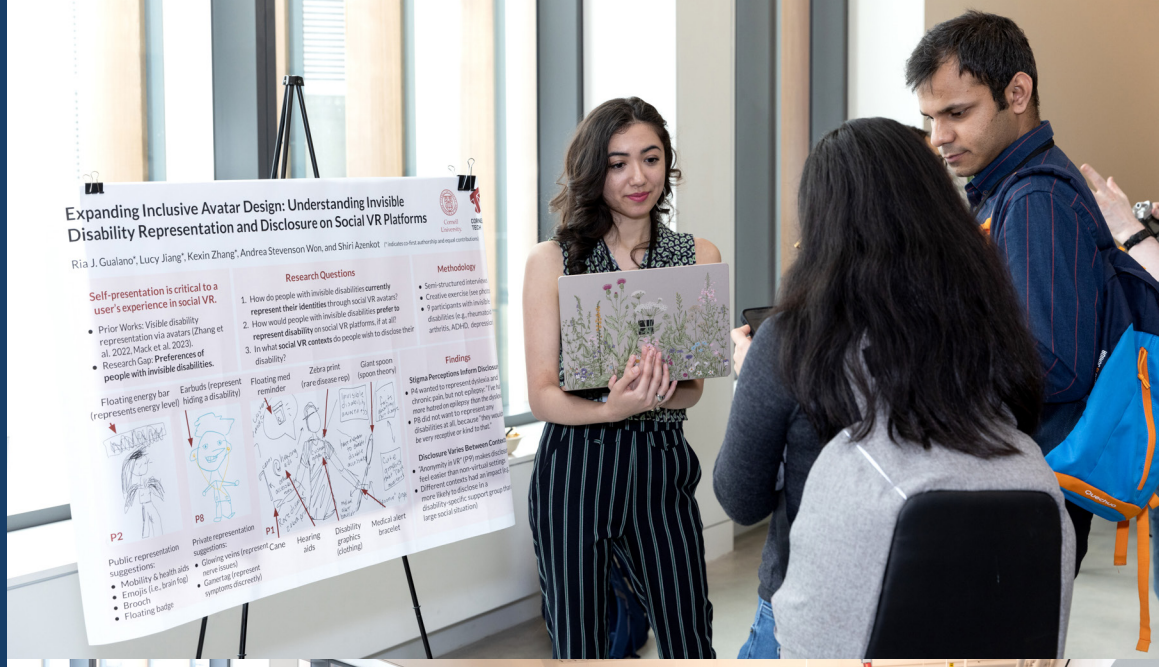


Top: Ria Gualano presents her research on Expanding Inclusive Avatar Design, showcasing how representation expands to those without visible disabilities.

Middle: The demo hall was filled with Symposium attendees learning about new research and applications.

Bottom left: An attendee tries out “Future or Career Development With Transfr,” experiencing how VR can be used to revolutionize job training.

Bottom right: The VR experience “Hear the Shape!” lets users identify objects by sound.



Towards a More Accessible Future

Key Takeaways

The Symposium covered an incredible breadth of topics that reflected the maturation of XR technology and the growth of related technologies like artificial intelligence. We saw accessibility become a part of mainstream consumer experiences like Cosmonius High and the Apple Vision Pro, and pushes to make not just the basics but the nuances of social XR inclusive to all. Here are two big takeaways to focus on.

XR Continues to Mature

XR technologies and infrastructure are maturing in more ways than one. Compared to the first XR Access Symposium in 2019, we're seeing fewer hypothetical questions about how to make the basics of XR accessible, and more real-world examples like Cosmonius High's Low Vision Update and pushes for institutional accessibility like the Virtual Experience Research Accelerator. Regulators like the Federal Communications Commission are taking a serious interest in how federal laws can be applied and enforced in XR. Altogether, we're beginning to discuss more and more how XR will work at the level of society, not just the individual.

Where research is being conducted, it's examining issues with increasing levels of nuance. How should a sighted guide in VR look and behave? How can we convert subtle nonverbal cues like eye contact and body language into nonvisual forms? How can avatars be made to represent the wide variety of human bodies, minds, and cultures? These questions reflect XR technologies that have had time to grow past the basics, and offer us the chance to deepen our understanding of humanity's future interactions with immersive 3D applications.

The Power and Promise of AI for Accessibility

The growth of artificial intelligence puts a powerful new tool in the hands of content creators and disabled individuals. AI's ability to sense the environment and translate data from static forms like printed text into dynamic forms like spoken audio or adjustable braille has already made it a staple of accessibility. Now, modern AI goes a step further: we may soon be able to modify interfaces on the fly to suit our unique capabilities, or speak to AI assistants using natural language to create entire worlds.

While AI offers new capabilities, it also comes with new dangers. AI trained on biased or inaccessible data is likely to produce poor results, making it vital to choose training data consciously and carefully. Additionally, we need to establish clear guidelines on what types of data devices can record, how they communicate they're doing so, and what happens to that data afterward; tools like facial recognition can be very valuable for disabled individuals, but risk creating a public backlash if used inappropriately.

Looking Ahead

Thanks to the huge effort from our organizers, volunteers, and sponsors, we're proud to consider this year's Symposium a big success. We're proud to have brought the Symposium back to being an in-person event for the first time since its inception in 2019, and intend to keep it that way moving forward. We hope to bring more hybrid functionality next year so that our remote attendees can participate fully in breakout sessions and networking events.

XR Access continues to move forward in pushing for accessibility via research, advocacy, and community building. Our research delves into the ways that blind and low vision people can access XR. We'll be putting on a number of seminars and community discussions to share the latest advancements and establish best practices. Our Stories project has begun to share some of the personal and emotional ways that XR technologies have touched disabled lives, and our Prototype for the People project has resulted in several new open-source products showcasing accessibility techniques. In the year to come, we hope to make great strides via the NSF Convergence Accelerator, Virtual Experience Research Accelerator, and more.

Of course, we can't do what we do without resources and funding. We have some excellent sponsorship opportunities for next year's symposium lined up for future-minded organizations, and if you would like to support or collaborate with XR Access, don't hesitate to reach out to us at info@xraccess.org.

Many thanks to everyone who made the 2023 Symposium a reality. If you want to join XR Access and help secure a more equitable and accessible future, make sure to visit our website, sign up for our newsletter, and join our community on Slack. We look forward to an even bigger and better event in 2024!