Accessible Technology for All

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Accessible Technology for All

Workshop Report
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Introduction

Accessibility needs evolve alongside the development of new technologies. New technologies, or even updates to existing technologies, often create new accessibility problems or reintroduce problems that had been previously solved. At the same time, advances in technology often have the potential to change the relationship between people and technology, which can be leveraged to create new accessibility solutions.

The past decade has shown tremendous advancement in technologies such as automatic speech recognition, machine learning, and wearable computing, while accessibility features have become mainstream[1], available by default in most major operating systems.

To identify the accessibility challenges and opportunities of the present moment, in February 2023, the Computing Research Association (CRA) held a workshop on Accessible Technology for All[2]. This workshop brought together over 40 participants, 20 being remote, from academia, industry, government, and disability advocacy groups. The purpose was to frame the state of the art of accessible technology, identify forces shaping the evolution of accessible technology, and develop an understanding of implications for the next wave of computer science research in accessibility. This workshop built upon the 2015 CRA Workshop *Promoting Strategic Access to Rich Online Content and Services*[3], summarized in its accompanying report[4].

The workshop began with a keynote address from Richard Ladner (University of Washington and Access Computing). Ladner emphasized the importance of designing technology with accessibility in mind from the beginning, rather than trying to retrofit it later. Other speakers at the workshop included representatives from major tech companies, researchers from universities, and advocates from American Association of People with Disabilities, American Foundation for the Blind, and Autistic Self Advocacy Network. They presented on a range of topics, including regulation, design processes, accessible educational technology, inclusive design, and emerging technologies like virtual and augmented reality.

The event concluded with a group discussion on the future of accessible technology research and innovation and big takeaways from the workshop. Participants identified several areas for future exploration, including the use of Artificial Intelligence (AI) and machine learning to enhance accessibility, the development of new tools and platforms to support accessibility, and the importance of inclusive design practices. The following report will go into these areas in more detail.

Accessibility: State of the Art and Emerging Challenges

The technologies surrounding accessibility continue to advance at a rapid pace. The workshop attendees discussed the substantial steps forward that have been made in recent years, along with new and remaining challenges.

One positive trend is increasing awareness of accessibility in the tech community and in society more generally. Previously, People with Disabilities (PWD) were often required to purchase and set up third-party software, or even specialized hardware devices, to access their computers. Over the past decade, accessibility features have increasingly been integrated into devices, browsers, and operating systems. Similarly, digital media such as movies and video games have increasingly included accessibility features. Overall, there are many more accessibility features available to users than before. Accessibility has also become more well known in society; companies have even used accessibility features to market their products[5,6,7].

While users now have access to more accessibility features on their devices, this raises the challenge of knowing what features might be helpful, and how to configure them to work best for their individual needs. This problem highlights the need to support discovery of these features, and training on how to configure and use them appropriately. Accessibility features that are dynamic or ability-based[8] can also support users in adopting accessibility features, although it's unclear how best to detect possible accessibility problems and notify the user about them.

Another trend is the development of advanced machine learning (ML) models and ML-powered accessibility features. Recent developments in ML have begun to enable many accessibility use cases that have previously been out of reach, such as computer vision-based detection of arbitrary objects[9], auto-generated alt text[10], and accurate real-time captioning and translation[11 12], although many of these solutions are still in active development. ML is also being used to address long-standing user interface problems, such as using computer vision to convert inaccessible interfaces into accessible interfaces[13].

While ML has the potential to solve accessibility problems, the introduction of these new technologies also introduces new challenges. New modes of interaction, such as augmented or virtual reality, introduce new accessibility problems and may impact different communities than other inaccessible technologies. Some populations remain excluded from recent advances in accessibility - for example, people who are not able to purchase the latest devices, or people from some underrepresented disability groups such as people with cognitive disabilities[14 15 16]. Making ML models inclusive will also require collecting appropriate data from users with disabilities and supporting personalizable models while ensuring user privacy.

Unmet Needs and New Challenges

1. Robust Design Processes to Support Accessibility

Making technology accessible requires that developers and content creators are able to do so; this requires knowledge of accessibility problems and affected disability groups, knowledge of accessible solutions; tools for performing accessibility-related tasks; and institutional buy-in to support accessibility work. Accessibility work takes multiple forms, including the creation of new, "born accessible" technologies, remediating accessibility problems in existing technologies, and improving the quality of existing accessibility features. It is necessary to support each of these approaches; while "born accessible" solutions often work better for their users, existing technologies and digital content must also be made accessible.

Alongside accessible standards (e.g., the W3C's Web Content Accessibility Guidelines), tech companies have begun to share guidelines for conducting inclusive design work. Workshop participants discussed the limitations of current design processes and the most pressing challenges.

One significant issue is the division between inclusive design methods and mainstream design practices. In some cases, work to support accessibility is conducted by separate teams and as a separate process than the creation of a product itself. In other cases, accessibility groups have graded product accessibility which motivated development teams to integrate accessibility. This separation makes it difficult to solve intersectional issues and may relegate accessibility work to a secondary status. Workshop participants expressed support for integrating accessible design practices into mainstream development processes, rather than maintaining separate processes. Accessible design practices might also be integrated into DEI activities or united with other forms of inclusive work (e.g. GenderMag)[17]. There is a significant need to increase and maintain the participation of PWD throughout the process of designing, creating, and supporting technology. Participation from PWD must not be limited to providing feedback on final products, but should exist at every stage of the process. Achieving this goal will require work improving recruitment and retention in schools and in industry positions.

Participation in the design process by PWD can also support accessible design practices, but this requires the development of appropriate design activities as well as other activities by the organization that supports the inclusion of people PWD.

Second, our increasing awareness of intersectional identities (see section 2) also extends to concerns about accessible design practices. Accessibility features are often targeted toward addressing a particular kind of disability. In the real world, people may also have multiple disabilities that may interact in different ways with accessibility features. Care must also be taken to understand the range of abilities within a particular disability category, and individual differences (cf. Stephen Shore's comment that, "If you've met one person with autism, you've met one person with autism")[18].

As AI and ML-based approaches dominate the conversations around advances in computing, these technologies also have the potential to support accessible design practices through the creation of new tools and technologies, and through supporting end-user customization or ability-based interfaces. As AI is increasingly integrated into everyday technologies, concerns about AI safety and AI data bias may take on different forms when considering users with disabilities. As some organizations have published guidelines for Responsible AI, which may be helpful in guiding the development of future accessible technologies, provided such guidelines consider users with disabilities.

Finally, all design improvements require appropriate training, tools, and resources, which often require institutional buy-in. Improving access to high-quality teaching materials[19], and making accessibility guidelines easier to follow, could improve the accessibility of future technology. Part of this is making these recommendations easy to adopt. Regarding organizational buy-in, accessibility guidelines could be further supported through the use of incentive structures such as regulation (for all organizations) and funding opportunities (e.g., research grants). These incentives could have increased impact by addressing areas of accessibility that are currently underserved, such as addressing overlooked populations (e.g., people with cognitive disabilities), or by addressing important, but underexplored problems (e.g., accessibility of legacy software systems as opposed to creating new systems).

2. Awareness of Intersectional Identity

When designing technology for PWD, we must consider the intersection of multiple disabilities, identities, technology, and policy (as shown in Figure 1). When someone has multiple disabilities, an open computing challenge is how we can provide all of the accommodations in a sociotechnical system and *adapt when they may conflict*. For example, if a Deaf person also had photosensitive epilepsy, they may need a fire alarm system to automatically adapt and provide them with different notifications. In addition to multiple disabilities, a person can have multiple identities (e.g., race, ethnicity, socioeconomic status) that may require additional care and accommodations in sociotechnical systems. For example, an AI system that encodes society implicit biases may perceive people of color with disabilities more negatively. People with disabilities also have diverse lived experiences around disability and accessibility. Researchers collaborating with folks with intersectional disabilities and identities should be careful to understand when one may be engaging in code switching to identify the true meaning of information being shared. For example, a participant from a historically excluded group may not be comfortable with disclosing challenges they encounter and may instead offer feedback more aligned with current majority group norms. Finally, researchers may want to consider if it is appropriate to understand the scope of participants' disabilities - whether a disability was congenital or acquired (e.g., aging, accident, medical issues, etc.).

Figure 1.

When multiple people are using the same sociotechnical system, researchers must design the system to adapt and accommodate one's needs. For example, individual students in the same classroom may need different–or even conflicting–accommodations (e.g., a person with vision loss needs high contrast, a person with autism needs low contrast presentations).

Currently, this type of accommodation requires manual labor from the teacher, but in the future, the system should be able to translate information to appropriate media and formats for all users. Researchers also must be able to detect conflicts between default device behaviors and the needs of users with disabilities. For example, a Deaf individual requires strobe notifications (and required by fire standards), however a person with photosensitive epilepsy may prefer to not have strobe notifications for their own health and wellbeing. Currently, systems do not detect these types of conflicts, thus solutions are typically dictated by legal policy or developer norms which may disadvantage some populations. Future systems could identify, negotiate, and accommodate conflicts while maintaining one's privacy. More research is needed to determine when personalization and customization should be manual, automatically decided by the system, or a hybrid approach.

3. Accessible Data Management

Adaptable systems would require technology that provides easy customization (where a user explicitly chooses) and personalization (where the system automatically chooses or suggests for someone). Everyone should have the right to opt out and override technology accessibility features to preserve privacy and autonomy. Ideally, decisions could be kept locally on one's own device so that people do not have to worry about possibly data sharing implications. For instance, Netflix would not know one was Deaf, however one's local system would alert one's browser that the user needs appropriate accommodations. In some cases, we envision that preference may need to be encrypted to keep information about disabilities private, and that management of accessibility preference data may need to be regulated as it currently is in domains such as health (e.g., through HIPAA) and education (e.g., through FERPA).

A continued computing challenge is how to communicate the implications of decisions and data sharing. More research is needed to make computer decisions transparent, interpretable, and explainable. For example, when one chooses some accessibility features on their phone, currently a pop-up explains that their phone will respond differently to common inputs and may provide a practice screen to allow the user to understand how the interactions change. In addition to this type of practice, users need to understand how their common interactions have been reinterpreted for the accessible functionality. In most cases, notifications about decisions and data sharing is one mode - written. In the future, we need to provide auditory, tactile, and possibly skeuomorphic icon output for training and explanations.

3.1. INCLUSIVE DATA REPRESENTATION

Understanding who and how people are represented in data is important to ensure data is representative of *all*. Current technical approaches may consider people with disabilities as "outliers" because PWD may be rare and diverse in data sets. This can be problematic when systems use data for speech systems, computer vision systems, language systems, etc. - the same systems that can benefit PWD. We must work to ensure PWD are represented in data sets without unnecessarily losing their anonymity.

We also need better ways to communicate about data sets and algorithmic explainability and transparency to *all* users through visual and non-visual mediums. More research is needed to fine-tune language models to simplify explanations and identify what characteristics of text would be best understood by diverse users. We need to explore how to explain data at scale and decisions through better accessible visualizations and convey the information equivalently through other modalities (e.g., vibrotactile).

Besides using and communicating data, *all* people should be able to create multimodal data visualizations based on their abilities. An open challenging research opportunity is how we can support the authoring and creation of data visualizations so that content is accessible from the start. We envision democratization of creation software so that fellow end-users can help to create workflows that enable novice users to create accessible visualizations. We see opportunities in AI-enhanced tools (e.g., ChatGPT) that can semi-automate and translate between visualization modalities. These automated tools would also require novel inspection methods by people with complementary abilities to ensure the data visualization is equivalent.

As computing and information visualizations become more ambient - embedded in everything from our home to automobiles to our clothing - accessible interactions must also be broadened. Currently, accessible technology typically supports user interfaces on computer systems and in controlled environments. More research must be done to explore usability proactively in the real, physical world (e.g., navigation in the world, identifying objects, technologies to detect user state or dangerous situations). In addition, as our ecosystem of information technology expands (e.g., one's phone communicating to one's car while preparing one's home safety and climate system for arrival), researchers need to explore how these systems communicate, share, and personalize one's experience taking into account PWD. We see promise in personal assistant technologies - AI-driven and human driven (e.g., Microsoft's Project Tokyo project that identified people in the environment to enable blind users to engage with people around them)[20].

4. Sociotechnical Interaction Support Systems

Mobile and wearable technologies paired with AI-enhanced tools can help PWD support relationships they are searching for or want to maintain. Workshop participants saw promise in technologies that supported mental health, wellbeing, social interaction, and interdependent, collaborative work. For example, video meeting systems have made it easier for remote sign language interpreters to make meetings more accessible. The systems could support rich, interpersonal communication in diverse settings with personalized modalities. Although a caveat is that these systems should not necessarily try to teach PWD how to act based on societal norms, instead, these systems can foster a bridge to bring awareness between people with different abilities who would like to interact together. Thus, more research is needed to understand the needs of diverse users - especially users with cognitive disabilities and those with intersectional perspectives.

If sociotechnical interaction support systems existed, research is needed to help people critically analyze the tools and how they interact with and for them. We need to train people to sense when technology fails - either because of bad actors using systems, generative AI text systems presenting false information, or system outages. End users need a rubric to assess how trustworthy tools are that are serving as intermediaries for their communication - from imperfect captioning tools using speech recognition to AI-enhanced communication tools misinterpreting someone's actions. Some users may want to easily understand how failures occur and how to navigate these situations.

5. Underserved Disabilities

Overall, there has been a lot of progress in integrating accessible interactions into mainstream technologies. In the next decade, we envision more progress in building accessible interactions for people with intersectional disabilities and disabilities that are more diverse. For instance, if a software engineer wants to ensure the system they design is accessible to people with a wide variety of cognitive impairments, there are few resources to help them easily integrate users' needs (e.g., W3C's COGA[21]), and these likely do not address all design challenges or application areas. There are thousands of design guidelines for PWD, however it is challenging to identify which guidelines to use for specific situations and which to prioritize if guidelines conflict. We need more resources to understand how to design systems that can support the needs of people with cognitive differences, cognitive disabilities, and learning disabilities. Creating such resources requires the active participation from the affected communities, as well as subject experts in education, rehabilitation, and related fields.

6. Research Enterprise

Computing research is sometimes idealistic about technology (e.g., AI) without fully engaging communities and people who will be impacted by the technology. We call for **grounding computing research with people within disability communities** early in the design process to ensure technology can be used by people with intersectional disabilities. In addition, we encourage the research community to be more inclusive in their interpretation of novelty because although a technology or system may be evaluated with non-disabled individuals, conducting assessments with PWD is important in future design, evaluation, and adoption of technologies.

In the future, we would like more robust data collection about the demographics of the computing research and development community. Specifically, how many scholars need accessibility accommodations and what kind? What accessibility challenges are faced by computing researchers? For example, although some research conferences and journals now require authors to create accessible PDF submissions (e.g., ACM SIGACCESS conferences[22]), PDFs may still have accessibility problems because of inaccessible content such as equations that cannot easily be read by screen readers, authors' inexperience in creating accessible PDFs, or errores introduced by the publishing process[23]. have adopted making PDF files accessible, equations are still difficult to convert to speech. We also need to carefully examine how the lack of accessibility impacts the diversity of computing researchers - if researchers cannot easily access tools, data, and articles, these barriers may exclude people who can make major contributions to computing.

As a broader research community, we need to improve the accessibility of mainstream tools and non-disabled researchers should advocate for tools to be accessible for all. From speech recognition tools (e.g., Siri and Alexa) to large language models - we may need more training samples to produce accessible text. For instance, prioritizing bulleted lists with direct language instead of dense paragraphs. We acknowledge that there is a balance between tools being cross-platform and easy to access online (e.g., Figma), however we advocate that current accessible technologies could be integrated into these systems to make them accessible to PWD.

Calls to Action

1. Increase funding opportunities for underserved accessibility needs

In addition to funding general accessibility research, funding bodies should create additional opportunities for research subjects that were identified as underserved. Our workshop participants identified three priorities for funding: addressing user groups whose needs are not currently being met, such as people with cognitive disabilities and people with multiple disabilities; supporting accessibility for existing legacy systems (and tools or techniques for supporting the accessibility of legacy systems); and developing methods for identifying and managing conflicting access needs.

2. Promote accessibility goals in all funded research, not just accessibility research

Researchers who do not specifically focus on accessibility work should be provided with incentives and support to promote positive accessibility outcomes in their research. One way to address this would be to provide supplemental funding to support accessibility goals within funded projects, similar to the National Science Foundation's Research Experience for Undergraduates (REU) program.

3. Increase efforts to improve representation of people with disabilities in technical and research positions

Increasing representation from people with disabilities in technology and research requires support throughout the education and pipeline. We note that there are ongoing efforts in this space already, including accessible CS learning tools such as the Quorum programming language[24], mentoring communities such as AccessComputing and CRA-WP, inclusive hiring programs (e.g., at AT&T[25], Google[26]), and mentorship programs (e.g., Google's CS Research Mentorship Program[27]). Workshop participants highlighted the importance of policies that support people with disabilities throughout their career, both in industry (e.g., promotion) and academia (e.g., promotion and tenure).

4. Encourage industry-university collaborations (Increase Accessibility in Industry)

Solving accessibility problems often benefits from collaborations between academia and industry. Improving accessibility in one of these areas often does not propagate to the other, due to differences in outputs (e.g., improving products vs. publishing results) and incentives. We see opportunities to support collaborative research in accessibility that includes both industry and academic partners, and opportunities to improve translation between work in industry and academia.

5. Consider ways to increase awareness of disability-related policy and law

The legal and policy framework for digital accessibility has a huge impact on when and if technologies and content are made or later become accessible. Current examples include pending Federal legislation on web accessibility, multiple rulemaking processes, and hundreds of lawsuits on digital accessibility which may lead to new legal precedents. Yet most accessibility researchers are unaware of the specific statutes, regulations, case law, and other legal rules impacting digital accessibility at both the state and Federal levels. We suggest that efforts are made to train accessibility researchers on the legal side of accessibility: this could come in the form of panels, workshops, short modules, or increasing involvement in multi-day training programs. We also suggest the integration of legal content into academic programs related to digital accessibility. We encourage accessibility researchers to not only focus on legal rules at the Federal level, but also to become familiar with legal rules at their state level where it is easier to get involved, inform policymakers, give testimony, and form long-term relationships.

6. Take a proactive approach to Accessibility Issues in Machine Learning

As machine learning becomes pervasive in the technologies that we use, new accessibility challenges will appear. It is necessary to understand and remediate accessibility problems early and often, including accessibility problems related to ML. This goal can be supported by additional community collaborations, including workshops for researchers and practitioners and “blue sky” idea tracks[28]. These efforts will work best when they include both “core” machine learning researchers, i.e. researchers working on ML models, datasets, and systems, and researchers with experience in understanding and solving accessibility problems. Improving representation of people with disabilities in ML datasets is also important to ensure that ML systems are accessible; there is a need to support additional efforts to collect and share accessibility datasets responsibility, such as in the Speech Accessibility Project[29], and further developing methods to collect, manage, and analyze accessibility data while maintaining users’ privacy and agency.

Conclusion

The needs, expectations, and challenges around accessible computing continue to evolve along with developments in computing technology. Accessibility is now often included as a consideration within research, however, some groups of accessibility stakeholders, technical accessibility challenges, and intersectional disability identities remain overlooked, and developments in machine learning and other computing technologies will create new types of accessibility problems. The computing research community can address these challenges by supporting people with disabilities throughout their education and careers; creating incentive structures to address underserved accessibility problems; and supporting community participation between technology researchers, accessibility experts, and members of the disability community.

Footnotes

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