SIGACCESS NEWSLETTER

A regular publication of ACM SIGACCESS: Special Interest Group on Accessible Computing

Report on ASSETS 2016

Jinjuan Heidi Feng and Matt Huenerfauth

Welcome to the January issue of the SIGACCESS newsletter. This issue highlights the ACM ASSETS 2016 Conference. The first article written by the General and Program chairs, Jinjuan Heidi Feng and Matt Huenerfauth, respectively, provides an overview of the conference.

Accessible Computing: ASSETS 2016 Doctoral Consortium

The following seven articles describe the research work of the students who attended the ASSETS 2016 Doctoral Consortium led by Amy Hurst and Karyn Moffatt.

Hugo Nicolau
Newsletter editor

Inside this Issue

About the Newsletter

SIGACCESS is a special interest group of ACM on Accessible Computing. The SIGACCESS Newsletter is a regular online publication of SIGACCESS that includes content of interest to the community. To join SIGACCESS, please visit our website **www.sigaccess.org**

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You may publish your work here before submitting it elsewhere. We are a very informal forum for sharing ideas with others who have common interests. Anyone interested in editing a special issue on an appropriate topic should contact the editor.

Overview of the ASSETS 2016 Conference

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This year was the 18th edition of the ACM SIGACCESS International Conference on Computers and Accessibility (ASSETS 2016)[1], which took place in October in Reno, Nevada, USA. The ASSETS conference is the premier computing research conference exploring the design, evaluation, and use of computing and information technologies to benefit people with disabilities and older adults. We set a new attendance record for ASSETS, with 173 participants from across the globe. In addition to a rich technical program, an increase in industrial sponsorship allowed the conference to support several receptions, including an event at the National Automobile Museum in Reno.

SIGACCESS made several awards during this year's conference: The SIGACCESS Outstanding Contribution Award was made to Professor Richard Ladner, from the University of Washington; Dr. Ladner gave the keynote presentation at the beginning of the conference. The best paper award went to "Would You Be Mine: Appropriating Minecraft as an Assistive Technology for Youth with Autism" by Kathryn Ringland, Christine Wolf, LouAnne Boyd, Mark Baldwin and Gillian Hayes. The best student paper award went to "Uncovering Challenges and Opportunities for 3D Printing Assistive Technology with Physical Therapists" by Samantha McDonald, Niara Comrie, Erin Buehler, Nicholas Carter, Braxton Dubin, Karen Gordes, Sandy McCombe-Waller and Amy Hurst.

Behind the Scenes

After a successful ASSETS 2015 conference in Lisbon, Portugal, last year, the ASSETS conference returned to the USA in 2016. Reno, Nevada, is a popular location for conventions and events, with close transportation links to the U.S. west coast. In addition, with nearby researchers who are members of the ASSETS community, we were pleased to have a lot of local support: Eelke Folmer from the University of Nevada Reno served as our local arrangements chair, and Bill Grussenmeyer of the University of Nevada Reno was our Student Volunteer chair. After considering several local hotel options, the Atlantis Resort was selected as a conference site, given its accessibility and on-site restaurant and entertainment options (which can simplify the logistics for our participants in planning evening events, without needing to consider accessible evening transportation options off-site). We thank our Treasurer and Registration Chair Raja Kushalnagar from Gallaudet University, along with our accessibility chair Erin Brady from Indiana University-Purdue University Indianapolis.

In the lead-up to the conference, announcements about the details were shared by email, our website, and on social media such as Facebook[2] and Twitter. We thank our Web Chair Lourdes Morales-Villaverde from UC Santa Cruz and our Publicity Chair Kyle Rector from University of Iowa.

In a spirit of welcoming new researchers into the community, the ASSETS conference continued its tradition of offering a mentorship program to support authors who had not previously published at ASSETS. Our Mentoring chair for 2016 was Leah Findlater from the University of Maryland, and we

[1] http://assets16.sigaccess.org/
[2] https://www.facebook.com/groups/318413479187/

thank our mentors: Erin Brady, Kotaro Hara, Amy Hurst, Hesham Kamel, Richard Ladner, Clayton Lewis, Kyle Montague, Alan Newell, Luz Rello, and Michele Williams.

The program committee and chairs also worked hard on the technical program for the event. The ASSETS 2016 program committee consisted of 56 international experts in the field of computing accessibility research from industry and academia. We received 95 submissions of full-length technical papers, of which 24 were selected for inclusion in the technical program: for an acceptance rate of 25%. As was done for ASSETS 2015, the acceptance decisions were made through a process of review and online discussion among the program committee members. The program committee also reviewed 58 posters submissions (29 accepted), 15 demos (7 accepted), and 10 experience reports (4 accepted). Our poster and demo chairs for 2016 were Stephanie Ludi (University of North Texas) and Kyle Montague (Newcastle University), and our Experience Reports chair was Tiago Guerreiro (University of Lisbon).

In addition, members of the program committee and other senior researchers helped to review submissions for the Student Research Competition (chaired by David Flatla of the University of Dundee and Anke Brock of Inria Bordeaux) and Doctoral Consortium events (chaired by Amy Hurst of UMBC and Karyn Moffatt of McGill University).

The Conference Program

On Monday October 24th, the program began with the chairs thanking our sponsors and the organizing committee for all of their work in supporting the event. The first session of the program began with the presentation of the 2016 SIGACCESS Award for Outstanding Contribution, an award that recognizes individuals who have made significant and lasting contributions to the development of computing technologies that improve the accessibility of media and services to people with disabilities. The recipient, Dr. Richard Ladner from the University of Washington, then gave a keynote presentation entitled "Accessibility is Becoming Mainstream."

Figure 1: Presentation of the Outstanding Contribution Award (left to right): SIGACCESS secretary/treasurer Jinjuan Heidi Feng, selection committee member Clayton Lewis, award recipient Richard Ladner, SIGACCESS vice-chair Matt Huenerfauth, and SIGACCESS chair Shari Trewin.

Following the keynote, we had a series of technical paper sessions organized around the following topics: Deaf and Hard of Hearing Users (chaired by Christian Vogler, Gallaudet University), Users with Developmental Disabilities (chaired by Kyle Rector, University of Iowa), and Tactile Information for Blind Users (chaired by Shiri Azenkot, Cornell Tech). The poster sessions during the day featured the accepted poster and demo papers, along with Student Research Competition and SIGACCESS Travel Scholarship recipients. The first day of the conference ended with a reception at the conference hotel.

On Tuesday October 25th, the program continued with sessions on Communication and Aging (chaired by Karyn Moffatt, McGill University), Rehabilitation and Clinical Technologies (chaired by Shaun Kane, University of Colorado Boulder), and Big Data and Blind Users (chaired by Kathy McCoy, University of Delaware). During the afternoon, a special technical paper session (chaired by Adam Sporka, the Czech Technical University in Prague) was held as part of the Text Entry Challenge; this session featuring research in the area of text-entry technologies was dedicated to the memory of Torsten Felzer, a researcher in the SIGACCESS community who passed away earlier this year. The technical portion of the program on Tuesday concluded with an afternoon session containing short talks from the finalists in the ACM Student Research Competition. The morning and afternoon poster sessions on Tuesday included poster and demo papers, along with posters on the topic of text-entry and posters from our Doctoral Consortium participants. After the SIGACCESS Business Meeting at the conference hotel, the day ended with a special reception at the National Automobile Museum, sponsored by Google.

On Wednesday October 26th, the technical program included sessions on Users with Visual Impairments (chaired by Sergio Mascetti, University of Milan), Haptic and Audio Feedback for Blind Users (chaired by Hernisa Kacorri, Carnegie Mellon University), Social Issues and Assistive Technology (chaired by Erin Brady, Indiana University-Purdue University Indianapolis), and Accessibility Education (chaired by Aqueasha Martin-Hammond, Indiana University-Purdue University Indianapolis). After announcing the Best Paper and Best Student Paper Awards at the closing session, we introduced Amy Hurst, the general chair for next year to announce the location of ASSETS 2017 (which will be in Baltimore, Maryland, USA).

A new aspect of the podium presentation sessions this year was that the program chair informed all of the presenters that they might be interrupted during their talks, if there was anything that was inaccessible about their presentation, so that they could clarify the information for the audience. Prior to the conference, detailed instructions had been provided to authors about how to ensure that their talks were accessible (including a video produced by Kyle Rector of the University of Iowa). The conference organizers were pleased to see how much care and effort presenters invested in ensuring that their work was accessible to the diverse participants of our conference.

TACCESS Presentations

Our technical paper sessions this year included six presentations by authors of journal articles accepted to the *ACM Transactions on Accessible Computing (TACCESS).* This high quality work enriched the technical program, enabling the community to learn more about this recently published work; accepted TACCESS articles submitted during the last year were eligible to be presented at the conference.

Doctoral Consortium

As in prior years of the conference, the Doctoral Consortium event was held on Sunday, prior to the main conference. This year, eleven students were supported by National Science Foundation (NSF) and Google to attend the event. In addition to the Doctoral Consortium co-chairs, a panel of three experts provided feedback and advice to the participants; we thank them for their time and valuable contributions to the students: Anthony Hornof from the University of Oregon, Christian Vogler from Gallaudet University, and Simon Harper from Manchester University.

Social Program for ASSETS 2016

Following in ASSETS tradition, we wanted to ensure that there was a strong social program to enable participants to meet and network in an informal setting. As was done last year, we organized our poster sessions around coffee breaks so that people can visit posters while they socialize. To avoid participants from feeling rushed, the same posters were available all day (in both the morning and afternoon). In addition, during these coffee breaks, Phil Weaver, a software engineer from Google who works on Android accessibility, offered a demonstration on "Learning to Develop Android Accessibility Services"; he also sought feedback from ASSETS participants about accessibility in the Android platform.

At the end of the first day, we had a reception at the conference hotel. Participants enjoyed appetizers and drinks while they visited posters presented by students from the Alliance for Person-Centered Assistive Technologies (APAcT), which is a National Science Foundation funded Integrative Graduate Education and Research Traineeship (IGERT) program at Arizona State University and California State University Long Beach. A large group of students and faculty from this program attended ASSETS 2016. The reception began with a brief presentation by Stewart Tansley from Facebook about TeachAccess, a collaboration between industry and higher education institutions to promote accessibility education in computing degree programs.

At the end of the second day, we arranged a reception at the National Automobile Museum, sponsored by Google, where participants enjoyed a buffet dinner and were able to tour the classic cars exhibits throughout the museum. Guided tours were provided through the exhibit halls (Figure 2), which included re-creations of city streets from various decades of the 20th century.

Figure 2: ASSETS attendees during a guided tour of the National Automobile Museum.

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Sponsor: SIGACCESS – Special Interest Group on Accessible Computing

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About the Authors:

Dr. Jinjuan Heidi Feng is a professor at the Computer and Information Sciences Department at Towson University. She received a Ph.D. in Information Sciences from UMBC in 2005. She conducts research in the area of universal accessibility, mobile health applications, and accessible security and privacy. She works closely with national and local communities to improve the quality of life for people with disabilities through information technology. Her current research projects focus on assistive technologies for people with cognitive disabilities in educational and professional settings, mobile applications for health related activities, and accessible security techniques for individuals with visual or cognitive disabilities. She is serving on the editorial board of *ACM Transactions on Accessible Computing* and has served on numerous conference program committees and review panels.

Dr. Matt Huenerfauth is an associate professor at The Rochester Institute of Technology (RIT) in the Golisano College of Computer and Information Sciences. He is a member of the faculty of the Department of Information Sciences and Technologies and the Ph.D. Program in Computing and Information Sciences. His research focuses on the design of computer technology to benefit people who are deaf or have low levels of written-language literacy, and his laboratory investigates the design and experimental evaluation of American Sign Language technologies. Huenerfauth has secured over $2.5 million in external research funding to support his work, including a National Science Foundation CAREER Award in 2008. He has authored 50 peer-reviewed scientific journal articles, book chapters, and conference papers, and he has twice received the Best Paper Award at the *ACM SIGACCESS Conference on Computers and Accessibility (ASSETS)*. He served as the general chair for ASSETS 2012 and as the program chair for ASSETS 2016. Huenerfauth is an editor-in-chief of the *ACM Transactions on Accessible Computing (TACCESS),* and in 2014, he became a Senior Member of the ACM.

Hearing Biochemical Structures: Molecular Visualization With Spatial Audio

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Abstract
Accurately perceiving the structure of biochemical molecules is key to understanding their function in biological systems. Visualization software has given the scientific and medical communities a means to study these structures in great detail; however, these tools lack an intuitive means to convey this information to persons with visual impairment. Advances in spatial audio technology have allowed for sound to be perceived in 3-dimensional space when played over headphones. This work presents the development of a novel computational tool that utilizes spatial audio to convey the three dimensional structure of biochemical molecules.

Introduction & Motivation
Biochemical macromolecules, such as proteins, nucleic acids, polysaccharides and lipids, comprise the fundamental building blocks of all life. These compounds derive their function in large part from their spatial structure. For this reason, the 3D visualization of molecules is critical to the study of biology, chemistry, and medicine. A number of tools have been developed for visualizing biochemical structures, such as Jmol [8] and RASMOL [6]. These graphics-based programs are designed for sighted users and are not accessible to those with visual impairment or alternate learning styles [10].

Gardner's theory of multiple intelligence states that spatial perception is just one of eight areas in which human intelligence can be understood [3]. For students and researchers with visual impairments, learning aids that take advantage of other intelligences must be used in order to comprehend such spatial structures [4]. For small molecules, tactile models can be created, while larger molecular structures rely on exporting atomic coordinates to text editors and braille output. Such systems have a steep learning curve for users with visual impairments and further demonstrate a need for new methods to convey molecular structural information.

It has been shown that software that uses audio tones appeals to musical intelligence and assists in the localization of points in three-dimensional space for both sighted and visually impaired users [5]. Even so, to the best of our knowledge, there has been only one study on relaying biochemical structures with sound [2]. In that study, coordinate data was mapped to audio cues, in the form of different musical tones, to convey spatial orientations of biological and chemical molecules. Such a translation of sound to x, y and z coordinates is non-intuitive for all but the most practiced users, presenting an added learning impedance to visually impaired users.

Proposal

Rendering 3D (or spatial) audio, realized through the use of head-related transfer functions (HRTFs), to sonify biochemical structural data, will allow for the design of intuitive interfaces for visually impaired users to study molecules. HRTFs are filters through which audio can be passed in order to give a listener the illusion of the sound coming from a point in 3D space. HRTF-based 3D audio has been successfully used to help individuals in navigating inside rooms [12] and has been shown to improve depth perception in sighted users [9]. HRTFs are often measured and tuned for each individual. While our work does not create custom HRTFs, there are many publicly-available HRTF databases, such as CIPIC [1] and LISTEN [11], as well as methods to achieve approximate fittings [7]. Structural data used to create the molecular model can be found in a variety of online repositories, such as the Research Collaboratory for Structural Bioinformatics Protein Data Bank (RCSB PDB). By producing sounds at the coordinates of the atoms in a structure, a complete representation of the biochemical molecule can be created with spatial sounds.

Ongoing Work

Development of an initial software prototype, which allows users to gain a sense of depth and location of different secondary structures within a protein using spatial sounds created through HRTFs, has been completed (Fig. 1).

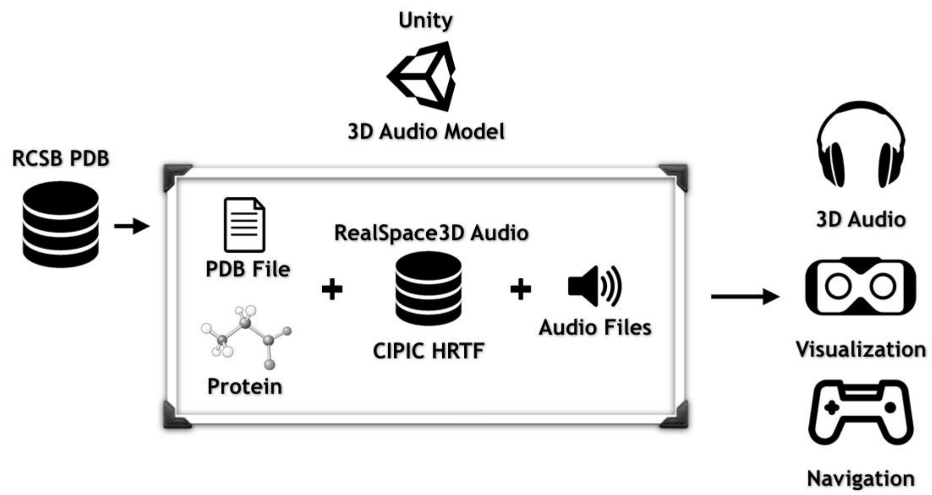

Figure 1: SOP's design. Protein models are created from RCSB PDB files. A spatial sound source traverses the protein polypeptide chain, which is output to users via headphones. SOP includes a virtual reality visualization. Future iterations will include haptic feedback.

The program is called SOP, short for the Sonification of Proteins. SOP positions a protein structure centered around the user's head. The spatial awareness produced by playing sounds along the polypeptide backbone of the protein, from amino to carboxyl ends, allows users to develop a mental image of its spatial structure. While the sounds indicate the location of α-carbon atoms and overall structure of the protein chain, changes in intonation and sound type indicate whether the secondary structure at that location is an α-helix, β-sheet, or loop. This variation in sound allows for multiple levels of abstraction within the same spatial model.

Initial experiments testing the SOP program with sighted and visually impaired users has been approved by the Internal Review Board. Tests will include a comparison of the accuracy in determining the form of different protein structures using audio only, audio combined with vision, and vision only. The time it takes users to find secondary structures within a protein under each of these conditions will also be measured. Evaluating user accuracy in determining the relative positions of multiple secondary structures within a protein will be carried out. Finally, a qualitative evaluation to determine the efficacy of the system design and intuitiveness of the user interface will be conducted.

A pilot study was carried out to determine how well users could localize a moving sound target. Spatial audio was played from a source traversing the perimeter of a basic shape (e.g. circle, triangle, square). The users' ability to follow the target, via pointing their nose at the sound source, was determined by collecting virtual reality (VR) head-mounted display (HMD) head tracking information for multiple 60-second runs. During each test, users were only shown a black screen. Half the users were able to follow the moving target within 3m, over 50% of the time. Three out of four users could follow the targets within 4m, over 50% of the time. These results give rise to the belief that the concept may be extended to proteins.

While the SOP program has undergone a number of improvements (Figure 2), its design continues to be iterated on. The current version aims to provide structural information about secondary structures. Proteins have multiple levels of abstraction, ranging from primary to quaternary, each of which has different design considerations when augmenting with spatial audio. More structural information will be added to create a comprehensive audio experience in future iterations. Beyond proteins, similar methods can be applied to sonify chemical compounds and cellular structures. This line of research leads to a number of questions that must be answered. For example, how are different bond types and orientations conveyed to a user at the molecular level with 3D audio? Design choices, such as what sound types should be used, and when and where continuous sounds should be employed, are also open questions that we plan to explore.

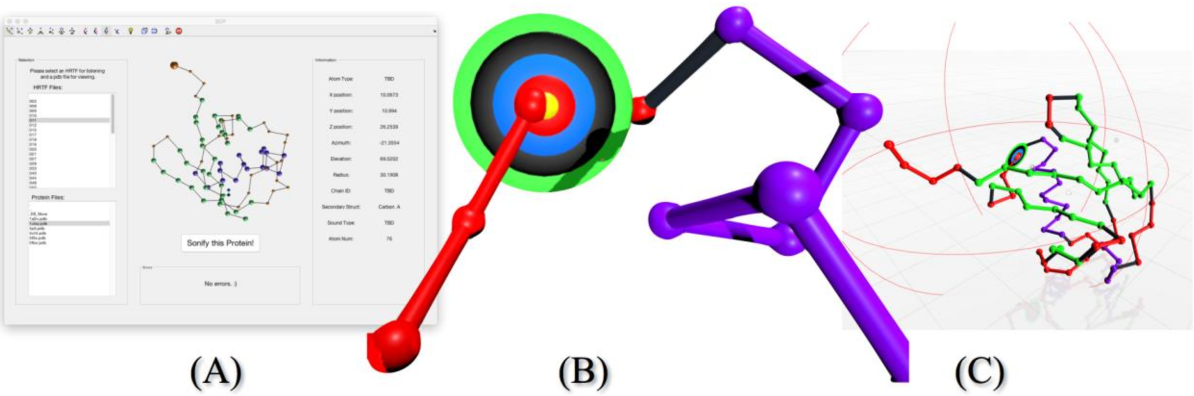

Figure 2 (A) An early prototype of the SOP program created in MATLAB. (B) A view of part of a protein and a spatial sound source traversing it. This is a more recent prototype of SOP, developed in Unity, as seen through a VR HMD. (C) A protein, as seen in the scene view. Note the red outline indicating the maximum distance a sound can be heard from, giving a depth cue to its location.

Contributions

Through the development of SOP and future 3D audio biochemical sonification programs, the answers to fundamental questions in conveying biological and chemical structures through sound will be determined. We envision that future releases of existing tools, such as Jmol and RASMOL, will incorporate 3D audio in their programs in order to increase their accessibility. This work will lay a foundation for the development of these programs by determining best practices for the design of 3D audio applications for biochemical structure sonification.

A number of uses for the developed software are possible for persons with visual impairments. In the field of education, integrating 3D audio into biochemical visualization tools can provide a means for teaching students structural biology, allowing for greater opportunity and advancement in scientific fields such as medicine and chemistry. Such tools will also give visually impaired researchers more independence in the laboratory. Another potential area of impact is in the biomedical and pharmaceutical industries. Companies are often interested in visualization tools to assist in their understanding of drug interactions. Using the SOP software, these tools can be enhanced to help biomedical engineers and pharmacologists quickly localize drug interaction sites and navigate large protein structures.

Acknowledgments

I would like to thank my advisor, Dr. Kyla McMullen for her support and guidance in undertaking this work.

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Terek Arce is a Computer Engineering PhD student at University of Florida. He conducts research under the guidance of by Dr. Kyla McMullen as part of the SoundPad Lab. His research interests lie at the intersection of biochemistry and 3D audio, combining them to give visually impaired and sighted users new and intuitive computational learning tools.

Dr. Kyla McMullen is an assistant professor in the University of Florida's Computer & Information Sciences & Engineering Department. Dr. McMullen's research interests are in the perception, applications, and development of 3D audio technologies. Her current projects include creating technologies for persons with visual impairments, evaluating the perception of 3D sound in virtual and augmented reality, and conveying spatial targets in real-time using 3D audio.

DISPLAYING CONFIDENCE FROM IMPERFECT AUTOMATIC SPEECH RECOGNITION FOR CAPTIONING

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Abstract

As the accuracy and latency of Automatic Speech Recognition (ASR) technology improves over time, it may become a viable method for transcribing audio input in real-time for specific situations. Such technology can provide access to spoken language for people who are Deaf or Hard of Hearing (DHH). However, ASR is imperfect and will remain in that state for a while, thus there is a need for users to cope with errors in the output. My research focuses on how to best present captions that make use of the ASR system's word-level confidence. This summary will describe the proposed solution, current state of study, and the planned contribution to the field of HCI and accessibility for DHH individuals.

Motivation

Advances in speech and language technology can benefit people who are Deaf or Hard of Hearing (DHH) by enabling access to information in the form of spoken language. Many of these users currently benefit from a wide range of services such as e-mail/instant messaging, American Sign Language (ASL) in-person interpretation, real-time transcription or captioning services, and Video Relay Service. However, in several situations such as work and education, DHH individuals would not be able to use sign language interpreting services due to their high cost or limited availability. Furthermore, DHH individuals who don't identify as Deaf or older adults who lose hearing later in life may prefer text-based accessibility tools, rather than sign language interpretation.

Recent advances in Automatic Speech Recognition (ASR), including the modern approach of off-loading the computationally intensive task of ASR to remote servers in order to enable use in mobile contexts, open the doors for tools to be created to meet the demand. For this reason, many researchers have considered whether fully automatic solutions for providing text transcriptions of spoken language could be useful for DHH users [5]. Some researchers have investigated the potential of ASR for automatically captioning the content of online videos to enable access to the spoken content of those materials [6]. In order to boost the accuracy of imperfect ASR, some researchers have turned to techniques such as human overseers who fix mistakes in the ASR output [1] or crowdsourcing the task of transcribing audio so that humans can accurately produce text [2]. Other researchers have considered whether applications based on ASR and Augmented Reality (AR) glasses could enable captions to be overlaid on the field of vision of a DHH user [3]. However, those researchers found that the quality of several ASR engines were unsatisfactory for daily usage by DHH individuals because noisy environments would result in Word Error Rate (WER) as high as ~60 percent.

In contrast, my proposed research selects a context which we suspect would work better: live one-on-one meetings between a DHH individual and a hearing person. A one-on-one meeting is easier for an ASR system compared to lecture audio, which may contain significant ambient noise from the audience or questions from the audience not well-captured by the microphone. Furthermore, in the case of a public lecture a lecturer may not change how they speak based on ASR output; during a live one-on-one meeting someone might do this which could lead to better ASR results. In my research, we focus on the case where the ASR results are displayed on a mobile tablet device viewable by the DHH participant in the one-on-one meeting with hearing individuals. In order to investigate design variations in how captions should be displayed, we have developed a set of videos simulating a one-on-one meeting between a DHH individual and a hearing person. By overlaying captions on this video, we can conduct experiments evaluating various captioning designs.

The display layout for a mock conversation is shown in Figure 1 with the video in the background and the text in the bottom black area containing the output from the ASR engine, representing where the DHH user might view a tablet device below the line-of-sight with their conversational partner.

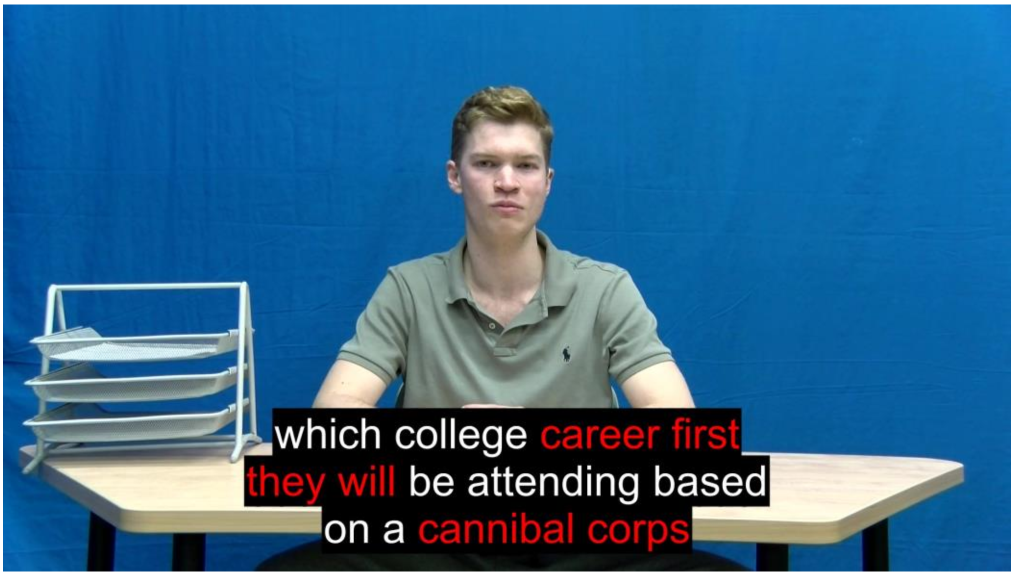

Figure 3: The research prototype tool examined in this work

There is evidence that users would benefit from captions, even if only a portion of the speech audio was successfully captioned. For example, a participant in one study using ASR captioning said: "*knowing the context and searching for keywords are essential steps to build their capacity of understanding*." [4] ASR engines assign confidence metrics to the words they hypothesize are being spoken in an audio input; this information could be utilized by the viewer to know which portions of the text they should trust. Currently, typical ASR applications do not convey this extra information to the DHH viewer who is using the system. Therefore, in this research, I hypothesize that knowing the difference between high-confidence (confident) and low-confidence (uncertain) words given some threshold may be beneficial for making automatically produced captions (containing errors) more useful for people who are DHH.

Research Goals

In addition to investigating whether providing information about the confidence of ASR is beneficial to these users, in this research, I will also investigate the best methods for providing this information visually. We must consider how to reduce the complexity of the information that is presented to users. In a live one-on-one meeting, we cannot expect the DHH participant to make use of complex visual information while at the same time reading the caption text and paying attention to the face and body language of their conversational partner. It is essential to develop a standardized way to display the uncertain words/phrases in a way that doesn't create additional barriers for DHH users by making the visual presentation of the information too complex. My current research intends to answer the following questions:

RQ1: When viewing captions of speech in a one-on-one meeting context, do DHH users prefer to see extra markup information that indicates the confidence of the ASR output?

RQ2: Which method of displaying the confidence is more usable for DHH users, as evaluated by subjective preference scores collected from users?

RQ3: Does the confidence markup actually benefit the DHH person while watching videos, as evaluated by objective comprehension questions of how much information content the DHH users understood and retained from the captions?

It is our aim to reveal the best way of displaying the confidence of ASR captioning to a DHH user. We want to investigate whether this extra markup of captioning will be beneficial to the DHH participant in one-on-one meetings. Furthermore, it is our goal for the results of my research to be incorporated in a tablet-based prototype for future experiments regarding ASR captioning in different contexts for DHH users.

Current Progress

I am starting my second year as a Ph.D. student at RIT, fall 2016, and have completed a year of research and coursework. I have already done a preliminary study with small N wherein participants viewed videos of different caption markups which conveyed the confidence values. We asked the participants preference questions and comprehension questions to explore how they perceived the different markup styles. In order to fully answer the research questions I raised, I would need to execute additional studies to ensure that additional design options have been examined.

During summer 2016, I mentored four undergraduate students working on topics related to ASR and captioning, as part of an NSF-funded Research Experiences for Undergraduates (REU) site at RIT. Additional experiments such as eye-tracking the fixation percentages on the captioning and interviews with participants exploring the tablet prototype are underway. I am also planning a larger follow-up study to focus on the subset of caption-display variations that participants responded most favorably to in my initial study.

Contributions

This dissertation research will help identify the most effective method for using ASR confidence information in real-time captioning. This project will yield a set of visual display design guidelines, algorithms for dynamically calculating the confidence threshold, algorithms for managing the captioning markup, and a set of published empirical evaluation studies that demonstrate how other groups can build on my work.

Doctoral Consortium

As I am a fledgling researcher in the field of accessibility, I hope to gain much-appreciated feedback from my peers on how I could improve and further pursue my research. Specifically, I could benefit from advice on how to best structure qualitative and quantitative studies to investigate DHH users' captioning preferences. While there is significant work for DHH users happening at RIT, I look forward to understanding the state-of-the-art of a wider breadth of accessibility research through my participation and attendance at the conference. I know that the experience from this conference will be invaluable as I continue working on my dissertation proposal.

Acknowledgments

As always, I am grateful for the wonderful support from my advisor, Dr. Matt Huenerfauth and my research committee members: Dr. Vicki Hanson and Dr. Raja Kushalnagar. This material is based upon work supported by the National Technical Institute for the Deaf.

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Increasing Access to Computer Science for Blind Students

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Abstract

Computer science has many aspects that are inaccessible to someone who is blind. My research has focused on identifying the different barriers that exist for blind students in computer science and creating technology to overcome them. I have done two projects towards this goal, StructJumper and a survey and interviews with blind students about their experiences learning programming. StructJumper is a tool that creates a tree based on the structure of the code, which can be used for navigation and discovering contextual information in the code. The surveys and interviews focused on the barriers that blind students faced in learning computer science. For my dissertation, I am proposing one more project investigating how to convey updates to data structures.

Introduction

Many recent efforts have worked to increase the diversity of computer science, including some that have worked to increase the presence of people with disabilities, like AccessComputing [9]. However, additional work needs to be done for students that are blind as there are many accessibility barriers that exist and can prevent them from succeeding in the field.

My work seeks to gain a better understanding of the barriers that exist in the field for programmers who are blind and to create solutions that overcome the barriers that exist. In order to gain a better understanding of the barriers faced by blind students, I did a survey and follow-up interviews with students who had completed their degrees in computer science or a related field. This work identifies the effect of the barriers these students faced. In my work to discover new solutions to help overcome the barriers that exist, I have done one project, StructJumper [1], which seeks to improve the experience of code navigation and searching for contextual information for blind programmers. I am proposing a second project that looks at how we can make diagrams of data structures more accessible, in particular when we have data structures that are undergoing changes over time that we are trying to highlight.

Related Work

The space of understanding the challenges faced by blind programmers and creating solutions for them is still a young area. Mealin and Murphy-Hill [6] did interviews with blind developers to understand their practices. They found that while many of the developers were using IDEs, they were not using the tools available within the IDEs. They also highlighted many of the practices that are employed by blind software developers such as having a temporary text buffer to store notes and also to work in.

There has been some prior work on creating accessible tools for blind developers, particularly to help teach introductory computer science camps and classes. Stefik et al. [8] created Sodbeans, a new programming IDE, which relies on audio cues to convey information such as complier errors or changing the values of variables while debugging. Another group created Audio Programming Language (APL), a new programming language designed to help teach people who are blind how to program [7]. Howard et al. [4] focused on how to provide feedback on the actions of the Lego Mindstorms NXT robots to blind students as they are commonly used in many popular with K12 students.

StructJumper

Much of computer science relies on visual cues to provide information that is not easily available in a non-visual manner. Code structure is one area where the visual cues can help a sighted developer navigate and search for information in the code. To provide this information to blind developers, we created StructJumper [1], which provides a new way for blind programmers to access and navigate the code. It does this by creating a hierarchical tree of the nesting structure of a program to allow users to both navigate within the program and gain an understanding of the structure of code. We create one tree per Java file. A node is a child to another node if the code of the child node is nested within the code of the parent node. Inner nodes represent classes, methods or control flow statements, and leaf nodes are code sections without any changes in nesting.

To evaluate StructJumper, we had seven blind programmers answer three questions requiring the user to navigate in the code or discover the context of a line of code. We found that the users in the study thought our tool was useful for navigation and for understanding the structure of code. There was also a trend that users were faster with the tool than without the tool.

Educational Experiences of Blind Programmers

My more recent work has focused on understanding the barriers that students who are blind face as they are learning to program in university and outside of the classroom. For this study we recruited 15 participants for a survey regarding their experiences in university and informal learning. We then did follow-up interviews with 10 of the survey respondents. The interviews went into more detail regarding their experiences and how they affected them. There were a few themes that arose from the interviews.

In many cases, the blind students had to do extra work that their sighted peers did not. This can include challenges such as not being able to follow the provided instructions for IDEs as they rely on using a mouse to having to do extra work setting up a system on their laptop because the lab machines do not have assistive technology on them. These challenges require the blind student to come up with their own solutions to barriers like these.

Additionally, the inaccessible technology and assignments can decrease the motivation of blind students. As many technologies are inaccessible, it made some students less likely to explore new technologies. Their past experiences made them believe that new technologies will not be accessible and thus they are less willing to try new technology. When assignments are inaccessible, students may be less motivated to complete them to the best of their abilities and may therefore not learn the concepts in the assignments as well.

Conveying Updates to Data Structures

Data structures are an essential concept in computer science that are often represented visually. The visualizations of these data structures are used extensively in lecture and in visual debugging, which is becoming increasingly more common with the development of tools such as Python Tutor [3] and jGrasp [2,5], both of which are commonly used in introductory settings. In both cases, we are often not just looking at a single visualization of the data structure, but rather a series of data structures that are showing changes as we insert, remove or move data. For my final project, I propose investigating how to convey the changes to a data structure.

To begin my investigation on how best to convey changes in data structures, I am going to look at a subset of data structures to investigate how to convey the updates. One method that I am considering is to make the data structure interactive so that there are links between the past and current version of the data structure such that when the users switches between the versions of the data structure they can see the change in context. For example, a node of a graph will be linked to its past version so a user can inspect how its edges have changed.

As blind programmers are rare, the study will be done online so that participants do not have to be local. The study will be done as an online survey where the users will be introduced to each of the conditions (the interactive condition and a base condition). Once the users are familiar with the system, the users will be taken to the real tasks where they will have a before and after version of a data structure and they will be asked to answer questions about the changes. A sample question might be which two elements in the array swapped locations. Their answers and the time they took on each question will be recorded.

Contribution

Through my work, I hope to increase the accessibility for the field of computer science for students who are blind. My contribution will come in two forms, increased understanding of the barriers that exist for blind students in computer science and new tools which investigate potential solutions for the barriers that exist. By gaining a better understanding of the barriers that exist, it provides better guidance to researchers on the areas that future innovation could have an impact on.

Acknowledgements

This material is based upon work supported by the NSF Graduate Research Fellowship under Grant Nos. DGE-0718124 and DGE-1256082. I would also like to thank my collaborators Lauren Milne and Cynthia Bennett and my advisor Richard Ladner for their support and help on these projects.

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DESIGNING IN, AND FOR, THE INCLUSIVE CLASSROOM

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Abstract

In France and in the global north in general, children living with impairments are increasingly attending mainstream schools, according to recent inclusion laws. My thesis explores how inclusion changes children's experience of school as well as how it influences designers' practices. In order to understand the issues at stake, in the case of children living with visual impairments, I conducted a longitudinal field-study, introducing and observing various probes and prototypes, developed using a co-design approach. I will present the current state of this interdisciplinary research, and in particular how these artifacts reconfigured the relationships between actors (children, caregivers, institutions' representatives). Our findings help understanding instructional technologies' adoption process, and provide design examples and guidelines for the inclusion of children living with visual impairments in the classroom.

Problem and Motivation

According to the World Health Organization (WHO) 285 million people worldwide are visually impaired, which includes 19 million children [7]. Disability being the result of the interaction between a person, their impairment(s) and their environment, various international and national laws aim at ensuring equal participation and equal chances for people living with impairments [8]. In other words, they encourage a more inclusive society, recognizing diversity.

Assistive technologies play an important role in ensuring inclusion, in education or in the everyday life, but new devices are often abandoned [6] or do not take into account subjective needs. Several authors have thus encouraged the development of a "Do-It-Yourself" approach [5], empowering users, or the development of co-design techniques to open the design brief [4].

These claims were backed by the stakeholders I worked with, whether children or caregivers. During interviews, caregivers outlined the lack of consistency between the proposed technologies and the context of use (e.g. instructional technologies are designed for specific impairments but do not take into account pedagogical project, or educational programs). Both children and caregivers, as not empowering enough. These preliminary findings orientated our research. We decided to broaden the scope of our investigation, to get a better understanding of children's experience of disability in general and the factors affecting it. The goal was to deepen our understanding of "in and around the classroom" processes, and to observe their evolutions when different prototypes are introduced.

Solutions

Field-study

All the projects presented were developed and implemented during a year and a half field-study in a specialized Institute for people living with visual impairments, using an ethnographic action research approach. It allowed us to involve children in design decisions and problem-framing, which they perceived as positive, but it also allowed us to "give back." Engaging in care relations, by producing needed items, teaching, introducing caregivers to digital fabrication techniques and supporting their learning, playing, participating in various projects, allowed us to switch from a hierarchical researcher-researched/user relation to a more equal one, and to foster trust.

MapSense, a multisensory map

Mappie, an interactive map (providing audio and tactile modality) was implemented in the studied Institute six months after the beginning of my PhD thesis, by a partner HCI research team [1]. We observed how it reconfigured caregiving practices as a system (organization and management practices) and as an approach. For example, it legitimated the use of audio cues proposed by children, in the classroom, and was as such empowering for them.

Based on our observations, we designed MapSense, enhancing the existing interactive map with a series of tangibles, some being scented or edible. We studied how each aspect of multimodality and their combinations contributed to children's representations, and to their learning processes. My hypothesis was that extended multisensory interactions would not only allow children to participate and collaborate more, thus reinforcing self-esteem, but that they would also help them develop more accurate symbolic representations. I observed and analyzed several lessons using this prototype. First results were already published (see [3]), but final results still need to be analyzed and published.

Probes

I also developed a series of probes, interactive or not. These included 3D busts of children to help them understand the organization of faces, and the expressions of emotions; customizable bracelets for teaching basic mathematics concepts to children between 4 and 6; Tactile globes; Wearable audio recorder. I am still working through what we learned from these various small projects.

Design recommendations and methods

To convey my findings, I am using different formats. For example, I listed a series of practical aspects to take into account when designing 3D printed models for people living with visual impairments (see [2]). But I have also been working on design tools for eliciting the conceptual model of disability and disabled users used by researchers from our team (in this case design cards including personas, see [2]). During this first experiment, during which I observed how explicitly taking into account environmental factors in the design process influenced the outcomes of the ideation. Following this first attempt, I designed new supports for ideation and project representation for a course introducing design students to design with / for people living with visual impairments. The impact of these supports still need to be evaluated, and will be through multimodal analysis and interviews during a third workshop in September.

Contributions

My thesis is at the crossroads of design research and sociology. It will articulate three main contributions. The first is in sociology: I show that children tend to experience inclusion a *test of resilience*. I outline the current barriers and challenges they encounter. The second is in the field of Human Computer Interaction. I investigate how inclusion as a normative ethic may influence the practices of design and HCI researchers / practitioners. The third contribution belongs to both these disciplines. I show the limits of approaching education through a design-based research, the difficulties that emerges on the institutional level, and the limitations of current approaches.

Acknowledgments

This research was conducted as part of the ANR project Accessimap (ANR-14-CE17-0018). It is supervised by Gilles Bailly and Annie Gentès.

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Blocks4All: Making Block Programming Languages Accessible for Blind Children

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Abstract

Block programming languages, such as Scratch and Blockly, are being used as to introduce children to programming, but because they rely heavily on visual aspects, blind children are being left behind their peers in access to computer science education. We propose finding new techniques to make these types of programs accessible to blind children. We plan to use an iterative design process to create a web-based application on a touchscreen laptop, where children can synthesize music using different instruments and recordings of themselves. We plan to work with students at a local school to test and refine initial prototypes in a workshop setting. We will then evaluate the final prototype in a longitudinal study with students: collecting the programs that they create over a two-week period, and conducting observations and interviews throughout that period in order to evaluate Blocks4All.

Introduction

Block programming languages, such as Scratch [4], ScratchJR [1], and Blockly[3], are becoming increasingly popular learning tools for children in elementary, middle and high school, as they allow children to avoid learning syntax and focus instead on logic and common programming concepts. These languages are composed of blocks that represent programming control structures as well as data structures and values. Each type of block has a specific shape, so that when blocks are joined together in a script, only legal syntax is allowed. This allows children to learn about logic and problem solving without worrying about the syntax and details (e.g. brackets and semi-colons) involved in most programming languages. Children can quickly build working programs without having to perform a lot of debugging just to get a program to run. However, because of the visual puzzle-piece nature of the blocks, block languages today are largely inaccessible to blind children, which puts these children at a disadvantage in learning computer science as compared to their sighted peers.

We propose developing an accessible block language that can be used by blind children, specifically 5-7 year olds, so they can learn high-level programming concepts like their peers without focusing on the low-level syntax. As part of this solution, we will develop non-visual techniques to help children understand which different pieces of code (or blocks) fit together, paralleling the visual affordances of the "puzzle-piece" blocks. We will also develop techniques that allow children to easily move and place the blocks, and techniques that allow children to understand the runtime execution of their code. Additionally, we will develop blocks that allow the children to create rich non-visual programs that are fully accessible, as the current choices (traversing mazes, animating stories) are generally not rich experiences for blind children. Our anticipated contributions are:

[3] https://developers.google.com/blockly/

1. The open-source code of our accessible block language,
2. Design considerations for accessible programming languages, and
3. Empirical findings on how the children interact with the games.

Ideally we will use the principles of universal design to create a block programming language that can be used and enjoyed by children whether they are blind, have low vision or are sighted.

Related Work

There are many block languages today that have their basis in visual programming languages. These include Scratch [4] and ScratchJR [1], both adaptations of the Logo language created at MIT, and the Blockly[1] library, which allows developers to quickly add block-based representations of code to their applications. Unfortunately, these languages are generally not accessible for blind children. The standard blocks in both Scratch and Blockly are not accessible to screen readers and the "drag and drop" paradigm is not feasible for children with either visual or motor impairments. There are exceptions to the general state of inaccessibility. Lewis [3] is in the early stages of creating an accessible language, Noodle, a nonvisual dataflow programming system, where functional units of code are strung together and the output of one piece of code is passed in as the input of another. There is also a version of Blockly that is accessible to screen readers, which allows users to access and place the blocks through hierarchical menu-based control, and navigate these using the principles of accessible web navigation.[4] Wagner et al. have also created a tool called Myna, which allows people with motor-impairments to use voice controls to program in Scratch [6].

There have also been tactile versions of block languages, including the commercial product Osmo[5], and the closely related Strawbies project [2], which both rely on tangible building blocks that can be pieced together and interpreted using an iPad to guide a monster on his quest to find strawberries, as well as the KIBO robotics kit, which allows young children to programmatically control a robot using wooden blocks [5]. While the tangible, tactile languages hold a lot of promise, they are not currently designed with blind children in mind and rely on a lot of visual aspects to convey what the blocks do.

Additionally, the output of both the tactile and digital block programming languages is generally not very accessible, as the programs created are visual: often animating a character to interact with others or traverse a maze with few audio cues. There are exceptions to this: Scratch includes blocks that allow for audio to be included (ScratchJR has much more limited support for this), and many of the languages support controlling robots, which is inherently accessible for blind children. We intend to build on this work and use the design principles these researchers have distilled to inform an accessible language: Blocks4All.

Blocks4All Design

We plan to develop a prototype using Google's open source Blockly code.[6] We will make the blocks accessible and design for touch interactions. Specifically, we plan to incorporate the following design principles:

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[4] https://blockly-demo.appspot.com/static/demos/accessible/index.html
[5] https://www.playosmo.com/en/
[6] https://github.com/llk/scratch-blocks

1. *Universal design:* designed to be usable by both sighted and blind children,

2. *Designed for young children:* as block-based languages have been most successful with young children in K-5,

3. *Touchscreen based:* using similar touchscreen interactions as used by the screen readers on iOS and Android,

4. *Allows for non-visual program exploration and construction:* Touchscreen elements can be explored using speech and sound output to give spatial information about program structure to blind children. The "drag and drop" action can be replaced with a more accessible "select, select, drop" action, which will also benefit children with limited mobility,

5. *Support for audio:* Programs that produce audio output can be enjoyable for all children.

We will develop a number of interactions to indicate how blocks can be put together using sound and allow users to make small customizations to blocks (e.g. change the number of times a loop will iterate). We will also design interactions so blind children can explore program structure and understand the state of the program during runtime. For the output, we plan on creating blocks that allow children to synthesize music by using different instruments, recordings of themselves and animal noises, as well as control structures such as loops and event-driven programming.

Evaluation

We will develop the initial prototypes iteratively with children at a workshop at a local school for the blind, taking note of challenges the students encounter and suggestions from both the students and teachers.

We will refine the prototypes, and test the final design in a longitudinal study over two weeks with children at the school. In the study, we will meet with the children and watch them interact multiple times a week, as well as allow them to use the system unsupervised and collect saved versions of their programs. We will report on qualitative results: how much they liked the system, and what they found challenging, as well as more quantitative metrics based on the collected programs: on how complex their programs were, how this changed over the two-week period, and how much the children interacted with the system.

Acknowledgments

Thanks Richard Ladner for his input and ideas in this space. This work supported by the National Science Foundation Graduate Research Fellowship under Grant No. DGE-1256082.

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PROPOSAL AND VALIDATION OF A METHOD FOR THE INCLUSION OF BLIND PEOPLE IN COOPERATIVE MODELLING ACTIVITIES

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Abstract

The inclusion of blind people in some computing-related courses and jobs is challenging. Among the reasons for that is the frequent use of models that keep a strong dependence on graphical representations, hereafter called graphical models. Challenges are related not only to individual access and editing of such models, as well as to scenarios in which other sighted and blind people work cooperatively. The literature on cooperative modelling involving blind people is scarce. In this PhD project, we aim at proposing and validating a method for the inclusion of blind people in cooperative modelling activities. To do that, we initially carried out two systematic reviews and developed a customizable prototype to support such activities. In sequence, we are going to conduct experiments with both blind and sighted people.

Introduction

According to the World Health Organization [1], there are about 39 million blind people all around the world. The inclusion of people with this impairment in some computing-related courses and jobs is challenging. Among the reasons for that is the frequent use of models that keep a strong dependence on graphical representations [2]. Examples of such models are entity-relationship models, data flow models, and the UML - Unified Modelling Language models.

While the literature on the accessibility of these models, hereafter called graphical models, is extensive from the point of view of individual activities [3-8], to cite only some, many activities conducted in academia and industry have a cooperative nature.

The existence of solutions for individual activities does not guarantee the possibility of performing cooperative activities since there are several features of the latter that are not present in the former [9]. Among these features are: (i) communication mechanisms, which facilitate the flow of speech and help overcoming breakdowns during it; (ii) coordination mechanisms, which allow people to share the activity control; and (iii) awareness mechanisms, which help finding out what is happening, what others are doing and, conversely, to let others know what you are doing. Despite a few studies have been recently published on cooperative work involving blind people, only few of them cover cooperative modelling activities [10-13].

In this context, the main objective of this project is the development and validation of a method for the inclusion of blind people in cooperative modelling of graphical models. The method will specify a set of principles and tasks that must be followed to make the inclusion viable.

The specific objectives of this project are: (i) Identify the main factors that influence that type of cooperative activity; (ii) Verify what interface/interaction styles can be used in this work; (iii)

Define what data about the participants and about the activity context must be gathered to choose the adequate interface/interaction styles, as well as coordination, communication, and awareness mechanisms; (iv) Describe how these data can be gathered; (v) Specify, develop and validate a computational tool to support these activities; (vi) Define how to use this data to produce a specification of the suitable interface/interaction styles; and (vii) Describe how to map this specification into customizations of supportive software systems.

Related Work

Winberg and Bowers [14] examined the cooperation between sighted and visually impaired people while playing Hanoi Towers games. The authors emphasized the importance of providing visually impaired participants with a continuous feedback on the game state (awareness). Not maintaining a shared cursor control among participants was also identified as a factor that improves orientation, involvement, and coordination of shared activities [15].

Oliveira et al. [16] discussed how visually impaired learners may interact with educators and with graphical content during Geometry and Trigonometry classes. The authors addressed how to translate deictic gestures made on a whiteboard with static content into a haptic representation.

Metatla et al. [10], [11], [12] proposed a tool, known as CCMi, which allows collaborative editing of graph-based graphical models for sighted and visually impaired people. The tool was developed in Java and allows the visually impaired to interact with the diagram via keyboard and a haptic device (Geomatic Touch 1). The model is represented in two ways: in its original state (no changes) and hierarchically. The authors implemented concurrent access to models by locking means. Aside from this, no other mechanism to regulate the cooperation was implemented.

Kunz et al. [17] described a system (CoME) that supports the inclusion of blind people in brainstorming sessions. The authors' main contribution was related to investigating collaborative aspects in dynamic content. The system allows blind users to access both 'artifact level' and 'non-verbal level' information through a Braille display. Pölzer et al. [18] presented the users' opinions about studies conducted in trios (2 sighted and 1 blind participant) with CoME. The studies aimed at collaboratively creating mind maps. Both artefact and non-verbal communication were established. Leap Motion was used to detect deictic pointing gestures. A tree-view of the mind map was presented to the blind and Braille displays were used in the tests. Although speech output could be used with the developed interface, the authors tested only Braille displays.

Regarding our previous published work in this field, we defined a set of high level user requirements to include blind people in cooperative e-learning activities in [13], [19]. Furthermore, we conducted a user study with 4 blind people to evaluate different awareness strategies.

Method and Research Status

To develop this project, we initially conducted two systematic reviews. One of them on the accessibility of diagrams for blind people and another on cooperative activities involving blind people. Additionally, we developed a prototype that supports cooperative modelling involving blind people and allows customizations regarding coordination, communication, and awareness mechanisms, as well as interface/interaction styles.

In sequence, we are going to conduct experiments with sighted and blind people. Before conducting the experiments, participants will answer a questionnaire with questions about their profile. The participants will have to perform a set of activities and answer questions related to each of them. The activities are organized into six (6) categories: identification, understanding, impact analysis, error correction, features addition, and refactoring.

To identify information about how the mental model of blind people influences the interaction with graphical models, the blind participants will be instructed to continuously verbalize what they are doing and the understanding they are constructing about the model. These participants will be divided into two groups: one that will verbalize during the activity and another that will do that only after finishing the activity.

In the experiments aimed at identifying the effectiveness of different modes of interface/interaction and of different coordination, communication and awareness mechanisms, the blind participants will use different configurations and the effectiveness will be measure by: (i) how long it takes to perform the activities; (ii) the number of successful activities; as well as (iii) the answers and opinions collected through questionnaires applied after the experiment.

The participation of sighted people is important to collect data that promote the evaluation of the computational equivalence between the representations adopted, because this factor may affect the effectiveness of cooperative work.

All experiments will be recorded in video and the sequence of commands and operations carried out by the participants will be registered in logs.

Contributions

At the end of this project, we hope to contribute scientifically with information on factors that influence the success of cooperative modelling involving blind and sighted people and on the impact of these factors in choosing appropriate computing resources. Yet, as a technological contribution, we will develop a tool (a prototype has already been developed) that can be used by blind people in this type of work as well as by other researchers who want to conduct experiments with individual and cooperative activities involving blind and sighted people.

Acknowledgments

We would like to thank Toshiba - grant 2014/Dr-02 (TOSHIBA-EPUSP) for supporting this research. This project also won the Google Latin America Research Award 2016.

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EXAMINING FACIAL RECOGNITION TECHNOLOGY TO AUGMENT THE INDOOR NAVIGATION EXPERIENCE OF INDIVIDUALS WHO ARE BLIND

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Abstract

Independent navigation is an important aspect in the lives of individuals who are blind. While orientation and mobility training often equip these individuals with skills for independent living, recent advances in navigation technologies could be used to augment the subjective quality of their navigation experience. In addition to outdoor navigation, blind individuals need to effectively navigate indoor spaces in different social contexts and environments. Moreover, they may need to identify the presence of known and unknown individuals in their vicinity in order to support social interactions (i.e. cueing the user to greet known individuals by name). Combining wearable solutions with computer vision and facial recognition (FR) technologies has the potential to help in this regard. However, only limited research has examined these technologies to inform the future design of assistive aids such that they meet the real world needs of this population. Research in this proposal aims to use a human-centric approach to understand both the technical and social aspects of FR technology and its integration with navigation aids. An optimal design framework will be sought in order to improve computer-vision-based navigation solutions for the blind community.

Introduction

For individuals who are blind, navigating independently is a challenge in environments that are not necessarily prepared and designed with accessibility in mind. This has consequences for blind individuals' autonomy, including difficulties of independent navigation, as well as challenges they may face in their social and professional lives [4].

Orientation and mobility training helps to provide the primary set of skills necessary for blind individuals to experience independent navigation. Recently, mobile technologies have greatly impacted the lives of these individuals by providing them with solutions to augment their primary navigation experience of using white canes or guide dogs. Examples include standalone GPS devices (e.g., Humanware's Trekker Breeze[7]), familiar smartphone apps (e.g., Google Maps) and blind-specific smartphone apps (e.g., BlindSquare[8]).

These technologies require map data as well as GPS signals, making them suitable for outdoor navigation. Similar to their sighted counterparts, blind individuals also need to effectively navigate various indoor spaces. These locations may have different social/environmental settings (e.g., professional/non-professional, familiar/unfamiliar locations).

In addition to navigation requirements, there are situations in which blind individuals may need to identify who is around in order to experience social interactions similar to sighted peers.

[7] http://www.humanware.com/en-usa/home
[8] http://blindsquare.com/

Perceiving this information increases the quality of their independent navigation and social life experience. Examples include knowing if another human is in the vicinity if help is needed, recognizing who is sitting around a table (if verbal inquiry is limited due to settings such as meetings), finding and proactively greeting coworkers and friends instead of waiting for them to announce their presence, and being aware of potential threats which may be quietly approaching. While reaching some of these goals is met through verbal communication or auditory sensing (e.g., asking who is present or passively waiting to be greeted by others), situations such as finding a specific person in a quiet meeting room or walking safely among intentionally quiet strangers may be challenging.

It is hypothesized that by combining wearable technologies with computer vision, the subjective indoor navigation experience of individuals who are blind will be augmented. Computer vision, in contrast with other indoor navigation technologies, does not need building preparations and infrastructure in advance (e.g., integrating Bluetooth or NFC sensors to build indoor maps). Moreover, the integration of FR in such mobile assistive technologies (ATs) may augment these individuals' social interactions.

Computer vision, as a technology, presents its own challenges. Computer vision algorithms may misidentify objects, make false negative errors (not identifying an object while it exists in the scene) and make false positive errors (identifying an object which in reality does not exist in the scene). Depending on the context of use (e.g., familiar versus unfamiliar location) or feature being recognized (e.g., identifying the appropriate restroom for the user, versus a closed door), blind individuals may react differently to errors that this technology makes. Therefore, examining this problem from a human-centric view helps technology designers better focus on the real needs of this population.

As part of computer vision technology, FR can help blind individuals with two types of recognition: (1) recognizing human faces and communicating this to the user, and (2) providing more detail about the other party (e.g., other party's name, relationship to user). Both of these types of the technology can help individuals who are blind be more aware of and react to others in their vicinity, by receiving augmented information from their surroundings.

Related Work

Limited work has been conducted examining the use of FR technology for individuals who are blind. Most of these studies propose prototype systems which are characterized by their emphasis on portability, convenience, intuitiveness, and cost-effectiveness. Examples include discreetly announcing names of coworkers by using smartphone camera for face recognition [1] and a wearable FR assistant with optimal recognition algorithm and hardware design [2, 3]. Panchanathan et al. [5] discussed the non-verbal cues which sighted people use during social interactions and enumerated the most important needs of individuals who are blind as they interact with others in social situations (e.g., number of people around, their direction of attention as well as their identity, their facial expression).

The primary focus of existing research in the area of facial recognition has been limited to enhancing recognition algorithms or in-lab studies. Further research is needed to identify the real-world requirements of individuals who are blind when exploring a range of indoor spaces with various social/environmental factors. Input/output interactions and requirements need to be investigated to better serve blind individuals in real-world settings using FR. The main goal of this research is to take a human-centric approach to examine the role of FR as an AT solution for this population.

Prior Work Inspiring Research

In January 2015, I joined a research team at UMBC designing an ultra-mobile indoor navigation technology using a human-centric approach. The team is exploring the ways in which computer vision technology can augment indoor navigation for blind individuals. Most recently, using a Wizard of Oz approach, we have explored the ways in which blind individuals interact with as well as react to the errors made by a hypothetical wearable technology capable of identifying certain building features using computer vision. Findings revealed that context of use impact the ways in which participants react to errors that the technology would make.

To collect comparable data, a survey with ten scenarios of use was designed, each containing a specific context and error type (e.g., familiarity, density, professional setting of the location, presence of friends versus strangers when the error occurred). A second section was added to the survey to investigate initial reflections from participants about having FR technology available on the device as well. They were asked how having this technology could help them in a subset of scenarios.

Initial findings revealed positive feedback about the idea of integrating FR technology with a navigation aid. Participants mentioned social circumstances in which they could benefit from this technology. These results, particularly the social concerns of blind individuals, combined with my previous work experience (as a visually impaired employee who faced challenges in proactively greeting colleagues or attending meetings in professional settings) triggered the idea of examining FR in more depth.

Planned Work

Based on our findings from the aforementioned survey, I plan to conduct an exploratory field study through observations and interviews at the Blind Industries and Services of Maryland (BISM), which provides blind individuals with mobility and skill training programs. I have been granted access to these programs as a participant observer. With this study, I plan to frame the research questions of my thesis. Based on preliminary findings through this observational study, the following studies will be planned to address the research questions defined. Broad questions as well as a series of studies currently planned are listed below.

1. How can the overall navigation experience for individuals who are blind be augmented/improved, using assistive technology design?
2. Can FR technology be used to support individuals who are blind to assist with navigation, particularly in indoor locations?
3. Can the social settings/environment impact the usability of FR technology to support blind users?
4. What are the key design features of FR technology to better meet the needs of individuals who are blind, specifically to improve the quality of the subjective indoor navigation experience?

Through an observational study, I aim to identify and categorize navigation and social requirements of blind individuals which FR technology may address. The impact of contextual and environmental factors will also be determined.

My next study will examine the optimal design of a facial recognition AT through focus groups of six to eight blind participants and follow-up interviews to prototype its interface, form factor and feedback system. In a follow-up study, effectiveness of the design in the presence of contextual factors will be evaluated in the wild through a "Wizard of Oz" study with eight to ten participants. This will help to elaborate on the optimal multi-modal interface that is well suited for different social and environmental contexts. It includes designing interface commands as well as the alerting and feedback system. Finally, in a complementary study, the usability and adoptability of the proposed solution will be examined in different social settings.

Expected Contributions

This work will contribute to the field of accessibility research for the blind population as well as the HCI community as follows:

1. Bridging the gap between technical and user-centric views in blind accessibility research (particularly indoor navigation solutions using computer vision and FR) by presenting the design of an AT solution which examines both technical factors as well as the impact of the situation or context.
2. Adding to the body of knowledge that will benefit the future design of AT for the blind community by addressing more of their contemporary and real life requirements, thus providing them with more independence and universal access to their environment.

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