SIGACCESS NEWSLETTER

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

My Path to Becoming an Accessibility Researcher

Richard Ladner

I realized that innovation in technology benefits greatly when people with disabilities are involved in the research, not just as testers, but as an integral part of the design and development team.

Following his recent SIGCHI Social Impact Award, Richard Ladner writes a very personal article on his path to become a full-on accessibility researcher. Indeed, a very interesting reading on the why's and how's of his career shift from mathematics and theoretical computer science to accessibility. Along the way he leaves us with useful advices and noteworthy experiences.

BESiDE – The Built Environment for Social Inclusion in the Digital Economy

Lesley J McIntyre

BESiDE is a multi-disciplinary research project that investigates the themes of ageing, wellbeing, accessibility, and digital technologies within the context of built environment design.

The second article describes BESiDE, an UK-based project, established within the context of older people's care environments. The fundamental aim is to provide understanding towards defining the enabling and disabling elements of the built environment. The author provides an overview of on-going research, initial findings, and future work.

Mosaic: Collaborative Ways for Older Adults to Use their Expertise through Information Technologies

Atsushi Hiyama, Masatomo Kobayashi, Hironobu Takagi, Michitaka Hirose

Accessibility research for older adults has mainly focused on technologies to support their health needs and declining abilities. We are considering the next level of assistive technologies, which seeks to remove barriers to active social participation.

In the third and last article, authors from University of Tokyo and IBM Research – Tokyo – describe a platform called "Senior Cloud" that supports a novel social model where seniors play an active role in society.

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.

SETH TELLER

1964-2014

Seth Teller, Professor at MIT, died on July 1, 2014 at the age of 50. He received his Ph.D. from the University of California, Berkeley in 1992 and joined the faculty of MIT's Department of Electrical Engineering and Computer Science in 1994 after two postdocs. His early work was in computer graphics, but later moved into robotics. His most recent interests were in applications of technology for people with disabilities. He was a leader of the Fifth Sense Project, a joint effort between researchers at MIT and Northeastern University to develop and test technologies for people who are blind or have low-vision. The project focused on navigation, facial expression recognition, and tactile/aural interfaces. The project is funded in part by the Andrea Bocelli Foundation.

With Professor Rob Miller, he created an innovative course titled "Principles and Practice of Assistive Technology (6.S196/PPAT)" in 2011. In this course, students work in small teams with a person with a disability to develop some piece of technology that would be useful to that person. The course includes guest lectures from practitioners and those who have disabilities. Lab exercises help students develop skills in building the kinds of technologies that will be useful. The course will continue to be taught by Teller's graduate students under the supervision of Professor Miller. See http://courses.csail.mit.edu/6.S196/fall2014/ for details about the course.

The **Seth Teller Fund to Advance Technology for People with Disabilities** that will support research, education, and other innovations that advance and improve assistive technology has been established by MIT to honor and continue his work. To donate by credit card please go to the website: https://giving.mit.edu/givenow/update-gift.dyn

To write a check, address it to MIT, mail to Bonny Kellerman, Director of Memorial Gifts, 600 Memorial Drive, W98-500, Cambridge, MA 01039, USA and indicate that the gift is in memory of Seth Teller.

Richard E. Ladner
August 3, 2014

Papers we should be reading

This section highlights some of the best accessibility related papers that were published in the last months in conference proceedings.

CHI'14 Best Paper Award

Exploring the Acceptability of Google Glass as an Everyday Assistive Device for People with Parkinson's

Roisin McNaney, John Vines, Daniel Roggen, Madeline Balaam, Pengfei Zhang, Ivan Poliakov, Patrick Olivier

In Proceedings of the 32nd annual ACM Conference on Human factors in Computing Systems (CHI'14)

CHI'14 Best Paper Award

B#: Chord-based Correction for Multitouch Braille Input

Hugo Nicolau, Kyle Montague, Tiago Guerreiro, João Guerreiro, Vicki L. Hanson

In Proceedings of the 32nd annual ACM Conference on Human factors in Computing Systems (CHI'14)

CHI'14 Honourable Mention

Never too old: engaging retired people inventing the future with MaKey MaKey

Yvonne Rogers, Jeni Paay, Margot Brereton, Kate L Vaisutis, Gary Marsden, Frank Vetere

In Proceedings of the 32nd annual ACM Conference on Human factors in Computing Systems (CHI'14)

CHI'14 Honourable Mention

Wearables and Chairables: Inclusive Design of Mobile Input and Output Techniques for Power Wheelchair Users

Patrick A Carrington, Amy Hurst, Shaun K Kane

In Proceedings of the 32nd annual ACM Conference on Human factors in Computing Systems (CHI'14)

W4A'14 Best Technical Paper Award

Helping Students Keep Up with Real-Time Captions by Pausing and Highlighting

Walter Lasecki, Raja Kushalnagar, and Jeffrey Bigham

In Proceedings of the 11th Web for All Conference (W4A'14)

W4A'14 Best Communication Award

Investigating the Appropriateness and Relevance of Mobile Web Guidelines

Raphael Clegg-Vinell, Christopher Bailey, and Voula Gkatzidou

In Proceedings of the 11th Web for All Conference (W4A'14)

W4A'14 Best Technical Paper Nominee

Evaluation of DysWebxia: a Reading App Designed for People with Dyslexia

Luz Rello, Ricardo Baeza-Yates

In Proceedings of the 11th Web for All Conference (W4A'14)

My Path to Becoming an Accessibility Researcher

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August 25, 2014

Because I started out in mathematics and theoretical computer science I am often asked how I got involved in accessibility research and in trying to increase the participation of people with disabilities in computing fields. In this article I will try to explain the why and how of becoming an accessibility researcher and why it is so important to include people with disabilities as accessibility researchers. In the process, I will describe the research that I and my students and colleagues at the University of Washington have pursued including our most recent work.

The Yearly Years

Although I am not disabled, disability is in my fabric as one of four children of deaf parents. Both my parents were highly educated and were teachers at the California School for the Deaf, then in Berkeley, California. They both used American Sign Language (ASL) and speech for communication, although not simultaneously. I grew up around deaf people and ASL, but did not become really fluent until I took some ASL classes in my mid-thirties. In my youth the word "disability" was not commonly used. To me people were either deaf or hearing, or maybe hard of hearing. Other people who had a disability were "handicapped." My parents were not handicapped in their view or mine.

While I lived with my parents, there was little in the way of technology that was available for my parents to use. My father sometimes wore a hearing aid to pick up environmental sounds. My mother hated hearing aids and felt that hearing aid salesmen were sharks just below used car salesmen and politicians. One early piece of technology was a light that went on when the doorbell rang. Sometime around 1970, while I was finishing graduate school, my parents got a

TTY which at the time was a surplus Western Union teletypewriter connected to an acoustic modem. The acoustic modem, invented by **Robert Weitbrecht** who was deaf, converted the electronic signals of the teletypewriter to sounds that would be transmitted over a standard telephone line [35]. The same modem would do the conversion of the sounds to electronic signals at the remote teletypewriter. The TTY enabled my parents to do personal texting from their home to others with similar systems. At the time I was studying in Vancouver, BC, without a TTY so I corresponded with them by mail every few weeks. Several years later, when they bought a newer TTY, I adopted theirs and moved it to Seattle, where I worked at the University of Washington. I needed a forklift to move it, as it weighed about 150 pounds. For the first time I was able to communicate with my parents from a distance in real time.

Moving Forward

When I started at the University of Washington in 1971 I had no intention of doing anything in the area of technology for people with disabilities. I worked exclusively in theoretical science where I had some modest success. Nonetheless, somewhere in the back of my mind the transformative nature of the TTY helped me realize the power of technology to improve people's lives. Around 1980 I began volunteering with the local deaf-blind community. I helped found the Seattle Deaf-Blind Service Center that is still going strong providing services for deaf-blind people in Washington State. A few years later, I saw that I could actually do something in technology to help people with disabilities, in particular deaf-blind people. In 1984, with funding from IBM, I created the DBNet project whose goal was to create a network of accessible computers for deaf-blind people to access news, e-mail, and bulletin boards from their homes. The home system was a personal computer (a first generation IBM PC) with a large print display or attached refreshable keyboard. The home systems would connect to a server (PDP-11/34) via a modem connected to a phone line. The deaf-blind users were provided a simple hierarchical textual interface to navigate the system. The DBNet system is described in some detail in a paper in the CHI '87 proceedings [30]. Soon after I created DBNet, AOL started and the first screen readers came into existence. As a consequence, the functions of DBNet could be provided by a mainstream system augmented with a screen reader. As a result of these changes, the DBNet project slowly passed away, but I learned about the importance of making mainstream systems accessible in the first place.

During this period I had the good fortune to work with a graduate student name **Ephraim Glinert** who developed a large font virtual terminal interface for Unix systems [21]. At that time Unix had a purely command line interface so having large fonts would make it more accessible for people with low-vision. He was the first student with a disability I worked with who had the creativity and skills to design and build technology that was useful to him and others. A light bulb went off in my head when I realized that innovation in technology benefits greatly when people with disabilities are involved in the research, not just as testers, but as an integral part of the design and development team. I should have seen this earlier with Robert Weitbrecht's work on the TTY modem, but alas, it took a few years.

It was also during this period, mid-1980s, when I met **Bill Gates** who visited our department to talk about common interests with a group of faculty members. At that time Microsoft was in one building in Bellevue, Washington with hundreds, not tens of thousands of employees. The Windows operating environment had just come out for MS-DOS. I noticed that it had a graphical interface and was concerned about its accessibility. At the meeting I blurted out to Mr. Gates: "How will you make Windows accessible? " He calmly explained to me the requirements of 1986 amendment called Section 508 to the Rehabilitation Act of 1973 that software purchased by the federal government must provide hooks that third parties can use to make it accessible. I had never heard of Section 508, but from that moment on, I recognized the power of law and how it can be used to benefit people with disabilities. I wanted to make sure everyone knew about Section 508, so I formed a distinguished panel for a discussion of Section 508 at CHI '88 [31]. Unfortunately, very few people attended the panel so its impact was somewhat minimal. One person who did attend the panel was **Bill Buxton**, the distinguished HCI researcher, who spoke passionately lamenting about why more people should be there. Because of the low attendance, I decided to write an article about the same topic for CACM, the flagship ACM publication with the largest circulation [30]. To date, the 1989 article has 19 citations as reported on Google Scholar and slightly more than 500 downloads from the ACM Digital Library. A few years later the important article "Computers and people with disabilities" by Glinert and **Bryant York** was published in CACM. It currently has 58 citations and over 800 downloads [22]. I have learned from these and many other experiences that accessibility is not always a popular topic. In November 2012, I was thrilled to see **Vint Cerf's** article in CACM titled "Why is accessibility so hard?" It already has 6 citations and over 20,000 downloads. I think there are many other indicators that accessibility is becoming a more popular research topic.

The Transition

During the 1990s and early 2000s I did not work on accessibility research, although I did keep abreast of developments both in industry and research labs. I continued to volunteer in the local deaf and deaf-blind communities. I continued my research program in theoretical computer science and added new topics such as image and video compression to my research agenda. In 2002, with the arrival of **Sangyun Hahn**, a new graduate student from Korea who happens to be blind, I began my transition from theoretical computer scientist to accessibility researcher. By 2008 the transition was complete.

When Hahn arrived, I was assigned to be his temporary advisor who would meet with him on a regular basis to give advice on what courses and seminars to attend. During our meetings he told me about a couple of problems with the courses he was taking. Hahn would have his textbooks scanned and converted to an accessible format. First, there were the math formulas that were not understandable by standard optical character recognition (OCR). They could be read aloud to him or converted to a Nemeth Braille or LaTex format that he could read. Second, there were the figures, which could be converted to tactile graphics, but the process used at the University of Washington through Disability Resources for Students was very slow. Figures were converted by manually tracing them in a drawing program, manually typing the text in the figures in a Braille font, then printing the resulting file on a ViewPlus Tiger Embosser. The majority of the time was spent in reconstructing the figures one at a time. As a result Hahn never got all the figures in his books, but only a few, and they were not always available when they were needed.

In Hahn's second year I suggested that he join me in starting the Tactile Graphics Project with the goal of automating, as much as possible, the process of converting figures into their equivalent tactile graphics. We put a team of students, staff, and faculty together and successfully found funding for the project. By 2005 we completed the Tactile Graphics Assistant (TGA) software that, when integrated with standard drawing, OCR, and Braille translation programs, could speed up the process of translating all the figures in textbooks as a batch process. By 2007 we had completed three science and math books with 2,145 figures in less than 8 minutes per figure average human time. We also did a number of training sessions with tactile graphics specialists to help them learn the process. Two ASSETS papers from 2005 and 2007 summarize this work [33, 24]. The Tactile Graphics Project continues to day with new research that will appear in ASSETS 2014.

A few years after starting the Tactile Graphics Project, **Eve Riskin**, my faculty colleague who I had been working with on image and video compression since the mid 1990s, approached me with an idea for a new project. Some early programmable smartphones had come out by then, so she suggested working on real-time two-way video for smartphones. We both knew about Sorenson video phones that had come out in 2002, but there was no mobile equivalent in 2004 when we started. This was in the era before 3G and 4G bandwidths were widely available so we thought that our work on low-bandwidth video compression would apply. We put together a team that included **Shiela Hemami** from Cornell University and successfully found funding for the project. The first paper on what we eventually called MobileASL (for Mobile American Sign Language) appeared in ASSETS 2006 [12]. The primary focus of that paper was on methods to improve the intelligibility of ASL at very low bandwidths. We later explored ways to preserve battery life, improve frame rate, and tolerate frame loss [16, 39, 18]. The key problem of understanding the limits in terms bandwidth, frame rate, frame loss to providing mobile sign language conversations have been fundamental to this research [40, 41]. A paper on one of these studies will appear in ASSETS 2014.

Through the Tactile Graphics and MobileASL projects, I started moving into accessibility research. My excitement grew about this research area and at the same time my excitement about doing theoretical computer science research waned. I was hooked.

Colleagues and Students

A key to my conversion to full-time accessibility research was my colleagues and students at the University of Washington who inspired me in many ways. Without them, I probably would have either retired or gone back to theoretical computer science research.

Early in my conversion, in 2006, a new faculty member, **Jacob Wobbrock**, a fresh Ph.D. from Carnegie Mellon University arrived on campus. For his dissertation, he had done some wonderful work on EdgeWrite a reliable stylus-based system for entering text for people who have trouble hitting the keys on a keyboard [44]. For the first time I had a colleague who was trained in Human Computer Interaction with an emphasis on accessibility. He taught me about how to do rigorous human studies and analyze the data from them. In addition, he was full of fresh ideas that I had no idea existed. I now had two fantastic colleagues to work with, Eve Riskin and Jacob Wobbrock who brought two completely different perspectives to accessibility research.

Over the next few years I watched Wobbrock work with his two exceptional students **Susumu Harada** (PhD 2010) and **Krzysztof Gajos** (PhD 2008) and admired their work. Harada developed VoiceDraw a hands-free, voice input system for drawing that uses vowel sounds [23]. After a few years at IBM Research, Tokyo, he moved to the Apple accessibility group. Gajos developed Supple, a system, using machine learning that automatically chooses interfaces for people with motor and vision disabilities [20]. Gajos is now a professor at Harvard University.

I have had the good fortune to co-supervise three students with Wobbrock, **Shaun Kane** (PhD 2011) whose dissertation was on the accessibility of touchscreens [28], **Jessica Tran** (PhD 2014) (co-supervised by Eve Riskin) whose dissertation was on the intelligibility of ASL conversations on mobile devices [42], and **Shiri Azenkot** (PhD 2014) whose dissertation was on eyes-free text entry on mobile devices [4]. Kane is now a professor at the University of Colorado, Boulder, after spending several years at the University of Maryland, Baltimore County. Tran started work at Thomson Reuters this summer. Azenkot started as an Assistant Professor at Cornell Tech in New York City this fall.

As I mentioned earlier, my colleague Eve Riskin suggested the MobileASL project, which we started working on in 2004. Riskin's electrical engineering (EE) background was invaluable in establishing a research agenda for the project and we were able to attract three EE PhD students to work on the project. One was Jessica Tran, mentioned earlier, who worked on the intelligibility of ASL conversations at low bandwidths and frame rates [39, 40, 41]. Another was **Jaehong Chon** (PhD 2011) who in 2007 implemented MobileASL on a HTC TyTN-II running Windows Mobile 6 over the ATT cellular network [19]. The third was **Rahul Vanam** (PhD 2010) who explored how the settable parameters in a video coder can affect the quality of ASL transmission [43]. Riskin and I also co-supervised one Computer Science and Engineering student **Neva Cherniavsky** (PhD 2009) who performed the first laboratory study of ASL conversations on smartphones testing various power saving algorithms [17]. Chon now works at Qualcom, Vanam at InterDigital Communications, and Cherniavsky at the Broad Institute.

My conversion was completed during the period 2006 to 2009, when I supervised three exceptional students: **Jeff Bigham** (PhD 2009), **Anna Cavender** (PhD 2010), and **Chandrika Jayant** (PhD 2011). Bigham did his dissertation on blind people to build accessibility into the Web [8]. His dissertation covered WebAnywhere [7], a screen reader as a web service and AccessMonkey [6], a framework whereby users and web developers can improve the web experience for blind users. After her early work on MobileASL [12], Cavender's dissertation [15] covered the ASL-STEM Forum [14], a web site for uploading and discussing American Sign Language (ASL) for terms in science, technology, engineering, and mathematics (STEM), and ClassInFocus [13], a system for deaf students to have an custom integrated classroom experience (instructor, instructor's display, captions, and/or interpreter) on a computer screen. Jayant's dissertation examined the problem of how blind people can best utilize a camera to achieve a desired result [26]. Bigham is now a professor at Carnegie Mellon University, Cavender is at Google, and Jayant is at Intel.

I have also served on the Ph.D. committee for three non-UW students who worked on accessibility topics: **Yevgen Borodin** (PhD, 2009, Stony Brook University) [9], **Raja Kushalnagar** (PhD 2010, University of Houston) [29], and **Martin Talbot** (PhD, 2011, University of Waterloo) [38]. Both Borodin and Kushalnagar hold academic positions and continue to work in accessibility research.

Of the nine PhD students I have supervised or co-supervised on accessibility related topics, three (Bigham, Kane, Azenkot) have gone on to academic careers focusing on human computer interaction (HCI) with an emphasis on accessibility. Six students hold industry positions where they can potentially use their knowledge and expertise to make help products accessible. Many of my students worked with each other on their own projects. A great example is the work of Kane and Bigham (with Wobbrock) on Slide Rule, a gesture-based non-visual interface for touch screen that appears to be the inspiration for the iOS VoiceOver screen reader [27].

In addition to the PhD students I have worked with about 60 undergraduate students on accessibility related projects in 2004. Most of these students were University of Washington students, but other were from Stanford, Harvey Mudd, Brown, Olin, Norfolk State, and University of Puerto Rico at Bayamon. Most often an undergraduate would work closely with a graduate student on a specific project.

Current Research Activities

Certain projects live on but not necessarily as research projects. Examples include:

- **WebAnywhere** where people can still go to get a screen reader as a web service.

  http://webanywhere.cs.washington.edu/beta/

- **ASL-STEM Forum** where people can go to learn about or contribute ASL signs in STEM fields.

  http://aslstem.cs.washington.edu/

- **Tactile Graphics Project** where people can go to download software to improve their productivity in transforming images in textbooks to a tactile format.

  http://tactilegraphics.cs.washington.edu/

- **V-Braille** where people can download smartphone games that encourage Braille literacy.

  http://vbraille.cs.washington.edu/

The main focus of my research these past few years has been on the MobileAccessibility Project with the tag line: "A bridge to the world for blind, deaf-blind, and low-vision people."

http://mobileaccessibility.cs.washington.edu/

The main idea of this NSF-funded project is to study how the capabilities of modern smartphones to help solve accessibility problems. Smartphones have multiple sensors (camera, microphone, GPS, compass, accelerometer, gyroscope, touchscreen) to help provide useful information, output modes (vibration, speech, sounds, display) to help provide access to useful information, and connectivity with the Internet and local devices such as Braille displays to augment its local power. All this makes the smartphone a device that, if programmed appropriately, serves as multiple function accessibility device.

I have a great group of graduate students, Shiri Azenkot, **Kyle Rector**, **Lauren Milne**, **Catherine Baker**, **Cynthia Bennett**, and a group of undergraduate students who are working on this project. Although Azenkot has just recently left the group, we plan to continue to collaborate on eyes-free input methods [1, 2, 3]. Of particular interest are extending the research on Perkinput and Digitaps to evaluate their effectiveness in the field. We have created instrumented iOS applications to gather data on the use of these two input methods. Azenkot's newest work on eyes-free speech dictation also shows promise of being a fast and accurate way to enter text for everyone, not just blind people. Rector's work on eyes-free yoga brings a new sensor, the depth camera, into play for blind people to participate more fully in yoga exercises [37]. Rector is also advised by **Julie Kientz**. Bennett will begin her formal graduate studies in the Department of Human Centered Design and Engineering after working as a staff researcher for the past two years. Milne, Baker, and Bennett have worked on a variety of projects. Milne and Bennett completed a field study of V-Braille games that will appear in ASSETS 2014 [36]. Baker, Milne, and Bennett completed a laboratory study of methods to access text in tactile graphics using QR Codes instead of Braille which will also appear in ASSETS 2014 [5].

The MobileAccessibility project will continue for quite a while as more sensors, input/output modes, remote services, and other features of mobile devices become available and wide-spread. For example, we are exploring accessibility applications that may be possible using Google Glass, mobile depth cameras, 3D motion detection, and external sensors to the smartphone. In the health and fitness area there are external devices that are wirelessly connected to smartphones that can track blood pressure, glucose levels, oxygen levels, and some physical activities. This introduces the possibility of a new area for research: accessible mobile health and fitness. We have investigated the accessibility and usability of current mobile health product and found them not very accessible or usable by blind iPhone users. Milne and Bennett gave a talk at the CSUN conference about this and plan to publish the results soon.

I strongly believe in the importance of sign languages as natural languages for deaf people to communicate effectively. In the United States over the past thirty years the popularity of learning American Sign Language (ASL) has grown dramatically. According to the Modern Language Association Language Enrolment Database's latest survey in 2009, more than 90,000 students took ASL at the college level, making it the 4th most taught language after Spanish, French, and German. This growth helps make the world more accessible to deaf people because it increases the number of people with whom they can directly communicate. With the acceptance of ASL in the hearing community, parents of deaf children are more likely to use sign language with them, which will benefit the children greatly as they grow up. The ASL-STEM Forum has the goal of enabling ASL to grow in science, technology, engineering, and mathematics (STEM) terminology. As such it can serve as an English-to-ASL dictionary in its range of vocabulary. There are several other English-to-ASL on-line dictionaries that cover more every-day terminology. Graduate students **Danielle Bragg** and Kyle Rector are working on the inverse problem of creating an on-line ASL-to-English dictionary where queries to the dictionary are provided by identifying features of signs that are observed. There have been a number of attempts to do exactly this, but to our knowledge none of them work effectively. We are approaching the problem using modern information retrieval algorithms solely on data provided by previous dictionary searches and an ASL "flash card" learning tool. We have evaluated the efficacy of their approach and hope to publish the results soon.

For the past year I have had the pleasure of working with faculty member **Alan Borning** and his graduate students **Caitlin Bonnar** and **Megan Campbell** who are developing ways to make public transportation more accessible. They have developed StopInfo an iPhone app for people to contribute and look up information about bus stops that is particularly useful to people with disabilities. They have evaluated the app with users in the field and their work will appear in ASSETS 2014 [11].

I have always been attracted to research problems that impact people with sensory disabilities (deaf, blind, deaf-blind, etc.). For these groups it is principally communication related technology that can benefit them. I wrote about this in a special issue of the *IEEE Proceedings* several years ago emphasizing the history of technology for people with disabilities and how it is important to keep in mind the social model of disability, rather than the medical model [34]. Nonetheless, I want students to have a broader view of accessibility. In 2005 I initiated a weekly Accessibility Research Seminar that is attended by students around the university. In recent years it typically has 10 to 15 students from Computer Science and Engineering, Electrical Engineering, Information School, and Human Centered Design and Engineering. Students are charged with finding papers to read in any area of their interests and leading discussions about the papers. In this way we can all keep up with developments in the field beyond those that relate to our narrow research projects.

It has been wonderful working with colleagues Wobbrock, Riskin, and Borning and with so many great students. Most recently two new faculty members with strong interests in accessibility have joined the University of Washington: **Maya Cakmak** who works in human-robot interaction with a strong interest in assistive robotics and **Katherine Steele** whose research focuses on using computational and experimental tools to understand human movement and improve the treatment of individuals with movement disabilities. The future looks bright for accessibility research at the University of Washington.

AccessComputing

In the early 1990s I met **Sheryl Burgstahler** who had just received an NSF grant to start the DO-IT Center at the University of Washington. DO-IT stands for Disabilities, Opportunities, Internetworking, and Technology. The goal of DO-IT is to "promote the success of individuals with disabilities in postsecondary education and careers, using technology as an empowering tool." For ten years from 1994 until 2003, as part of the DO-IT Scholars program, I taught a one-week workshop where students would write programs that modelled cellular automata and produced image transformations. In the process, I met many high school students with a wide range of disabilities. This fun activity solidified my belief that people with disabilities should be the innovators of technology that would benefit them.

In 2005 Burgstahler approached me about working together to create AccessComputing in response to a new NSF program called Broadening Participation in Computing (BPC) [10]. Her idea was to create an alliance with the simple goal of increasing the participation and success of people with disabilities in computing fields. The new alliance would build on the success of another program AccessSTEM that had the broader mission of getting more people with disabilities into STEM fields. She had three basic strategies:

- **Direct intervention**: provide resources and opportunities to students with disabilities that help them succeed.
- **Institutional change**: provide help to colleges and their STEM departments become more accessible and welcoming to students with disabilities.
- **Dissemination**: create information resources for students, parents, faculty members, and administrators to help them solve any problems that arise in including students with disabilities in STEM fields.

I really liked her approach and felt that we would make a great team. From my own experience, I already believed that the computing field needed more people with disabilities and AccessComputing was a mechanism by which I could make that a reality. The first of three grants was awarded in 2006 and we are about to begin our tenth year. It would be impossible in limited space to list all the achievements of AccessComputing so I will mention just a few. We have about 250 students as part of the AccessComputing Team. These students have access to internships, tutoring, conference attendance, and other activities to help them persist in their computing fields. We have 35 organizational and institutional partners throughout the USA who share our goal and act toward that goal in different ways. We have an on-line knowledgebase of more than 450 articles. The knowledgebase receives about 100,000 hits per month.

One activity that I am particularly proud of is the Summer Academy for Advancing Deaf and Hard of Hearing in Computing that I developed with the help of **Robert Roth** who is deaf. The Summer Academy is a 9-week rigorous high school to college transition program where students take a college level programming course for academic credit and an animation course for certificate credit. They also meet deaf or hard of hearing computer professionals who serve as role models and mentors. They visit companies like Microsoft, Adobe, Valve, and Boeing to learn more about what it takes to work for these companies. Eighty-three students completed the program over its 7-year run from 2007-13. About half of these students became computer science or information technology majors. Two of my PhD students, Anna Cavender and Kyle Rector, who had studied sign language, helped students immensely with tutoring in multiple years of the Summer Academy.

Whenever possible I invite my students to participate in outreach activities sponsored by AccessComputing or to attend events where they can meet people with disabilities. In this way students will be engaged with people with disabilities beyond using them as participants in studies. I believe that their personal experiences with people with disabilities will help make better researchers. In the same way I don't think that my work in AccessComputing takes away from my research, it actually makes it better.

Conclusion

I hope you now have an idea of why and how I became an accessibility researcher. You hopefully see the connection between my research and outreach efforts with AccessComputing. I have tried to include students with disabilities in the research. To date, I have worked with five PhD and five undergraduate students with disabilities on various research projects. These students have brought insights to the projects that I would never have brought. They all had the skills to make direct technical contributions as well. If I have one message for accessibility researchers it is simply to try to include qualified people with disabilities as researchers on your projects. You will be rewarded. For students who want to become accessibility researchers I also have one piece of advice. Get involved at a personal level with people with disabilities. With this direct knowledge you are more likely to create a solution to an accessibility problem that will be adopted, not one that will sit on the shelf in some journal or conference proceedings.

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BESiDE – The Built Environment for Social Inclusion in the Digital Economy

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Abstract

This article describes BESiDE, a multi-disciplinary research project that investigates themes of ageing, wellbeing, accessibility and digital technologies within the context of built environment design. Through the development of dialogue tools, indoor localization and physical activity tracking sensors, BESiDE is taking steps towards enhancing understanding of accessibility within the design of care home environments.

Focused on initial reflections from contemporary design practice, we have found that, design guidance; a lack of research 'tools' to engage with users; an absent research culture; and missing elements of design training, are factors preventing a designer's holistic engagement with the experiences of older people and technologies within the built environment. In addition to reviewing these findings, an overview of BESiDE'S continuing work and methods planned for assessing the accessibility within older peoples' care environments is discussed.

Introduction

A fundamental impact of ageing is that a person's needs and abilities change. However, regardless of current guidance and building legislation, buildings still exclude many different types of users [1] [6]. Understanding how to design an appropriately supportive built environment for older people remains a key challenge facing contemporary built environment design professionals. Despite current building legislative statutes [16] and design guidance [3] little is known from empirical evidence (generated by experiences of older people, their families, care providers and built environment designers) to define the enabling and disabling interactions with the built environment.

Factors of social inclusion, enablement, independence and physical activity remain high priorities for design, especially within the context of care homes. Therefore, BESiDE (The Built Environment for Social Inclusion in the Digital Economy) begins with an overarching question: *How can the built environment facilitate physical ability and wellbeing in care homes?*

Grounded within a manifesto of social inclusiveness, BESiDE's methods build on McIntyre's [8][9] previous architectural research which, through working with people with a range of visual impairment, revealed a multitude of disabling elements and design insights using methods of conversation and 'real-world' building walk-throughs. T BESiDE's project advances these methods by investigating how older people are currently marginalized from society via the built environment. Collaboration across disciplines of Computing, Architecture, Healthcare and Design is driving this research forward. Undertaken with care home and architectural design partners, BESiDE's research analyses the holistic design insight gained from evaluating the physical environment coupled with older people's experience of their surroundings. In addition we review the context of contemporary design practice.

Our primary objective is to understand how the built environment can facilitate physical ability and wellbeing in care homes. To achieve this we are developing dialogue tools, indoor localization and physical activity tracking sensors to capture evidence from care homes. In addition, methods of interviews, observations, and critical analyses from stakeholder interaction coupled with the sensors, will converge evidence focused on the research question. This paper introduces the multidisciplinary context of BESiDE. It discusses insight derived from the contemporary architecture before focusing on the on-going research being undertaken to investigate what enables older people within care environments.

Background and Motivation

The built environment is a diverse entity that encompasses both the internal and external conditions of our surroundings and is the context for every single human activity and interaction. To be holistically sustainable and 'future proof', the design of the built environment needs to respond to the requirements of many different users. Architectural design is an outcome of many elements (inclusive of, yet not limited to, constituents, culture, context, materials, nature and topography). Understanding design for ageing within the built environment has emerged as a fundamental focus for BESiDE.

The world's population is getting older and this impacts on what is required from the built environment in order for people to remain mobile, independent and socially included in society. There is an urgent awareness that all building users should be able to carry out their work and leisure activities efficiently, safely and pleasurably according to their abilities. Yet despite a wealth of government directives on access, the design of the built environment specifically focused on the changing needs of an older population has lagged behind considerably. Although the priority is to enable people to stay in their homes for as long as possible, there will always be those who require extra layers of assistance which can only be provided by residential care. The challenge for creators of these environments is to support, for as long as possible, the abilities of residents through adding extra layers of assistance as needed.

Immersed within this context, previous studies have investigated the architectural and physical environment design of homes and the effect on older people [2] [15]; quality of life and building design [12]; and spatial layout and patterns of space use (i.e. building layouts in delivery of social work services [4] and space syntax [5]). There is also a vast amount of research into monitoring peoples health [13]; the prevention of falls by older people [10] [11]; and technology to detect when falls have taken place [7].

However, there lacks a systematic method to collate empirical data of people living, working and visiting within care homes. Furthermore there is no quantitative data that enables the facilitators and inhibitors of the environment to be rigorously understood [2]. The relationship between people and their environments is dynamic and research is needed to understand the specific needs of older people within the built environment. BESiDE aims to fill this knowledge gap and will be informed by a number of efforts on assisted home living (e.g. Smart Homes) and community development projects focused on aspects of ageing.

BESiDE

BESiDE's research is established within the context of older people's care environments (Figure 1) and contemporary architectural design practice. The fundamental aim is to provide understanding towards defining the enabling and disabling elements of the built environment.

Figure 1 Older People's Care Home Precedent in the UK 2013/2014

Context and participants

There are two types of participants within BESiDE's research: 1. Those designing within the context of the built environment (e.g. architectural designers); 2.Those living, visiting and working within these environments (e.g. residents, family, friends and care staff). Here we concentrate on findings derived from the perspective of built environment design professionals before considering the implications for design and the continuing research of BESiDE.

Initial Findings: The Design Perspective

To provide insight into the current design process (methods, and precedent examples) of contemporary design practice, focused on designing for the future of the ageing population, we began BESiDE work by interviewing professional designers and architects. Initial interviews were conducted with n=10 participants in Scotland (primarily from Dundee, Edinburgh, and Glasgow).

N=6 were male and N=4 were female; all had been involved in designing different types of buildings, with the years of professional experience ranging from 5 – 25 years.

From these interviews, several factors have emerged as typical barriers for the designer in creating interactions within a built environment for older people. In this article, we discuss four of the developing key themes and consider how they will inform the research.

1. Building Legislation and Guidance: Barriers

Building guidance, focused on designing accessible environments, was highlighted as a factor that can create barriers for the designer in understanding both the reason for the guideline, in terms of context, as well as which guideline to follow, as the vast amount of guidance can be contradictory. As one Architectural Designer explained:

> *'Guidance nearly always lacks the context and doesn't really connect well with ideas of ageing in terms of how it relates to design. We need the reasons as to why we are supposed to design something in a certain way. That way we can come up with better, more aesthetically pleasing and technically relevant solutions.'*

An Architect added:

> '*From a designer's point of view, one of the biggest hurdles I've found is there's too much guidance and it is always different depending on where you look but it lacks ideas relating to ageing*.'

2. Working with Users: Capturing Experience

Contradictory to [14], some Architects do attempt to work with users of their buildings, especially within the early stages of a project. However, they have recognized that they lack the research 'tools' and processes to help them engage fully with their user groups. It was stated:

> *'We never really have a plan at these afternoons and mostly let the client lead the discussion. It can sometimes go off point and a lot of it is not related to design at all.'*

3. Design Practice: A Lack of research

Closely related to theme 2 is that a lack of recording these user interactions, to evolve and refine methods of engagement, was also raised as an issue. An architect described the problem:

> 'I have been the lead architect on care homes for several years and I am about to move jobs. When I move all that knowledge I have built up over my experience will also go and that's not good for the office or for the next care home designed within the office.'

4. Design Training vs. Sales Agenda

Designers training (Continual Practice Development (CPD)) was raised as a factor that often lacked an educational/research element and instead became a sales pitch from product suppliers. In addition a lack of technology- based CPD's were noted. An Architect highlighted:

> 'I have been in architectural practice for nine years, with at least 2-3 CPDs per month, and have never been to one that has been focused on ageing and design. It would actually help in design practice development and would bring ageing and ideas about different types of tech, and what this means for design, to the front of our minds. You find with the CPD events that

some of them can be glorified sales events, because they are there to sell their products. We never hear about technologies really… just things like assistive doors.'

Findings Summary

Our interviews with design professionals highlight a lack of connection between designers of the built environment and the experiences of those living, working and visiting older peoples care homes. Lessons taken from these interviews underscore that BESiDE's findings must relate and be tailored in response to the sensibilities of the designer. As part of the BESiDE effort, opportunities exist to develop a Continual Practice Development (CPD) seminar, focused on ageing and the interventions of supportive digital technology within the built environment; and to provide the link between working with users in more relevant ways. Although residential care environments are the focus of this research, the findings will transcend the care environments and provide detail to inform the built environment as a whole (inclusive of range of external and internal public settings).

Continuing Work & Thoughts on the Future

Design is constantly responding to changes in society and buildings are continually evolving and changing depending on what they are needed to be. To be holistically sustainable and 'future proof', the design of the built environment needs to respond the requirements of many different users. However, there lacked a systematic process to collate empirical data of users experiences of the built environment [2].

BESiDE aims to further uncover experiential insights in order to enable both current and future design to remain sustainable, support mobility and enhance the wellbeing of older people. We are addressing this challenge through applying multidisciplinary approaches across key activities: *The Voice of the Users, Tracing and Modeling Movements within Care Homes, and Physical Activity within Care Homes*

The Voice of the Users

Using interviews and critical analyses from stakeholder interactions we are using conversations supported by new tools to aid in conversational prompting, conversation capture, analysis, and sense making.

In addition to further establishing the context of design practice (with a wider sampling of the profession through questionnaires) we are using interviews and critical analyses from stakeholder interactions to provide understanding of the ways in which the built environment is currently shaping the behavior of care home residents, staff, and visitors.

Tracing and Modelling Movements within Care Homes & Co-Design of Wearables

In-door location sensors worn by care home occupants will be used to capture information about the movement of care homes occupants in relation to building design.

This work begins with co-design methods to create engaging and appropriate ways for care home residents to wear or carry sensors. This research in co-design of wearable artefacts will include co-design workshops with older adults, care home residents, and carers to establish aesthetic preferences, wearability and comfort. Based on the workshop outcomes, the design team will develop prototype 'carriers' for the sensors to a higher level of fidelity that will be evaluated in further workshops. The most successful and appealing of the designs will be further developed before being deployed in care homes. Read more about the BESiDE Co-Design Work

Data collected through the use of the indoor-location sensors will be augmented with observation data of care home interactions including social interactions and physical activity. Using the open-source e-Science Central cloud infrastructure for data analysis, the coded observations and associated recorded sensor data will support the development of machine learning algorithms to automatically recognise future interactions and activities from the sensor data.

Using architectural-model programs (i.e., AutoCAD) the data about physical activity in care environments will be visualized (Figure 2). The hierarchy of the care environment models will take into account key factors such as the physical layout of the building, conflicting people flow, external environments, accessibility, personal spaces, safety spaces, visiting spaces and emergency egress.

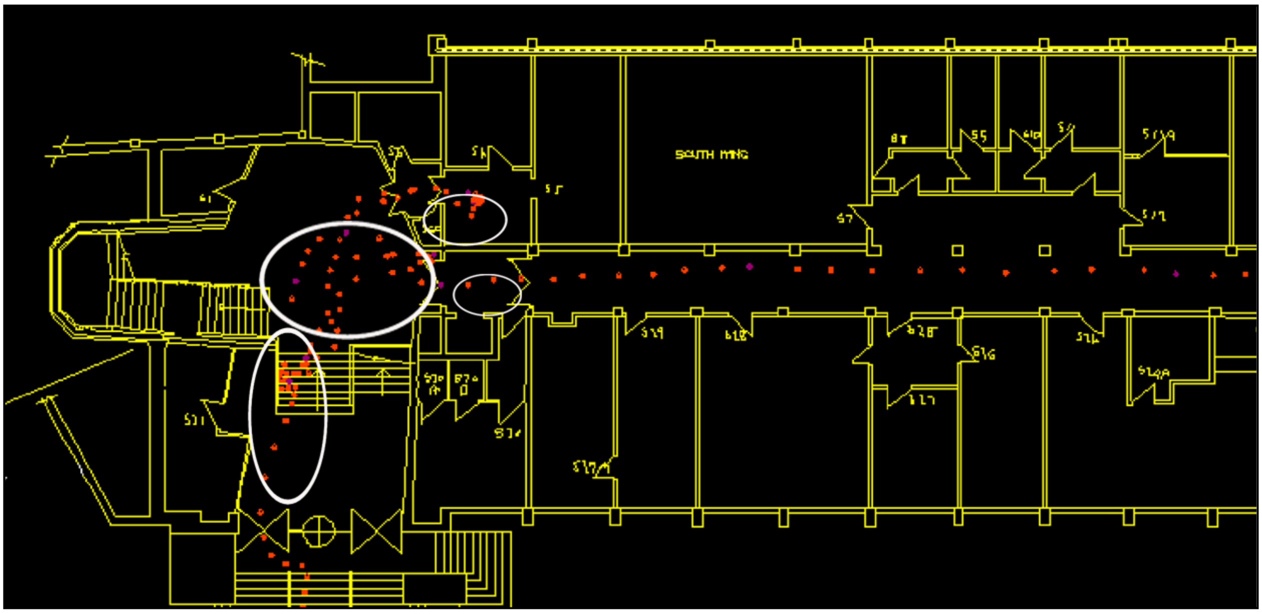

Figure 2 Movement Trace and Hot-spots. Example of 'movement trace' overlaid on floor plans, showing hotspots (from [8]).

Hot spots: The figure above illustrates data of a physical movement trace of a participant walking through and interacting with a building (each second represented as dots on the floor plan). The clusters of dots highlight a hot spot of movement – an area of critical significance – when all movement has slowed down or stopped altogether.

This highlights to us that something has happened within this specific area of the building in response to either physical impediment or decision-based change in trajectory. This could be a positive hot spot (e.g. meeting a friend in the hallway for a chat) or a negative hot spot (e.g. a wheelchair blocking a doorway).

Data collected from interviews, conversations and observations will illuminate whether hot spots are positive or negative and the underlying reason(s) for it occurring in the specific location of the building.

Physical Activity within Care Homes

Wrist-worn sensors are used to understand the physical activity of care home residents with respect to building design. We collect data from sensors, recording activities (such as walking) in relation to a location and situation variables (such as lighting). Self-reported physical activity is notoriously inaccurate, and known to be insensitive to walking, the most common activity for most older people. Furthermore, very little data on daily activity levels is available on either the oldest-old (over 80s) or those living in care settings. We will address this gap in the research literature by recording physical activity, along with coded observations, to gain a greater understanding of the activity and socialization context.

Combining Data

Through combining the activity and indoor location sensor data with the observation data on social activity we will provide, for the first time, insights into the geographical locations and spatial conditions of where older care residents are most physically active (i.e. by mapping activity 'hot spots' in the home). This mapping will create an understanding of when and where different types of social interactions take place. More importantly, it will allow building locations to be understood in relation to the design of the built environment. We will generate a rigorous and useable modelling of the built environment in relation to ageing, mobility, wellbeing and physical activity. This model will aid understanding of what the built environment needs to be to support the ageing population and will be disseminated as a useable resource for the different stakeholders.

BESiDE Impact

Although residential care environments are the focus of this research, the findings (based on 'real-world' data) will transcend the specialist care environments and provide detail to inform the built environment as a whole (inclusive of range of external and internal public settings). The bigger picture is that this research has the potential to instigate change that will: 1. Actively involve and inform professional practices of built environment design across the lifespan experience of ageing. 2. Impact on professional practice through developing digital technologies within the built environment. 3. Inform policy as to what designs and digital interventions encourage activity and how these can be engineered to facilitate increased wellbeing in older people.

Conclusions

There is an intrinsic link between buildings and the wellbeing of those who occupy them. This work carried out with Architects has begun to 'set the scene' of contemporary design practice and has uncovered implications for both the future of the profession in terms of designing for older people and in terms of disseminating BESiDE's findings.

Ageing has become a hugely important human condition impacting on what the built environment needs to be. Through the development of dialogue tools, indoor localization and physical activity tracking sensors BESiDE is taking steps towards enhancing understanding of accessibility within building design of care homes. Furthermore, throughout the research we will be asking the question: *Where the design of the built environment fails, how can technology enable accessibility and inclusion?*

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Further Information about BESiDE
To find out more about the different elements of the BESiDE project please visit our website www.beside.ac.uk You can also sign-up to receive our newsletter, follow us on Twitter @BESiDEResearch or 'like' us on facebook www.facebook.com/besideresearch.

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MOSAIC: COLLABORATIVE WAYS FOR OLDER ADULTS TO USE THEIR EXPERTISE THROUGH INFORMATION TECHNOLOGIES

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Abstract

The demographic ratio of people over 65 in Japan passed 25% in 2013. Although there are countless challenges posed by an aging population, they can be overcome by harnessing the relatively increasing vitality and productivity of senior citizens. We are studying and developing an information technology (IT) platform called the "Senior Cloud" for a hyper-aged society. The Senior Cloud innovates by proposing a novel social model that leverages the power of senior citizens. Maintaining relationships with the surrounding community is an important factor for improving the quality of life of the elderly. Working at an occupation is one of the simplest ways to sustain social relationships. However, after retirement it is often difficult for senior citizens to find suitable full-time jobs. Their preferable post-retirement working style may be part-time or working online, situations in which they are often less restricted by the working hours or locations. To realize the less-restricted working style of elderly, we introduce mosaic-type working styles that combine the skills of elderly people to form a single "virtual worker". We consider the combination in terms of the temporal, spatial, and skill dimensions.

Introduction: Is aging a social welfare problem?

The proportion of people aged 65 or over is growing rapidly in most developed countries [10]. When this age group exceeds 21% of the total population, the country is defined as a hyper-aged society [1]. Japan is the first country that became a hyper-aged society. Successful aging is a major research topic for social scientists in Japan. A recent report from Friedman et al. described one of the key factors to successful aging is being in an active relationship with the surrounding community [2][3].

The left part of Figure 1 shows the predicted demographic pyramid for Japan in 2055. As you can see, more than 40% of the population is over the age of 65. This will be a heavy burden for the younger people, even with IT support. When it comes to harnessing IT for an aging society, we tend to focus our effort on healthcare applications and assistive technologies to supplement declining physical and cognitive abilities. However, our research has led us to believe that the major problem facing the hyper-aged society in Japan may be that we are still clinging to ideas based on a society with a small working generation. People over the age of 65 are not expected to participate in the workforce, even though 90% of them may be healthy and active. If we rethink the problem, welfare is not the major issue.

We are trying to construct an innovative new social model that considers senior people as IT-supported workers. In this new social model, senior people will use IT to help younger people with their wealth of knowledge and experience. In a sense, we seek to reverse the demographic pyramid of Japan, as in the right side of Figure 1.

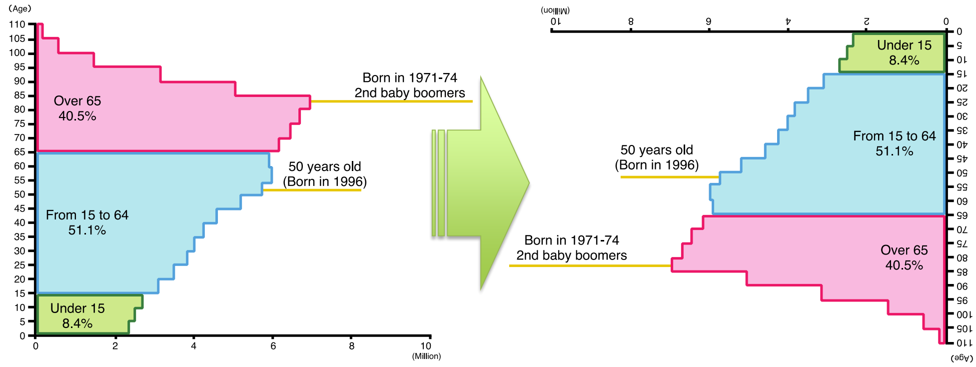

Figure 1. Reversing the demographic pyramid of Japan in 2055. (Left) Younger people support the society. (Right) Senior people support the society.

Mosaic: a collaboration framework for active senior workers

What is the senior workforce like? We examined the characteristics of retired people and found four main characteristics. They have temporal constraints and often find it hard to work full time because of their lifestyles and physical conditions. They also have spatial constraints, since many of them are unable to travel freely due to physical problems. Since each of them had unique careers before retirement, they have a wide range of experiences and abilities. Finally, they have various other reasons for working beyond the monetary motivation, such as maintaining social relationships, having new experiences, making new friends, or maintaining their health.

Figure 2 illustrates the characteristics of the senior workforce. Compared with the traditional working style, senior workers often find it difficult to work steadily at the same times and locations. Senior citizens mostly prefer to work in their spare time, and they may find it difficult to be constantly available at one location. Many seniors like to travel as tourists and they are also more likely to need time off because of their medical conditions. Can IT provide support for occasional and mobile working styles, so that seniors can be participants in their society's workforce?

We are proposing to support three kinds of working styles that combine various groups within the senior workforce.

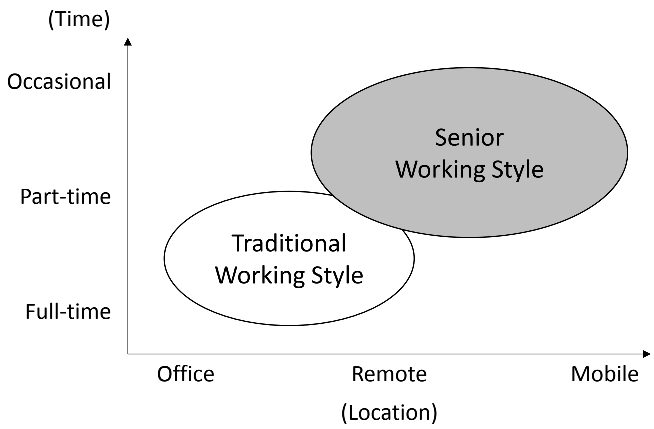

Figure 2. Preferred working style zone for seniors.

"Time" mosaic – solving time constraints

The first dimension is a time mosaic work style that combines part-time workers along the temporal dimension to simulate a virtual full-time worker. To combine the schedules of several seniors, the sharing of information must be seamless. Without IT support, when workers change their schedules, it will be difficult to communicate the changes among the senior workers. As the number of workers increases, the difficulty of editing the work schedule also increases. The scheduling must be flexible to consider the characteristics of the elderly workers. On the other side, the employers want to know that the group of employees can function as an autonomous and stable labor force. To satisfy the needs of both employers and employees, a shift-editing groupware system with a senior-friendly interface has an important mediating role. According to the interviews after our experiments, we found that our system was effective in forming and modifying the schedules. In particular, it was effective for them to provide three display modes: (1) individual availability by working days and hours, (2) total working time in the month, and (3) a matching mode linking the available work days and hours, where we use a double circle to represent a wish to work, a single circle indicating availability as a substitute worker, and crosses to indicate unavailability for work at that time.

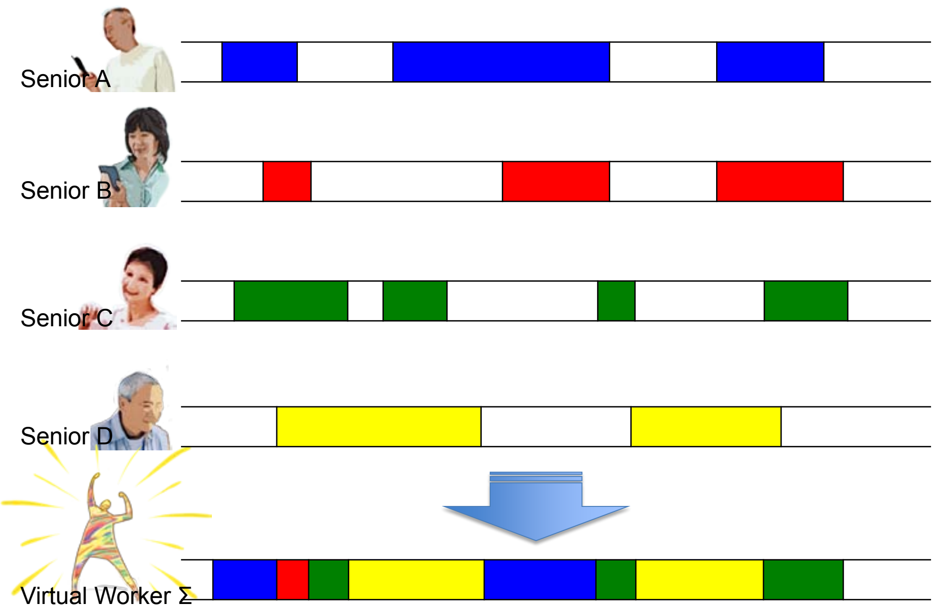

Figure 3. "*Time*" mosaic working style.

"Space" mosaic – bridging the distance

The second dimension is a spatial mosaic work style. By using advanced network and interface technologies, seniors will be able to work remotely while supporting younger workers. Wearable computers and telepresence robots will be core technologies for this working style. By using such technologies, senior citizens can be highly effective teachers or mentors in remote learning applications because of their profound knowledge and experience. To design these systems, it is important to help the remote operator concentrate on communicating with the learners at the other sites, not on the system operation. We believe that that designing harmonious combinations for autonomous recognition of the real world environments and rich communication interfaces will be the main research topics in this domain.

Figure 4. "*Space*" mosaic working style.

"Skill" mosaic – composing pieces of skills

The last dimension is for the skill mosaic work style. If we could systematically measure each worker's skills and physical conditions, then we could combine each person's specialty towards producing one effective virtual worker. In this dimension, we can also consider including the skills of younger workers. We are studying ways to discover and represent senior citizens' skills through the logged data, including text (as in social networks) and sensor data (perhaps from lifelogs).

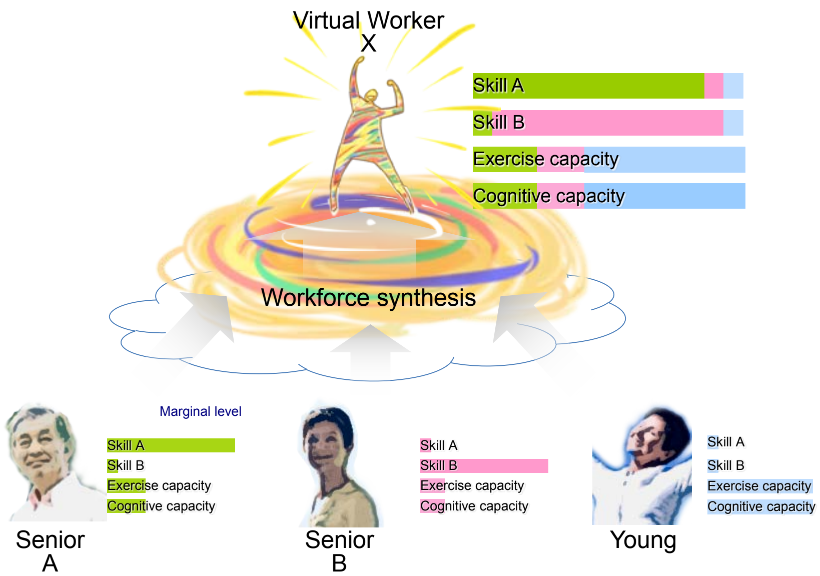

Figure 5. "*Skill*" mosaic working style.

Pilot studies

As a part of the ongoing mosaic framework initiative, we have studied various proof-of-concept systems. Each section includes references for more details.

Onsite cooperative work based on “time” mosaic

To assess the feasibility of a time mosaic of senior workers, we developed a Web-based schedule management system and tested it at cooperative farms in a suburban agricultural area [8]. The system supports iPads as a target device because of their portability and seniors’ preferences. Once a farming task for a particular day is added in the system, the system helps assign that task to some of the workers who are available for that day. In this situation a dynamic, flexible time management system is needed because, for agricultural work by seniors, the task assignments may frequently change based on the weather and plant conditions, as well as the workers’ health and family situations. The workers found that the system was effective and, in comparison to traditional communication methods, the introduction of the system drastically reduced the communication costs among the workers to reach a consensus on the schedule. In addition, even though the system itself was only intended to support the time mosaic, the workers reported that they did consider how to form a team of complementary skills when seeking the consensus, which indicates that the system would be more effective if it provided some mechanisms to support the skill mosaic.

Remote work through crowdsourced micro-tasks

To assess the feasibility of crowdsourcing-style work involving seniors, we developed a Web-based proofreading system and deployed it in a project to make accessible digital books in collaboration with a public Braille library [4][5]. The system decomposes the proofreading tasks into three types of micro-tasks and dispatches them to crowd workers. Due to the nature of crowdsourced micro-tasks, the system supports the time and space mosaics in the context of online work, where the workers are allowed to work at their preferred times and locations, leading to the production of collective outcomes. The results were promising. On average, crowds of senior citizens performed more tasks and showed more sustainable participation than younger crowds. This indicates that, even though the seniors have rarely participated in this kind of opportunity, i.e., crowdsourcing, they can be highly dedicated workers once they are involved in the community of crowd workers. More interestingly, the young and senior workers showed different preferences on the three types of micro-tasks, where the tasks required different skills and abilities. The two age groups tend to make complementary contributions to the collective outcomes, which is also a skill mosaic. Now we are studying the quantitative skill assessment of individual workers based on a variety of numerical models, so that the system can more accurately assess and combine the participants’ skills.

Remote classrooms to study information technologies

A fundamental requirement to effectively utilize the mosaic framework is that each senior worker have a certain level of motivated IT skill. However, in practice the lack of IT skills often prevents them from trying new opportunities. Even if the system is easy to use, their typical fear of new technologies is likely to inhibit the active use of information technologies [6]. It is known that face-to-face instruction is an effective way to initiate seniors into the digital world [5][7]. One major problem is that the skilled seniors (with a deep understanding of their generation’s needs) who can effectively instruct less skilled seniors are often distant from the potential students. For this reason, we developed and tested a remote classroom system that seeks to provide a learning experience similar to an in-person instruction course [9]. In addition to the main screen, where the instructors are shown to the learners, the system provides several additional and parallel communication channels. Instructors can see the learners’ real-time operations on their screens as well as their facial expressions, which allows them to easily find the learners who are having trouble. Each leaner in trouble can be provided with private guidance by a remote instructor via a headset. The results showed the effectiveness of the system, at least as measured by comprehension.

We plan to extend the system so that it can be applied to a broader scope of remote collaborations. A promising approach might be the use of robot avatars, which would allow remote work for jobs that also require physical interactions, e.g., agriculture or handicrafts. Even in the remote classroom scenario, the avatar robot might be effective for more sophisticated remote communication. In this scenario, we are interested in such questions as: In what situations is the avatar robot more effective? What kinds of robots are more effective for each situation?

Conclusions

Our "mosaic" approach is a framework that facilitates seniors' higher-level participation in society by flexibly managing their expertise in the workforce. It includes three major dimensions for time, space, and skill mosaics. The time mosaic dynamically arranges the scheduling preferences of a number of part-time workers to produce a suitable schedule. The space mosaic represents remote collaboration, including on-site work via avatar robots as well as Web-based online work. For the skill mosaic, the system addresses the gaps between the required and existing skills of the workers by forming a team with complementary skills. The team may have young workers with higher physical and cognitive abilities, or add in some technologies that can enhance the senior's abilities. To evaluate our framework, we tested three systems: (1) a scheduler for on-site part-time work, (2) an online micro-tasking system (crowdsourcing), and (3) a remote classroom to improve the IT skills of seniors. We are currently investigating skill assessment mechanisms and the use of avatar robots. Each of the described solutions work as pillars on our Mosaic Framework; by connecting them, senior citizens will be provided with many opportunities to use their expertise. One possible example might involve two retirees in developed countries, where one has 30 years of professional experience and the other has expertise in translation, who could collaborate to create a virtual on-the-job trainer at a startup company in an emerging country, all of this done by ignoring the barriers of time zones and languages.

Accessibility research for older adults has mainly focused on technologies to support their health needs and declining abilities. We can see these as the first level of assistive technologies, which aim to remove barriers against their independent living (i.e., "access to life"). On top of that base, we can consider the next level of assistive technologies, which seeks to remove barriers to active social participation (i.e., "access to society"). These higher-level technologies will address not only physical and cognitive barriers, but also mental and social barriers by designing motivating scenarios such as appropriate opportunities to use the expertise, encouraging instructions, etc. We assume that it represents a new area of accessibility research, which will lead to more social inclusion, where senior citizens are transformed from "assisted people" to "assisting people".

Acknowledgments:

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