Determining Accessibility Needs Through User Goals

Kevin Carey[1], Rosaria Gracia[1], Christopher Power[2], Helen Petrie[2] and Stefan Carmien[3]

[1]humanITy, Hassocks, UK, BN6 9PX
{humanity,rosaria}@atlas.co.uk

[2]Department of Computer Science, University of York, York, UK, YO10 5DD
{cpower,petrie}@cs.york.ac.uk

[3]Fraunhofer-Institut (FIT), Sankt Augustin, Germany, D53757
stefan.carmien@fit.fraunhofer.de

Abstract.

Access to information remains a major challenge for people with disabilities. In this paper, an approximate model of how people access information is proposed. This model is presented in the context of the sequence of goals that must be completed by a user to access an information source. This model has led to the development of a tool, the Accessibility Information Matrix that can be used to guide the design of technologies and techniques for information access.

Introduction

The field of accessibility has advanced substantially over the last 10 years. With innovations in assistive technologies, along with the provision of various guidelines for accessible content, it would seem that many of the problems faced by those with people with disabilities should be solved.

However, despite these advances, and the increased awareness regarding accessibility that has come with them, there are still enormous challenges for people with disabilities when interacting with information. Examples can be seen in the report by Burton [1] regarding the use of cell phones by people with visual disabilities where, even though screen reader functionality was outstanding in its performance, users frequently experienced problems with advanced functionality such as audio note taking. Similar reports are seen in the experiences of blind users navigating table renderings on websites. This is a prime example of where information can be perceived but not navigated, and thus unique browsing solutions are required [2]. Finally, there are experience reports of deaf learners having challenges participating in class discussions, even when an interpreter is available to assist them with communication [3].

From these examples, it becomes clear that accessible information is not a simple on and off proposition. It is not the case that once a user can perceive the information, he/she will have complete access. There is a broad range of activities that occur after the initial perception that a person must undergo to fully comprehend and then interact with information.

The paper provides an approximate model of information access that describe the types of goals that a person completes when working with an information source. Each goal presents new accessibility challenges and new needs for particular groups with disabilities.

Additionally, presented in this paper is a tool based on these goals: the Accessibility Information Matrix (AIM). This tool indexes accessibility needs and solutions by both the goal and a disability group.

This paper begins with an introduction to Norman's stages of action [4], which is then related to eight distinct goals of information access. These goals are then described and an example of their use in organizing the needs of people with visual disabilities is presented. The paper concludes with directions for future work, such as the inclusion of the AIM in scenario based design and other design projects.

Norman's Stages of Action

Don Norman's high-level schema of human actions [4] is intended to support discussions and design concerns of the interactions of people with artifacts in their world. Two key concepts from Norman's model are *goals* and *intentions*. He defines a goal as "…something to be achieved…" and an intention as being "…a specific action taken to get to the goal…"

Using these definitions, Norman's model starts with the setting of a goal, and then the execution of intended actions that allow the person to reach that goal. Finally after performance of those actions a person must perform evaluation of the state of the world to see if the desired result was achieved. This continues in a cycle until the original goal has been completed to the satisfaction of the user. The execution stage can be further broke down into three steps:

1. The user forms an intention to act to achieve the goal.
2. The user builds a sequence of actions planned to achieve the goal.
3. The user physically executes the intended actions to achieve the goal.

Similarly, the evaluation stage can be broken down into three parts:

1. The user perceives the state of the world after the performance of some actions.
2. The user interprets those perceptions according to the expectations resulting from the actions.
3. The user must examine the current world state with respect to both his/her own intermediate expectations and his/her over-arching goal.

Therefore, the seven stages of action are comprised of the goal step, the three steps of execution and the three steps of evaluation.

It is important to note that goals are not necessarily atomic. In many cases goals can be broken down into sub-goals, each of which must each be executed and evaluated. The model of information access presented in this paper uses this feature of Norman's model to break down the goal of acquiring access to information into a set of sub-goals required to fully interact with a particular information source.

As an initial example of how this discretization of goals can occur, consider a person who is blind wishes to understand educational material for a class. Her first step is to generate a goal: to comprehend the contents of a lecture on Shakespeare. Then, she makes a plan to get a copy of the slides and read them. She breaks this into the steps of calling her professor, accessing the slides on a file server and having her computer speak the slides to her. After contacting the professor and downloading the slides, she has her computer use a voice synthesizer to speak the notes to her. When she is done, she recognizes that several plays are missing from the notes, as the table of contents covers all of the plays of Shakespeare. Realizing this, the student decides to call the professor to see if she is missing some lecture slides.

When looking closely at the example, it can be seen that there are several sub-goals that are implicit in the student's actions. Before she could comprehend the materials she had to acquire the information source, and then had to find a way to perceive the contents of that source. These sub-goals in themselves are not unique to people with disabilities; indeed they are what all people wanting to achieve the overall goal must do implicitly to access information. What is important is this: for people with disabilities, these implicit sub-goals are often places where accessibility problems appear.

Goals of Information Access

In order to address the various goals involved in accessing information, consider a further example of a person researching a topic from an encyclopedia.

First the person must obtain the encyclopedia. This is where the first challenges could be presented to a person. For example, the goal of *acquisition* of a resource has associated with it commonly faced challenges by people with physical disabilities. This might involve physically obtaining a book from a very high shelf, or turning on a computer to visit an encyclopedia website. Such challenges can be overcome by personal assistants or through technology (e.g. sip/puff interface). Despite resources regarding the need for accessibility in this goal [5], one can see examples everywhere of this type of accessibility need being overlooked, such as terminals at rail stations that are too high or two low to be useful to someone in a wheelchair.

After the resource has been obtained, the user must *perceive* the information contained within. This is possibly the most common goal that is addressed by current accessibility efforts. Screen-readers, sign language interpretation of speech and colour contrast adjustments are all examples of services designed to improve the perception of information.

With the perception of information complete, the person must undertake *cognition* of the information to become aware of and understand its meaning. An example of an accessibility tool intended for use in this state is word-highlighting enhancements used to aid people with dyslexia [6].

Once the information has been found and understood, there is an *integration* step where information must incorporated into the body of knowledge that the person already possesses. Challenges in this area, in particular regarding the management of a potentially large group of resources, are often encountered in people with a variety of learning disabilities.

Understanding the *intent* of the author is often a challenge when working with information. In spoken language, comments can be meant in humour, or in irony. In text, the typesetting of emphasis through italic text or underlining can provide key information regarding the original intent of the material.

When these goals have been completed, a person can now *navigate* through an information space, he/she can *interact* with existing materials or participate in the *creation* of new materials.

The order that these goals are taken in is as they were presented in this section, with a diagrammatic representation of this ordering presented in Figure 1.

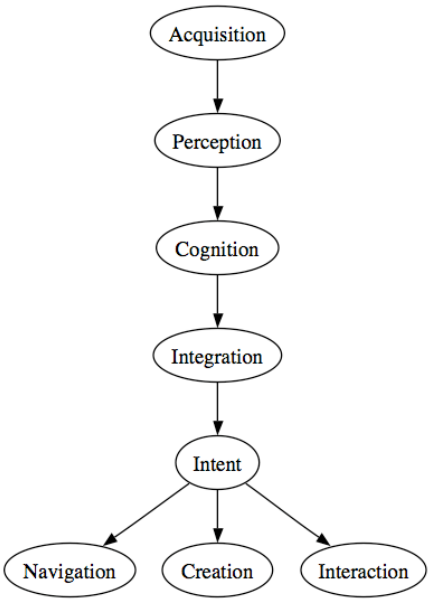

Figure 1 The ordering of goals for information access.

Goals and Accessibility Needs

The types of challenges that can be encountered in each of the above goals will be unique to any individual person; however, there are several challenges in accessing information that have been identified to be present in common to people in a particular disability group. In this section, a set of accessibility needs for one group, people with visual disabilities, is discussed. In each case the accessibility needs are associated with the goal that is to be accomplished in gaining access to information.

Acquisition

The acquisition of resources that are in appropriate formats remains a challenge for people with visual impairments. Whether this is related to tactile or audio materials, resources are often not available [7].

Perception

The perception of printed text and graphics is perhaps the most obvious of the challenges presented to people with visual disabilities. As a result, this is perhaps the most addressed in terms of assistive technologies/techniques, be it Braille, tactile diagrams, audio presentation of text, or multi-modal diagrams [8].

Cognition

For those who are unfamiliar with tactile or audio information sources, such information can be difficult to comprehend. While such challenges are sometimes overcome with practice, the proper design and organization of data can also assist with these challenges. For example, many of the guidelines for tactile pictures are designed to limit those features that are confusing to people with visual disabilities; such as avoiding large amounts of empty space between objects or the consistent mapping of symbols.

Integration

One of the integrative challenges associated with visual disabilities is the problem associated in dealing with multiple sources. Having to cross-reference knowledge from one audio source with another can be difficult due to the serial nature of the information.

Another associated problem with this goal for people with visual disabilities is the lack of information available for integration. In some cases, information sources assume prior knowledge regarding a topic. That prior knowledge must itself be accessible for the new knowledge to have meaning.

Intent

The use of emphasis notation in text can be perceived through screen reader technology if properly indicated through document markup; however, with this perception there needs to be an understanding of why such emphasis is being used may be lost without proper context information surrounding it. Other examples of challenges in this area are the understanding pictorial irony or humour.

Navigation

There are several distinct challenges faced by people with visual disabilities in navigation depending on the medium a resource is presented in. Due to the serial nature of both audio and tactile presentations, the lack of a proper table of contents or index can make a large source unmanageable [9]. Indeed, similar arguments are made regarding the need for proper use of headings/semantic markup in web pages for navigation purposes [10].

Interaction

For people with visual disabilities the ability to manipulate documents and other types of materials remains a challenge. Examples can be seen in the World Wide Web where web forms cannot be followed properly due to incorrect tabbing order. This type of problem can be overcome by explicit ordering of interaction rules and proper adherence to best practices for the interaction medium.

Creation

The creation of materials by the visually impaired for other users remains a challenge. While there are some aspects, such as Braille transcription into ASCII/Unicode text, that are well understood, solutions for other types of creation, such as self-made tactile diagrams, are still lacking [11].

The Accessibility Information Matrix

The above (far from complete) set of challenges encountered by people with visual disabilities in accessing information begins to demonstrate how complex addressing accessibility needs can be in any given design. This model of information access provides a way of parameterizing accessibility needs by the goals of the individual and by disability group. This cross-referencing creates lookup table: the *Accessibility Information Matrix* (AIM). The cells of an instance of the AIM are populated by accessibility needs of the users, and possibly a list of solutions, either technological or otherwise, that address those needs.

While a complete matrix is beyond the scope of this paper due to its size, an example layout of such a matrix is presented in Table 1. The AIM has the sub-goals for information access on the vertical axis, with the various groups of users across the horizontal axis. In Table 1, four broad categories of users are presented: people with learning disabilities, people with physical disabilities, people with auditory disabilities and people with visual disabilities. These are not the only categories that could be included, with more precise groupings possible (e.g. colour-vision deficiencies etc.), as well as other people with disabilities (e.g. cognitive disabilities).

Table 1 The layout of the Accessibility Information Matrix (AIM).

Sub-Goal/Group	Learning Disabilities	Physical Disabilities	Auditory Disabilities	Visual Disabilities
Acquisition	…	…	…	…
Perception	…	…	…	…
Cognition	…	…	…	…
Integration	…	…	…	…
Intent	…	…	…	…
Navigation	…	…	…	…
Creations	…	…	…	…
Interaction	…	…	…	…

The AIM can be used in a variety of ways in the design process. If a designer has an existing design, he/she can identify the set of sub-goals within the matrix that applies to the user tasks performed in it. These goals can then be used to reference the needs of each disability group, with the intention of identifying if the design satisfies the needs therein, or if not, what appropriate solution to those needs is available.

Discussion

It is important to note that this model of information access, much like Norman's original model of human action, is only an approximate model of the behaviour of information access; it is not a complete psychological theory. There are many ideal assumptions made regarding the progress of a user through the various sub-goals. In particular, there are occasions where a person will need to repeat a sub-goal several times before finding an adequate solution. An example of this would be a person who is blind using a screen reader and Braille to perceive information. In the same way, it is difficult to put firm boundaries on when a particular sub-goal ends and another begins, such as perception and cognition.

The model was validated through the examination of the experience reports by people from a variety of disability groups, in particular those from the groups of people with learning disabilities and people with visual disabilities. From these experience reports the authors reconstructed the common sub-goals that cause barriers to information.

Despite the fuzzy boundaries between the various sub-goals, this model has already proved useful in design settings. The AIM was applied in several scenario-building exercises by the authors [12]. When completing the problem scenarios for a person completing an information access task, the various sub-goals clearly identified the points where barriers to information occurred. This gives some evidence that the AIM could be used throughout the scenario-design process.

Future work on validating the AIM includes its use in several more example scenario-building exercises, with its use being applied through to a final design evaluation. The AIM will also be used in identifying the needs of real users based on large-scale interview and surveys in relation to the participation of people with disabilities in learning settings.

Conclusion

In this paper an approximate model regarding how people interact with information has been presented. This model has been demonstrated to break the overall goal of information access into sub-goals, as proposed by Norman in his work on the stages of human action.

These sub-goals have been used to breakdown and understand the types of accessibility problems that occur for people with disabilities. With this model, and its related tool the Accessibility Information Matrix, designers, practitioners and researchers will be able to more accurately identify those places where accessibility needs are not met in their designs. This analysis will result in better designs that provide better access to information for all users.

References

[1] Burton, D.: Talk me through it: An Evaluation of Two Cell Phone-based Screen Readers. Access World **8** (1) (January 2007)

[2] Yesilada, Y., Stevens, R., Goble, C., Hussein, S.: Rendering tables in audio: the interaction of structure and reading styles. In: Proceedings of the Sixth International ACM SIGACCESS Conference on Computers and Accessibility. (2004) 16-23

[3] Freebody, P., Power, D.: Interviewing Deaf Adults in Postsecondary Educational Settings: Stories, Cultures and Life Histories. Journal of Deaf Studies and Deaf Education **6** (2) (2001) 130-142

[4] Norman, D.: The Design of Everyday Things. MIT Press (1990)

[5] Gill, J.: Public Access Terminals. In Abascal, C.N.J., ed.: Inclusive Design Guidelines for HCI. Taylor & Francis (2001) 179-192

[6] Petrie, H., Fisher, W., Weber, G., Langer, I., Gladstone, K., Rundle, C., Pyfers, L.: Universal Interfaces to Multimedia Documents. In: Proceedings of 4th IEEE International Conference on Multimodal User Interfaces. IEEE Computer Society Press (2002) 319-324

[7] Halliday, J.: Personal Braille Libraries - How the 21st Century is Redefining Braille. In: Proceedings of CSUN 2004 (19th Annual Conference Technology and Persons with Disabilities). (2004)

[8] Gardner, J.: Access by blind students and professionals to mainstream math and science. Computers Helping People with Special Needs 8th International Conference, ICCHP 2002. Proceedings (Lecture Notes in Computer Science Vol. 2398) (2002) 502-507

[9] Petrie, H., Fisher, W., O'Neill, A.M., Gladstone, K., Rundle, C., Pyfers, L., van den Eijnde, O., Weber, G.: Navigation in multimedia documents for print disabled readers. In Stephanidis, C., ed.: Universal access in HCI: inclusive design in the information society. Lawrence Erlbaum Associates, Mahwah, NJ (2003)

[10] Chisholm, W., Vanderheiden, G., Jacobs, I.: Web Content Accessibility Guidelines 1.0. Online Website at http://www.w3.org/TR/WCAG10/ Retrieved February, 2006 (1999)

[11] Way, T.P., Barner, K.E.: Automatic Visual to Tactile Translation - Part I: Human Factors, Access Methods, and Image Manipulation. IEEE Transactions on Rehabilitation Engineering **5** (1) (March 1997) 81-94

[12] Rosson, M.B., Carroll, J.M.: Usability Engineering: Scenario-Based Development of Human-Computer Interaction. The Morgan Kaufmann Series in Interactive Technologies. Morgan Kaufmann, San Francisco (2001)