2022
THE JOURNAL ON TECHNOLOGY AND PERSONS WITH DISABILITIES

AI Based Recommendation and Assessment of AT for People with Cognitive Disabilities

Peter Heumader, Tomas Murillo Morales, Klaus Miesenberger
Institut Integriert Studieren, Johannes Kepler University Linz,
Altenbergerstraße 69, 4040 Linz
peter.heumader@jku.at, tomas.murillo_morales@jku.at,
klaus.miesenberger@jku.at

Abstract

Nowadays a considerable amount of assistive technology (AT) is available for people with cognitive disabilities. However, many users with cognitive disabilities do not make use of any AT, as they are not aware of which suitable technologies are available for their specific needs. This paper describes a modern web-based recommendation system, named Buddy, that enables persons with a cognitive disability to discover AT without the need for external support

Keywords

web accessibility, cognitive accessibility, assistive technology

Introduction

In recent years a considerable number of accessibility tools have become available on the market, aiming to provide better support to people with cognitive disabilities when accessing the World Wide Web (Miesenberger, K., Edler, C., Heumader, P., & Petz, A.: Tools and Applications for Cognitive Accessibility). Being able to access and navigate the Web in an autonomous manner is essential for inclusion in society in most aspects of daily life, such as education, work, leisure, and overall participation in society. Although increased web accessibility is being improved by policy, standards and regulations, there is evidence that the uptake of digital content by people with cognitive disabilities and their formal and informal service sectors has been considerably lagging behind.

State of the art

Despite the lack of legally binding requirements, technical support for cognitive accessibility is being developed at different levels (Miesenberger, K., Edler, C., Heumader, P., & Petz, A.: Tools and Applications for Cognitive Accessibility):

- Mainstream mobile technology based on touch/gesture interactions, which people with cognitive disabilities often use without support from formal or informal care providers, often reaches the necessary level of usability and comprehensibility by cognitive disabled people.
- Well-established website manipulation techniques can support users with cognitive impairments, for example by offering layout adaptation capabilities such as font selection, font size, line/character/word spacing, foreground/background color, as well as voice in/output. However, these are hard to find and handle for our target audience.
- Some digital content is becoming more adaptable and customizable in terms of the language level, images, symbols and videos it employs. Content and interaction personalization can be particularly useful for users with cognitive impairments.

- Content customization is well supported through the trend of enriching the web with semantic information, which allows for better personalization and cognitive support.
- Pioneering approaches to supported or automated translation into easy to read, symbol languages annotation, for language translation are available. These technologies are not yet fully reliable but show the way forward for better digitally supported cognitive accessibility and digital services.

All in all, there is knowledge about cognitive user needs and there are tools on the market which can address many of these needs. Although technology is available, many users with cognitive disabilities are not aware of their existence and therefore struggle with digital content and services.

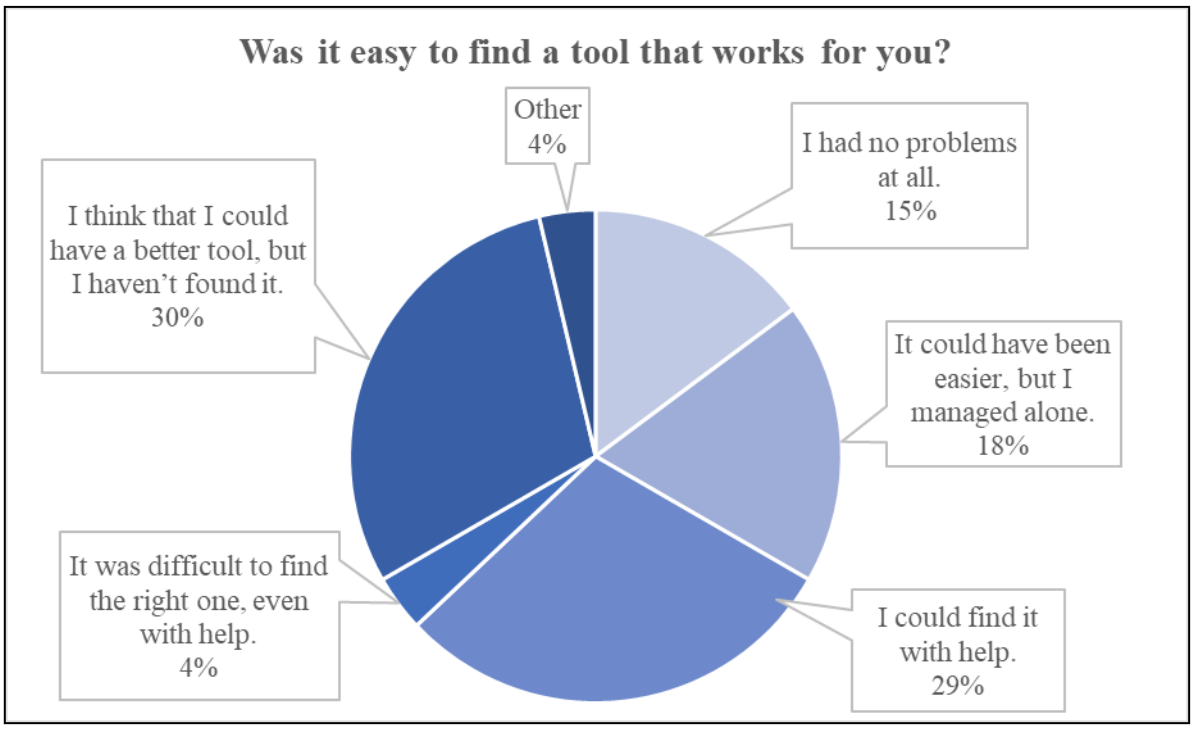


Fig. 1. Results from a User Study on Assistive Technology Usage in Sweden and Austria.

The present research started by studying how end users with cognitive disabilities discover and use AT by conducting an online survey with selected participants in Sweden, Austria, the United Kingdom, and Lithuania. 88 valid responses were received. Almost half of these participants reported that they were responding for themselves, with the remaining

ones reporting that they were filling in the survey on behalf of a cognitive disabled person (most commonly, a friend or relative). This split suggests that respondents cover a wide range of the cognitive spectrum.

One third (32%) of respondents report using AT of some type, whereas the remaining 68% do not currently employ any AT to support their needs. However, it is important to note that out of the respondents not using AT, nearly two thirds reported that they do not need it. Figure 1 shows the share of AT users according to the perceived difficulty in obtaining suitable AT for their needs. As depicted, only 15 percent of users stated that they managed to find suitable AT on their own without any problems. Over 60% of AT users needed external support to find the right technology for their needs.

These results suggest that the AT provision process has a significant gap when it comes to training, support, and maintenance. On the other hand, 64% of participants already using some form of AT reported on a subsequent question that they do not need help using it. It can therefore be concluded that the greatest barrier in AT provision (at least in the selected countries) comes from users not being able to find the proper AT for their needs, not from the AT solutions themselves.

Discussion

In order to bridge the gap between existing AT solutions and end users, this paper tackles the problem of developing a solution for simple, effective, and autonomous discovery of AT by persons with a cognitive disability. Addressing the accessibility challenges mentioned above, our approach is implemented as a repository of relevant tools (features, apps, ATs, etc.) and an Artificial Intelligence (AI) assisted recommendation system that helps users with cognitive disabilities to access online contents and services. The solution, named Buddy, is based on two main components, namely: (1) an online repository of AT entries and user profiles that stores the support categories of available tools and the abilities and

preferences of each user, and (2) an intelligent recommender that leverages the stored knowledge about users and AT entries to create personalized recommendations on suitable AT fulfilling the specific user needs.

User profile

To generate recommendations for assistive technology for a specific user, the needs and preferences of this user must be known. As a basis for eliciting the user requirements, we mapped the definition of cognitive functions and needs in the ISO guidelines for the design and development of cognitively accessible systems, products and services (ISO 21801-1:2020) against the cognitive abilities as defined in the ICF framework (World Health Organization: International Classification of Functioning, Disability, and Health: ICF). This process resulted in a list of relevant cognitive user needs. The list was also complemented by definitions of cognitive user requirements developed within research initiatives that explicitly look at requirements for the web, most notably the research conducted by the W3C COGA group (Seeman, L., & Cooper, M.: Making content usable for people with cognitive and learning disabilities).

As a result of this research, the following list of user needs for support covering the required aspects was determined:

- Reading
- Writing
- Understanding
- Calculation
- Focusing on a task or information, and keeping the focus
- Managing tasks (getting started and completing them)
- Memory
- Managing time (planning, allocating and controlling)

- Managing choices (evaluating options, deciding)

Profile generation

Individual support preferences can be set by the user with a classic multi step web-form, where each step represents a user need mentioned above. However previous projects and user involvement activities showed that people with cognitive disabilities often struggle with long forms which can be tedious and too complex to fill in. In addition, sometimes users do not know or are unable to express which types of support they need. Therefore, an innovative game-based approach has been designed, where users play mini games which detect the users' needs for support. At the moment, 6 mini games have been developed covering 7 out of the 9 support categories.

Reading game

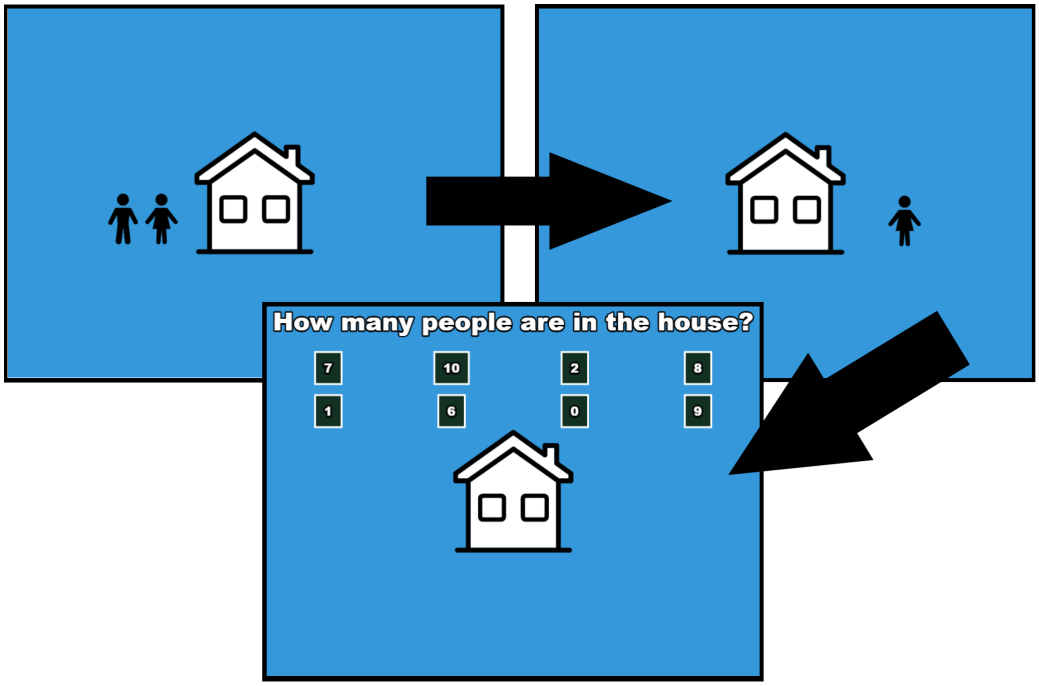
In the first step the reading and spelling capabilities of the user are determined. This is done in a three-stage quiz game. In the first stage, text is read out aloud, and users have to select the proper text for the spoken text within a set of answers displayed on the screen. In the beginning wrong answers differ greatly from the correct answer, whereas at the end of this stage they only differ in certain words. In the next step, wrong answers are derived from the right ones with the addition of spelling mistakes thus giving an indication about the spelling capabilities of the user. In the last stage of this game, users have to read a paragraph by themselves and answer a question about the paragraph.

Writing game

The next game determines the writing abilities of the user. Text is read aloud via synthetic speech, and then users are asked to input the spoken text in a text area. A keyboard listener then detects how fast the text was entered and analyzes grammar and spelling. In this manner, a basic estimation of the user needs for writing support is inferred.

Math game

This game detects the basic capabilities of math and also provides some insight into the working memory capabilities of the user. In this game, a random number of people are shown entering or leaving a house in several batches. Users have to count the number of remaining people in the house after a few batches have passed.



The game consists of several levels. In the beginning, batches move slowly and each batch consists of a small number of people. However, depending on the outcome of previous levels, the amount and the movement speed of people is increased. This game allows the Buddy system to infer the basic math capabilities of the user.

Memory game (short term):

In this game random items fall onto a conveyor belt which slowly transports them until they fall into a suitcase and disappear. Users have to remember the items that have previously fallen into in the suitcase and have to remove duplicate items before they land in the suitcase.

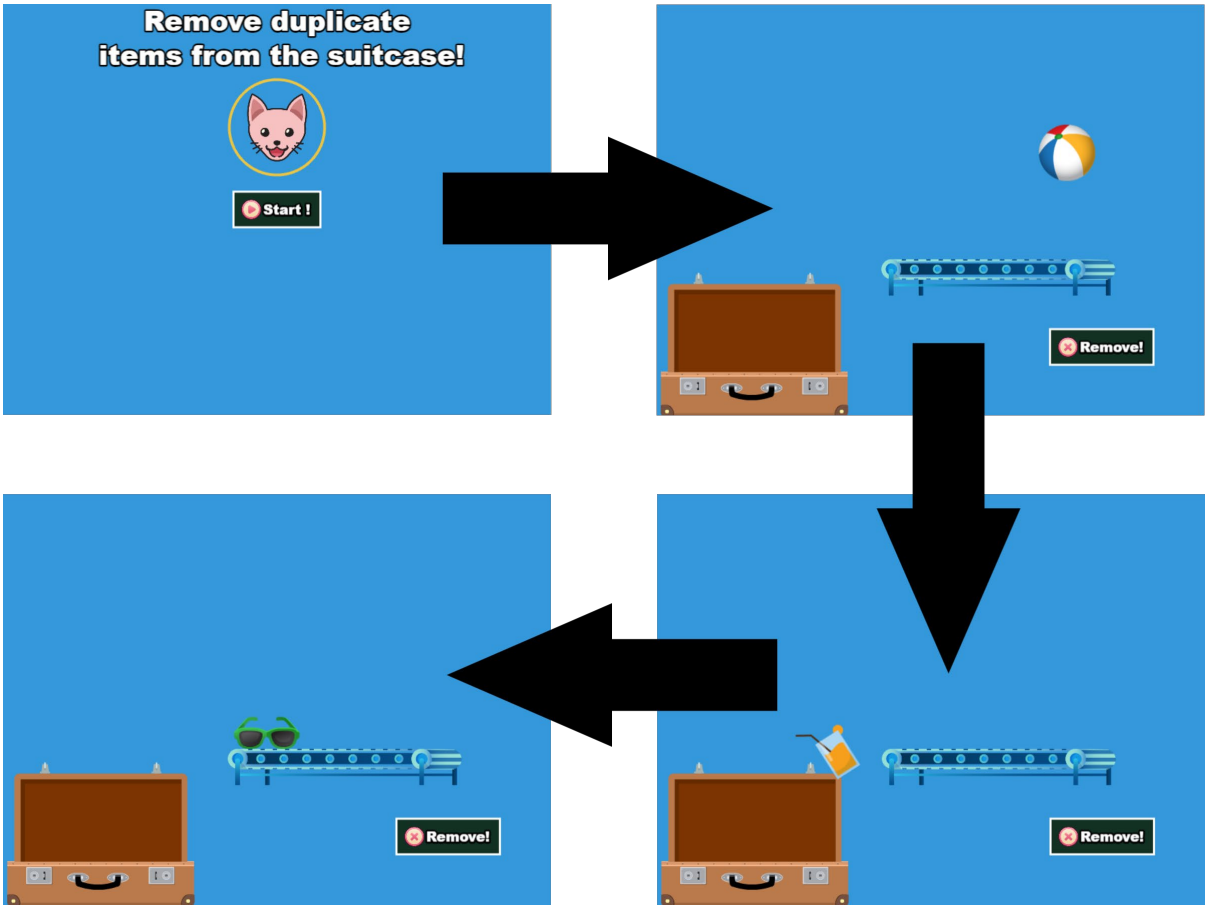


Fig. 3. Memory Game.

In this manner, a basic estimation on the needs for short term memory support of the user can be determined.

Focus game

In this game users have to follow a coin that is hidden inside a cup among a set of empty cups. These cups then get shuffled with a randomized animation. To distract the user, disturbances in the form of random, eye-catching moving figures are added. After shuffling is complete, users hat to locate the cup containing the coin. Users have to play the game several times, with increased difficulty by adding more cups and distractions if they succeed, or reducing the difficulty if they fail.

Managing task and time questionnaire

The last game is a questionnaire based on the Assessment of Time Management Skills (ATMS) which was developed to measure the extent to which people actively manage their

own behavior to ensure effective management of time (Suzanne, White., Riley, Anne & Flom, Peter.:Assessment of Time Management Skills (ATMS): A Practice-Based Outcome Questionnaire). Users have to answer several questions based on the ATMS so that the basic needs for task and time assistance of the user can be determined.

Current status

In general, games were chosen based on desktop research on actual projects (Hautala J.,Heikkilä R.,Nieminen L., Rantanen V., Latvala J., Richardson U.: Identification of Reading Difficulties by a Digital Game-Based Assessment Technology) in related domains and informal interviews with psychologists. Next, these games will be tested with user tests to determine whether users understand the games and how reliable the user needs are inferred. More work will be done in order to explore whether all user needs can be covered with this approach. Informal preliminary evaluation with cognitive disabled users shows that, even if the game-based approach takes significantly longer than the completion of the traditional multi step form, all users preferred to set up their profile this way. Once the user has finished setting up his or her profile with all preferences for support, it is stored to the Buddy system and the user may start discovering suitable AT.

AI based recommendation

The second main component of the Buddy system consists in an intelligent recommender service. Its main purpose is to discover suitable ATs for specific users that may not be aware of their existence. In this manner, users are encouraged to try out new technologies that support their specific needs, thereby benefiting both end users and AT vendors. This service, designed as a distributed weighted hybrid recommender system (Burke, R.: Hybrid recommender systems: Survey and experiments), hinges on two complementary methods:

- A knowledge-based recommendation approach that matches ATs to users directly by exploiting explicit knowledge about the support needs of users and support categories of ATs in the repository. A similarity score between ATs and a given user is computed, and the highest-scoring ATs recommended to the target user. Because AT entries in the system and user profiles are underpinned by the same support categories, computing this similarity measure is very straightforward.
- Data-driven recommendations leveraging user ratings of individual ATs to discover similar users and ATs regardless of their specific profiles. This system is inspired by well-established collaborative filtering methods commonly employed in e-commerce websites. Users of the Buddy system can rate the repository entries of AT they use or have tried out in the past by choosing the corresponding score in a Likert-type scale from 1 to 5, where 5 indicates that the user is totally satisfied with the AT solution. A Likert-type scale has been selected due to its finer granularity and low cognitive demands. Users and/or ATs are represented by their aggregated scores, and similar ones are retrieved according to their similarity in data-space. In this manner, suitable ATs for a target user may be found even if partial or incorrect knowledge about them is stored in the repository.

The final recommendations offered to a user are based on a weighted mean of both scores in order to smoothen the final score while benefiting from both techniques. Initially, more importance will be given to the knowledge-based score. As more user ratings are inputted into the system, emphasis will be placed on data-driven scores.

Conclusion

This paper presents an online repository, named Buddy, that is able to recommend suitable assistive technology (AT) to individual users with cognitive disabilities, thereby bridging the existing communication gap between end users and AT providers. Buddy

benefits end users, since it allows them to discover otherwise hard-to-find AT for their specific needs. In addition, the system is also a valuable tool for AT vendors by exposing their products to a suitable audience.

Work Cited

Burke, R. (2002). Hybrid recommender systems: Survey and experiments. User modeling and user-adapted interaction, 12(4), 331-370.

Hautala, Jarkko & Heikkilä, Riikka & Nieminen, Lea & Rantanen, Vesa & Latvala, Juha-Matti & Richardson, Ulla. (2020). Identification of Reading Difficulties by a Digital Game-Based Assessment Technology. Journal of Educational Computing Research. 58.

Miesenberger, K., Edler, C., Heumader, P., & Petz, A. (2019). Tools and Applications for Cognitive Accessibility. In Web Accessibility (pp. 523-546). Springer, London.

Seeman, L., & Cooper, M. (2019). Making content usable for people with cognitive and learning disabilities.

Suzanne, White., Riley, Anne & Flom, Peter. (2013). Assessment of Time Management Skills (ATMS): A Practice-Based Outcome Questionnaire. Occupational Therapy in Mental Health. 29. 215-231. 10.1080/0164212X.2013.819481

World Health Organization. (2001). International Classification of Functioning, Disability, and Health: ICF. World Health Organization, Geneva