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ABSTRACT

User profiling provides personalized and relevant content for users of information technology. Describing and representing an individual's capabilities and interests can enhance assistive technology for users with severe disabilities, such as paralysis and the inability to speak. These users are particularly challenged when attempting to interface with technology because of their limited means for providing input. This paper describes the extent to which user profiling can be helpful for encapsulating the preferences of such disabled users. It also presents a methodology for capturing and representing user profile information in augmentative and assistive communication devices. User profiles are developed for both disabled users and their conversational partners. These profiles will ultimately be used to help improve the richness of conversation for severely disabled users by enhancing conversational prediction.

Keywords

User profiles, personalization, augmentative and assistive communication, conversational prediction.

INTRODUCTION

User profiling allows a user's preferences and interests to be captured and represented for personalizing services, providing targeted marketing, or customizing user interfaces. User profiling has traditionally targeted able-bodied users, but is promising for adapting and customizing assistive technology for severely disabled users. Users with profound motor and speech disabilities, such as *locked-in syndrome*, are challenged in communication because of slow input abilities. Augmentative and assistive communication (AAC) devices exist to help improve the speed and accuracy of conversation for disabled users, but improvements are needed.

AAC incorporate static contextual information to greatly enhance communication speed (Cornish & Higginbotham, 2000; Todman, 2000). Unfortunately, input to these devices is hindered by the extent of the user's physical disability. Furthermore, these devices have not yet achieved the level of prediction and speed necessary for effective conversation that may be realized by incorporating dynamic contextual information. This information about the situation and conversational participants may be captured in the form of user profiles.

The objective of this research is to develop and use user profiles to increase the speed and accuracy of communication for people with severe motor disabilities. To accomplish this we develop a methodology for capturing, representing, and employing user profiles and real world knowledge about different application domains. The contribution is to significantly improve the ability of locked-in users to communicate by using profiles to optimize the performance of communication technology interfaces. The work will also contribute to research on the capture and organization of real world and domain-specific knowledge and further understanding of how to apply user profiling.

This paper describes a methodology for capturing information and representing it in the form of user profiles for both the user of an AAC device and their conversational partners. It provides background on AAC devices and user profiling, describes a framework for classifying conversational partners for disabled people, and presents a methodology for deriving user profiles.

BACKGROUND

Augmentative and Assistive Communication

AAC devices "increase, maintain, or improve the functional capabilities of individuals with disabilities (Assistive Technology Act of 1998)" in their efforts to communicate. However, inputting text into these systems is extremely slow for severely physically disabled users. Typical speech rates for conversation are 150-200 words per minute (wpm) whereas users of augmentative devices typically achieve only 10-15 wpm (Copestake, 1996). Users with severely limited mobility may utilize biometric channels, such as galvanic skin response and their brain signals, for input. Users of biometrically controlled word spellers have achieved 3 letters per minute (Adams, Hunt, & Moore, 2003; Wolpaw, Birbaumer, McFarland, Pfurtscheller, & Vaughan, 2002), and so can only communicate basic phrases within a bounded time period. Unfortunately, communication rates below 3 wpm are too slow for interactive conversation (Goodenough-Trepagnier, Galdieri, Rosen, & Baker, 1984). Conversational partners experience limited feedback and grossly limit their interactions to a one-way dialogue. Therefore, to increase interaction with severely disabled users, it is necessary to develop methodologies for improving communication rates while maintaining accuracy.

Conversational prediction models, such as the one employed by the Conversation Helped by Automatic Talk (CHAT) system (Alm, Arnott, & Newell, 1992), have been shown to increase AAC speed by enabling context-aware prediction. The extremely slow input rates that occur with eye movement or other biometric channels means that even incremental improvements to reduce the burden of making selections can make a significant impact. Therefore, an AAC system will benefit from prediction based on information about the conversational participants captured as user profiles. It will help users more effectively apply stored phrases to create topic-based discussions. The system may make more informed predictions about which topics should be promoted for selection by the user.

User Profiling

When presenting information to users, it is important to have an accurate understanding of their needs and desires to provide more personalized and relevant content during a conversation. Research on user profiling and ways to effectively use information about the user have been proposed to help interface problems (Davis, Moore, & Storey, 2003). User profiling allows information filtering based on a user's personal characteristics (Hanani, Shapira, & Shoval, 2001). By comparing information against a user profile, we can greatly improve the relevance of information presented. Even the slightest amount of filtering of information can increase the accuracy of results

Knowledge about the user may be acquired via explicit or implicit means. An explicit approach requires active user involvement to provide the information. One of the most popular techniques is interrogation whereby the user is asked to complete a questionnaire or selects closest matches from a predefined set of profiles (Hanani et al., 2001). User interrogation began with the Lens system (Malone, Grant, Turbak, Brobst, & Cohen, 1987) to define a set of rules with which to filter information. In contrast, an implicit approach requires no user involvement. The system watches and records the user's behavior and then makes inferences about the relevancy of information based upon the user's reaction (Hanani et al., 2001).

When developing context-aware systems, both the current and long-terms characteristics of a user should be combined with the environmental context (Jameson, 2001). Current state characteristics include aspects of the user's current cognitive or psychological state. Longer-term characteristics include: objective personal characteristics; level of knowledge of particular topics; level of interest in particular topics; and perceptual and motor skills and limitations. Although Jameson's work includes these necessary components, it is limited to modeling just the user and his or her particular location. It does not consider anyone who interacts with the user, which an important component of any communications system.

COMMUNICATION FRAMEWORK

Davis et al. (2003) present a general framework for capturing context-aware user profiles to improve communication systems for severely disabled users. The framework focuses on analyzing the interaction between a disabled user and their visitor and storing contextually relevant information for future conversations. Users with severely limited mobility tend to have a predictable array of visitors since they usually reside in a hospital or long-term care-giving facility. Visitors are classified according to familiarity and according to their relationship with the user as shown in Table 1.

Classification Type	Possible Values
Familiarity	Unfamiliar/Familiar
Relationship	Personal/Professional
Personal	Relative/Friend
Professional	Medical Professional/Researcher

Table 1. Classification of Visitors

METHODOLOGY FOR DERIVING USER PROFILES

The first step in utilizing user profiles for enhanced conversational prediction is to develop a methodology for deriving profiles of both locked in users and their conversational partners. Both explicit and implicit approaches to creating the user profile should be incorporated. During the setup process, explicit methods are used to capture accurate information from the user. An implicit approach will later be added to enable the system to learn about the user from patterns in conversational history and make updates to their profile as the user evolves. Initially, the user must directly interact with the system to fine tune their profile as significant events and changes take place not captured by environmental sensors. Initially, information is captured about the user's longer-term properties, based upon those categorized by Jameson (Jameson, 2001) and expanded by Davis, et al. (Davis et al., 2003):

- objective personal characteristics,
- level of knowledge of particular topics,
- level of interest in particular topics,
- perceptual skills,
- motor skills and limitations, and
- medical considerations.

Generating Input

Information related to the properties listed above is obtained through a variety of means. Since feedback from a severely disabled user may be limited and unreliable, information must be triangulated using multiple sources including transcripts from conversations involving the user and their visitors, questionnaires, and interviews of visitors. The following describes this process for a nearly locked-in user, "Todd".

Conversational Transcripts

First, conversations were recorded and transcribed between Todd and his visitors. He was unable to speak and communicated through limited eye movement. Therefore, without a formal communication system, the conversation was limited with only "yes/no" responses indicated by Todd's eye movement and verbally confirmed by the visitor. The following is an example of a conversation with a friend about what to watch on television, an activity that occupies most of the locked-in user's time. From this, we infer Todd's favorite genre of shows to watch and with whom he shares this pastime.

```
FRIEND: …  Do you want to watch something else? (Speaking Todd's response out loud) Yes.
Let's see what we can find...  Do you want to see the movie, Starship Troopers?  The sci-fi,
action movie?  (Speaking Todd's response out loud) No.  Okay.  Do you want to check out
Barbarians on the History Channel… That would be a No.  Do you want to watch the last little
bit of COPS?  Wait, is that a "Yes"?  Do you like to watch COPS?  Sure, we can see COPS.
```

This conversation was tape-recorded and manually transcribed. Once a series of conversations was transcribed, we performed content analysis to pull out key properties about the user including popular topics of conversation. We verified the significance of each topic by analyzing recurrent themes across conversations. Since Todd did not speak, we assumed that by a visitor asking particular questions that these themes were important to him. The visitors all had credible knowledge of

Todd from having personally known him while he was able to be more expressive or from their professional knowledge of his condition. The result was the generation of initial profiles for the user and his visitors and a core vocabulary.

Questionnaire

Second, we devised a questionnaire to gather information on the contextual components of the user and visitor profiles. The questionnaire was based on the long-term user properties and the *Yahoo!* Personals' profile. It first gathered basic demographic information and captures information about the person's habits, interests, and relationships. A disabled user could complete this questionnaire at anytime, and a visitor could complete this questionnaire prior to their arrival perhaps through an online scheduling system that would be a related component of the AAC system. A sample of the questionnaire for gathering information about potential topics of conversation and the user's level of interest is shown in Figure 3. The results provided supplemental information for the user and visitor profiles and core vocabulary.

Topic	**Scale** **Dislike - Neutral - Like** **1 - 2 - 3**
Family	1 - 2 - 3
Movies	1 - 2 - 3
Listening to Music	1 - 2 - 3
Watching Sports	1 - 2 - 3

Figure 1. Sample of the Questionnaire

Interviews

Finally, a substantial amount of information for the user profile was also extracted from interviews with Todd's family, friends, medical personnel, and affiliated researchers. These interviews consisted of open-ended questions to assess the level of interaction with Todd and his perceived interests. Again, these results were used to supplement previously stored information and vocabulary for Todd and his conversational partners.

Representation

Once the information was gathered, it had to be captured in a format for inferencing. We used the CLASSIC Knowledge Representation System (Brachman, McGuinness, Patel-Schneider, Resnick, & Borgida, 1991) to formalize the user profiles. A sample instantiation of the concept definition for personal information for the user is shown in Figure 4. Profile elements are represented by "fills" statements which specify attribute values.

```
(cl-create-ind 'Todd-Profile
      '(and USER-PROFILE
            '(and USER-INFO
            …
            '(and PERSONAL-INFO
                  (fills person-name "Todd")
                  (fills gender male)
                  (fills age-category 40-to-60)
                  (fills education high-school)
                  (fills employment unemployed)
                  (fills profession construction)
                  (fills marital-status single)
            )
      )
)
```

Figure 2. Sample of User Profile Representation

CONCLUSION

This work provides a methodology for deriving user profiles to improve conversations with an AAC system for severely disabled users. To complete this work, we will show how inferencing can take place with the knowledge representation defined above. We will integrate the user profiles with ontologies of real world and domain knowledge into a working environmental control and communications system. The user profiles will benefit from contextual knowledge about the physical environment and the partners involved in conversation. We can filter conversational topics that are of shared interest to both the user and their visitors based on their respective profiles. Relevant topics will gain more salience in the system and be presented to the user first as predicted options for topics of conversation thus reducing the selection time. Ultimately this reduction in selection time will speed up conversation without sacrificing accuracy. We will test and validate our methods with able-bodied and locked-in users to ensure that we do provide improvements to the speed, efficiency, and effectiveness of conversation.

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