MAPS: Dynamic scaffolding for independence for persons with cognitive impairments

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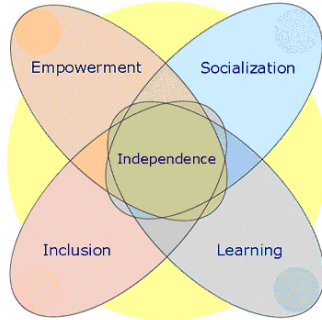University of Colorado at Boulder
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Keyword: PDA Prompting

Abstract: Individuals with cognitive disabilities are often unable to live independently due to inability to perform daily tasks. Computationally enhanced dynamic prompting systems can mitigate this. High levels of assistive technology abandonment are driven by poor user interfaces. MAPS provides an effective prompting system with an intuitive interface for configuration.

CLever Project / L³D

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1. BACKGROUND

In the U.S. alone, there are approximately 20 million persons with cognitive impairments, or 7% of the U.S. general population, [19]. Cognitively impaired individuals are often unable to live on their own because of deficiencies in memory, attention, and executive functionalities. These deficits can create inability to consistently perform normal domestic tasks like cooking, taking medications, performing personal hygiene, and taking public transportation. A common way of transitioning from assisted living to independent or semi-independent living is through the use of prompting systems. Prompting systems consist of breaking down a task into constituent parts and creating prompts, consisting of pairs of images and verbal instructions, for each step. A prompting script is a set of prompts that make up a task.

Traditionally, prompting has been implemented as static printed images, checklists, or more recently, with stationary PCs. By providing only pre-task generated prompts, changing environments, dynamic situations and evolving user needs are ignored making the potential for task failure high.

Device rejection is the fate of a large percentage of purchased assistive technology [8]. Caregivers report that difficulties in configuring and modifying configurations in assistive technology often lead to abandonment [9]. Some experts estimate that as much as 75% of all such devices and systems are purchased and not used over the long run [15]. My research attends to the particular interface requirements for users with cognitive impairments, views the configuration and other caregiver tasks as a different and equally important requirement for a second user interface, and applies techniques such as task-oriented design [12], in the hopes of mitigating technology abandonment problems.

My research contribution focuses on providing a mobile prompting platform, providing context sensitive prompts, and acknowledging dual user interface requirements in assistive technology design.

The target populations for MAPS (**M**emory **A**iding **P**rompting **S**ystem) are cognitively disabled individuals [19] in the 'trainable Mentally Handicapped' (IQ 55-72) range and in the upper range of 'Severely Mentally Handicapped' (IQ >55); as well as the caregivers who

would compose MAPS scripts. Caregivers will be assumed to have computer skills on the level of being able to compose a letter on a word processor. (Figure 1)

Figure 1
MAPS interface user population

2. RELATED RESEARCH

Prompting studies provide a background for design and study of computationally based prompting systems [10, 11, 13]. There is a small body of literature concerning the design and implementation issues for assistive technology and augmentative and alternative communication devices, including King [8] and Beukelman [3]. Existing computer based prompting tools provide more information to base design and theoretical inferences. Of special interest is the Visions System [2], a stationary PC based prompting and scheduling tool using stationary touch screens to prompt thru complex domestic tasks like cooking. Visions uses sets of cards to assist away-from-the-system tasks like grocery shopping. Existing PDA-based systems include the Able Link team's 'Pocket Coach' [1], the Swedish Isaac project [7] (which did much initial exploration of PDA's for cognitively disabled), and the PEAT [14] system.

This research is based on several topics from the larger HCI community. MAPS context sensitivity and error detection and correction design is informed by various studies of distributed cognition [17, 6]. The underlying notion of prompting itself is an extension of the notion of 'using and learning on demand' [4]. Finally, while MAPS is not primarily designed as a learning tool, but as a permanent aid in daily life, it is capable of fucntioning as a training tool and as such the design is influenced by studies on using scaffolding in designing learning tools [16].

3. SCENARIOS

Following are several scenarios that illustrate the possible uses and delineate functionality of the MAPS system.

3.1 Shopping

Jim is a 26 year old with a level of cognitive disability that would allow him to use the MAPS system. He has lived with a system like Visions [2] for the last year and worked well with it. He has had MAPS for the last month and it fits well with Jim's level of functioning as well as his life in his own apartment.

Jim has been reminded by his apartment based prompter that, since it was Saturday, today would be a good day to go shopping for the weeks' groceries. Jim's mother has programmed the stationary system with his favorite meals, and the system walks him thru selecting meals for the upcoming week. After Jim has selected his menus using the touch screen, the speaker in the kitchen (where he does most of his interaction with his house based prompting system) will then ask him to place his PDA into its cradle. His stationary system then calculates Jim's net need for groceries (based on a combination of a rolling tally and an earlier inventory of Jim's pantry that it had 'walked' Jim thru as part of the menu planning process). It then creates a prompting script for Jim to use at the market, which lists exactly what Jim needs to buy.

When Jim arrives at the supermarket, his PDA's first prompt directs him to the produce section then prompts him to put a head of lettuce into his cart (figure 3). The verbal prompts are generated from a list of appropriate words and spoken by his mothers' voice. The images that go with the prompts are color photos of the actual items, taken in this store. As each prompt is successfully followed, Jim presses the PDA touch screen to step to the next prompt, one after another until he reaches the last prompt that directs him to the checkout line with a picture of his familiar checkout clerk – the one he always talks to. In the process of following the script, if Jim becomes distracted, he may back step thru the prompts till he reaches a prompt that he knows he did correctly.

Jim is confident in his use of his PDA because he knows that if he gets confused or lost he can always press the panic button on his PDA and he will get appropriate instructions of what to do (usually just to wait where he is) while the wireless connectivity of his device reaches out to his on-call caregiver and informs her of Jim's situation. If Jim took too long at a given prompt (a time tied to a specific step in a given script) a second prompt would have popped up with relevant instructions, in the case of Jim being 'stuck'.

When Jim next loads a prompting script into his PDA, the PC will upload the log from the last prompting session on the PDA and write it into the data structure of the last script that was run, for caregiver evaluation and perhaps adaptive

'collapsing' of several steps into a single step in preparation for the next run of that script.

4.2 Bus trip

Megan decides that today would be a good day to visit her grandmother. She goes to her home-helper screen and puts her prompter into its little cradle. She pushes the picture of her grandmother, on the monitor attached to the PC, and then pushes the bus picture (rather than the phone or greeting card picture). Her helper beeps and shows a picture of her front yard when she has finished getting ready for her trip. Megan takes the prompter out of the cradle and putting on her coat and picking up her backpack leaves the house. She knows that she must go to the bus stop across the street because the picture on the prompter shows *that* bus stop and the voice prompt tells her to cross the street to get to it. She crosses the street and as she reaches the bus stop she touches the bus stop picture on the MAPS prompter. The prompter says "Megan, please wait here till your bus arrives. You could listen to music if you wish, I will call you when it comes." In a few seconds the screen on her device shows a swirly pattern that reassures Megan that the prompter is 'waiting' for the arrival of her bus. Megan sees the swirly pattern progressively change into a series of increasingly larger dots (the Isaac duration indicator – see the Isaac project), letting her know in an appropriately intuitive way the time lasting till the arrival of *her* bus.

The MAPS prompter is wirelessly tied into the Mobility for All system [18]. When its monitoring of the GPS on the bus and in the prompter allows it to calculate that the current incoming bus is the one Megan's script requires, the Mobility ofr All server triggers the prompter, via the wireless network, to play the prompt announcing "Megan, here is your bus". Just as the last dot turns almost completely white a bus pulls up and Megan walks up the steps. Megan's prompter display briefly goes swirly and the bus driver looks at a LED display located above the entrance door. The driver says "Going to Riverside, mam? This is the right bus." Megan goes all the way in and sits in the seat right behind the driver. The bus pulls out……….

Before the bus arrives at her stop the prompter turns down any music she is listening to, vibrates briefly, and plays a prompt telling and showing her that this is the stop for her to get off on.

In the case of Megan exiting the bus at the wrong bus stop, MAPS error monitoring function, comparing its current location with the location that it should have been at this step in the script, plays an appropriative set of prompts. The prompts displayed are determined by the combination of Megans user profile, the type of script, and the point in the script that the error occurs. The repair subscript directs Megan either in the steps needed to get back on track of her intended task, or to a safe place to wait for the help that the prompter, in concert with the LifeLine system (a CLever

project to monitor and provide support for socio-technical systems used by persons with cognitive disabilities and their caregivers) [5], has summoned.

Figure 3 The MAPS PDA prompter

4. DESIGN

My MAPS system is composed of a PDA prompter and a PC based script editor tool. On the basis of studies of the abilities of the user populations a set of requirements for the system were generated. In summary, the device chosen as a platform for the project needs to:

- Display an image of high enough quality to be experienced as a 'picture' rather than an icon;

- Have sound quality and volume enough for clearly hearing prompts in outdoor environments;

- Have affordances 'chunky' enough for not so finely coordinated fingers.

Functional requirements include a simple way to backtrack, or start over, to allow for mistakes during task completion and appropriate wireless connectivity for dynamic, context based prompt generation and 'panic button' functionality. In general it should be a very 'forgiving' interface, to reduce anxiety over failure in using it. The prompting device should be perceived as 'cool' not 'dorky' or 'handicappy' [8].

The caregivers interface, the prompt script editor and the system configuration software, must be simple enough to get used immediately and deep enough so that many different types of tasks can be scripted. As a script is
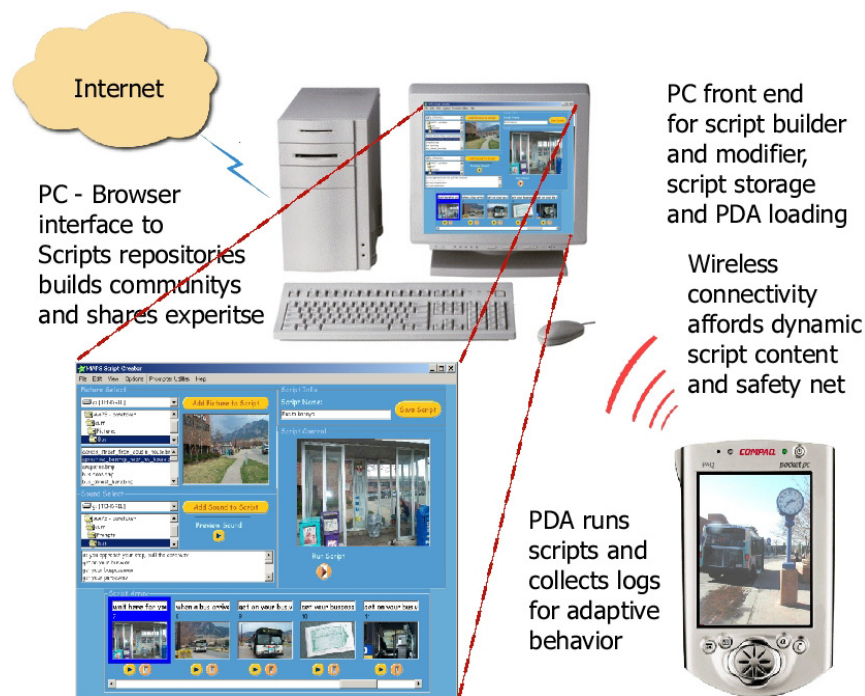
Figure 2   MAPS Architecture

played, the instrumented prompter generates logs for script refinement and analysis as well as for immediate generation of alternate prompts for perceived and flagged breakdown situations.

The MAPS caregiver interface, a PC based application, provides tools for script creation, previewing, modification and sharing via a repository of scripts. The interfaces for the initial installer and ongoing changes are targeted at non-computer professionals, and are simple and intuitive.

Innovative aspects of MAPS design include dynamic error detection and correction, wireless dynamic prompt generation and using user-modeling techniques to implement templates for task-type error detection and correction.

A MAPS script may have several points where the timing and content of the next required step is dependent on the context of the user and environment. For instance, on a bus trip, the user may need to wait at the bus stop *until* the correct bus arrives, and when the right bus arrives the user needs to be prompted to board the bus. With the advent of GPS equipped buses, ubiquitous wireless networking, and GPS equipped prompting platforms (PDA/cell phones), the entire infrastructure is already in place to support context-aware prompting. By interfacing the MAPS prompter with a system like the Mobility for All CLever project, the running of a typical bus trip script can interact with the real time events on the streets, prompting the user to wait and proceed when appropriate [18].

One of the advantages of computationally enhanced prompting systems is the ability to track and repair errors. This dynamic adaptivity affords great gains in useful functionality and reliability but at a cost in configurational complexity. Since every script is by design unique to the user and situation, then the number of potential error states and sets of error trapping flags becomes unmanageably big, if configured individually (40 typical steps to a script, between 2 and 5 error trapping sensors/flags for each step in a script that need to be set individually).

My design solution to this possible combinatorial explosion is to make the population of a user profile matrix part of the MAPS caregiver script editor/creator configuration setup. MAPS users (the prompter user with cognitive disabilities) have individual levels of abilities and personal styles that can be selected for a menu and implemented in the application such that error states can be remedied in the most appropriate manner. Similarly, MAPS is designed to create scripts of several generic types, and error situations at typical stages of a given type can be identified for uniform *templates* of correction (which will be instanted with the appropriate contextual data). This combined user needs model (user specifics and generic task/segment error correction template) affords almost automatic error flag pattern trapping, as well as appropriate dynamic prompt generation.

A simple example can illustrate how this might work: Carl, a caregiver, is setting up the MAPS system for two residents in the assisted living centre where he works. Sally is a 23 year old woman with moderate cognitive disabilities

and a history of successful employment and use of public transportation. Phil, on the other hand, is more severely constricted by his lack of abilities, and at 19 is just starting to learn how he can best get around and contribute in his community. Sally's template specifies that if she misses her stop while on a bus trip during the daytime, her prompter will aid her in eliciting help in deciding the best course of action from the bus driver. In a similar situation, Phil may be instructed to exit at the next (specified) stop and wait there for help which will arrive, summoned by the LifeLine system on the Mobility for All network. The prompts generated by the MAPS prompter are dynamically generated on the basis of the context of the event, the needs of the user, and resources available.

5. DEPLOYMENT AND EVALUATION

Both the PDA prompter and the script generator/editor are implemented and the initial studies of component design will have been done by April 2003. These include usability studies of the prompter and scripter interfaces, task-to-script heuristics evaluation, and studies to base heuristics for image attributes and script text. I identified a population of appropriate subjects with the assistance of assistive technology (AT) experts, and have collected a library of typical tasks deconstructed into prompted steps that has been successfully used by a team of AT specialists with expertise in guiding young adults transitioning into independence.

6. OPEN ISSUES & NEXT STEPS

The full scope of my research, beyond implementing and evaluating of the prompter and script editor, includes utilizing and evaluating user modeling techniques to create individual 'templates' for script design, error detection, and error correction for specific task domains, such as using public transportation, or shopping. A rough framework and preliminary design of database schema for user modeling templates, generic script types, and script error type segmentation has been developed, but much work has to be done to provide details and merge these functions with the existing MAPS script editor/creator and prompter.

Implementing and evaluating context sensitive wireless dynamic prompt generation, such as in the case of a bus delay or missed connection, constitutes the second challenge in my research. Because of the designed reliance on and tight integration of the MAPS prompter and several other CLever projects, Mobility for All [18], and LifeLine [5], issues of data format standardization and intercommunication need to be addressed and solved.

Ethical issues caused by the use and retention of logs of events in the performance of MAPS scripts are compounded by the vulnerabilities of the MAPS prompter user target population. Resolution of the tradeoffs between exposure of private data and the powerful leverage afforded by the contextual information in error resolution and evaluation of usability are beyond the scope of this research, but the MAPS design needs to provide for secure transmission and storage of this data.

Finally the issue of usability evaluation, while well covered in more traditional populations [12], will provide a challenge in evaluating and refining the interface for the cognitively disabled part of the target population.

7. ACKNOWLEDGMENTS

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