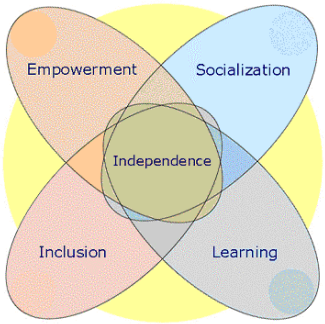

CLever Project / L³D

MAPS: PDA scaffolding for independence for persons with cognitive impairments

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Abstract: Individuals with cognitive disabilities are often unable to live on their own because of deficiencies in memory, attention, and executive functionalities, leading to an inability to consistently perform daily tasks. Computationally enhanced prompting systems can provide a necessary bridge to independent living. High levels of assistive technology abandonment are driven, in part, by poor user interfaces for the configuration of these devices. MAPS (**M**emory **A**iding **P**rompting **S**ystem) provides a simple effective prompting system with an interface for caregivers designed to effect high rates of integration into daily life.

1. Introduction

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. 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. A common way of transitioning from assisted living (or living with ones family) to independent or semi-independent living is thru the use of prompting systems.

2. Cognitive Disabilities

In the U.S. alone, there are approximately 20 million persons, or 7%, of the U.S. general population, who are afflicted with cognitive disabilities costing over $100 billion per year in maintenance, long term care, and lost productivity [Coleman 01]. Computationally enhanced prompting systems can provide a bridge to independence for many persons with cognitive disabilities. Prompting systems provide a learning tool to acquire skills and ‘scaffolding’ for daily life, as well as supporting mobility and employment. A portable tool that provides multi-modal prompting and allows easy creation of new scripts extends and adds additional functionality to current one-on-one prompting systems.

Several computer based prompting systems have been created for home living, with some success. Transition professionals, assisting cognitively impaired young adults in the change from special education school environments to independent living, identified these four broad areas where prompting can be of use [Byrd 01]:

- Community
- Recreation
- Vocational
- Domestic

Device rejection is the fate of a large percentage of purchased Assistive technology [King 99]. Users (caregivers) report difficulties in configuring and modifying configurations in assistive technology that often lead to abandonment [Kintsch 02]. Some experts estimate that as much as 75% of all such devices and systems are purchased and not used over the long run [Reimer-Reiss 00] .The MAPS project is primarily driven by (and will be measured as a success in the context of) the extraordinarily low adoption and retention rates in existing complex assistive technological systems. Secondarily, research [Fischer 00] and interviews have demonstrated that complex, multifunctional systems are the most vulnerable to this challenge, therefore the initial goal will be of a simple system that does one (or few) things very well for a large range of users/caregivers. By viewing the configuration and other caregiver tasks as a separate and equally important interface, and applying techniques such as task-oriented design [Lewis 94], this abandonment problem could be mitigated.

Additionally, there is a lack of small granularity information (i.e. at the level of individual events) about the actual use of assistive technology devices that would assist in adjusting configuration, long-term evaluation of the user/device/configuration match and provide a foundation for longitudinal research.

2.1 Target population

The target population for MAPS would be cognitively disabled individuals. Using standard notation [AAMR 92] this would be "trainable Mentally Handicapped' IQ 55-72 and the upper range of 'Severely Mentally Handicapped" IQ >55. Rather than use diagnostic language it is more to the point to discuss what the user target population cannot do:

- they cannot read;
- they have significant memory issues;
- they cannot use abstractions (i.e. symbols have no extensible meaning); and
- their language is very minimal

What they must be able to do:

- They work well with prompting techniques
- They are socialized enough to use commercial establishments without having/causing problems
- They have fine enough motor coordination to use a palm pilot sized touch pad (and perhaps the set of keys below).
- They are sufficiently capable to not lose or damage a PDA as well as use it consistently

There may be other populations that could benefit from the device, as an augmentative and alternative communication device; and the design should keep this in mind. Similarly the possible curb cut effect[1] of spillover into aging and memory loss areas should be kept in mind as an extended use for the device.

Figure 1
MAPS interface user population

There are two other target populations that the device's interface needs to be designed for: the installer (often a trained assistive technologist) and the caregiver (often a family member) who would eventually re-configure the system. These users need an intuitive interface that is scaled to their level of skills with computers. They will be assumed to be able to compose a letter on a word processor but not much more.

2.2 Existing research

There is a small body of literature concerning the design and implementation issues for assistive technology and augmentative and alternative

[1] Curb cuts were originally developed for wheelchairs, but they have a broader usefulness for baby strollers and shopping carts.

communication devices, including Thomas King [King 99] for general AT design guidelines and Beukelman [Beukelman 98] for issues specific to augmentative and alternative communication device implementation. The proceedings of the ASSETS conferences [ASSETS 00] and several journals [JHTR 02] [AJMR 02] [JCR 02] have been useful.

Prompting by independent living transition professionals with and without cards is an established technique used for both learning and performing a task by cognitively impaired adults and older children. In meeting with the Adam 12 high school to adult life transition group [Byrd 01], prompting was presented as a primary tool for both training in new tasks and as scaffolding enabling ongoing task completion.

Prompting studies provide a (meager) background for design and study of computationally based prompting systems - there have been several papers on the topic of computerized prompting and individuals with cognitive impairments by a European research group [Lancioni 99] [Lancioni 00] and several others [Lynch 95] [Kim 00].

Existing computer based prompting tools provide more information to base design and theoretical inferences. Of special interest is the Visions System [Baseman 00], a stationary prompting and scheduling system based on PC's using speakers and stationary touch screens to prompt thru complex domestic tasks like cooking; sets of cards assist away-from-the-system tasks like grocery shopping. The Able Link team [Ablelink 02] with a product called 'Pocket Coach' that gives a series of vocal prompts running on a PDA using WinCE, and the PEAT [PEAT 02] systems are of interest.

A more complete visualization of the role of PDA's in support of individuals with cognitive impairments was the Swedish Isaac project [Isaac 97], which did much initial exploration of PDA's for cognitively disabled. Isaac utilized a modified Apple Newton connected to a custom made PC with practically every add-on that is currently being discussed. Additionally research was carried out into issues of data representation (i.e. time) tailored for the cognitively challenged individual.

Underlying much of the proposed system are concepts, basic to the Center for LifeLong Learning and Design (L^3D) [L3D 02], such as aiding communities of practice, developing end user modifiable tools rather than simply artifacts, personalization, presentation of the right knowledge at the right time, and an emphasis on an active engagement with the design and evolution of the system by all stakeholders

3. MAPS project

MAPS is a part of the CLever project [Clever 02]. The mission of CLever is to provide computationally enhanced environments to assist people with a wide range of cognitive disabilities (including their support communities and caregivers) and elderly people. It addresses particularly the following problems:

1. People with disabilities form "a universe of one" requiring research in personalization, user modeling, and adaptation.
2. Different learning paths are needed to match individual needs and learning styles.
3. Individuals with special needs and very different cognitive abilities offer a unique window into understanding the human thought processes in general, which will require research in new collaborative human-computer systems.
4. Mobile computational systems must mediate between the unique needs and capabilities of the user and the situational context of the world. The challenge is to build a system dynamic enough to recognize when simple, direct instructions are necessary (e.g., the person is in danger; the situation is confusing; the person is on a tight schedule; etc.) while also understanding when more open-ended choices are possible (e.g., choices are relevant to the person's needs and the person is capable of understanding the choices; it is possible to "recover" if a mistake is made; etc.).

MAPS uses a PDA platform to display verbal and pictorial prompts in a sequence that comprise a script. The PDA provides backtracking, restarting and 'panic button' functionality (via wireless connectivity). As a script is played a timer logs the events and provides logging information for script refinement and analysis as well as immediate alternate prompts for breakdown situations. Concrete images are gathered using a built in digital camera

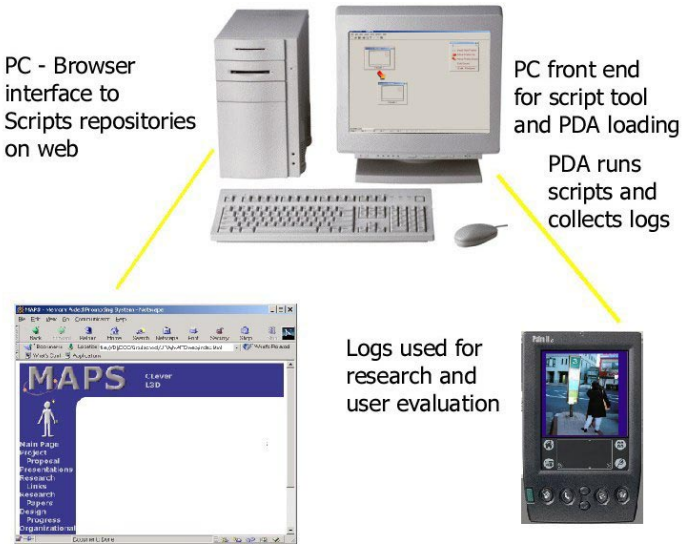

Figure 2 MAPS Architecture

A PC based application provides tools for script creation, modification and sharing with other users via a web-based repository of scripts. The web repository has a browser based search, storage, and retrieval engine facilitating sharing and building of a body of successful scripts

There will be several levels of logging, from the ability to trace steps not taken on an immediate basis to long term logging for diagnostic analysis.

The interfaces for the initial installer and ongoing changes are targeted at non-computer professionals, and will be simple and intuitive. Doing this part right is, from the perspective of adoption of the device, as important as the user interface.

4. Scenarios

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

4.1 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 [Baseman 00] 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 it's 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, that 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 (fig. 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 till 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 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 palm pilot 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 it's finished getting ready for her trip. Megan takes the palm pilot 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 palm pilot 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 pilot. The pilot says "Good Megan, now let's make sure this is the right one! Wait a bit while I see if it is "

In a few seconds the screen on her device shows a swirly pattern the reassures Megan that they are 'talking' about what she wants to do and what is the best plan. Megan then sees the swirly pattern has changed to a series of progressively larger dots (the Isaac duration indicator – see the Isaac project), and a voice says "Megan, this is the right bus stop and the bus you want will arrive soon" Megan waits patiently for her bus occasionally looking at the changing dot pattern on her pilot, and, when a bus pulls up, looking at her pilot and still seeing the changing dots, continuing to wait patiently. Just as the last dot turns almost completely white a bus pulls up and Megan walks up the steps. Megan's palm 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…….

5. MAPS Design

MAPS is a system, consisting of several hardware parts (the PC and the PDA) and several different interfaces (for the user, installer, and reconfigurer) By designing a *System* - including easy to create and modify prompting scripts, small 'atomic' groups could be connected thru the medium of sharing and modifying scripts in *repositories* of scripts. This could provide an immediate cause for the creation of a forum of users, caregivers and designers that would assist in overcoming the insulated life that these problems often produce.

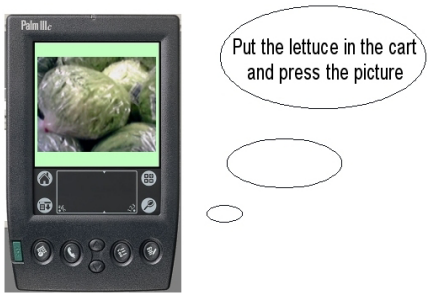

Figure 3 The MAPS PDA prompter

5.1 Design rationale

This project has several dimensions which all need to be satisfied. It must be an adequate learning project and it must be a tool that will be useable and used by several target communities: the cognitively impaired, their ongoing staff, the assistive technology professional that initially sets up the tool, and the larger research community.

The initial parameters and basis of the project should be a result of a research-based process for determining system requirements. Each part of the project will be intentionally part of a hypothesis; an example might be the interaction of the touch screen, the image and auditory information can be determined in the context of studies of various types of cognitively challenged individuals.

The device chosen as a platform for the project needs to:

- be easy to carry;
- 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;
- be robust both as a software platform and as hardware: to minimize focus on the tool and maximize the use of the tool;
- have affordances 'chunky' enough for not so finely coordinated fingers;
- provide positive feedback of visual or auditory nature to indicate that controls have been activated [King 99];

To succeed on a bare human level the device must have clear, uncluttered screens. Controls that are not immediately needed should be removed from the screen. The interface needs to map intuitively, to be as similar to existing controls and information sources as possible. An example might be to map familiar radio or television controls to the controls of the device.

There should be a simple way to backtrack or start over to allow for mistakes during task completion, in general it should be a very 'forgiving' interface, to reduce anxiety over failure in using it. The interface for caregivers should be uniform in each mode (i.e. setup screens all the same look and feel, etc.) to minimize cognitive load [King 99]. Each step of the use process must be appropriately passed and 'sized' (the right size of jump from the last step), so that the user does not get lost in the cognitive mapping of step to next step in the process.

Appropriate concern must be paid to privacy issues in the use of wireless connectivity between the PDA and the world. There may be cases (see Bus Trip scenario) where personal information (such as level of functioning and specific needs and immediate goals) is narrowcast to public figures. Explicit study of these issues needs to be done with all stakeholders contributing to maximize chances of widespread adoption.

Beyond the bare minimum of hardware and software the issue of 'look and feel' needs to be addressed. The device should be perceived as 'cool' not 'dorky' or 'handicappy'. Studies have shown that devices that look 'retarded' stand a much lower chance of being adopted, particularly by young adults [King 99].

The other users requirements need to be properly addressed. The system and its configuration software must be simple enough to get used immediately and deep enough so that many different tasks could be configured. The person responsible for the initial configuration needs a good tutorial and sufficient explanation of the operations and theory of the system so that the initial programming is not a 'by the book' exercise, which often comes to a standstill when the unexpected occurs. As much as possible the device should be intuitive to configure, with help from 'wizard' setup tools, similar to the successful Microsoft applications.

In implementing the creation and saving of scripts for sets of prompts, there could be facilities for a repository of such scripts and this would encourage creation of communities of practice about the users of the palm based prompting system.

The device needs to have logging: short-term immediate feedback to aid the assistive technologist / caregiver in evaluating the setup of the tool and appropriateness to the user; long term for further research. As much as possible the possible extension of the device for other purposes such as an augmentative and alternative communication device, a GPS platform, or for personalizing input via IR or Bluetooth into a collaborative design environment [EDC 02] should be kept in mind during the design.

5.2 Methodology:

Prototypes, derived from research and collaboration with experts in platform technology, using task centered design techniques, will be produced in a staged, iterative fashion (just a PDA, PDA and PC front end….etc.) with evaluation at each stage and feedback into design improvements.

By forming partnerships with research groups at CU such as John Bennett's project to create specific PDA like platforms [Bennett 02] which the system could run on and with the database research group to guide the efficient storage and retrieval (especially in the issue of images and searching) of supporting data in the proposed system, duplication of effort (by researchers whose field of expertise is not specific to that part of the effort) is avoided and synergistic opportunities exploited. Working with professionals in the use of assistive technology (and techniques) such as the Boulder Valley School District group represented by Anja Kintch and the Adams 12 independent living transition team (focusing on the transition of young cognitively disabled adults from school to home) [Byrd 01] will facilitate building the systems upon domain expertise: usability (by both caregivers and users) and high levels of adoption will be facilitated.

6. Future Directions

The MAPS prompting and script building system will be designed to integrate into the 'Mobility for All' [Mobility 02] and 'PITA-board' [Eden 02] CLever projects as a personalized front-end. It could also be used as a scheduler and an Assistive and Augmentive Communications device.

Beyond the basic PC/PDA/PITABoard system for creating scripts, we envision the use of a web based browser technology for sharing these scripts as templates (with a goal of community building). MAPS technology could be used as a scheduling tool (with logging providing short loop feedback mechanisms for critical behaviors such as medication). We see extensive use of the tool by persons other than those with cognitive disabilities population, such as the aging and closed brain injury sufferers.

Further integration with systems such as the Querylens system extensions developed by Shin'ichi Konomi [Konomi 02] or the "Digital Angel" system [Digital 01] into locations like bus stops could yield interactive cognizant waypoints and move the system from static to dynamic deployment.

6.1 Research to be done

The MAPS project will focus on further research on existing literature regarding prompting (in contrast and as part of 'guidance') systems (especially for cognitively challenged). Additional literature search will be done on body of research on image recognition and the use of icons and abstract visual representations with respect to cognitive disabilities. However, the over arcing task will be reading and research into the cognitive psychology aspects of the MAPS system, into both norms and pathological aspects of these issues. Work will be done in the area of usability studies with the cognitively impaired, and analysis of cases where there was rapid adoption of a device compared with devices that were promising but never widely used. Acquiring a sufficient knowledge of the target population and testing and evaluating possible PDA interfaces are part of an implementation strategy. And finally evaluating, at multiple points of the design, with experienced 'real world' experts like Cathy Bodine of Assistive Technology Partners, University of Colorado Health Sciences Center, School of Medicine to gain insights into existing developments and the real world development process.

6.2 Evaluating MAPS

Evaluation needs to be done at different stages in the design and with the different target populations. Initially, I will want to do a basic usability study with the bare idea and both disabled users and experts in the field. Evaluation with the cognitively disabled becomes very difficult in both objective terms and getting help with what the user wants. The process of evaluation could itself be a promising and useful project for the CLever team.

As the design becomes more solid usability studies with the installation and configuration population will need to be done. Finally when the project is complete, I will do some analysis as to the usefulness of the device with respect to the abandonment issue. This will be hard to do in a non-trivial manner. I will probably assemble a team for the design and testing comprising colleagues, experts, family members and, of course, the actual intended users.

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