MemoryLane:
An Intelligent Mobile Companion for Elderly Users

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Abstract

Mobile technologies have the potential to enhance the lives of elderly users, especially those who experience a decline in cognitive abilities. However, diminutive devices often perplex the aged and many HCI problems exist. This paper discusses the development of a mobile intelligent multimodal storytelling companion for elderly users. The application, entitled MemoryLane, composes excerpts selected from a lifetime's memories and conveys these past memories in a storytelling format. MemoryLane aims to possess the capability to produce bespoke stories that are both appropriate and pleasing to the user; this paper documents the proposed methodology and system design to accomplish this. As MemoryLane is expected to be deployed on a Personal Digital assistant (PDA), the preliminary field work to date investigating the usability of PDAs by elderly users is also discussed.

Keywords: Digital Storytelling, Multimodal, Elderly, Usability, MemoryLane.

1 Introduction

The elderly population is dramatically increasing, especially in the more economically developed countries of the world and Ireland is no exception, according to the 2002 census [Department of Health and Children, 2007] there are 436,001 people aged 65 and over living in Ireland, an increase of 22,119 since the previous census of 1996. It is well accepted that with age there is often an associated cognitive decline, which varies among individuals, affecting abilities such as memory and planning. For example, severe cognitive decline in the form of dementia currently affects 1 in 20 over the age of 65, 1 in 5 over the age of 80, and over 750,000 people in the UK [Alzheimers Society, 2006]. Cognitive decline is an inherent part of the natural ageing process ensuring that the numbers of sufferers increase steadily as the elderly population grows. Catering for such a diverse sector requires detailed analysis.

Reminiscence plays an important role in the lives of elderly people; many perfect the art of storytelling and enjoy its social benefits. The telling of stories of past events and experiences defines family identities and is an integral part of most cultures. Losing the ability to recollect past memories is not only disadvantageous, but can prove quite detrimental, especially to many older people. Ethnographical studies rely on participants' powers of recall to successfully conduct their research, and often bear witness to the intangibility of precious memories. Considerable research is being conducted into how technology can best serve and assist the elderly. Pervasive environments (smart homes with smart appliances) are being developed to assist elderly users to remain living independently in their own homes while maintaining a high quality of life. This, in turn, minimises the emotional and financial strain often caused by nursing home accommodation. Memory prompts have been developed to remind users to perform imminent activities and the prospect of personal artificial companions has often been proposed [Wilks, 2005]. Mobile technology is commonplace and offers the potential to be harnessed as a tool to assist many of these elderly people. However, diminutive devices often perplex the aged and many usability problems exist. Consequently this potential is very often not maximised.

The aim of this research is to develop a usable, mobile intelligent multimodal companion for elderly users. Due to the known benefits of reminiscence among the elderly, the objective of the companion will be to assist the elderly in recalling their own past life events and memories as they experience the natural cognitive declines associated with the ageing process. The application is entitled MemoryLane and will employ digital storytelling techniques to relay the memories to the user. MemoryLane will be deployed on a Personal Digital Assistant (PDA) which will equip users with the ability to re-live bygone days, and the portability to relay them to others. The application will also address the usability problems encountered by the elderly when using mobile devices. In addition to this, it is envisaged that MemoryLane could posthumously be inherited by family members and drawn on to revive the memory of a loved one. This paper will discuss the background areas and related work to the research, the system design, the work accomplished to date, and the remaining challenges.

2 Background and Related Research

The focus of this research is underpinned by several distinct research areas including gerontechnology, HCI, usability studies, memory, reminiscence, life-caching, pervasive computing, mobile companions, ethnography, digital storytelling, artificial intelligence and multimodality. A background to these areas is now provided.

2.1 Intelligent Storytelling

Traditionally, intelligence is perceived as problem solving techniques, where composing and listening to 'stories' may be construed as a peripheral aspect of intelligence. However the term 'intelligent' implies having the ability to relay appropriate information, of particular relevance to the user, in a suitable context and format [Schank, 1995], such an ability is also a critical feature of intelligent storytelling. Humans possess an intrinsic desire to both tell and hear stories. It is widely accepted that children are especially fond of stories yet adults too love to read or watch stories in various formats. Schank [1995] observes that it is essential for people to discuss what has happened to them and to hear about what has happened to others, especially when such experiences directly affect the hearer, or the teller is known personally. Schank [1995] considers the connotations of how recalling past stories shape the way in which new ones are heard and interpreted, he also endeavors to develop storytelling systems which not only have appealing stories to relay, but encompass the awareness to know when to tell the stories. Indeed Schank's work [Schank, 1995] forms the basis of various other storytelling systems.

Intelligent storytelling systems very often incorporate multimodality and interactivity for a rich user experience. Larsen & Petersen [1999] developed multimodal storytelling environment in which the

user traverses a virtual location in subjective camera view and is both active story-hear and story-teller. Similarly, the Oz project [Loyall, 1997] also allows the user to interact with a virtual environment called 'The Edge of Intention', a peculiar world populated by 4 ellipsoidal creatures called Woggles. The user embodies one of the Woggles, the remaining 3 being controlled by the computer. KidsRoom by Bobick et al. [1996] is also typical of interactive multimodal storytelling systems. KidsRoom is a fully-automated, interactive narrative play-space for children. Images, lights, sound, and computer vision action recognition technology are combined to transform a child's bedroom into a curious world for interactive play. Such storytelling systems enable the user to dynamically interact during storytelling, allowing them to play pivotal roles in the proceedings. However, in contrast to this genre of storytelling systems, which focus largely on story scripts, Okada [1996] developed AESOPWORLD. This storytelling system is not interactive, moreover it aims to model the mind, developing human-like intelligence, and modelling the activities of the central character accordingly. STORYBOOK by Callaway & Lester [2002] uses a narrative plan to convert logical representations of the characters, props and actions of a story into prose. MemoryLane will draw on the intelligent storytelling techniques discussed in this section to relay memories to the user.

2.2 Gerontechnology

Due to the increasing numbers of the elderly population they have become the focus of much research designed to improve, prolong and enhance their lives. Gerontology is the study of elderly people and of the social, psychological and biological aspects of the ageing process itself, as distinct from the term Geriatrics, the study of the diseases which afflict the elderly. Gerontechnology, the merger between gerontology and technology is a newer genus, concerning itself with the utilisation of technological advancements to improve the health, mobility, communication, leisure and environment of elderly people, effectively allowing them to remain living independently in their own homes for longer. Stanley & Cheek [2003] discuss what is understood by the 'well-being' of the elderly in their comprehensive literature review. Therefore gerontechnology is heavily concerned with the ways in which elderly people interact with computers and technology, and substantial research is being conducted in this area.

Willis [1996] discusses cognitive competence in elderly persons, while Melenhorst et al. [2004] investigated the use of communication technologies by elderly people and explored their perceived and expected benefits. Fisk & Rogers [2002] discuss how psychological science might assist with the issues of age-related usability, and Van Gerven et al. [2006] formulates recommendations for designing computer-based training materials aimed at elderly learners. In a recent paper, Zajicek [2006] reflects upon established HCI research processes and identifies certain areas in which this type of research differs significantly from other research disciplines. Pervasive environments designed to assist older people to live independently and maintain a high quality of life have been developed. Search engines have been specifically designed for elderly users [Aula & Kaki, 2006], and many pervasive gadgets are evident, including a meal preparation system [Helal et al., 2003], a self monitoring teapot [AARP, 2005] and a hand held personal home assistant capable of controlling a range of electronic devices in the home [Burmester et al., 1997]. By implementing MemoryLane, we hope to add to the large body of gerontechnology research.

2.3 Digital Memories

Digital memory aids have been designed to assist users in various ways, acting as digital companions, especially in later life. The value of such devices was initially debated by Bush [1945], and has since been deliberated and discussed by Wilks [2005]. In addition to digital memory aids, memories themselves are being digitalised. Nokia provide a digital photo album, often utilised by the blog community to organise photos and videos to a timeline. Kelliher [2004] discuss an online weblog populated by the daily submissions of events experienced by a group of camera phone using participants. An experiment which digitalises and stores the lifetime memories of one man is being conducted by Gemmell et al. [2006], and another of the UKCRC's Grand Challenges is focused in this area (GC3 project). The GC3 project aims to gain an insight into the workings of human memory and

develop enhancing technologies. Incidentally, this project also envisages featuring personal companions in the next 10 to 20 years, using information extracted from memories to aid elderly persons as senior companions for reminders. SenseCam [Hodges et al., 2006] is a revolutionary pervasive device, which aims to be a powerful, retrospective memory aid. SenseCam is a sensor augmented, wearable, stills camera, worn around the neck, which is designed to record a digital account of the wearer's day. SenseCam will take (wide-angle) photographs automatically every 30 seconds, without user intervention, and also when triggered by a change in the in-built sensors, such as a change in light or body heat. The rationale behind SenseCam is that having captured a digital record of an event, it can subsequently be reviewed by the wearer to stimulate memories. Dublin City University's Centre for Digital Video Processing (CDVP) is currently using two sensecams in their Microsoft funded 'personal life recording' research project. MemoryLane will use similar 'life-cached' data to compose personal digital memories for output.

2.4 Usability Studies

Myriad HCI usability studies are being conducted in the area of computers and the elderly, but substantially less are being conducted into the specifics of how the elderly interact with pervasive devices, despite the fact that active researchers within this area have discussed the benefits of mobile devices to the elderly, and have highlighted the need to learn more to design for this genre [Goodman et al., 2004]. An initial PDA usability study conducted by Siek et al. [2005] compared differences in the interaction patterns of older and younger users. This work attempted to ascertain whether older people, who may be subject to reduced cognitive abilities, could effectively use PDAs. However, this initial research was conducted with a small sample of 20 users, made up from a control group of 10 younger users aged 25-35, and 10 elderly users aged 75-85 years. The study was restricted to the monitored analysis of the participants' abilities to perform 5 controlled interactive tests using a 'Palm Tungsten T3 PDA'. The findings of this basic study failed to identify any major differences in the performance of the two groups which could be due to the fact that the elderly group was extended extra practice time privileges. Siek et al. work [Siek et al., 2005] offers an early insight into the nature of the proposed field work for this research. A study conducted into determining the effects of age and font size on the readability of text on handheld computers is also of particular interest [Darroch et al., 2005]. Additional research has been conducted into mobile phone usage by the elderly; usability issues identified include displays that are too small and difficult to see, buttons and text that are too small causing inaccurate dialling, non user-friendly menus, complex functions and unclear instructions resulting in limited usage, usually reserved for emergencies [Kurniawan et al., 2006]. Research shows that mobile devices that are not designed to include the needs of the elderly have the potential to exclude them from using the device, therefore it is imperative that MemoryLane be developed using a user-centred approach.

2.5 Ethnographical Studies

Cultural probes and props such as photographs and memorabilia are often used in ethnographical studies to prompt participants. The benefits of photo elicitation have been widely acclaimed by Quigley & Risborg [2003] who document tremendous success with the elderly users of their digital scrapbook. The work conducted by Wyche et al. [2006] also employs cultural probes in a 'historically-grounded' research approach to designing pervasive systems and assistive home applications which present findings from an ethnographic study which examined ageing and housework. The study employed a physical 'memory scrapbook' as seen in Fig. 1, and used photo elicitation to provoke responses from elderly participants. The memory scrapbook was constructed from an 8.5 x 11 inch, fabric bound volume and was filled with dated images and memorabilia applicable to the focus of the study. Approximately 100 photos, greeting cards, magazine snippets, advertisements and other mementos were displayed. Wyche et al. [2006] found that the images contained in the memory scrapbook stimulated the memories of participants and evoked deep elements of human consciousness which yielded rich user experiences. It is envisaged that cultural probes be used in a similar way during subsequent ethnographical studies for MemoryLane to elicit oral histories from participants.

Fig. 1. The Memory Scrapbook [Wyche et al., 2006]

3 MemoryLane Design and Architecture

MemoryLane will accept various media objects as input, personal items applicable to the history of the user such as photographs, video clips, favourite songs or even a favoured poem. These objects together with personal details and preferences of the user will be intelligently utilised in the composition of a story told for the pleasure of the user. MemoryLane needs to mimic the notion of understanding to compose appropriate and interesting stories and respond effectively to the user. People have a memory full of experiences that they may wish to recount and relay to others. MemoryLane needs to create an account of the right ones to tell in anticipation of their eventual use. The platform for deployment is a PDA, which would enable the users to carry their memories in a mobile companion. A visual concept of MemoryLane is depicted Fig. 2.

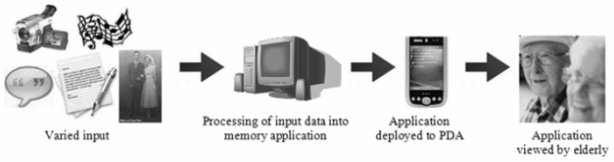

Fig. 2. Concept of MemoryLane

The need for multimodal intelligent user interfaces has been identified and embodied in various applications such as landmark project SmartKom [Wahlster, 2006]. In accordance with this requirement, it is envisaged that MemoryLane be designed to support multimodal input via a touch screen and possible use of simple voice control commands. The benefits of multimodal interaction are widely discussed by López Cózar Delgado & Araki [2005], and the design of MemoryLane will assure a multimodal interface which will accommodate elderly users with different capabilities, expertise or expectations. MemoryLane will also provide multimodal output in the form of images, video, audio and text to speech synthesis. There are several security and privacy aspects of MemoryLane which will require definition during MemoryLane's development phase such as, ownership of the media and the rights of individuals present in other people's memories. The Unified Modelling Language (UML) will be used as a method for designing the application incorporating use cases and the standardised graphical notation to create an abstract high level model of MemoryLane as a whole.

3.1 Artificial Intelligent Techniques for Storytelling

MemoryLane will incorporate Artificial Intelligence (AI) techniques to compose life-caching data into appropriate and pleasing 'stories' for the user. It is vital that stories are constructed in an intelligent way, so that they (a) make sense, and (b) don't include erroneous data objects that do not belong to the history of the current user. Case-Based Reasoning (CBR) and Rule-Based Reasoning (RBR) will be employed for the decision making in MemoryLane. Decision making will be necessary to

appropriately compose the various input data objects into personalised stories. MemoryLane needs to be aware of sensitive data, how to handle it, and be able to accommodate the preferences of the users.
Speech processing can be divided into several categories, two of which are related to this research: speech recognition, which analyses the linguistic content of a speech signal, and speech synthesis, the artificial production of human speech. Speech recognition will be investigated as a possible user input mode, however speech recognition is notoriously difficult, the main problem being that speech recognition systems cannot guarantee as accurate an interpretation of their input as systems whose input is via mouse and keyboard [McTear, 2004], and the varying speech abilities of the elderly may cause problems in this area. MemoryLane will employ Text to Speech (TTS) to convert normal language text into speech for both verbal directions to guide user interaction and as part of the memories output to the user. Speech synthesis systems allow people with visual impairments or reading disabilities to listen to written works which will prove beneficial in systems designed for the elderly, however, speech synthesis systems are often judged on intelligibility, and their similarity to the human voice [McTear, 2004].

3.2 MemoryLane Architecture

The architecture as depicted in Fig. 3 visually represents the data flow of MemoryLane. To begin, the elderly user interacts with the AI multimodal interface and inputs a request to view a memory. This request is transmitted to the AI decision making module, which uses RBR and CBR to interpret the user's request. The decision making module will first establish if the request is for a previously viewed memory (saved as a favourite) or for a new, (previously un-composed) memory. The decision making module will then either retrieve a complete previously seen 'favourite' memory, or the data objects required to compose a new one from storage. The decision making module will also commit favourite memories to file for future viewing. The user's previously input personal data objects (images, audio, video and text) are stored on the storage module and are made available to the decision making module. The decision making module uses its rule bases to compose a memory for output in association with the personal user information stored by MemoryLane. This memory transcript is transmitted to the memory composition module which will design the memory output in a 'storytelling' format, using speech processing if required. The formatted memory is then relayed to the multimodal interface which will output the memory to the user. The multimodal interface also transmits and records user information during user interaction, for example, MemoryLane may record the preferences of the user for subsequent usage.

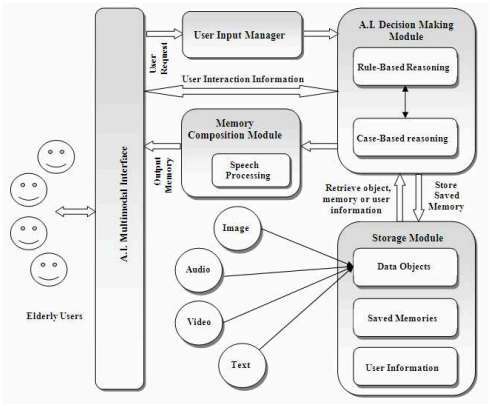

Fig. 3. MemoryLane Architecture

3.3 Software Analysis

It is envisaged that MemoryLane will be coded using the Visual Studio developer suite. The utilisation of X+V the latest addition to the XML family of technologies for user interface development, will be investigated for its usefulness to the project as will the various development platforms as discussed by McTear [2004]. It is also envisaged that SPSS (Statistical Package for the Social Sciences) be used in the statistical modelling of the data. A variety of handheld devices, such as smart phones and tablet PCs, may be investigated for their usefulness to the project; however the preferred hardware PDA device is a Dell Axim™ X51v-624 MHz Handheld which runs the Windows Mobile 2005 operating system. The Axim has a colour touch screen, stylus, and navigational input buttons.

3.4 Usability Evaluation

The completed MemoryLane application will be deployed on a PDA device for testing and evaluation. The preferred deployment platform, a DELL Axim X51v PDA device is pictured beside an impression of the proposed MemoryLane prototype in Fig. 4. In the final phase of the project it is hoped to conduct a usability evaluation of the PDA based MemoryLane prototype with a section of original participants from the field study which evaluated the usability of a PDA.

Fig. 4. Dell Axim X51v PDA

4 Usability of PDAs

The initial stage of this research began with a preliminary HCI pilot study conducted with a sample of elderly users and aimed at investigating the usability of a PDA. Prior to conducting interviews many preliminary visits were initially required to gain trust and build a rapport with the elderly participants. The pilot study sample comprised 15 participants of apparent good health. The sample was aged between 55 and 82 years and included 6 males and 9 females. Participants were selected from four different sources; 6 attended an Age Concern centre, 3 were members of The University of the 3rd Age, 2 were day patients of a local Nursing Unit and the remaining 4 were selected at random from responses received from volunteers. Each participant was interviewed separately in a one-to-one structured interview format in familiar surroundings. The interviews involved completion of a detailed questionnaire, a demonstration of how to interact with a PDA by the researcher, followed by observation of participants' capability in attempting to complete pre-set interactive PDA tasks. Initial research for the questionnaire design discovered that questions requiring prose type answers took participants too long to complete, during which they often became frustrated and seemed to prefer yes/no or tick box answers. Prose answers also proved ambiguous and often difficult to quantify, therefore the questionnaire followed the 5 point Likert- type scale giving participants 5 optional answers. The ensuing questionnaire was divided into sections A and B. Section A of the questionnaire was designed to acquire background information regarding participants' physical characteristics, socio-economic factors, perceived technical abilities, prior exposure to technology and personal opinions of modern day technology. Section B of the questionnaire was designed to be completed in conjunction with undertaking the interactive PDA tasks; this section determined the participant's ability to complete the set tasks and ascertained their HCI preferences. This section centred on questions regarding preferred interaction modalities and aspects and elements of the PDA hardware and software. As part of section B, participants were asked to attempt 6 basic tasks on the PDA as

illustrated in Fig. 5. This section of the interview was videotaped where possible, in conjunction with the participant's approval.

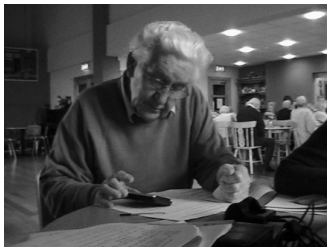

Fig. 5. Participant Interacting with PDA

It was clear from the outset that the participants found the PDA extremely complicated to use and had difficulty even knowing where to start; no one found the interface instinctive or intuitive. This was evidenced by the level of assistance requested and given. Despite the functionality of a PDA being demonstrated beforehand, not one of the participants could carry out even the most basic of tasks unaided. There was also a noticeable level of general disinterest in applications hosted on the PDA; none were of particular personal appeal to the participants. For example most thought that its functions as a calendar or diary were of little interest as they preferred a pen and diary. When asked, many agreed that they would certainly be more interested, and inclined to engage with the PDA if it provided an application of personal interest, such as MemoryLane. However, despite participants initially expressing concern about being unable to partake in the study due to their lack of computer knowledge, and the difficulties incurred during the tasks, many participants said they actually enjoyed the experience of PDA interaction. Most felt that their skills would improve if they had more time with the PDA and some expressed a desire to learn more about a PDA given the desired surroundings and instructor. The portability of a PDA appealed to the majority of participants who remarked on it being 'small enough' to fit into a handbag or breast pocket. This would imply that many elderly users possess a genuine interest in engaging with mobile technologies and that a PDA has a certain appeal to many elderly people, however, due to complex interfaces and interactions, many choose not to experiment with such devices. These findings suggest that the interface for MemoryLane must strive to be simplistic, usable and intuitive to be successfully deployed on a PDA.

5 Relation to Other Work

Mobile devices that are not designed to include the needs of the elderly users have the potential to exclude them from using such devices. Technologies are often developed for elderly users without specific usability studies having been conducted with target users, and are typically based on generic HCI guidelines. Minimal usability studies focus on elderly users' interaction with mobile devices [Goodman et al., 2004] and those that have are small scale [Siek et al., 2005]. This research aims to incorporate a large sample and perform a detailed analysis in a bespoke usability study using the intended hardware conducted with the target audience prior to developing the application. MemoryLane will then be designed and implemented in a storytelling format based on the specific findings of the study. This research also aims to deploy MemoryLane to a PDA - rarely used in Gerontechnology, and as yet no PDA based multimodal storytelling companion, which takes existing memory data and builds it into a coherent story for users, exists. Most existing memory assistive devices are prompts for current or future events [Morrison et al., 2004]; MemoryLane will be a multimodal reminder of memories and past events. Therefore the contributions of this research are a set of design guidelines for PDA based applications for the elderly users and multimodal storytelling of memories and past events.

6 Conclusion & Future Work

This paper provides a summary of issues relating to the development of MemoryLane. The objectives of MemoryLane, in providing a usable, intelligent mobile companion for elderly users have been defined, and the importance of reminiscence to the elderly clearly stated. The work completed to date has largely centred on requirements gathering, the first stage of which took the form of an investigative study into the usability of PDAs by the elderly and the second phase of requirements gathering, a field study which will investigate reminiscence patterns among the elderly is currently underway. This next phase of requirements gathering is concerned with eliciting the user requirements for MemoryLane. In order to develop a system which presents users with digital accounts of their memories, it is first important to see how people reminisce and recall their episodic memories.

This study will establish what the users require from such an application and will form the basis of the design and implementation of MemoryLane. The study will also initiate storytelling and reminiscence to elicit oral histories of the past lives and experiences of the elderly participants. Video-taped informal focus groups will be conducted, at which, there will be guided open discussion. Questionnaires will not be used at this point to avoid incorporating bias and inhibiting the flow of conversation. Participants will be observed to ascertain how well they remember, and the manner in which they recount their memories. The participants will also be observed to elicit the emotions and feelings that reminiscence evokes, to note if the experiences are pleasant or uncomfortable; MemoryLane can then incorporate procedures to handle sensitive data. The focus sessions will also aim to establish any omissions, similarities, patterns or trends in the discourse of participants. A bespoke 'memory scrapbook' will be constructed and used in the next phase in this research. Photographs and mementos of by-gone eras, applicable to the socio-economic climate of the area will be included in the scrapbook. Cultural probes, everyday artefacts from bygone days, will also be used in the study to provoke responses from participants. Participants will be asked about their ability to recall memories prior to using the scrapbook and then, in contrast, whilst using the scrapbook as a visual aid and prompt. The hypothesis is that the latter discussions, with the scrapbook, will elicit far richer oral histories than discussion based on recollect alone.

The remaining challenges of the research will be to implement the design for MemoryLane while adopting a user-centred methodology. The development process will be iterative in nature, requiring repeated evaluations with the elderly sample, and will incorporate the findings of the two field studies.

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