Browsing Large Personal Multimedia Archives in a Lean-back Environment

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Abstract. As personal digital archives of multimedia data become more ubiquitous, the challenge of supporting multimodal access to such archives becomes an important research topic. In this paper we present and positively evaluate a gesture-based interface to a personal media archive which operates on a living room TV using a Wiimote. We illustrate that Wiimote interaction can outperform a point-and-click interaction as reported in a user study. In addition, a set of guidelines is presented for organising and interacting with large personal media archives in the enjoyment oriented (lean-back) environment of the living room.

Keywords: Personal Digital Archives, Browsing Technologies, Lean-back Environment.

1 Introduction

Driven by the increasing penetration of data capture and storage technologies such as digital video cameras and digital photo cameras devices, we note the increasing trend people becoming content creators and not just consumers. At the same time, there can be seen a notable trend recently towards the integration of content management technologies into the lean-back (enjoyment-oriented) environment of the living-room. To take one example, multimedia content analysis technologies are beginning to be integrated into the living room TV, such as the recent incorporation of DVR functionality and internet access into TVs. Such creeping functionality points to the fact that TV manufacturers have identified the living-room TV as an environment in which viewers are relaxed and willing to interact with their own created and downloaded or online media. The next step in this technology convergence process is the integration of personal content organisation facilities into the TV itself, which poses a number of challenges because this needs to be performed by non-expert users, sitting in front of a TV with a remote control in a distractive environment, and not at a desktop computer with use of a keyboard and mouse.

Therefore, in this paper we are concerned with examining how we can support a user in organising and interacting with large personal multimedia archives in the lean-back environment of the living room TV. We can concerned with large multimedia archives due to the fact that we are all becoming content creators and are gathering much larger digital archives than heretofore. The archive we chose to work with is a (HDM) Human Digital Memory archive, chosen because it represents an extreme challenge in the management of personal archives. To represent the lean-back environment we employ a large-screen TV and utilise the Nintendo Wiimote as an interface tool. Note that we are not focusing on the ideal implementation of a gesture recognition technology, this work is ongoing elsewhere, such as the work of Schlömer et al.[1], rather we focus on an exploration of how useful gesture-based interaction can be for managing personal archives in the lean-back environment.

2 Personal Media Archives and the Lean-back Environment

Users have been gathering personal digital media archives since the advent of the digital home computer. Whether photos or emails, audio files or video content, organization of, and access to, these personal archives has been the subject of ongoing research. Naaman [2] and O'Hare [3] have shown clearly how it is possible to develop highly effective digital photo search and organization tools as a means of managing ever growing personal digital photo archives. In addition the TRECVid [4] series of workshops has presented many techniques for managing archives of video content, many of the outputs of which can be applied to personal and broadcast content. However, most such techniques are designed for the desktop computer, or in some cases mobile devices, will not necessarily transfer into the lean-back living room environment, for reasons such as user interaction support, ease of querying and even Consumer Electronics (CE) device processor speed. It is our conjecture, however, that since a living-room TV acts as a natural focal point for accessing personal media archives, that taking into account the significant limitations and challenges of developing for such an environment is essential to successfully deploy multimedia content organisation technologies. Indeed initial work in the area by Lee et al. [5] suggests that simplicity of interaction is more crucial for the lean-back environment than in any other digital media domain and that ultimately, this simplicity of interaction determines the success or otherwise of any new applications. The challenge therefore is to marry the competing requirements of supporting complex organization technologies with the simplicity of interaction required for successfully developing content organization technologies for the lean-back environment.

2.1 Human Digital Memory Archives

Human memory is fallible; we find our own limitations every day, for example, the names of people, the dates of events or episodes from our past. Humans have found ways to circumvent these limitations by employing tools and technologies such as diaries, notebooks, digital archives, etc. In recent years, we have noted a new form of extreme personal data capture in the maintenance of HDM (Human Digital Memory archives), which attempt to digitally capture many of a person's life experiences, including continuous image or video capture. The MyLifeBits [6] project at Microsoft Research is perhaps the most famous effort at gathering and organizing life experiences into a HDM. In the MyLifeBits project, Gordon Bell (inspired by Vannevar Bush's MEMEX) is capturing a lifetime of Bell's experiences digitally, everything from books read, photos captured, home movies, emails, and other personal digital sources. Other related research [7] has focused on the contextual gathering and organizing of HDMs with an emphasis on visual capture of user's experiences and the employment of information retrieval techniques to automatically organize the HDM using content and context data. To enable the capture of everyday activities visually, Microsoft Research have developed a device known as the SenseCam, which is a small wearable device that passively captures a person's day-to-day activities as a series of photographs[8]. It is typically worn around the neck and, and so is oriented towards the majority of activities which the user is engaged in. In a typical day, a SenseCam will capture up to 5,000 photos, which are sequential in nature and suitable for summarization to remove inherent duplication. For example photos from a SenseCam, see Figure 1. In a typical year, well over one million SenseCam photos will be gathered, and like conventional digital photos, one of the key automatic organisation methodologies is event segmentation, to segment a continuous stream of visual HDM data into a sequence of meaningful events. Doherty et al. [9], has worked extensively on automatically organising streams of SenseCam photos into events and representing each event with a suitable keyframe. It is a HDM archive that we utilize for this research, as an example of a very large and challenging personal archive.

Fig. 1. Example images captured by a Microsoft SenseCam

2.2 Related gesture-based input research with the Wiimote

The Wiimote is an input device for the Nintendo Wii games console which incorporates a tri-axial accelerometer to recognize user gestures and utilizes Bluetooth to send gesture data to a host device (typically the games console). There have been a number of uses of the Wiimote as a non-gaming user interaction device, for example work by Gallo and DePietro [11] on using the Wiimote as an interaction mechanism for 3D interaction with medical data. Schlomer et al. [12] have carried out an exploration of how to use the Wiimote to recognise a set of (and arbitrary new) gestures and positively evaluated the average recognition rate of these gestures. Lapping-Carr et al.[13] have utilised the Wiimote as an intuitive robot remote control interface while Shiratori & Hodgins [14] have utilized Wiimotes to dynamically control a simulated animated character. This research suggests that the Wiimote is a capable gesture-based user interaction device with a number of uses beyond gaming and we have chosen it as our input device of choice for this research.

3. Designing for Lean-back Environments

In this work we employ the lean-back/lean-forward terminology to separate the enjoyment oriented (lean-back) living room environment from the task oriented (lean forward) environment of the office computer or laptop. Lean-back interaction has been the subject of research in the interactive TV community for quite some time. While a number of surveys and ethnographic studies at home have been done to better understand how people interact with TV, the work on translating these understanding of the special characteristics of TV interaction into actionable, prescriptive design guidelines has not been done extensively. With the lack of such transferrable knowledge base and difficulty in leveraging more well-known design guidelines for conventional desktop Graphical User Interface and for the Web, very few interactive TV applications have been commercially successful, and heuristics on some aspects of interactive TV such as social interaction is only appearing now [10].

When developing organization technologies for a certain device, cognissance must be taken of the inherent device limitations. For example, screen size, processor speed, ease of interaction, etc. Studies on interactive TV highlight the special characteristics of lean-back environment and they show design implications and guidelines for a technology operating in such a context. In this section, we summarise the characteristics of lean-back interaction from the perspective of interactive TV literature, serving as a base rationale for our design for Wiimote operated HDM interface on the living room TV.

3.1. Use of Remote Control as an Input Device

The main input device for the TV in the living room is a remote control. Due to the different affordances which a remote control of a TV and keyboard/mouse of a PC exhibit, suitable interaction mechanisms and widget behaviour of the two platforms are inevitably very different. A straightforward menu hierarchy with scroll bar, radio buttons and icons which are all very usable on a PC or Web environment (using a mouse and keyboard) becomes completely unusable when ported to, for example, a TV with remote control. The remote control has very coarse interaction continuity (few buttons for input) therefore the ideal interaction for the remote control should be based on discrete jumping from one area on the TV screen to another, avoiding complex hierarchical navigation but supporting a flat or shallow menu where a few remote control buttons can directly select frequently-used features. The design

implication from ethnographic studies (such as [15]) suggests that a small number of frequently-used features should be identified and mapped directly to remote control buttons thus reducing menu navigation burden on the user.
Entering text using a remote control has been a major problem and has been addressed in a number of previous works. Having a virtual keyboard on the TV screen or an SMS text messaging style input have been suggested but currently the research community seems to agree that cumbersome text input with a remote control should be avoided if possible. Allowing each viewer's own mobile device (such as a mobile phone or PDA) as a text input device has been suggested as possible solution [16], [17] but the real utility and experience of such methods is still to be experimented with real users. We envisage that future remote controls will be equipped with motion sensor and operated with a few buttons in conjunction with motion gesture, thus becoming a more similar to Wiimote.

3.2 Viewing Distance

Unlike desktop PC or mobile interaction, lean-back interaction with TV occurs in the user typically sitting 2-2.5m away from the display screen. Due to this distance, the interactive elements on the TV screen need to be large enough to be noticed and read albeit the exact size of these will depend on the size of TV screen itself. Most of the currently available design guidelines for interactive TV suggest a minimum font size of 18pt [18] [19] and the maximum amount of text on the screen of 90 words [18] suggesting a requirement to focus on visual interactive elements, although the ever-increasing consumer TV screen size and resolution today will continue to make relatively smaller font size and more number of words more acceptable over time. Although much more investigation is required to set a standard widget and text sizes for TV interaction, having less details and small amount of comfortably large-size widgets and text is an important implication for designing for lean-back interaction.

3.3 Enjoyment-Oriented Design

The design for lean-back interaction cannot assume a highly-attentive user like traditional usability engineering methods do [20], because a more *enjoyable* interaction is not necessarily a more *efficient* one [21]. There is growing evidence that traditional desktop usability principles do not account for the pleasure of the user experience [22], focusing rather on the task-oriented nature of desktop interaction. Therefore an enjoyment-focused service such as interactive TV requires different designer focus, mindset and priorities from the start. Usability evaluation issues for interactive TV interfaces have been drawn and explored in [23, 24], and a structured evaluation framework for interactive TV has been suggested [9], but these are still based on the theoretical assumptions and past experiences from other media devices and need to mature further. The aesthetic quality of a TV interface is closely related to user enjoyment, therefore priorities for interactive TV design include designing for quick decisions, short attention spans and instant gratification [25].

3.3 Derived Lean-back Interaction Guidelines

After examining the characteristics of CE devices in lean-back environments, and based on previous research and our own experiences of developing information retrieval systems for lean-back devices [5], we have compiled a set of guidelines for developing interactive multimedia applications for lean-back environments:

- **Minimise user input where possible**. Remove the need for a user to engage with complex query input mechanisms, such as textual querying and rather rely on remote control style browsing interaction. This requires that the system must be able to proactively seek and recommend content to the user or support information seeking via a small number of frequently used interactive features. This will likely require the deployment of hidden back-end technologies that make the user experience better, such as summarizing recorded video content in a DVR [5] or content recommendation technologies.
- **Engage the user with simple, low-overhead and low-learning time interaction methodologies, that are enjoyable to use.** Given the enjoyment oriented scenario of the lean-back environments and the disruptive nature of such environments, it is important that the interaction mechanisms employed must be both intuitive and easy to learn (for example the TV remote control or the Wiimote).
- **Represent complex digital multimedia objects visually**. Complex multimedia objects, such as photo collections, video archives or HDM archives need to be visually represented and manipulatable on screen, with few textual elements so as to maximize user attention in the distractive lean-back environment.

Where the lean-back environment in question includes information presentation on a TV screen, the existing guidelines for conventional or interactive TV [18, 26] can also complement the above suggested assuming the conventional viewing distance. For example, use of a standard iTV font, minimum text size, maximum words/screen, chunking text into small groups, clear menu exit point always visible, correctly sized interactive elements (e.g. thumbnails, icons), etc. should be employed.

4. The HDM Browser, an experimental prototype

By taking into account the three guidelines just described, along with the existing conventional interactive TV guidelines, we developed a Wiimote based browsing interface to a HDM archive. While it would be tempting to simply integrate as many interface technologies as possible to organise a HDM (e.g. many axes of search such as location/people/colour, keyframe browsing, textual querying, etc.), this would only serve to complicate the prototype and break our guidleines. In this prototype, the user is presented with a HDM archive segmented temporally into a sequence of days. The daily stream of photos is segmented into a sequence of events using the approach of Doherty et al. [9] and these events are presented in a temporally arranged storyboard at the bottom of the screen, with a keyframe selected for each event [9]. As the user browses a given day, the storyboard moves with the browsing, to give the user context of the temporal surrounding events that took place on that day. No attempt is made to identify the importance of an event on a given day, as this would require a query mechanism to generate a ranked listing of events, which was not the focus of this experiment.

Selecting an event begins playback of that event, which occurs in the large central area of the screen. Playback cycles through images in that event, fast or slow depending on user input. The horizontal arrows support next/previous event switch and the vertical arrows signify next/previous day switch. Jumping to the next day, will begin with the first event of the next day, regardless of what time of day the jump is made. In addition, the small slider control illustrates the speed of playback or rewind and there is minimal textual data on screen (event sequence, date, time and location only). The day-by-day browsing and playback interface as shown in Figure 2.

Fig. 2. The Prototype browsing interface showing playback (paused) from the fourth event of the day, which took place in early afternoon in Dublin, Ireland.

Exactly how the three guidelines impacted on the prototype is now illustrated:

- The prototype *minimized user input* by organising the HDM with a calendar as the key access mechanism. A user could select next/previous days (via a simple Wiimote gesture) and then select next/previous event (another simple Wiimote gesture). Upon selecting an event, the event playback began which cycled through the images comprising that event at a fixed speed. The speed of this playback (from pause to fast-forward/fast-rewind) was user controlled by twisting the Wiimote as if one is twisting a dial or a knob.
- The prototype engages the user with *low overhead and low learning time* interaction methodologies that users found enjoyable to use. The Wiimote gestured employed were limited in number and as a result were very intuitive to a user. Simple button presses and gestures controlled all interaction with the HDM archive browser.
- *Represent complex digital multimedia objects visually*. A HDM archive is an enormous repository of data and as such it needs to be summarised and visually easy to browse and interpret. Therefore, the many thousands of images captured daily are treated as a continuous steam (as one would digital video) and undergo an event segmentation process [9], thereby representing a days' images as a set of about thirty individual events that the user can

browse through. A keyframe was automatically selected for each event on the basis of its visual significance within that event [9]. These events were then easily played back at varying speed in the interface, allowing the user to quickly and easily view an event.

The HDM browser just described provided one half (gesture-based interface) of our user experiment. In order to do a comparative analysis with a more conventional lean-forward interaction scenario, we provided a baseline system for user evaluation. This baseline system was functionally and visually identical to the gesture-based HDM browser, however it operated via conventional (lean-forward) mouse click interaction, and therefore required lean-forward interaction.

4.2 Experimental Setup

Two weeks of HDM data gathered by one SenseCam wearer was employed for this experiment. This data was chosen from a three year HDM archive and was three years old at the point this experiment was carried out. This data consisted of about 50,000 individual SenseCam photos, each of which was indexed by date/time of capture and textual location (from an accompanying GPS log). For this experiment, we employed seven participants; six users who had no prior experience of HDM archives and one user who was the data owner (i.e. the actual SenseCam wearer from three years before). Since the experiment included the actual sensecam wearer, it was important that the data was not recent, so as to avoid any short-term memory bias from this user. It is our conjecture that including the SenseCam wearer in the experimentation process is important because a HDM is likely to be a private archive (of a person's life experience) and most data access is likely to come from this particular user. We are especially fortunate to have the three-year gap between data capture and this subsequent experiment. We validated that the sensecam wearer did not review the images prior to this experiment.

5. Evaluation and Findings

We focus first on the six novice users. They were each allocated an identical set of six information finding tasks, though organised in such a way as to avoid any bias as a result of learning. Therefore alternate modes of interaction were employed; the Wiimote and the baseline system alternating, which resulted in each topic being evaluated three times by different users on each interface and never at the same point in the task sequence for any user. After completing the experiment (which lasted about 17 minutes), participants completed a post-study system usability questionnaire (adapted from [27]) for both Wiimote and baseline systems. All participants were allowed up to 5 minutes to learn how to use both systems. During these five minutes the participants were encouraged to ask questions. The participants were then given the six search and retrieval tasks to complete. Four of these tasks (task 1, 2, 3, and 6) were single-item (known-to-exist) searches, meaning that the participants were asked to find a described event in the collection as quickly as possible. An example would be, ‘find the time the HDM owner was giving his lecture’. The remaining tasks (task 4 and 5) were multi-item searches, meaning that the participants were asked to locate as many events with a particular characteristic as possible in a given time frame (two minutes). For example, ‘find as many instances of meal eating as you can’. Each system utilised an identical event segmentation approach [9], therefore offsetting any impact of the event segmentation on the experimental results. No attempt was made to interrupt the user using the gesture-based interface, beyond the interruptions of a research lab environment and the co-ordinator keeping a record of user performance.

Table 1. Participant and HDM Owner performance for single-item retrieval

	Participant Users		HDM Owner	
Task	Wii (mean time)	Baseline (mean time)	Wii (time)	Baseline (time)
1	88 (seconds)	54	-	76
2	33	40	08	-
3	97	*Not Completed*	-	90
6	91	79	03	-

Table 1 illustrates the time taken (in seconds) to complete the four single-item retrieval tasks, with the max time allowed. Lower times are considered to be more successful. For the six participant users, there is no significant difference in the findings between the Wiimote interface and the baseline (mouse/desktop) prototypes. This is encouraging because we note that the (less familiar) gesture-based interface did not hamper the overall user performance in any way. Indeed, one notable finding is that using the baseline system no user managed to complete the third task at all, while it was completed with the gesture-based interface.

For the HDM owner, the Wiimote prototype significantly outperforms the baseline system, which suggests that when the user has some knowledge of their own archives (e.g. likely time of day of an event taking place), that a gesture based interface may help in locating desired content. For all but one of the four tasks in Table 1, the HDM owner was significantly the fastest user. Note that the HDM owner only evaluated each query on a single interface, hence there is not a score for each query on each system for both tables 1 and 2.

Table 2. Participant and HDM Owner performance for multi-item retrieval

	Participant Users		HDM User	
Task	Wii (mean score)	Baseline (mean score)	Wii (score)	Baseline (score)
4	12	7	19	-
5	8	6	-	17

Table 2 shows the average number of relevant items located by the within the allocated time for multi-item retrieval tasks. Participants performed the score based tasks more effectively using the Wiimote interface for both queries, with users of the baseline system only finding 58% of the items that the users of the Wiimote system found for task 4. The HDM owner significantly outperforms the other six participants, possibly because it would be easier and quicker for the HDM owner to identify relevant images, thereby reducing the requirement to pause or rewind playback; however there was no significant difference between the performance of the Wiimote and baseline systems for the HDM owner. There was no requirement to actually stop and mark the relevant items when located; a simple identification was sufficient and the count of successful identifications was kept by the experiment coordinator..

As expected, the owner of the HDM archive performed overall more successfully on the majority of the tasks compared to the other participants. Immediately post study, a questionnaire (for each of the two systems) was given to the six participant users (but not the HDM owner). This was an 11 item questionnaire using a 7-point likert scale which asks participants to agree or disagree to statements concerning their satisfaction using the both prototype systems. The results of this questionnaire are displayed in Figure 3. It can be seen that participants rated the Wiimote higher for satisfaction, efficiency, productivity, recovery from error and functionality. The baseline (labelled ‘mouse’ in Figure 3) was rated higher for comfort and ease of learning and there was no difference in the user rating for effectiveness and interface/interaction pleasantness. Overall though, there was no significant difference between the two prototypes in the questionnaire. How much the demanding nature of time-limited topics affected the user questionnaire answers is not known. It would have been anticipated that the Wiimote system would have been rated higher for comfort and pleasantness, which was not the case. Figure 3 shows the mean of the six participant ratings for nine aspects of the interface (two aspects incorporated two merged similar topics).

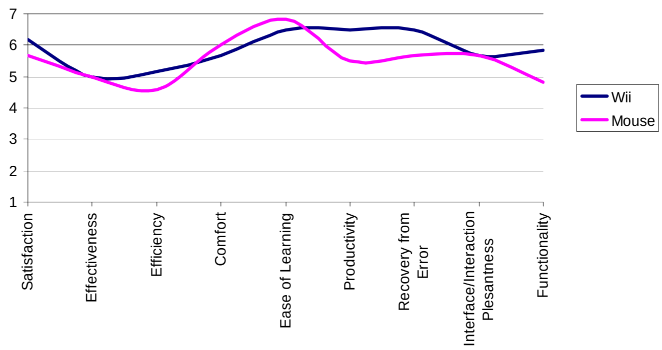

Fig. 3. The averaged user feedback (Likert scale) for the post-experiment questionnaire

Finally, informal feedback from the six participants suggested that although they were all more familiar with a computer mouse, they felt that the Wiimote gesture interface was easy to learn and that it allowed them to complete their tasks more efficiently than the mouse. Overall participants declared themselves to be more satisfied with the Wiimote than baseline, even though some did comment that the gestures were slightly too sensitive as implemented in this prototype.

6. Conclusions

In this paper a prototype HDM browser that implemented a gesture-based interface for a lean-back environment was described and evaluated. The prototype was influenced by a set of guidelines for lean-back environment information systems that were proposed. The findings of a user experiment suggested that the gesture-based prototype was as effective (and sometimes more so) than a functionally and visually similar lean-forward (mouse interaction) desktop prototype. It was found that users were very comfortable with the gesture-based interface and that they found it easy to learn, effective and more satisfying to use than a point-and-click mouse equivalent. It should be noted that to achieve this result, event segmentation technologies and keyframe extraction techniques [9] were employed (behind the interface) to maximize ease to use, which is the key point from all three guidelines presented in section 3.

Future work includes a larger user study, as well as identifying what other axes of organisation are possible in the lean-back environment. For example, implementing a mapping interface (geostamped HDM) would better suit a desktop device than a gesture-based device, but how it could be employed in a gesture-based interface is not known. In addition, it is important to identify how effective is a lean-back, gesture-based interface to other personal archives, such as digital photos or an archive of home movies. Finally, for a HDM owner knowledgeable about their own data, the gesture interface showed significant performance improvements, and needs to be the subject of a larger study, though locating sufficient HDM owners will be a challenge.

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