Venturing into the Labyrinth: the Information Retrieval Challenge of Human Digital Memories

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ABSTRACT

Advances in digital capture and storage technologies mean that it is now possible to capture and store one's entire life experiences in a Human Digital Memory (HDM). However, these vast personal archives are of little benefit if an individual cannot locate and retrieve significant items from them. While potentially offering exciting opportunities to support a user in their activities by providing access to information stored from previous experiences, we believe that the features of HDM datasets present new research challenges for information retrieval which must be addressed if these possibilities are to be realised. Specifically we postulate that effective retrieval from HDMs must exploit the rich sources of context data which can be captured and associated with items stored within them. User's memories of experiences stored within their memory archive will often be linked to these context features. We suggest how such contextual metadata can be exploited within the retrieval process.

General Terms

Personal Information Management, Human Digital Memories, Context data, Context-based retrieval

1. INTRODUCTION

Vannevar Bush could never have envisaged the impact his 1945 article "As We May Think" [3] would have on computing science and society. His article is largely credited with predicting many recent innovations in computing including the World Wide Web. However, Bush presented a vision encompassing far more than the idea of linking pages of information. He foresaw a world where all information associated with someone's life could be stored and, importantly, retrieved at a later stage.

Advances in digital capture and storage technologies mean that Bush's ideas are now coming to be realized. Vast digital archives of one's personal life experiences (more formally referred to as "Human Digital Memories (HDMs)") can now be generated. Content recorded from someone's life might include: all documents read, written, and downloaded; photographs taken; videos seen; music listened to; details of places visited; details of people met etc. Capturing all this data requires using a range of devices and technologies, at present these include personal computers, mobile phones, cameras, video and audio recorders, GPS devices and Bluetooth sensors. The best known example of a prototype HDM archive is that of Microsoft's Gordon Bell who has dedicated much time in recent years to digital capture of all of his personal data, as part of the *MyLifeBits* project [7]. The wide range of technical and ethical issues raised by HDMs form the basis of the ongoing "Memories for Life" Grand Challenge for Computing in the U.K. [2].

While a person's entire life experiences can now reasonably be stored on a computer, little attention has been given to how the individual (or a descendent of the individual) might access this vast archive. Current information retrieval (IR) techniques, as exemplified by web search engines, are good at retrieving relevant items from formal content archives in response to a user's queries. However, the characteristics of HMDs are quite different to those of the document collections for which current search engines have been developed. Looking into an HDM archive we can imagine seeing a diverse range of item types, incompletely linked into information structures, forming a complex and seemingly unintelligible labyrinth which we have no hope of successfully navigating. Retrieving items from such complex and unpredictable data structures presents great challenges to IR. The iCLIPS project [1] at Dublin City University is focused on the development of new IR strategies suitable for HDMs. We believe memory cues can play a strong role in IR for the HDM domain, within our work we are exploring methods to enable context data to be used for search within HDMs. We are interested in both how context can be used to link and annotate items, and also how it can be used interactively in user interfaces to enable users to explore their HDM.

In the remainder of this paper we look at efforts that have been made towards effective IR in HDMs and suggest directions for future research. In particular we focus on context, memory cues and visualization.

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2. THE HDM RETRIEVAL PROBLEM

The characteristics of HDMs mean that they provide a number of challenges for retrieval. Among these features are that: items will often not have formal textual descriptions; many items will be very similar, repeatedly covering common features of the user's life; related items will often not be joined by links; the archive will contain much non-useful data that the user will never wish to retrieve; the user may be unable to describe clearly what they are looking for; and the user may not even be aware that an item was captured and is available for retrieval. New techniques for IR which take these features into account need to be found if we are to successfully provide applications that allow people to browse and search their archives effectively and efficiently.

We can illustrate some of the challenges posed by HDM retrieval using an example. Consider a scenario where someone is looking for a particular photo from her HDM archive. All she remembers about the picture is that last time she viewed it, the sun was glaring in the window and she was talking on the phone to her friend Jack. Conventional IR techniques would not be capable of retrieving the correct photo based on these context criteria which are unrelated to its contents. New approaches to IR using context could enable her to search for pictures viewed while speaking with Jack while the weather was sunny.

2.1 Context in HDM Retrieval

The notion of using context to aid retrieval in this and other domains is not new. Context is a crucial component of memory for recollection of items we wish to re-retrieve from a HDM. As part of our investigation we are examining which forms of context data, or combinations of them, might prove most useful for search. Issues to be explored include whether different item types are associated with different context features, and the extent to which these are personal to individuals or are consistent across groups.

There are examples of use of context in simple ways in existing work. The Microsoft *MyLifeBits* [7] and *Stuff I've Seen (SIS)* [6] systems make use of context data to aid retrieval of personal files. MyLifeBits uses features such as people, location or date. This context data allows for linking of items, for example a photo containing Jack could be linked with an email from Jack. The SIS system similarly uses features such as date and author to enable an individual to search for items. An extension of SIS, PHLAT [5], uses *tagging* as an additional context feature. With tagging the user can add whatever type of text-based annotation they desire to items; these annotations can then be used subsequently in retrieval. A significant disadvantage of these current systems is that much of the burden for annotating items with context features is placed on the user. Users of course are often busy people or sometimes just plain lazy, and very often will not take the time to add annotations to items; but they would still like the benefits of a system enabling them to search using rich annotations derived from context data. Widespread takeup of context based search clearly requires methods for automatic annotation and linking of items with minimal user involvement.

Additionally, we believe that there are many other sources of context which can be integrated to improve retrieval in the personal archive domain. For example, the earlier image search scenario requires integration of photo access with details from the searcher's phone records and records of the weather conditions. A primary focus of our research is the capture of diverse and novel sources of context information, and exploration of the role they can play in retrieval.

Many current technologies, such as timestamps, GPS technology, Bluetooth, and biometric sensors, already enable us capture many sources of context data which can be used directly or used to derive useful context-based search features. Some examples are as follows:

- Timestamps can be useful to infer temporal annotations when a person may recall the time, day, month, season or relative year when an item was created or accessed, e.g. *I remember the photo was taken during the winter time in the past few years.*
- GPS technology can enable users to retrieve an item based on location of item creation or previous access, e.g. *I remember I last looked at that document on my laptop when I was in Boston at a conference.*
- Combining timestamp and GPS information, we can determine such things as the light status and weather conditions at the time of item access or creation [9], e.g. *It was getting dark and very cold when that photograph was taken.*
- Use of Bluetooth networking enables us to monitor other devices present in the nearby vicinity - in today's society many people have Bluetooth technology activated on their mobile phones. Using this information we can maintain a record of who was present when our subject was creating or accessing items from their HDM [4].
- Biometric sensors provide information on a subject's physiological state. In the CDVP at DCU we are exploring the use of two Biometric sensor devices - heart rate monitoring and capture of other features using a BodyMedia SenseWear armband. The BodyMedia SenseWear armband is worn around the upper-arm, and captures physiological data, including Galvanic Skin Response (GSR), a measure of skin conductivity which is affected by sweat from physical activity and emotional stimuli; Heat Flux, which is a measure of the heat being dissipated by the body; Skin Temperature, which is a measure of the body's core temperature; and accelerometers, which is a measure of movement or lack thereof. These measures can be used with heart rate as an indication of different levels of arousal, such as excitement or boredom, which may correlate with more significant events in a person's life.

2.2 Information Linking in HDMs

In addition to annotating items with context metadata, we are also interested in linking related items to support search. This is motivated by the successful exploitation of the link structure of the web by web search engines. Link structure is used in computing to measure page importance. This information has proven an important component in successful ranking of pages in web search, most notably in the *Google* search engine, which uses the PageRank algorithm [10]. The basis of PageRank is to assign an importance factor to each

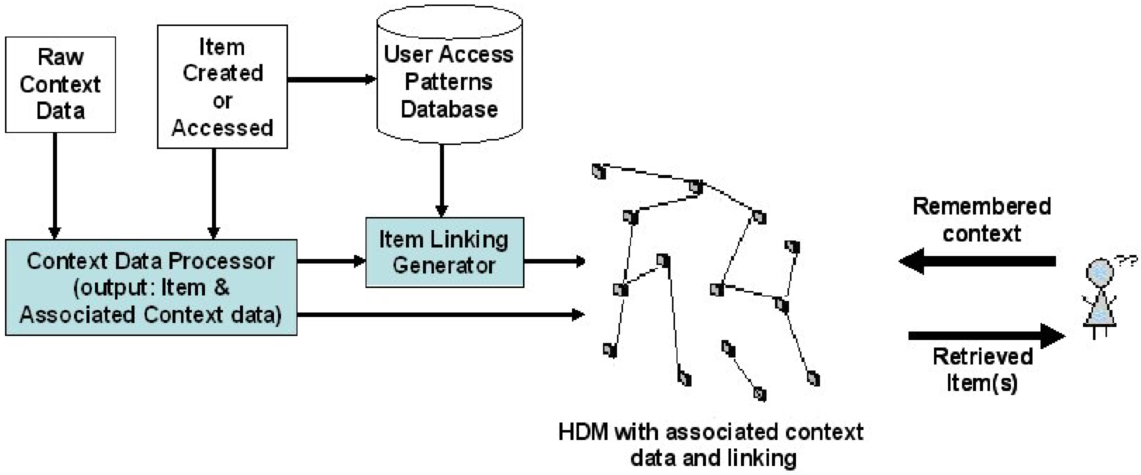

Figure 1: Context-based retrieval from a HDM using memory cues.

web page based on the number and importance of web pages which link to the page.

Items captured within an HDM by contrast are not directly joined together by inter-item links. We believe that building and exploiting such link structures has a valuable role to play in HDM search. Other researchers have also begun to investigate the possibility of using linkage in retrieval from personal archives, thus enabling the use of algorithms such as PageRank to aid the retrieval process. For example, the Connections system [11] retrieves items from a person's personal collection by first forming a relation graph from the personal collection using successor models which reflect user access patterns to files. The system then ranks the results of a text-based search query using PageRank type algorithms. We are similarly interested in exploring different methods of exploiting a user's past information access patterns and past interaction with items in their HDM to form inter-item links. We also plan to explore a broad range of other methods of forming potentially useful links, such as through the use of related context and association based on content similarity. The linking combinations which yield the best search results will then be further investigated. As part of this investigation we will explore how PageRank type algorithms might be extended to help locate interesting items based on the contextual component of user's memories of required items.

Figure 1 demonstrates how context information and linking might tie together to aid retrieval in an HDM. More specifically, this figure shows how a user's HDM can be transformed into a linked graph using user access patterns and context information associated with items. The user can then query this linked structure using recalled context information.

A linkage structure in an HDM could have other uses beyond simply allowing for ranking of retrieved items. A linked HDM could for example allow for the suggestion of items which are closely linked to the item currently being examined or worked on, we return to this topic in the next section.

2.3 Interfaces for HDMs

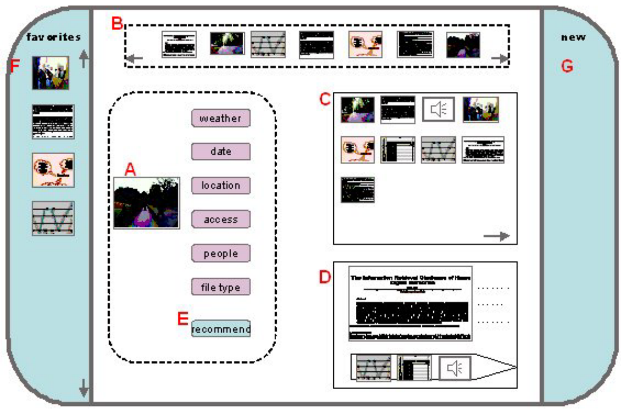

Figure 2: Sample HDM interface.

The complex and heterogeneous nature of an HDM means that simple ranked retrieval is unlikely to support many of the user's information searching tasks. As we imagine gazing into the partially linked labyrinth of an HDM, we can expect to see items related in some way (contextually or topically) to the one that we are currently examining. From the currently viewed item the user may wish to browse to one of these items or use links as a path to navigate to another location in the maze of their HDM. To support this exploratory search activity will require a suitable user interface designed to support the user's search activities. Such an interface should be intuitive, simple to use, and afford the user all the functionality they require.

We anticipate that people's remembering processes can be used as a basis for the design of an effective interface to aid IR in HDMs. A good example of this is [8], where memory cues are used for a meeting video retrieval system. From a user study, they found what types of items people easily remember and easily forget about meetings. "location of the meeting room", "table layout in the room", "seat positions" and "main speaker names" were found to be among the items remembered, while items like date, time, dress and posture were hard to recall. They used this information in the design of an intuitive interface that uses information which can act as memory cues for the retrieval of the desired meeting video.

An interface for an HDM should allow the user to easily explore and search through their archive. This poses obvious problems arising from the potentially vast size of an HDM, its heterogeneity and the diverse needs of the user. Various methods, such as fish-eye views and linking and zooming spaces, have been developed successfully for information visualisation in other domains. In iCLIPS we will investigate the suitability of existing visualisation techniques for the HDM domain, and also explore new ideas, such as those depicted in the interface design shown in Figure 2. Interface design for the complex HDM space is proving a very challenging problem for us due to the fact that an HDM may be vast in size, and a given item may be labelled with many context features and linked to a large number of other items. Added to these problems is the fact that the space is personal to the user, and as such the user has specific memory cues which they may use to recall an item.

The interface design shown in Figure 2 is suggested as a possible solution for both the searching and exploring of an HDM. With this interface users can follow context memory cues E for a given item A, including date, location, people present, to search, and then enter their context search using the 'recommend' button at the bottom of E. This will then display the 'best' links from a given item. The resulting items are displayed in pane C as individual items or 'èvents' combining multiple items. Elements in C can be enlarged and explored in pane D. Pane B shows items previously viewed to allow the user to jump back to these search states if they wish. Panel F allows the user to add items to a list of 'favourites' for future access. Finally the user can drag an item they wish to explore in detail into panel G, this item then becomes the new item A and its associated attributes are displayed allowing the user to browse from this point.

One aspect that we find interesting is the representation of search states in pane F. The volume of items in panes B and F may build up very quickly. In this situation it will be hard for the user to recall the search state associated with each item. Humans generally find it easier to recognize than recall things, with this in mind we plan to display an intuitive summary of the search state when the user hovers over an item in one of these panes. The key challenge here lies in the creation of a summary that effectively reminds a user of the given search state. We will explore techniques which extract key points or attributes from items in the creation of these summaries, however exactly how to do this remains an unsolved problem.

3. CONCLUDING REMARKS

In this paper we argue that if context information is exploited correctly, it can form a valuable component in meeting the challenges of IR for HDMs. We envisage HDM IR systems which respond and adapt to the user; systems which work and evolve with the user's needs and the way they remember information. In the near future it will be hard for people to imagine a world where HDMs did not exist. In the iCLIPS project we are exploring the development of retrieval techniques and interfaces that address the unique retrieval challenges of HDMs, and contribute to the realisation of Bush's original vision of the Memex.

4. ACKNOWLEDGMENTS

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