Challenges in Interface and Interaction Design for Context-Aware Augmented Memory Systems

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ABSTRACT
The human long-term memory is astonishingly powerful but fallible at the same time. This makes it very easy to forget information one is sure one actually knows. We propose context-aware augmented memory systems as a solution to this problem. In this paper, we analyse the user interface and interaction design challenges that need to be overcome to build such a system. We hope for fruitful interdisciplinary discussions on how best to address these challenges.

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Augmented Memory, Context-Aware Computing, Wearable Computing

ACM Classification Keywords
H.5.1 Multimedia Information Systems: Artificial, augmented, and virtual realities; H.3.m Information Storage and Retrieval: Miscellaneous; H.5.2 User Interfaces

INTRODUCTION
Human memory can perform astonishing feats—the tiniest snippet of information can trigger whole chains of associations, ending at an item long-believed forgotten. While modern information systems excel at systematic manipulation of structured or semi-structured information or even vast repositories of unstructured textual information, they are still far from the capabilities of the human memory.

Unfortunately, human memory is prone to failure. It is quite common not to be able to recall a piece of information, though it will be easily remembered at other times. A personal system that augments human memory through means to store and access information could have huge benefits.

There is evidence from research in psychology that humans have an episodic memory (see the work cited in [11]). This means we tend to remember a piece of information more easily when we have access to a description of the circumstances—the context—in which we first encountered this information. The human memory also appears to work in a highly associative fashion. Vannevar Bush recognised this in his visionary 1945 article about the *Memex* [3], a proposed system to manage personal information.

While research in such systems and in related areas has made enormous progress since then, we are still far from fulfilling Bush's vision—and further still from what one can imagine today.

“Memories for Life”' has been recognised as one of the Grand Challenges for computing by the UK Computing Research Committee (see *www.memoriesforlife.org*). Envisioned applications build virtual memories for particular events in a person's life and transform memories into stories [6]. There are many issues to solve in this research area, both on a technical (multimedia retrieval; software and hardware design) and a sociocultural level (privacy; appropriateness of use). Our project focuses on a smaller part of this area: We aim to augment a person's memory in specific situations with personal software that runs on a wearable or portable device, captures as much data as possible about its user's experiences and allows him/her to interact with these stored memories to recall forgotten information. In contrast to many other related projects, our emphasis is on information modelling and retrieval together with interface and interaction design instead of automatic detection of “interesting” moments in multimedia recordings.

In this paper, we first present a usage scenario for the system we propose. We then derive requirements from the scenario. We describe a conceptual architecture of a context-aware augmented memory system to provide a shared vocabulary for discussion of these systems. We analyse existing research and identify gaps that still need to be bridged. Finally, we explore challenges for further research in this area. We hope to spark and fuel discussions about how best to address these challenges.

SCENARIO: TRAVEL DIARY
We have previously examined how a context-aware augmented memory systems can support a conference attendee [14]. Here, we present a second scenario: a traveller who uses a context-aware augmented memory system as a travel diary.

Typical activities for this scenario include:

- getting from one place to another.

- visiting sights, e.g. a museum, a church or a waterfall.
- participating in more or less structured activities, e.g. a sea kayaking trip or a guided city tour.
- staying at hotels, campgrounds or other places of accommodation.
- talking to other travellers—in particular, exchanging
- opinions and recommendations for sights, activities, places of accommodation, means of transportation etc.
- taking pictures/movies.

During or after the trip, a traveller might want to remember certain information related to his or her experiences during their trip. Here are some example questions:

- When was I at a given place?
- With which organiser/company did I undertake a given activity at a given place and time?
- When/where did I take a given picture?
- Which pictures did I take at a given place?
- What are the contact details of a person I met at a given place/time?
- What recommendations did I get from a given person or about a given activity/place?
- Which path did I take between two given locations?

Without the use of dedicated hardware and software, ways to answer questions like those presented above are limited to:

- looking through guidebooks and at brochures from sights, accommodation providers and other companies.
- consulting handwritten or electronic notes taken during or after the trip.
- looking at pictures and videos taken during the trip.

REQUIREMENTS

In both scenarios, the user knows in advance that she or he will want to remember details about the situation. For example, most travellers collect artefacts related to their trip: Photographs, movies, postcards, seashells, commemorative mugs, T-shirts and brochures are just some examples. We focus on these scenario types and therefore assume that the user is willing to invest some effort in preserving her or his experiences.

We identify the following requirements for context-aware augmented memory systems:

Input. The main focus of the user's attention is on the situation itself. To best support its users, an augmented memory system should acquire as much information as possible in an autonomous, automatic way. However, we cannot assume that all information important to the user can be captured automatically. Thus, the system should also let the user manually enter information.

Model. Following the associative nature of the human memory, the data model for an augmented memory system should support entities and relationships between these entities. The data model needs to be generic and allow the user to decide which information entities to represent and which properties they have.

User Interaction. Besides manually entering information, the user needs to be able to

- view the data stored in the system;
- change and delete items, properties and associations;
- access the stored information using suitable access paradigms.

CONCEPTUAL ARCHITECTURE

This section proposes a conceptual architecture for a context-aware augmented memory system. The architecture builds upon the requirements identified earlier. Describing this architecture and explicitly naming its components gives us a shared vocabulary for discussions about context-aware augmented memory system.

Figure 1 shows the core components and interfaces for interaction. The rectangle in the centre represents the system itself. Interaction with the system is possible in two ways: from external services, shown to the left of the system, and from a human user, shown to the right.

The system has three core components. The storage module holds all data that has been entered into the system. The association manager is responsible for keeping track of relationships between information items. The filter engine implements an algorithm that accepts queries in a suitable query language and retrieves matching information items from the storage module.

We now describe in more detail how external services and users can interact with the system.

Interaction between External Services and the System

External services are shown on the left of the system in Figure 1. They supply context data and other information. Examples are location information, audio/video capture, news and weather conditions. The augmented memory system and the external services interact with each other automatically, without user intervention.

Each external service has one or more concrete endpoints that provide the data. For example, a location sensor could have endpoints for communication with a GPS device, for a Bluetooth-based indoor location sensor and for a mapping service that transforms coordinates (obtained via GPS) into street addresses where this information is available.

From the perspective of the augmented memory system, the endpoints are hidden by a common interface. All the system needs to know is whether the service will push data to the system, or whether the system needs to query the service in regular intervals or whenever necessary. Concepts from

Figure 1. Conceptual architecture of an augmented memory system

event-based computing could be helpful here.

Data from external services can be turned into information entities or properties of information entities. Data from some sources might be archived completely, or the data might only be captured at certain points in time.

Interaction between the User and the System

The user's view of the system is shown on the right of Figure 1. All interaction between the system and the user goes through the user interface layer. Besides visualising the data that is stored in the system, this layer also provides the user with several options for interacting:

Defining and editing the data schema: specifying which information entities can be represented in the system, which attributes they can have and how they relate to each other. Also, specifying which entities/properties should be automatically populated from external services.

Marking a moment for later annotation: telling the system to capture as much external information about the current point in time as possible.

Entering data into the system: manually adding text or multimedia data as an information entity or a property of an entity.

Rearranging stored data: creating, changing and deleting associations between information entities.

Navigating: navigating between information entities, either by following associations between entities or within a classification scheme of entities.

Finding data: keyword search; typed search (retrieving all entities of a given type that fulfil a given set of criteria); possibly other types of narrowing down the information displayed to the user (e.g. filtering, zooming [15])

Editing data: changing and deleting information entities and their properties (text and multimedia data).

ANALYSIS OF RELATED WORK

In this section, we analyse existing augmented memory systems. We point out how each of these systems has some shortcomings with respect to the requirements identified earlier in this paper.

The first published vision of an augmented memory system, Bush's Memex [3], already mentioned a wearable device in 1945. However, such devices were not implemented until the mid-1990s. Due to technical limitations, these early systems ran on purpose-built devices and focused on combining textual information with context data. Examples are Forget-me-not [11], Jimminy [13] and the Conference Assistant [4]. Just like the systems themselves, their user interfaces were closely tailored to the application and focused mainly on textual information. An exception is Jimminy's graphical language to construct queries by specifying which entities and in which order should occur in the query results. All systems also provide a timeline view of the stored events.

Following the technological progress of more powerful wearable systems, the concepts introduced in the early wearable systems were extended to continuously recorded multimedia data; examples are MyLifeBits [7], Life logs [2], iRemember [16] and Evitae [12]. The user interfaces of these systems include a timeline view. Most also include a map-based view and keyword search. Some of these systems combine a wearable device for information capture with desktop-based retrieval and viewing tools.

Some concepts useful for augmented memory systems can also be found in programs for semantic personal information management. These programs are desktop-based and thus do not take the user's physical context into account. However, they transcend the more traditional data models used in most wearable systems for multimedia capture by employing techniques used in the semantic web. Examples are Haystack [9], Personal Chronicling Tools [10], Semantic-LIFE [1] and Semex [5]. Unlike the wearable systems, these systems do not have the constraint of severely limited screen real estate. As a consequence, most user interfaces are much richer.

When we compare these systems with the requirements, the following shortcomings are apparent: The data models of the wearable systems are very limited, both in the information types and the kinds of relationships they support. The models of the systems for semantic personal information management are richer, but are still not expressive enough for real-life data. On the user interface and interaction side, most systems resort to temporal, spatial and textual representations of the stored information. None of these show other types of relationships between items. Most systems do not allow the user to edit data. Few systems go beyond the classical information access paradigms of searching and browsing. While the systems for wearable multimedia capture come closest to our proposed system, they heavily focus on multimedia retrieval and do not allow for explicit manipulation or even representation of stored information.

SUMMARY: RESEARCH CHALLENGES

In this section, we summarise our paper by identifying research challenges that need to be addressed when building a context-aware augmented memory system.

How to model and store the data

An important step in the development of an information system is to decide which data can be handled by the system. This includes identifying information types, their attributes and their relationships. Augmented memory systems should not be restricted to a single problem domain. Thus, it is necessary to develop a generic meta-model.

This challenge will be most relevant to the information modelling and information retrieval communities. However, it is also relevant to other communities since the data model for a given system has an influence on other issues, for example the design of user interfaces and interaction.

How to visualise the data

Context-aware augmented memory system need to present the stored data to the user. We believe that it would be beneficial for users to be able to edit stored data, for example as their understanding of an event evolves. It is an open question how to organise complex, semi-structured data for viewing and editing.

How to navigate and access data

Closely tied to the storage system and to the data visualisation are the means to access the stored information. Classical paradigms for information access are searching and browsing. The first allows the user to find items that match the supplied criteria, the second to navigate along predefined structures (for example, classification hierarchies). Given the associative nature of the human memory, another way of browsing is to follow associations between items.

Following the ideas of experiential computing [8], most notably directness of interaction and identity of query space and information space, further ways of information retrieval may be suitable for augmented memory systems. Finding appropriate access paradigms is an important challenge in both interaction design and information retrieval.

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