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SharedLife: Sharing of Augmented Personal Memories in Ubiquitous Environments

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The rapid deployment of low-cost ubiquitous sensing devices - including RFID tags and readers, global positioning systems, wireless audio, video, and bio sensors - makes it possible to create instrumented environments and to capture the physical and communicative interaction of an individual with these environments in a digital register. One of the grand challenges of current AI research is to process this multimodal and massive data stream, to recognize, classify, and represent its digital content in a context-sensitive way, and finally to integrate behavior understanding with reasoning and learning about the individual's day by day experiences. This augmented personal memory is always accessible to its owner through an Internet-enabled smartphone using high-speed wireless communication technologies. In this contribution, we discuss how such an augmented personal memory can be built and applied for providing the user with context-related reminders and recommendations in a shopping scenario. With the ultimate goal of supporting communication between individuals and learning from the experiences of others, we apply this novel methods as the basis for a specific way of exploiting memories - the sharing of augmented personal memories.

1. Introduction

The rapid deployment of low-cost ubiquitous sensing devices - including RFID tags and readers, global positioning systems, wireless audio, video, and bio sensors - makes it possible to create instrumented environments and to capture the physical and communicative interaction of an individual with these environments in a digital register. One of the grand challenges of current AI research is to process this multimodal and massive data stream, to recognize, classify, and represent its digital content in a context-sensitive way, and finally to integrate behavior understanding with reasoning and learning about the individual's day by day experiences. If we add the clickstream history, bookmarks, digital photo archives, email folders, calendar, blog and wiki entries of an individual, we can compile a comprehensive infrastructure that can serve as his augmented memory. This personal memory is always accessible to its owner through an Internet-enabled smartphone using high-speed wireless communication technologies. We have realized a broad range of augmented memory services in our system Specter [Kroner 06].

Ever since ancient times, storytelling has been a way of passing on personal experiences. The selective sharing of personal augmented memories is the modern counterpart of storytelling in the era of mobile and pervasive internet technology. In our SharedLife project, we are creating augmented episodic memories that are personal and sharable. The memory model does not aim at a simulation of human memory. Instead we are realizing an augmented memory in an unintrusive way, that may contain perceptions noticed by Specter but not by the user.

Although some researchers believe that it is feasible to store a whole human lifetime permanently, we are currently concentrating on a less ambitious task. We try to record and understand an individual's shopping behavior for a few days and share relevant experiences with others in a way that doesn't conflict with his privacy constraints. Dealing with shopping experiences is a limited, but meaningful task against which we can measure progress on our augmented memory research.

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2. Related Work

The building of augmented personal memories in instrumented environments for the purpose of extending the user's perception and recall has been studied for more than 10 years [Gemmell 04]. While this research has focused on user interface design for the retrieval of memories [Aizawa 04], other research has looked into ways of processing the contents of such memories so as to increase their accessibility to their owner [Horvitz 04].

The exploitation of augmented memories has been researched for diverse scenarios. For instance, work conducted in the E-Nightingale project shows how automatically created nursing records may help to avoid medical accidents in hospitals [Kuwahara 03]. In the project Living Memory [Stathis 02], records of people's activities and access to community-related information are automatically processed in support of community-related behavior in relatively complex ways. An example of how memories can support social matching is offered by the system AgentSalon [Sumi 02]. The system uses experience logs of participants in an academic conference in order to stimulate conversation via rather extraordinary means, involving animated characters.

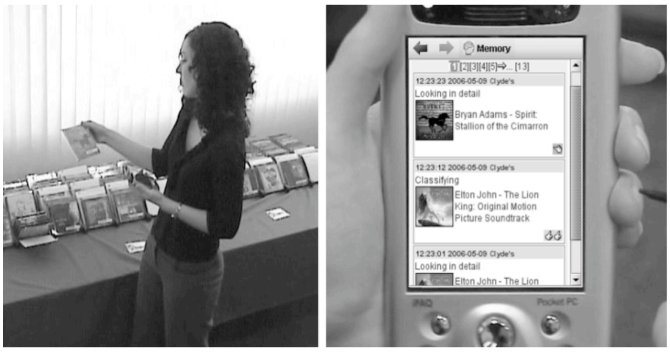

Figure 1: Creating an augmented memory in SPECTER at an instrumented CD shop.

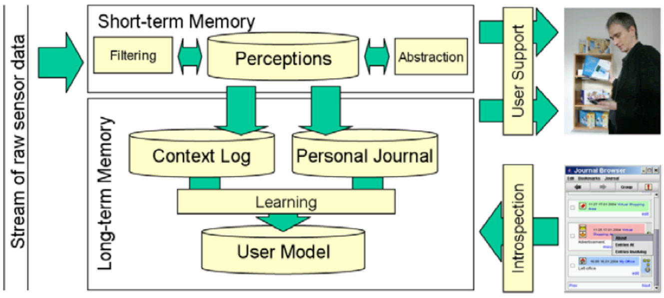

Figure 2: Building augmented memories from perceptions.

3. Augmented Personal Memories

3.1 Example Scenario: CD Shopping

Today, the retail industry introduces sensor networks based on RFID technology for advanced logistics, supply chain event management, digital product memories, innovative payment systems, and smart customer tracking, so that shops turn into instrumented environments providing ambient intelligence. Instrumented shopping environments like the METRO future store or the experimental DFKI Cybershopping mall support mixed-reality shopping, which augments the usual physical shopping experience with personalized virtual shopping assistance known from some online shops. Currently, our DFKI installation includes three small shops with instrumented shelves: a grocery store, a camera and phone shop, and a CD shop. The left side of Fig. 1 shows the user looking at a RFID-tagged CD, which she has grasped from the instrumented rack. The right side shows a screenshot from her PDA, which she is holding in her left hand to access the augmented memory services.

3.2 Creating Memories

The first step towards the creation of augmented memories is the automated recording of contextual information as perceived from various types of sensors. In our example scenario, each CD is an RFID-tagged smart ob ject, which allows tracking its presence within the store areas (shelf, basket, cashier). The user's location may be determined using IR, RFID, and/or GPS. Biosensors provide further information about the user's state, which is applied for choosing an appropriate communication channel and for automatically evaluating events. Finally, Web services allow the system to acquire rich context information, which may later on serve as an access key to the memory.

Sensors provide the system with perceptions; their RDF-encoded content contains simple statements such as "user reaching shelf " or "user holding CD". At any given point of time, the set of all available sensors' latest perceptions defines the context of an event in Specter. Information contained in perceptions references an ontology based on the IEEE SUMO and MILO. The user's state is modeled using the general user model ontology (GUMO), a mid-level ontology which provides applications with a shared vocabulary for expressing statements about users.

In order to describe how perceptions are processed and stored we have developed a memory model (see Fig. 2). In this model, incoming perceptions are stored in a short-term memory, which serves two main purposes. First, it is of special relevance for the recognition of situations and thus situated user support. The facts stored in the short-term memory model the user's current context; a BDI planner matches this context against patterns of service bindings specified in the user model. The second purpose of the short-term memory is to trigger, based on events and event chains, the construction of episodes in the long-term memory.

3.3 Exploiting Memories

Depending on the user's current context, the system offered recommendations and reminders related to that context with the goal of putting information about past experiences relevant for the current situation into the user's mind. For instance, if the user is inspecting some CD in a shop, the system might come up with cheaper offers previously seen, or with recommendations of similar CDs in this shop.

A crucial factor for the quality of such support is information about the relevance of the numerous events recorded over time for a given situation. The relevance is determined by several factors, and one of them is explicit or implicit user feedback. Feedback is represented by ratings, which may be attached to personal journal entries. We experimented with various rating dimensions including evaluation (a general quality judgement of objects referenced by the entry), importance (how important is the entry with respect to the user's current goals), and urgency (how urgent is the entry with respect to the user's goals). Ratings are assigned either explicitly by the user or implicitly based on feedback from biosensors and domain-specific heuristics. Ratings assigned by the system may differ from the user's perception, e.g., due to noise within the sensor data or inappropriate heuristics. Furthermore, especially in the case of an "untrained" system, the mapping of situations to services might require an adaptation to the user's personal needs as well. The user may address such issues by performing an introspection of her augmented memories.

We think of introspection as a process of inward attention or reflection, so as to examine the contents of the mind. In the case of our approach to augmented personal memories, introspection consists of processes in which the user and/or the system explore the long-term memory in order to learn about the course of events. From the user's point of view this includes the option to explore and to rate journal entries, including those produced in response to system actions. From the system's point of view introspection is an opportunity to refine, collaboratively with the user, the user model.

4. Sharing Augmented Memories

4.1 Example Scenario: Grocery Shopping

As seen in our shopping scenario, users have memories filled with their experiences. But as an alternative to acquiring experiences on their own, we often share memories with others (e.g. actively by telling stories or, more modernly, by blogging, passively by watching movies or reading autobiographies and test reports). Given augmented memories created on the basis of observations in instrumented environments and given several users with such memories based on our Specter software, the key research question of our SharedLife project is: can we reproduce the natural exchange of memories to some degree to enrich the memories of individuals and support their activities?

In our first version of the SharedLife, the user's behavior, his ratings and past choices are captured in his augmented memory. This personal memory can be used for a combination of reminding and recommendation, which we call "recomindation". The system reminds the user that he had listened to the soundtrack while he was watching the DVD with friends. In addition, it recommends to buy the CD, since the augmented memory includes a very favorable personal rating of this soundtrack. The user can publish parts of this shared memory with privacy constraints, so that a selective sharing of the augmented memories becomes possible.

In addition to the CD shopping scenario, the grocery shopping scenario involves more complex constraints on cooking for a particular dinner guest, such as availability, food allergies, dietary rules, and religious food preferences. Thus, shopping tips and shared cooking experiences are most welcome and SharedLife may grant limited access to the augmented memory of friends and family members with cooking expertise. In the following, we explain in details regarding two important issues for realizing sharing augemented memories: how to handle sharing requests and how to select shraing partners.

4.2 Handling Sharing Requests

The previously described instrumented environment supports its users in sharing augmented memories containing information such as recipes, personal cooking instructions, and experiences with ingredients. The employed sharing processes are controlled by means of a mobile device, which accompanies the user through the different scenarios in addition to various stationary services. Its user interface grants access to the user's augmented memory and the user model. The latter one is carrying scenario-specific preferences, which include a group of users (so-called *sharing partners*) the user thinks to be of special interest for the respective scenario.

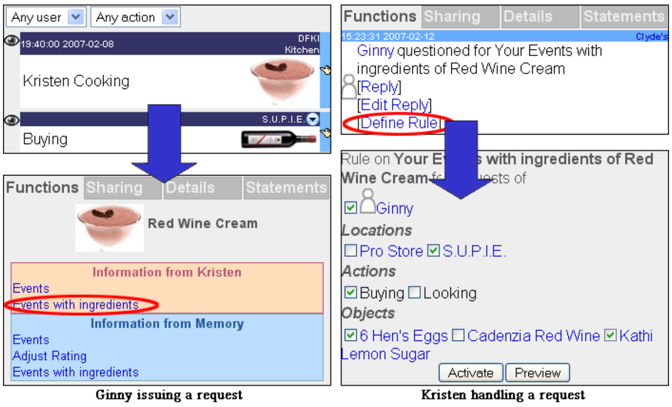

Figure 3: Issuing a sharing request (left-hand side) and exploring a response rule (right-hand side).

Let's assume for simplicity that User1 (Kristen)'s cooking experience is already accessible to User2 (Ginny). Once she accesses the corresponding event, she is supported with related functions (e.g., retrieval, recommendation) based on her augmented memory and current location (see the left-hand side of Fig. 3). Of course, accessing other user's memories leads to the question of how to handle incoming requests, or, following our example, how Kristen can be supported in setting up a response to Ginny.

In order to learn about potential users' opinion regarding this question, we developed various mockups of user interfaces for sharing experiences more or less automatically. Together with examples of sharing occassions, these became subject a focus group study consisting in questionnaires and a discussion round. Its 23 participants did not vote cleary for a specific method to handle incoming requests. The potentially large number of such requests was well understood and thus the participants appreciated automated methods for reducing the need of manual intervention. However, some participants expressed concerns regarding the efforts needed to configure of such services, especially in a "cold start" situation where a new system needs to be personalized. Others worried about losing control of their augmented memories if the set of constraints affecting the sharing process becomes complex. Here, they favored mechanisms known from cell phones, such as assigning access rights to user groups, and voted strongly for the possibility to make exceptions from such general approaches to protect selected data (e.g., to hide events which could be misinterpreted by a recipient).

We are exploiting the participants' comments to guide the initial implementation of a peer-to-peer sharing mechanism. Initially, in that system all data are considered to be protected and incoming requests will not be replied by the system. Instead, they are recorded in the user's augmented memory, so that the user (and the system as well) may handle them at a later point of time. This manual treatment is complemented by rules, which can be created to trigger automated sharing behavior (e.g., reply, dismiss, notify user) in response to future requests for events matching the characteristics of a given request. The precondition

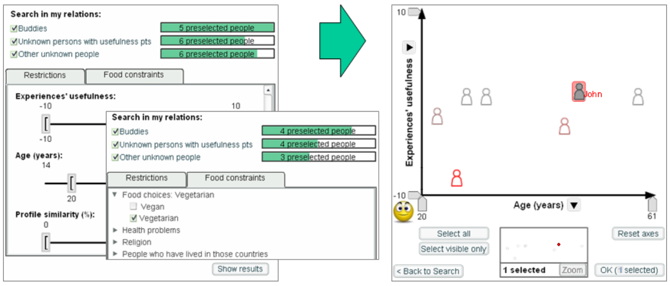

Figure 4: A user interface for discovery and selection of sharing partners.

of such a rule are features such as location, action type, action patient, which are extracted from experiences in the user's memory matching the request. If desired, the user may edit these features (see the right-hand side of Fig. 3) and control their impact on a potential response.

4.3 Selecting Sharing Partners

The grocery shopping and cooking scenario involves complex constraints on cooking for a particular dinner guest, such as availability, food allergies, dietary rules, and religious food preferences. Our contextual inquiry indicated the special value of food profiles for the selection of sharing partners in our scenario: countries of origin, religion, health issues and dietary constraints are attributes.

In order to design a user interface for the exploration and selection of sharing partners, we conducted two iterations of design and evaluation. We created four prototypes, all offering the same possibilities of selection criteria based on information from food profiles (e.g., "is vegetarian"), some other relationships by common properties (e.g., age or physical proximity) and relationships by communication (e.g. number of experiences exchanged).

In each design the community members were grouped into three categories: the user's buddies (i.e. people known from the user in the real world), "familiar strangers" who are unknown community members with whom the user built some relationships with time, and finally all other unknown members. For the prototypes' design, we chose techniques known from community-based applications (buddy lists, social networks) and from applications where information masses are presented on a limited space (data clouds, fish eye view effect).

Participants to the evaluation had to perform the same selection tasks with all of the prototypes (in a different order for each participant). They performed the best with a regular interface based on basic widgets such as checkboxes and sliders constraining the set of selected community members. As preview, it provides the user with the number of persons from each member category satisfying the current selection constraints (this prototype consisted in the left-hand side of Fig. 4). However, while well-suited for the selection task, that interface does not support the user in exploring the community and learning about the users, which is reflected by a participant's comment: "not enough information about the persons is available". Therefore, we decided to combine this prototype with another one which was ranked on the second position and received quite high scores from the participants for different usability criteria: a two-dimensional plot in which the community members are distributed according to two customizable dimensions. This prototype complements the previous basic prototype with a graphical representation of the community, which supports the exploration task via data clouds (see right-hand side of Fig. 4). A second iteration of design and evaluation allowed to attest that the combination was better than the previous prototypes and to clarify how the two prototypes should be combined. In the resulting design, the interface with the basic widgets is used to specify initial constraints on the selection, whereas the plot is employed to explore and refine the selection.

5. Conclusions

We presented our SharedLife project, in which we are creating augmented episodic memories that are personal and sharable. We described the experimental DFKI Cybershopping mall, which supports mixed-reality shopping and which augments the usual physical shopping experience with personalized virtual shopping assistance known from some online shops. In the technical core of the paper, we described in detail the memory sharing mechanism of SharedLife.

Our future work on SharedLife will address the question of how the sharing of augmented memories can contribute to the communication within small, potentially ad-hoc formed groups. We want to provide mechanisms for automated and semi-automated memory sharing. Such mechanisms must not only take into account situated access constraints on privacy and trust, but also the structure of the group.

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