Learning from Human Memory: Managed Forgetting and Contextualized Remembering for Digital Memories

Claudia Niederée

Leibniz Universität Hannover / Forschungszentrum L3S
30167 Hannover, Germany
niederee@L3S.de

In the human brain, forgetting is a very effective way of focusing on the important things, while unstressing irrelevant details. In the ForgetIT project, we use forgetting and other processes in the human brain - such as the context-driven reconstruction of memories - as an inspiration for creating intelligent methods for joint information and preservation management. In this paper, we present selected results of the ForgetIT project with a special focus on the concept of managed forgetting in digital memories and on personal preservation.

1 Introduction

The fast growing amount of personal content such as photos, social media posts, and emails, created, collected and shared today, raise the question on what should happen with this content in the long run. With the decrease of storage prices and the availability of cloud storage services, storage itself is not the core problem, here. However, we face two major risks for long-term information management in the personal setting: Accidental "Digital forgetting", e.g., by hard-disk crashes and technology obsoleteness creates random information loss. Furthermore, the mere size of, for example, accumulated personal photo collections creates the risk of practically creating personal "dark archives", which are rarely revisited again. Therefore, alternatives are required to the dominating *keep-it-all* approach, which make digital memories and archives, especially personal ones, manageable, durable, and enjoyable, again.

While preservation technologies are meanwhile well-established in memory institutions, adequate approaches and best practices for preservation in the personal setting are still in their infancy. In this paper we present results of the European project ForgetIT, which investigates intelligent preservation solutions for personal and organizational settings. Work in the project leverages methods learned from the human brain such as forgetting and reconstruction of memories, for developing a forgetful approach to preservation, which bridges the gap between information and preservation management, creates immediate benefit, supports the user in what to select for preservation, and eases interpretation, when revisiting archived content (*contextualized remembering*). In more detail, we present the reference model and the architecture developed in the project, as well as our approach for managed forgetting. We conclude with our vision of a joint model of forgetful human and digital memory.

2 ForgetIT: A Forgetful Approach

A major roadblock for a wider adoption of preservation solutions in personal and organizational settings is the gap between the preservation system responsible for the long-term information management and the "Active System", i.e., the system, where information, which is in active use, is managed. This can for example be a content management system or a solution used for personal information management.

Therefore, the goal of the approach followed in the ForgetIT project is to better bridge between such an Active System and the Preservation System. This is done by creating a mediating middle layer for reducing the gap between those systems as well as by creating immediate benefit from the adoption of a joint information and preservation management system.

Core contributions for this approach, which have been developed in the ForgetIT project are the *Preserve-or-Forget (PoF) Reference Model* and the *PoF Architecture* described below. The purpose of the reference model is to serve as a basis for further discussion of the forgetful approach and as a starting point for realizing joint information and preservation management systems that follow a forgetful approach. The PoF architecture underlies the implementation of the forgetful approach in the ForgetIT project and is used both to guide and validate the reference model in an iterative approach.

2.1 The PoF Reference Model

The design of the reference model is driven by five desirable characteristics for such a system[1]: It should be value-driven, forgetful, brain-inspired, integrative, and evolution-aware.

A first version of the reference model, which has been developed in the project, distinguishes three layers. The *Core Layer* introduces the core processes (a) for *Preservation Preparation*, which handles the transition between active system and preservation system and (b) for *Re-activation*, which handles bringing back the content into an active environment in a meaningful way, even if a longer time has passed since content archival. The core layer only includes the core functionality of basic connectivity.

Subsequently, those processes are extended in the second layer, the *Remember and Forget Layer* of the reference model. In more detail, this layer introduces ideas of managed forgetting and contextualized remembering into the Preservation Preparation and the Re-activation processes. This includes information value assessment and managed forgetting functionality, which help to decide, what to preserve as well as functionality for enriching content with context information, such that it can be more easily interpreted, when it is re-activated at a later point in time.

Finally, the third layer, the *Evolution Layer*, introduces three more processes for monitoring and reacting to evolution in the joint information and preservation management system. Those three processes refer to (a) evolution in the active system, especially in its knowledge structuring (*Situation Change processes*), (b) to changes in the practices and technology, i.e., more traditional preservation tasks (*Setting Change Processes*) and (c) to changes in the overall system architecture (*System Change Processes*) such as exchange of the Active System or the Preservation System, respectively.

Along those processes functional entities have been identified, which are required for implementing the respective processes on the three identified layers. The layering structures the reference model and enables different levels of conformity for systems, which implement the reference model.

2.2 The PoF Architecture

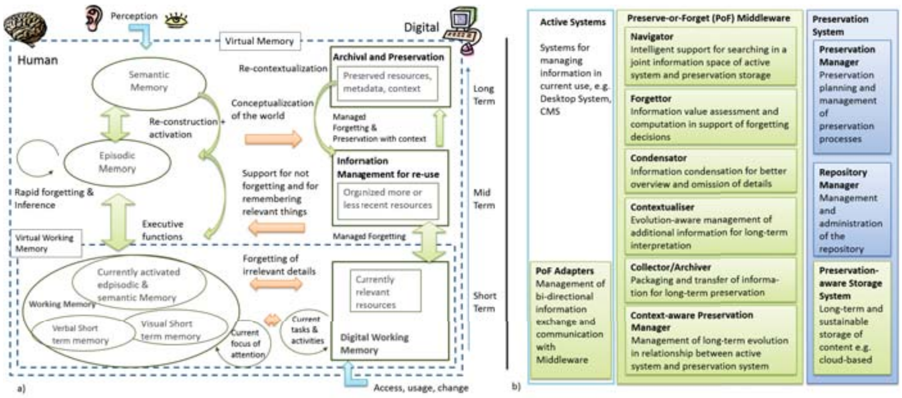

Fig. 1: (a)Joint Model of Human and Digital Memory and (b) PoF Architecture [1]

In the ForgetIT project, an architecture for the PoF Middleware, which connects the Active System and the Preservation System has been developed and implemented. Figure 1 b) shows a high level overview of the architecture. In a nutshell, the PoF Middleware consists of six main components:

- The *Navigator* manages information access in the joint information space composed from the Active System and the Preservation System. In its search functionality, it takes into account information decay and differences of importance of content objects (see managed forgetting).
- The *Forgettor* implements the managed forgetting functions described in section 3. For this purposes it collects evidences from the Active system, e.g., information about usage pattern.
- The *Condensator* supports forgetting actions by providing methods for summarizing and condensation of content objects and content collections.

- The *Contextualizer* adds the required context information to objects to be archived, in order to ensure their long-term interpretation. It also manages context evolution and re-contextualization into the current (typically changed) context, when archived content is brought back into active use. In addition, methods for re-contextualization [2] are developed in the project, i.e., methods for a-posteriori adding more context to older content objects.
- The *Collector/Archiver* is responsible for the bi-directional transfer of resources between the Active System and the Preservation System.
- The *Context-aware Preservation Manager* is a metalevel component, which monitors and manages the interaction between the active system and the preservation system, e.g. the frequency of formats of the resources exchanged.

3 Managed Forgetting

Managed Forgetting is the core ingredient of our forgetful approach [3]. It is inspired by the effectiveness of human forgetting in focusing on the import things, while forgetting irrelevant details. The idea here is to learn from human forgetting and remembering, while not copying it. Rather, it is desirable to complement human forgetting.

In more practical terms managed forgetting is composed from methods for information value assessment and from forgetting actions. Taking into account the goal of creating immediate benefit, we consider short-term as well as long-term information value, both imposing different challenges.

Short-term value, which we call *memory buoyancy*[1], has to quickly adapt to changing needs and interests, taking into account usage pattern, information decay inspired by forgetting functions [4], and spreading of activation via semantic networks [5]. For creating immediate benefit memory buoyancy can, for example, be used to declutter the desktop or for query result re-ranking as forgetting actions.

In contrast, long-term information value, which we call *preservation value*, "reflects the expected value of a resource for the future"[1]. It is used to decide, how much to invest into the preservation of a resource and if it is to be preserved at all. This task is related to appraisal in the archival domain [6, 7].

The prediction of future usefulness of a resource is a challenging task, especially, when thinking about long-term storage. For developing a better understanding of the factors driving long-term preservation decisions, we performed studies and experiments for different types of content in personal information management [8–10, 3].

A special focus has been on photo selection for preservation due to the high importance of photo collections for personal preservation settings. In addition to studies on users' keep or delete decisions [10], we have also developed methods for semi-automatic photo selection based on preservation value computation from a wide variety of factors [8]. We followed a novel approach, which focuses on user

[1] The name memory buoyancy is inspired by the idea that information sinks away from the user with decreasing buoyancy (i.e., importance).

expectation, exploits advanced concept detection and does not expect manual effort by the user for photo annotation. In contrast to many other works in photo selection (e.g. [11, 12]), we, furthermore, unstress the role of coverage as a major selection factor. For the novel task of photo selection for preservation we have achieved a major improvement of selection performance with this approach [8].

4 Vision: Joint model of Human and Digital Forgetting

The concept of complementing human memory has already been discussed above. Going a step beyond, human and digital memory can be modeled as a joint system, as it is shown in Figure 1 a) (from [1]): On the left hand site, core processes of remembering and forgetting in the human memory are depicted (following [13]). Several types of memory are distinguished. The verbal short term memory (things just heard) and the visual short term memory (things just seen) together with the currently activated episodic and semantic memory form the human working memory, i.e., the memory used for current activities and tasks. Knowledge is activated on demand from the semantic and episodic memory according to current needs via the so-called executive functions. This activation is - amongst other factors - triggered by human perception. However, perceived signals are first interpreted using things already known (for making sense out of them), before they become part of the verbal or visual short term memory. The other types of memory episodic memory and semantic memory are responsible for different aspects of mid- and long-term-memory.

In the digital memory (right-hand site) we also distinguish working memory, i.e., digital content, which is important for current tasks and interests from *Information Management for Re-use*, which targets information management for a mid-term time perspective. Similar to the executive function in the human brain, we foresee managed forgetting functions for the transition between working memory and mid-term memory. Such functions might, for example, decide, which information to keep on your mobile device and which information to put on a server or in a cloud storage system. As discussed above, managed forgetting functions are also used for controlling the transfer of information into long-term storage (*Archival and Preservation*), together with functions for enriching the content with context information.

In an envisioned joint model, both types of memory together form a type of virtual memory. In this context, the interactions between the two types of memory have to be considered as well. A first set of interactions are already shown in the figure such as the human conceptualization of the world reflected in information structuring and the digital memory supporting the human in not forgetting important things.

However, this joint model still requires further investigation, since it is expected that there is also a strong mutual influence between the two types of memory. For example, the digital memory system available will influence the type of information, which is memorized by the human, as it can be observed with the end of memorizing phone numbers triggered by the introduction of more intelligent phones.

In the optimal case, these mutual and evolving influences should be incorporated in the joint model and in the design of adaptive memory systems, which ideally support and foster the human brain on concentrating on the really important things that cannot be taken over by a digital system.

References

1. Niederée, C., Kanhabua, N., Gallo, F., Logie, R.H.: Forgetful digital memory: Towards brain-inspired long-term data and information management. SIGMOD Rec. **44**(2) (August 2015) 41–46
2. Tran, N.K., Ceroni, A., Kanhabua, N., Niederée, C.: Back to the past: Supporting interpretations of forgotten stories by time-aware re-contextualization. In: Proceedings of International Conference on Web Search and Data Mining. WSDM '15 (2015)
3. Kanhabua, N., Niederée, C., Siberski, W.: Towards concise preservation by managed forgetting: Research issues and case study. In: Proceedings of the 10th International Conference on Preservation of Digital Objects. iPres '2013 (2013)
4. Ebbinghaus, H.: Über das gedächtnis: untersuchungen zur experimentellen psychologie. Duncker & Humblot (1885)
5. Anderson, J.R.: A spreading activation theory of memory. Journal of Verbal Learning and Verbal Behavior **22**(3) (June 1983) 261–295
6. Cook, T.: Macroappraisal in theory and practice: Origins, characteristics, and implementation in canada, 19502000. Archival Science **5**(2-4) (2005) 101–161
7. Schellenberg, T.R.: The appraisal of modern records. Bulletins of the National Archives **8** (1956) 46 pages
8. Ceroni, A., Solachidis, V., Niederée, C., Papadopoulou, O., Kanhabua, N., Mezaris, V.: To keep or not to keep: An expectation–oriented photo selection method for personal photo collections. In: Proceedings of International Conference on Multimedia Retrieval. ICMR '15 (2015)
9. Djafari Naini, K., Kawase, R., Kanhabua, N., Niederée, C.: Characterizing high-impact features for content retention in social web applications. In: Proceedings of International Conference on World Wide Web. WWW Companion '14 (2014)
10. Wolters, M.K., Niven, E., Logie, R.H.: The art of deleting snapshots. In: Proceedings of the extended abstracts of the 32nd annual ACM conference on Human factors in computing systems - CHI EA '14, New York, New York, USA, ACM Press (April 2014) 2521–2526
11. Walber, T.C., Scherp, A., Staab, S.: Smart photo selection: Interpret gaze as personal interest. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. CHI '14, New York, NY, USA, ACM (2014) 2065–2074
12. Rabbath, M., Sandhaus, P., Boll, S.: Automatic creation of photo books from stories in social media. ACM Trans. Multimedia Comput. Commun. Appl. **7S**(1) (November 2011) 27:1–27:18
13. Logie., R.: The functional organisation and the capacity limits of working memory. Current Directions in Psychological Science **20**(4) (2011) 240–245