Towards a Simple Textual Trace Based Personal Exo-Memory

Pierre Deransart

Inria Rocquencourt, BP 105, 78153 Le Chesnay Cedex, France
Pierre.Deransart@inria.fr

Abstract. This paper presents an experimentation with a continuously updated textual exo-memory used to assist the natural memory of a subject. It shows how trace theory could be used to improve the device. Main characteristics of such a memory aid are maintenance by the subject, limited size, plasticity, and persistence of the recall quality in the long term.

1 Introduction

This paper is an attempt to define a digital artifact capable of serving as an personal exo-memory[1], with the aim to strengthen the biological memory. It does not attempt to address proved memory deficits nor to treat diseases associated with aging, although this study could help to design adapted artifacts. On the contrary, it is assumed that the user has no brain deficit, and that he wants to improve his practical skills of life. This requires having access at any time to some detailed information (of a person, a visited venue, a past event, a current affair, a personal curiosity ...), which may help to recall facts from biological memory.

A simple example is a current telephone alphabetically organized notebook (paper or digital), the names of which are associated with information such as phone number, address, and other details. Another common support is a notebook for working notes or of personal diary which includes series of paragraphs describing daily events. If the support of the book is physical such as paper, the difficulty of retrieving information increases in relation with the total size. In practice therefore, finding a phone number in such a book can become impossible or very cumbersome if the name of the person to call has been forgotten. A notebook may become useless because very related events may become widely separated in the medium (for example reports from periodic meetings on a given topic) and recall of some decision may become virtually impossible.

[1] or external memory. This artifact falls into the category HDM (Human Digital Memories) and has links with the areas PIA (Personal Information Archive), or PIM (Personal Information Management).

Today there is a huge number of digital media offering not only the basic functions mentioned above, but also a great variety of services such as collective or shared calendar, handwritten computer aided notes which are immediately stored. Moreover, the exponential growth of digital storage media, beyond the simple Moore's law[2] suggests that almost all events of life can be stored on a single hard drive. In [2] the authors estimate that around 16GB per year are sufficient to store all elements of the daily life of a person (including all elements of life context, emails, sounds, images, videos and music). This offers today the possibility to keep on a digital medium a very detailed trace of all activities and social interactions performed during the whole life of a single individual. Even if the speedup of the means of communication and exchange suggests that these volumes can be underestimated, it is now possible to consider retaining all its "memories" on a single private digital medium, with outstanding opportunities to navigate in this ocean of memories.

It must first be noted that outsourcing one's own memory in order to assist it or just to keep it, takes up a large amount of human activity. Writing notes, categorizing them, using a calendar, building a personal library or documentation, organizing its environment, all contribute in achieving such a goal. Elderly people live in an environment full of objects "memory"[3] which contribute to their quality of life, i.e. helping them to preserve some of their memory. If the idea of auxiliary memory may be extended to include large social systems, this study is restricted to what is usually called "personal memory", closer to a sophisticated booknote aimed at accompanying the person at every moment of his/her life.

This article includes four main sections. In the first (Section 2) we characterize what we mean by exo-memory. The second (Section 3) describes an experiment with an exo-memory represented by a text file handled with a text editor. The third (Section 4) gives some possible theoretical foundations using the notion of trace, and the last one (Section 5) discusses some features that are essential to this type of exo-memory and some limitations. A full version can be found on archive [4].

2 Personal Exo-memory

In this section we identify the essential characteristics of what we call here exo-memory.

In 1945 Vannevar Bush wrote an article entitled "As We May Think" in which he laid the foundation of Memex [5]: "a device in which an individual can

[2] A version of the law known as "Moore's law" states that computer processing power has doubled every two years since 1969. This exponential growth is three to four times higher for digital storage media [1].

[3] Collection of objects likely with a strong emotional charge which correspond to meaningful life facts and help to recall them. This is very well described in the romance of D.Coulin [3].

store all his books, music and other elements of communication, and mechanized so that it can be accessed very quickly in a flexible manner."

Today this article looks still prophetic. A feeling still prevails that the WWW gives almost unlimited access to a kind of universal memory, which contains all the old and uptodate knowledge. The development of services and in particular the possibility to access all distributed information around the world gives the feeling that it is enough just to store links to automatically supply our knowledge, giving us a sort of magnified brain.

This view is entirely correct if we see memory merely as a storage of knowledge with the ability to retrieve them quickly. Today we understand that human memory cannot be seen as an access mechanism to information continuously accumulated without any limit. Despite its rich combinatorics, no human brain would have a sufficient storage capacity. Memory has very specific functions such as capacity of short or long term storage, abstraction, recall and, last but not least, forgetting.

Without going into the details of the involved biological processes, it is useful to assess the fundamental properties of human memory to be able to characterize exo-memory.

As summarized by G. Chapouthier [6], we can characterize human memory with three axes: sensory, temporal and abstract. The *sensory axis* includes all sensations that are tactile, auditory, visual, olfactory, etc. The *temporal axis* refers to the persistence of memory: short persistent is the working memory (at most a few minutes), also known as episodic or transient memory. More sustainable (from a few hours to several years) is the reference memory. It corresponds to the stable knowledges. Finally on the *abstract axis* are the procedural or implicit memory (acquired habits) and the explicit or declarative memory (the meanings). In the first, recall is spontaneous and immediate (for example the highly exercized sport gesture, but whose execution is made thanks to fast neural circuits), while in the second a longer reflexion is needed. This one requires the use of some form of reasoning.

So broadly categorized, each type of memory has its own mode of use or recall. For example for the implicit memory the recall is unconscious and mechanical, whereas for the explicit memory, the recall is conscious and may require application of rules. These mechanisms of recall, more or less quick, are associated with a phenomenon of forgetfulness that operates a selection in both directions on what needs to be "recorded" or not, and what needs to be recalled or not taken into account.

Here our goal is not to try to build a model of the biological memory as described above, but mainly to search for forms of mechanical extension, which could strengthen it. One way to address this issue is to retain from the biological memory the parts which can be outsourced, and possibly processed numerically.

We will therefore focus on the forms of memory corresponding to: digitized information (sensory axis), persistent (temporal axis), and conscious (abstraction axis).

There are two additional key features of an exo-memory as we see it.

- Private vs. Public: an exo-memory is a private artifact. Its isolation from the outside world and its access restricted to one subject are the key assets for the exo-memory to work. This memory is indeed useful only if the subject can enter whatever he wants with a complete feeling of liberty and security; for example storing his most secret codes.

  This aspect of the exo-memory imposes some experimental limitations. This is clearly shown in [7] where it is noticed that experimentations must take into consideration legal and social aspects. Moreover, the inviolability of the support must be ensured. In the current state of technology, this is not possible[4]. One way to approach this, in particular, is to limit the exo-memory size to a small file that can be encrypted on a personal computer (or a similar artifact).

- Automatically vs. Human managed: The exo-memory cannot be limited to accumulating data obtained from all kinds of sensors attached to the subject. Initially, it can only be controlled by the subject. Only the subject can select the events he considers appropriate, introduce them and annotate them in such a way that he will be able to retrieve them even in case he has forgotten them completely. Such a task cannot be accomplished -at least on an insufficiently full exo-memory-, by an automaton, since only the subject can perform the event choices on the fly using his biological memory. Perhaps this would no longer be possible within seconds or minutes later.

3 Experimentation

We report here some experiments with an exo-memory whose management is done through a text file, used and maintained for several years using only "emacs" as text editor, the use of its function "search" as a recall function, and a single subject (the author of this paper). The description is somewhat simplified, but reflects the essential structure of the artifact and the behavior of the subject.

The basic information unit is a line (of any length), called *m-line*, *m* for "memo". M-lines can be added one after the other or placed in the middle of others; a m-line can simply be amended. The principle is that a m-line has a single main topic. A m-line consists of strings of words or symbols separated by a comma or a separator of any kind. The m-lines are separated from each other by simply starting at the beginning of a line without any spacing. Each m-line is supposed to reflect or stimulate a memory fact useful or important for some reason.

The text is written without special formatting and all kinds of information can be inserted. If we wish to introduce information that is not textual (image,

[4] This point deserves a further development, but it is not treated here.

sound, long document in a different coding), one introduces only the metadata (see below) and some pointer on the location of the document (personal computer space, physical domestic space or WWW pages). The search function of the text editor serves also as search engine. At any moment one can do a search to verify consistencies between different m-lines. It is important to note that the search engine is not used to retrieve an exact information, but to find some memory facts. Hence we call it "recall engine".

The complete file is called *m-book* (for *memo-book*). Several precautions must be taken however so that the engine can operate efficiently: normalization in writing, insertion of metadata and file organization.

- **Normalization in Writing**. To be recalled without difficulty, some parts of the text should be written without misspelling[5]. Family names must be correctly written, telephone numbers must have the same shape, in short, the respect of some text norms is necessary. This standardization effort is required at least for some words which will play the role of keywords. For example it must be possible to perform a reverse lookup on a phone number. These "standards" however, may remain personal. The only reason for such standardization is to allow the subject to conduct a reverse search. He must use the standards that he knows precisely or is able to memorize on the long term (using his most stable habits).
- **Insertion of Metadata**. A metadata is a piece of text which will help to recall a m-line. A wide discretion is left to the form of metadata that can even be formulated in an incomprehensible or unstructured language. This data can be put anywhere in a m-line and is generally redundant. For example, to recall the name of a person one can seek it with the first name first or with the family name. One cannot usually predict what will come first to mind, especially if one has been without any relationship with this person for many years. If a m-line deals with `Pierre Deransart` one can set a metadata as `Pierre Deransart pierre` or `deransart pierre Deransart`.
  More generally, one can put in the metadata context information that can help to find the memory fact by using other information. For example, one can enter:
  ```
  Pierre Deransart beardless pierre clear eyes
  sport pierre sport Logic Programming ICLP
   Deransart lp ....
  ```
  The principle is to put several peculiarities, trying to imagine with which words `pierre` could be retrieved after several years, after having forgotten all about him.
- **File Organization: Building m-Paragraphs and m-Pages**. As the size of a m-line increases it becomes more difficult in practice to read the information it contains. It can then be better to split it into several m-lines. For example, after a few years, one has accumulated several types of information

[5] At least with a spelling that is consistent for the subject. With a modern recall engine including some grammatical treatments, such a requirement could be avoided.

about a person such as location(s), contact means (email, phone, fax, ...), family composition evolution, meetings of interest (cultural events, debates ...), jobs, adventures, pictures, publications,..., which it was felt that could be useful to keep the memory without creating any particular medium of archiving. A better readability can be thus obtained by splitting the existing m-line into several m-lines with a better thematic homogeneity. These m-lines are separated by "new-line" characters. This new set of m-line without spacing is called a *m-paragraph* and is devoted to a particular topic. A m-paragraph may change over time, resulting in enrichment of size and numbers of m-lines. From time to time, if the topic is growing, new paragraphs or new m-lines can be created by extension or by splitting.

Here is a non compromising and relatively understandable example of a short paragraph with m-lines and metadata about the management of a coffee machine in the research team on "constraints" at INRIA where the subject is working.

```
CAFE inria cafe machine cafe inria cafe depannage cafe
contraintes cafe projet cafe commande cafe
-Societe D8, 7-8 rue Leon Geffroy, 94408 Vitry Cedex
-Client 30700
-commande: 01 47 18 38 40, par 200 pour 70 euros, 3 cat:
fort (brun), moyen (vert) et faible
-depannage: 01 47 18 38 30  7h30-17h  (9h samedi)
-matricule appareil: 034726
-commande 9/4/10: 35 euros (cafe 100 doses, gobelets, spatules
et sucres, sinon 32 euros) livraison a l'occasion (a partir du
lundi 12)
```

The first m-line sets the main topic. The spelling is simplified following subject rules (lack of accents); the m-lines are very short and relate some data concerning the machine, incidents or orders. The metadata of the first m-line was introduced to improve previous painful researches of the m-paragraph and correspond to different possible combinations of main topic and contexts: "coffee inria" (workplace) or "coffee constraints" (project team) or "coffee project" or "coffee order".

Since there is no growth strategy of the exo-memory, several m-paragraphs on similar topics may have been created. It is then possible to group them in order to facilitate the understanding of the general topic. Here the physical medium is reaching its limits as it is used, because of course many combinations are possible and this support is not intended to allow all sorts of groupings. This point will be discussed later. This grouping is purely casual, but it can also be obtained by adding metadata to identify a new set of m-paragraphs and to allow to scroll through the m-paragraphs corresponding to this new topic. Such a grouping is called *m-page* and there are likely several kinds of possible m-pages. The final decision is left to the subject whether to create a new m-page, or rearrange m-pages.

– **Treatment of obsolete data**. Some data may become obsolete (e.g. change of address of a friend), some are just uncertain (name misheard over the phone or age of a person not known with certainty). Since the data are not formally transformed, but just selected by the subject when trying to recall them, the single symbol "?" is used for uncertainty, and "%" for obsolete data. The prefix operator "%" applies to the entire sentence. The prefix or suffix operator "?" applies to a word.
The obsolete data remain stored and sometimes moved at the end of a m-paragraph for better readability. It may be interesting to keep them. A question still concerns the complete erasure of data (for example in case of change of an URL). Such a deletion is rare, because keeping an obsolete data does not disturbing in general neither recall nor readability.

Evolution of the m-book therefore develops the following (non exhaustive) action types. For the m-lines: creation (*create_m-line*), insertion of data or metadata (*insert_m-line_content*), linguistic corrections, marking dead data (*dead_content*) or uncertain (*uncertain_content*); for m-paragraphs: creation, split or combination of m-lines (*create_m-paragraph*), fusion (*fusion_m-paragraph*) or split (*split_m-paragraph*) of m-paragraphs; for the m-pages: creation by grouping of m-paragraphs (*create_m-page*) or by adding metadata in the m-paragraphs which compose it, grouping of m-pages (*fusion_m-page*).

Note that we could increase the number of higher level structures indefinitely (m-chapters, ... etc.). The exo-memory, as implemented here, makes it difficult to go beyond two levels and this is unsatisfactory since the creation of a m-page may disrupt another one. In practice the multiplication of levels is not really useful, because it would amount to impose an overall structure on the m-book. Moreover there is no certainty that this structure retains the same consistency over time since the subject evolves and his memory as well. Allowing different possible m-paginations would be useful.

We have tested for 6 years this approach with a private text file which reveals to be an exo-memory in practice very useful, fast, efficient and overall persistent in the sense that the recall engine does not speed down over the time. The strategy that avoids this degradation and, on the contrary, that continually improves the effectiveness of the recall (at least for frequently consulted facts), consists in consistently extending metadata, each time a m-line or a m-paragraph is not immediately recalled, with a few keywords or a single expression. Such new metadata cannot be automatically inferred since the words or phrases that one would like to add (as a form of mnemonic shorthand) are terms that come out from the subject's memory and are often unpredictable.

Through continuous use, the growth of m-book has been around 200 KB per year. This growth is linear and not exponential, since the introduction of new information is made exclusively manually, in such a way that the size of the inputs remains proportional to the average time needed to introduce them. The size is also limited by the fact that, even if it is possible to introduce portions of

text using copy and paste, generally only pointers or references are introduced in case of voluminous data. It is essential for the m-lines to be as short as possible in a m-paragraph. This shows that during a whole life the size of the m-book (of the order of several tens of MB) cannot be a real obstacle to the efficiency of many possible applications and services, particularly of the recall engine.

The growth speed would be different if the m-book was built automatically, for example from a personal ontology reflecting potential personal interests. This would only reflect the exponential growth of global knowledge, but corresponds to a different problem. It would still be necessary to make a data selection in order to retain only the information sufficiently reliable and significant from the subject point of view. This can only be achieved by the subject.

Along the years, m-paragraphs and m-pages are created, completed and reorganized. The ones which are more frequently used are easily recalled. Interestingly but not surprisingly there is constant need of completion of metadata. However as long as these most frequently used m-pages are consulted, recalling them is easier. For m-paragraphs or m-pages which are not consulted at all after built, the recall may be costly, but rarely fails. It may be observed that m-pages evolve as current interests of the subject are evolving too.

4 Modeling with Traces

We briefly present a possible theoretical approach based on the notion of trace as presented in [8–10] and inspired by software engineering.

The main idea is that the m-book as described above is one of the several possible representations of the state of a system (the "memory") which results from a serie of events called *trace*. This trace can be formalized by a so called *actual trace*[6]. The state of the memory at a given time, whose m-book is a visual possible presentation, is said *virtual state* of the memory. At time zero, the *initial* virtual state, as the memory, are assumed to be empty. The *current* virtual state (beyond the initial state) can be fully known using the actual trace only.

The semantics associated with such a trace is a semantic of reconstruction or *interpretive semantics* (IS) that allows to reconstruct a current virtual state from the actual trace. The IS is given here with the trace. It allows to interpret the actual trace[7] by representing it in the form of a m-book. It is important to distinguish the interpretation of the trace as an abstract data structure (parts of text ordered by a system of pointers) and the various representations it may have. Here we limit ourselves to a two-dimensional representation in the form of m-book, but one could imagine applications that perform more sophisticated representations including several possible dimensions and offering the possibility of several m-paginations.

[6] Contiguous integral actual trace in [8].
[7] For this reason, it is called *interpretive semantics* in [8].

In this approach one can consider that any m-line, any m-paragraph or m-page, ..., is a sub-trace. The m-book can thus be seen as a trace base system in the sense of J.-C. Marty and A. Mille [11, 12] whose the actual trace described here forms a *primary trace* ("trace première"). This opens for using learning methods in a theoretical well founded framework to design tools helping the subject to use his exo-memory to assist him in discovering new knowledge based on his own experience.

5 Discussion

We discuss this model of exo-memory and compare it with works on biological memory, knowledge engineering and existing note organizer softwares.

In a neuro-biological approach G. Edelman and G. Tononi [13] pointed out that memory is essentially non-representational[8] and that the brain is actually filled with hundreds or even thousands of memory centers in constant interactions. Our exo-memory enables us to maintain in a persistent way pieces of memory, allowing to construct and to maintain all kinds of personal semantic networks. But it has some limitations. On what we have called the sensory axis the introduction of a new information may be related to several sensations. These may correspond to the context of an event which may contribute to its recall, but will not be stored in the exo-memory because this would take too much time or because this kind on influence is unconscious. For example, in the experiments of [2], the influence of the color of a document or the weather at the time of recording a fact are stored. Such information is rarely noted with our type of textual exo-memory, mainly because, at the moment of writing it, such factors are unconscious.

Somehow the exo-memory focuses on the abstraction axis, hence handling conscious acts and relations only. It is likely that the act of introducing some information in the exo-memory helps by itself to its memorization and contributes also probably in the unconscious part of it. But it also has a constraining aspect which may contribute to restrict the proper act of storing memories.

In the field of medical assistance to patients with recognized memory deficits [14], the introduction of memory facts, .i.e the selection of relevant facts, is done with the help of staff carer or a relative. The problem, as the results one can expect, are essentially different.

Researches in knowledge engineering are better oriented towards social memory, i.e. the storage and sharing of knowledge within groups of people as diverse as family, business, social network or even the entire humanity in the globalization context. So in the Handbook of Research on Emerging Rule-Based Languages and Technologies [15] most of the related works concerns the automatic construction of ontologies for the management of archives in various social contexts.

[8] This means in particular that we do not memorize all details of a scene, but only a few elements used to partially reconstruct it according to specific needs.

These approaches frequently include semantic network or memory, as introduced by Quillian in 1968 [16]. It is important to observe that some network can be built from the virtual memory represented in the physical medium. It could serve as a basis for several applications that facilitate access to and management of the exo-memory. But in order to preserve the plasticity of the exo-memory, such network should be built and used only gradually, and especially cannot be imposed a priori.

The case of software designed to manage notes, if not all carriers of the subject's activities, as EverNote, DevonThink, CintaNotes, SOHO Notes 8 Yojimbo, ShoveBox or wikidPad, among others, correspond to an intermediate situation where the aim is to facilitate the organization not only of a few notes related to the subject's life, but to some extent of all documents to be manipulated. These programs usually require a structure that, at some stage of development, may become constraining. We can not here discuss each system, but our approach has a serious advantage: the simplicity of the needed software to run it. Indeed many proposed systems are extremely sophisticated and te user may become dependent on some supplier. By using a system whose functions can be reduced to a "single" text processing, the subject can be pretty sure that he/she may use his exo-memory on the long term.

In our approach, personal information storing on digital media actually has two parts: exo-memory and personal archives (the collection of all documents stored by the subject). The exo-memory, reduced to a single file, can act as a gateway to help to find archived documents, playing the role of the thesaurus of an encyclopedia. On one hand the exo-memory must have an exclusively private status (private property and exclusive access by the subject) and its way of handling reduces its growth; on the other hand, the status of the archives is necessarily different because of their mode of growth that can be shared, automated and exponential. Thus its private status and relatively self-sufficient semantics may not be guaranteed at all. Thus we see that there are two distinct areas of research and the respective related works, while retaining some common topics, are of different nature.

6 Conclusion

We have shown how a consciously written trace including as many spontaneously selected or thought about life facts as possible, that are tirelessly recorded and organized by its subject, could be an exo-memory. We have shown how a very coarsely structured text file that is manipulated using a text editor, could constitute a useful approximation, taking into account some plasticity aspects of the neuronal memory. Finally, relying on the observation that the sequence of updates is a primary trace, we found that this approach allows the development of utilities liable to improve the performance of the exo-memory thanks to interfaces that make it easier to use. Many improvements are indeed becoming possible, based on combining existing tools, in particular, in the fields of

databases, data mining, abstract interpretation and information retrieval. Such applications are partly included in the note organizer softwares we have quoted.

The originality of this approach lies in the essential characteristics of this form of exo-memory: simplicity and efficiency, mnemonic and creative functionalities, and feeling of satisfaction. This last point is particularly important. To the extent where the subject very often feels that he recovers " memory" thanks to this tool, or at least he does not lose it, its usage induces a positive reinforcement to use it even more. Provided that this feeling is not counterbalanced by the difficulty to use the tool, the lost time to enter data is clearly outweighed by the time saved in recalling them.

The first point (simplicity and efficiency) is also essential for use by a non-specialist of keyboard, mouse and a text editor, but it is also a guarantee of independence and long term availability of the exo-memory. The accessibility is probably a major technical difficulty to overcome. However other input methods such as audio input or handwriting could be adapted to facilitate exo-memory management. With regard to the mnemonic and creative features, they are guaranteed by the voluntary act of choice of the relevant events which accompanies and enhances the activity of the biological memory of the subject. The memorized events are not selected by an automated process, but chosen and adapted by the subject who is himself changing all the time.

Finally, we insisted that exo-memory must remain completely private and that only information chosen by the owner may be communicated outside (it is indeed the case of the biological memory). An exo-memory has no other social function than to provide assistance to its owner.

The approach presented here is more like a working tool on oneself [17], notepad or personal hypomnema. If it is true, as asserted by Michel Serres [18], that the new technological means generate forms of neo-Darwinism[9], such new facilities should also help in fostering a work on oneself, always intimate and essential, while benefiting from technological advances.

Aknowledgments

I thank the referees for their interesting and inspiring remarks.

References

1. Delahaye, J.P.: Complexités. Aux limites des mathématiques et de l'informatique. Belin - pour la science (2006)
2. Fuller, M., Kelly, L., Jones, G.J.F.: Applying contextual memory cues for retrieval from personal information archives. In: PIM 2008 - Proceedings of Personal Information Management, Workshop at CHI. (2008)

[9] Basically, the idea is that modern storage capacities of Information obviate the need to concentrate efforts on pure human cerebral memorization, and can thus allow to release new functionalities of the brain.

3. Coulin, D.: Les traces. Editions Bernard Grasset, Paris (2004)
4. Deransart, P.: Towards a Simple Textual Trace Based Personal Exo-Memory. Technical report, Inria Paris-Rocquencourt (septembre 2010) `http://hal.inria.fr/`.
5. Bush, V.: As we May Think. The Atlantic Monthly (July 1945) The electronic version was prepared by Denys Duchier, April 1994, `http://ccat.sas.upenn.edu/~jod/texts/vannevar.bush.html`.
6. Chapouthier, G.: Biologie de la mémoire. Odile Jacob (February 2006)
7. Vemuri, S., Bender, W.: Next-generation personal memory aids. BT Technology Journal **22**(4) (October 2004)
8. Deransart, P.: Conception de Trace et Applications (vers une méta-théorie des traces). Technical report, Inria Paris-Rocquencourt (march 2009) Working document `http://hal.inria.fr/`.
9. Langevine, L., Deransart, P., Ducassé, M.: A generic trace schema for the portability of cp(fd) debugging tools. In Apt, K., Fages, F., Rossi, F., Szeredi, P., Vancza, J., eds.: Recent Advances in Constraints. Number 3010 in LNAI. Springer Verlag (May 2004)
10. Deransart, P., Ducassé, M., Ferrand, G.: Observational semantics of the resolution box model. In Vanhoof, W., Hill, P., eds.: Proceedings of the 17th Workshop on Logic-based Methods in Programming Environments (WLPE'07), a post-conference workshop of ICLP'07, Porto, Portugal (September 2007) `à paraître dans le Computing Research Repository (CoRR)`.
11. Marty, J.C., Mille, A.: Analyse de traces et personnalisation des environnements informatiques pour l'apprentissage humain. Hermès, Lavoisier (2009)
12. Mille, A.: From case-based reasoning to trace-based reasoning. Annual Reviews in Control **2**(30) (2006) 223–232
13. Edelman, G.M., Tononi, G.: A universe of Consciousness. How Matter becomes Imagination. Basic Books (2000) French translation: "Comment la matière devient conscience", Odile Jacob, 2000.
14. Matthiew, L.L., Dey, A.K.: Lifelogging memory appliance for people with episodic memory impairment. In: Proccedings of UbiComp'08, Seoul, Korea, ACM (September 2008)
15. Giurca, A., Gasevic, D., Taveter, K.: Handbook of Research on Emerging Rule-Based Languages and Technologies, Open Solutions and Approaches. Information Science Reference (2009)
16. Collins, A.M., Quillian, M.R.: Retrieval time from semantic memory. Journal of Verbal Learning and Verbal Behavior **8**(2) (1969) 240–248
17. Foucault, M.: L'écriture de soi. Dits et écrits **4**(329) (1984) 415–431 1980-1988, 912 pages, 140 x 225 mm. Collection Bibliothèque des Sciences humaines, ISBN 2070739899.
18. Serres, M.: Les nouvelles technologies, que nous apportent-elles? Interstice (2006) Michel Serres's conference recorded at "Ecole Polytechnique", decembre 1rst, 2005.