Can digital libraries generate knowledge?

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Abstract: *»Können Digitale Bibliotheken Wissen vermitteln?«*. This paper argues that the information processing paradigm which is still fundamental to digital library engineering is not adequate for the way in which information and informational objects – as stored in Digital Library systems – should be treated. The recent move within information science towards emancipation from the Shannon/Weaver information theory concept provides some indications of how Digital Libraries could be conceptualised in a way that has not yet been implemented in standardised formal frameworks such as the DELOS or the 5S-Framework. A deeper understanding of information processes beyond the concepts and usage of such systems could help to make better use of the enormous potential and resources in the field of Digital Library engineering. Resulting effects could be the way in which knowledge transfer and acquisition processes are supported by adequate interfaces and, subsequently, by new ways of embedding collections in communities of information practice, such as research teams or learning groups.

Keywords: digital library, document, embedded cognition, information science, library management, DELOS, 5S-Framework.

Starting Point

In his review article on the current state of Digital Library research in ARIST 2007, David Bearman summarises the use of Digital Libraries by stating (p. 250): "we could even ask whether use of a Digital Library actually increases knowledge". Indeed, this leads us to fundamentally question the usefulness of generations of research and engineering in this domain.

As a scholar of French literary history – a domain in which I earned my PhD 20 years ago – I welcome the coming age of eHumanities. I remember the first time that I was finally able to use the Encyclopédie online in the Galica Digital Library, and how I wished I could have had access to it when I was doing my research on censorship in the Enlightenment.

Having since become a LIS scholar, I deplore the development taken by the cyberinfrastructure over the last 20 years. After a tremendous start in the 1970s when the first databases were developed, it has become more of a technological information industry than a user-welcoming knowledge base. I hope to be able

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to explain this point of view in the following. Let me begin by first discussing the concept of a Digital Library, even though this question has been dealt with many times in the field of Digital Library research.

We should ask ourselves several questions: What is a Digital Library compared to libraries as we have known them for several hundred, if not thousands, of years. It is apparently not just books that are stored in digital libraries, so what exactly do they contain? And more importantly, what is the purpose of these digitisation endeavours worldwide? Who could be the users of such global systems? How could usage be optimised? If we understand Digital Libraries as information systems, how could information that is stored and transferred from a Digital Library become knowledge?

Definitions

When talking about the Digital Library, we should therefore start by defining the library on a more general basis.

Walther Umstätter (2011, 11), a well-known German library science scholar, defines a library as follows:

Def. 1: A library is an agency which collects published information, arranges it and makes it available under archival, economic, and synoptic aspects.

The traditional understanding of a library as an agency takes the form of an organism in three parts: a storage area, a usage/user area and an administrative area. Following Umstätter, the digital version of a library becomes four-tiered because in its reference function it not only catalogues items but gives direct access to information objects in digital form and mostly via remote access. Therefore, the fourth part of the Digital Library is the digital world outside of it (Umstätter 2011, 15-8).

Whereas the main definition of a library (Def. 1) seems quite satisfactory, Umstätter's reflections on the Digital Library leave us dissatisfied. A digital library is not just a library outside of its own walls, as the difference between a traditional storage place and an electronic, remote one is not only functional. It remains a facility for remote resource storage which requires an instrument in order to be used, even though access is immediate. Only the possibility of accessing the library from the outside might be a new structural definition for a traditional library offering such a new form of user area. The main elements in the definition of a library are also valid for a Digital Library:

It is or belongs to an agency for administration, keeping it alive by applying a special business ("economic") model to it. It arranges its objects perhaps not always in the same synoptic way as a physical library where you can browse the stacks visually, but most systems use visual metaphors or forms of presentation in order to make the material available. And finally the discussion about digital preservation shows the archival interest of most Digital Libraries.

The main difference as we enter the digital era seems to lie in the changing character and functionality of the resource itself. The definition mentions the publication aspect in order to differentiate a library from an archive or an internal business documentation centre. When a resource is collected in a digital library, it is published at the latest in the moment it is integrated into the system, and normally we do not think of closed circle systems when we think of a Digital Library. It may not have been "published information" in the common format of a book or an article, but when incorporated into such a system it becomes both published and "information", even if it is an object which would be found in a museum in the analogue world.

The problem is that the term "information" is so vague that nearly every academic discipline claims it as a key concept or at least a very important ingredient of its theories: from genetics to physics, from philosophy to economics, from linguistics to cybernetics. Use and understanding of this term therefore varies to a large extent. However, looking more closely at the information science understanding of "information" may well be helpful in Digital Library development.

Information and Documents

"Information" technology is such an omnipresent and powerful domain that the fact that it bears this term in its name would indicate a clear understanding of what information is. Digital libraries show how wonderful the information age can be, leaving us to play with vast amounts of "information" – or at least information objects processed by information technology. It might seem astonishing, but from the perspective of an information scientist it is legitimate to question this immediate assumption that IT is all about information.

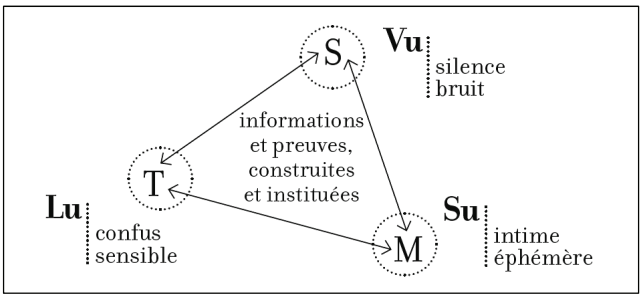
A group of French information scientists publishing under the pseudonym "Roger T. Pédauque" (2006, 2007) recently discussed the development of widespread digitisation under the topic of "re-documentarisation of the world". By this they were pointing to the fact that we are experiencing global movements similar to when documentation was first invented some 150 years ago. Paul Otlet, Melvil Dewey and others developed the idea that a universal knowledge classification system might help us to master the information flood and at the same time might even advance mankind. The concept of the World Wide Web and especially the semantic web is not far removed from this idea. On the other hand, Pédauque brings to mind the old epistemological discussion of what a document is. Early information scientists did not talk about information but about documents and the process of documentation. It is only fairly recently that institutions such as specialised graduate schools, journals or organisations dropped the word "documentation" and sometimes even "library" in order to concentrate on the word "information", like the so-called iSchools which mostly started off as "library schools". A striking example of this quest

for a more legitimising naming of an institution is the "American Society of Information Science and Technology". It began in 1937 as the "American Documentation Institute" (ADI), adopted Information Science (ASIS) in 1968 and only in 2000 added the word "Technology" to its name to become ASIS&T.

New technological possibilities which give rise to the semantic web remind us that what is distributed via networks is not information but objects, even if they are treated "semantically". When these objects play a role in an information process, they become documents which indeed not only transport information but also represent evidence, like the antelope in the zoo which often serves as an example of a non-textual document made famous by Susan Briet (1951).

In this respect digital library resources *are* documents.

Figure 1: The Three Dimensions of the Document: As Sign and Form (S) As Text and Content (T) and As Medium or Relationship (M) (Pédauque 2006)



Pédauque sees digital documents in three dimensions which correspond to the semiotic triangle: they are a sign and they have a form and a digital structure (S) which must be *perceived* (seen, heard: "vu"), thus emerging from chaos (silence, noise). They serve as a "text" or content (T) which can be *read* and understood ("lu"), which helps to surmount "cacophony" (confusion, sensation). And finally they are a communication medium (M) which is *known* ("su") at a certain level of relationship, serving as a function against oblivion (ephemeral, intimate).

This reconceptualisation of the document "reformulated for electronic documents" (Pédauque 2006) sheds light on the resources of Digital Libraries. We recognise the objects that are processed, described and stored in our systems. Taking all three dimensions as being equally important, we also understand a certain bias or perhaps certain underdeveloped aspects.

My impression is that the existing Digital Library frameworks (Candela et al. 2007, Gonçalves et al. 2008) still continue to stick too closely to the "forms and signs" dimension of the document, neglecting understanding ("lu") and social knowledge ("su"). Having said above that a resource in the Digital Library becomes "*published* information" when it is integrated into the system

(and thus perceivable by a user), it now becomes clear that this statement was not far reaching enough. If we accept that the objects we integrate into the Digital Library are documents, we should also acknowledge their role both as a text and as a medium.

Information Science

This argument inevitably touches on the unsolved question of the exact nature of the "stuff" that is dealt with by information science. Is information like data something you just "process" or arrange in a more or less formalised manner, something which you can engineer? Or is it more a question of the philosophical endeavour of describing and "representing" the external world? Is it the key to Karl Popper's (1978) World III of independently existing cultural artefacts? Or is it something which is continually generated due to interaction between agents in some space/time arrangement? In my opinion, we are still dealing in fact with the old information science debate of whether information belongs to the naturalistic or objectivistic domain of the so called "information theory" of Shannon and Weaver (1949) or to a more "culturalistic" one, as coined by the German philosopher Janich (2006). In the light of recent discussions in the library and information science community, looking back in such a fundamental way may well be worthwhile. As Warren Weaver himself stated in his commentary on the seminal treaty (1949, 94f.): Shannon's mathematical theory of communication only tried to formalise the syntactical aspects ("level A ... the technical problem", as he calls it) of the semiotic triangle of information (level B being the meaning: "The semantic problem", level C how it affects conduct: "the effectiveness problem").

At that time, beginning with level A just was a question of convenience. When establishing semiotics, Charles Morris first of all addressed the question of meaning, which is the semantic side of the semiotic process. He then discussed the question of whether a sign has an effect on the interpretant (i.e. pragmatics) and only in the last stage of analysis did he suggest looking at the relations between signs, which is the syntactical side of the triangle. Warren Weaver did not cite Morris directly, but even in his wording and in the structure of his arguments it is clear that he based his discussion of the foundations of information theory on the arguments postulated by Morris but inverted the order (Janich 2006, 43f.). He finally confesses that Shannon's theory is restricted "in the first instance only to problem A" and hopes that the discoveries at level A are so significant that they also apply for level B and C. Unfortunately, this part of his information theory was never elaborated and the majority of subsequent computer and information science research remained at level A.

For a long time the main paradigm for information science was an information retrieval point of view that mainly addressed the question of how many

information units an information system could deliver with what kind of transmission algorithm. The most important keywords in this context are "recall" and "precision": the measures for characterising the success of the mere act of technical information processing. The question of whether the result conveys any meaning (semantics) or even has any effect (pragmatics) on the user of the system was not a research objective at this time, neither in computer science, artificial intelligence engineering nor in information science in general.

This only changed in the 1970s when the question arose as to how the retrieval results could be communicated to normal "end-users", as they were called at that time (Taylor 1968). Eventually, the semantic problem appeared in the engineering of databases. The cognitive approach of the "information seeking and behaviour" paradigm took quite a long time to consolidate, but in 2005 Peter Ingwersen and Kalervo Järvelin were able to state that the "Turn" had been taken. This approach is now mainly concerned with the aspect of meaning and sense-making (Dervin 2003; Kuhlthau 2004; Fisher et al. 2005).

The third aspect of the semiotic triangle only appeared quite recently in the research paradigm of information science: the pragmatic question of whether the semantic representation conveyed by signs and data delivered by the databases and communication networks will have any effect in the real world of users. Interestingly enough, it can be seen together with a general paradigm change in the social sciences, which have experienced a "spatial turn" and discovered "practice" and human (and non-human) "activity" (Lefebvre 1974, Soja 1989, de Certeau 1980, Lave 1989; Schatzki et al. 2001). In information science, concepts from this current academic development have been successfully employed in several distinct fields like the theory and practice of knowledge management (Hobohm 2011), the critical discussion of artificial intelligence (Clark 2011) and new approaches in interface and interaction design (Kaptelinin and Nardi 2006, Heilig 2010, 2011). This has led to the broad reception of sociological concepts and activity theory approaches in information science (Cronin 2008; Leckie et al. 2010; Huizing and Cavanagh 2011; Allen et al. 2011) and to a profound revision of Peirce's elaborated semiotics, combined with a rediscovery of phenomenology (Brier 2010).

While the purely cognitive approach of information seeking still has difficulties in fully understanding what semantics actually do in information systems, Brier (2010) suspects that this is because the approach is still too close to the information processing domain. Semantics without context of the "conscious of living systems" lack a theory of meaning.

This fits well with the development in cognitive science which has evolved from a computational model of the brain into the concept of cognitive embodiment (Dourish 2001; Anderson 2003; Cowart 2005; McCullough 2005). Recent cognitive science has empirically shown that the brain does not just process information but also needs a body in order to understand and develop intelligence. In information science this development is leading to a combination of

the cognitive paradigm with the spatial and practice approach. First attempts at implementing these findings in practical information systems and knowledge work in libraries look quite promising (Heilig et al. 2010, 2011; Reiterer et al. 2010).

Bodies in the Blended Digital Library

The concept of the blended library addresses the problem that the usage of Digital Library systems is quite often restricted to the single user sitting in front of his or her screen. The theory of cognitive embodiment postulates that this form of knowledge reception is not effective enough because spatial, bodily and social aspects are missing. In traditional Digital Libraries the haptic sensorium is rarely used and the physical, collaborative co-presence of other community members is seldom feasible. The blended library uses the possibilities offered by digital advancements, especially new technological developments such as multi-touch tables, big touchscreens, transponder technology and portable devices, in order to integrate it into the analogue practice of collaborative learning and knowledge elaboration (cf. also Van House 2003).

In the light of cognitive processes we can identify new forms of perception here ("S" = "vu") which enhance the legibility of the text (object) and generate knowledge socially. This new understanding of cognition also gives the synoptic aspect back to the Digital Library, allowing for serendipity as with analogue stacks (Foster and Ford 2003).

Many users see Digital Libraries as warehouses of dead objects which they encounter only upon specific request during their information journey (Adams and Blandford 2005). Niklas Belkin (1980) and other information scientists pointed to the fact that every information-seeking process needs an initiating mechanism. He calls it the "anomalous state of knowledge" (ASK) which – when perceived by a user – might generate his decision to use an information system (e.g. a library) and let a person start a search formulation process. Whether ASK recognition leads to an "informatics moment" (to the encounter with a machine, as described by Kate Williams (2012)) is quite uncertain in the light of general user studies. Ubiquitous computing and the ambient findability of information (Morville 2005) brings this moment closer to everybody, but it is still questionable whether people would really use formalised, more in-depth information systems rather than just Google or Wikipedia on their smartphone. As a blended library, the Digital Library generates more opportunities for triggering an ASK than the formal search process with Google or other black box systems because the user is more immersed. In the Digital Library, the informatics moment is more embedded in the knowledge creation process.

The two remaining dimensions of the digital document still need to be addressed. For Pédauque it is even a question of maturity that all three dimensions are elaborated. I would add that this also holds true for a collection of

documents which forms a library. However, as Weaver pointed out, treating the syntactical dimension thoroughly might have an effect on the other levels. New forms of interface and user integration already implicitly take them into account because the nature of the information process is understood more in depth.

Pédauque correctly describes the semantic aspect of the document as a text which is to be read. Experiences with new collaborative devices like multitouch tables indeed show that they generate stories (i.e. texts), which then generate knowledge by telling them to someone else (Yahiaoui et al. 2011). The prerequisite, of course, is a social relationship as encountered in communities of practice (which is the M dimension). The collaborative usage of documents in the blended library supports such social relationships.

Beyond Warehouses

Generating stories to make Digital Libraries and their documents readable and focussing on topical and practice communities rather then just reproducing the warehouse paradigm might be a good way to leverage Digital Library investments. The idea of total redocumentarisation of the world in digital form will prove to be as unrealistic as the universal documentation movement in the late 19th century. Every document always bears its three dimensions: it naturally has to be perceived as a sign and in its form, but its semantics are only understandable in the social perspective of pragmatics and the ever-changing practice of real life.

Digital Libraries are often aimed at the general public as part of their mission. However, as Sieglerschmidt (2010) states for the German Digital Library, the user- and problem-oriented approach sometimes comes after the establishment of the "Library": "We have the solution! Where is the problem?" is the title of his talk at a recent German Library congress. Astonishingly, his answer is that the Digital Library will only serve as a more sophisticated search engine and not as a tool for learning and generating knowledge, for instance in the sense of Polanyi (1958). Looking at the way he constructs the arguments for his answer, one can observe that he (and the German Digital Library as an idea in its own right) is not able to depart from the engineering point of view, despite the fact that he begins his argument in the documentation tradition like Pédauque. More often than not, it can be observed that information system construction does not go beyond level A of Shannon/Weaver's information theory, remaining "simple" technological engineering at the syntactic or sign level.

Although some research is being conducted in the direction of the ideas presented here (e.g. van House or O'Day and Nardi in Bishop et al. 2003), looking at the mainstream of Digital Library engineering (e.g. Gradmann et al.) the user and his practices are not really the focus. The 5th "S" of the 5S model (Gonçalves 2004) apparently needs to be elaborated further. It is not just engineering

the usability of such systems that counts. Even profound user modelling will not provide a solution (Nika et al. 2010) as this is only done in the warehouse and search engine perspective of a Digital Library, imagining the user at his desktop just looking at representations of Popper's World III on a screen, in other words flat semantic surfaces without a body, physical presence or real interaction. Analysing the quality model behind Digital Library frameworks (Gonçalves et al. 2007) or in existing evaluation approaches (Zhang 2010), we find a concept of quality which indeed stems from the warehouse paradigm and is not rooted in modern customer-oriented quality management. In my opinion the conception of Digital Libraries most often lacks a profound discussion of the organisational goals and objectives of the library. As Borbinha pointed out in 2007, a more enterprise like approach is needed.

One point – and this is not only a personal lamentation because it involves my teaching area as a professor for library management – is particularly striking with the DELOS framework of Digital Libraries: in the reference model the question of where the librarians actually are arises explicitly (Candela et al. 2011, 25). Despite general statements about the changing role of librarians in the digital era, the framework itself classifies them as "end-users". I think it is here that the general problem lies: librarians – or better: information science englobing library management – should be more involved in Digital Library conceptions because they are trained in focussing information services to the mind's eye (and body, I might add) of users, being familiar with both their usage and the systems.

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