Digital Paper Bookmarks: Collaborative Structuring, Indexing and Tagging of Paper Documents

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Abstract

Bookmarks provide an efficient and well established means for structuring, indexing and tagging documents, all important processes for successful learning. We present a prototype of Digital Paper Bookmarks, writable adhesive stickers which combine the intuitiveness of paper bookmarks with electronic processing. Electronic tracking of the bookmarking actions performed on a paper printout provides for tangible bookmarking and tagging of electronic documents. A collaborative visualization of own bookmarks and shared ones of other users allows contrasting the own understanding with those of others. Four different semantic types of bookmarks scaffold learners in their learning processes and enable automatic aggregations.

Keywords

Digital paper, structuring, bookmark, computer-supported collaborative learning (CSCL), e-learning.

ACM Classification Keywords

H.5.2 User Interfaces – Input devices and strategies; Interaction styles. K.3.1 Computer Uses in Education – Collaborative learning; Distance learning.
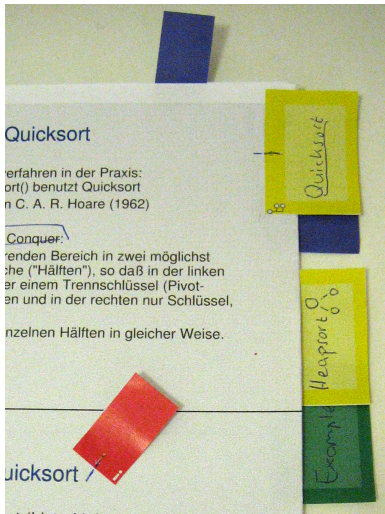
Figure 1. Users can structure a printed document with Digital Paper Bookmarks, adhesive stickers that can be labeled. The automatic electronic synchronization provides for sharing and collaboration.
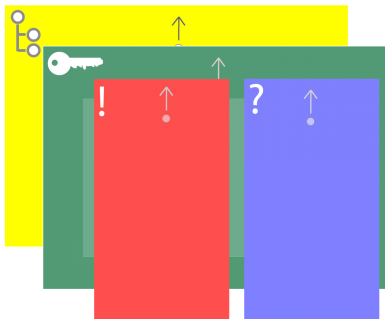

Figure 2. Four semantic types of bookmarks differ in colors and symbols.

Introduction

The processes of structuring learning material individually, identifying important passages and assessing own difficulties are important factors for the learning success of students [5]. Empirical work [10] indicates that interacting with printed documents with pen and paper has intrinsic advantages over interacting with digital documents: Two-handed navigation, ease of annotation and the ability of being laid out in physical space are beneficial for understanding the structure and for comparing specific parts of a document.

Within this context, paper bookmarks are a very efficient means for structuring documents, marking specific passages on paper and quickly accessing them later on [11]. We aim to leverage the ease of this interaction also for structuring *electronic* documents via their printouts. Moreover, paper bookmarks are difficult to share with other people. Yet, sharing seems very important, as collaboration has shown to efficiently support learning processes [2]. Through the contrasting of their own structure with those of others, with their markings of relevant or unclear passages, learners can assess and improve their own understanding of the material.

In this paper, we introduce Digital Paper Bookmarks which combine the advantages of paper-based bookmarking with electronic processing and collaboration. These are writable adhesive stickers with an automatically synchronized electronic counterpart. Four different colors of bookmarks represent four semantic categories, which support both content-centered and meta-cognitive learning processes. We assume that these can scaffold students' learning and moreover support the electronic interpretation, filtering and aggregation of bookmarks.

Digital Paper Bookmarks

Digital Paper Bookmarks span both the paper and the electronic worlds. They are Post-it like adhesive stickers of different colors which can be attached to physical pages of printed documents at arbitrary positions (Fig.1). Digital Paper Bookmarks are writable and can optionally be labeled with a title using an electronic pen. They are synchronized with the electronic system and serve as electronic bookmarks for these pages.

For the paper/digital synchronization, our system relies on the Anoto technology [1]. This uses a specific dot pattern printed both on the sheets of the printed documents and on the Digital Paper Bookmarks. The pattern enables an electronic pen to identify both the page and its position on this page. In contrast to other solutions for capturing handwriting on paper, no specific sensing device other than the electronic pen is needed. This provides for a natural writing and switching between paper sheets like with a traditional pen and paper.

Users can easily create Digital Paper Bookmarks via three steps (see Fig. 3):

- *Attach:* Bookmarks can be attached to arbitrary pages of the printed document at arbitrary positions.

- *Associate:* With a simple pen gesture, the paper bookmark can be associated with the page it is attached to. It is then also available as electronic bookmark. This association gesture is a short line connecting the bookmark with the page it is attached to.

- *Label:* Since the Anoto dot pattern is printed on the stickers, one can use the electronic pen to write a tag or title on them, which will be synchronized.
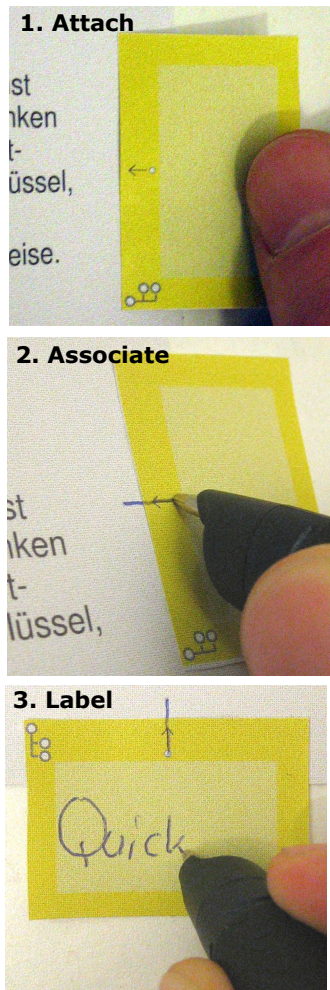
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Figure 3. Creating Digital Paper Bookmarks includes three intuitive steps.

Once created, Digital Paper Bookmarks can be altered:

- *Modify:* The position of a bookmark can be modified by sticking it to another position and performing the association gesture at this new position. Handwritten labels can be modified with the electronic pen later on as well.

- *Delete:* Bookmarks can be deleted by physically removing them from the paper sheet and writing a cross out deleting gesture on the bookmark.

Digital Paper Bookmarks thus maintain the intuitiveness of manipulating paper bookmarks and their advantages for structuring, marking and re-finding passages of paper documents. In addition, users can electronically search for specific labels. Our visualization (see next section) indicates the position of a bookmark in the paper document and hence supports cross-media navigation from positions within the electronic document to its printed instance. The proposed solution for creating bookmarks is entirely mobile and does not require many changes from traditional paper-based work. Only the printed document, some Digital Paper Bookmarks and an electronic pen are needed.

Our first prototype uses Digital Paper Bookmarks within a collaborative notetaking system, where students can annotate and bookmark printed PowerPoint slides. Yet, the interaction technique is more generally applicable both to other than learning settings and to other document types, e.g. with an Acrobat plug-in for PDF files.

Semantic Types

Digital Paper Bookmarks support learning processes through specific semantic types. Depending on the meaning of the bookmark, users can choose between four different types, each represented by a specific color and an additional symbol (Fig. 2). Offering different types of bookmarks has two main advantages: First, the availability of specific types can support meta-cognitive learning processes by encouraging and reminding students to perform specific important learning activities which are related to bookmarking. Second, some common semantic classes facilitate the computer interpretation of bookmarks, the sharing with other learners and automatic aggregations. We distinguish the following four types on two layers:

- The two semantic types on the *structure layer* support learners in structuring the learning documents: *Section* bookmarks (yellow) mark the beginning of a new section. The name of this section can be written on the bookmark. *Key* bookmarks (green) can be used to mark key passages, where subject matters are defined or explained.

- The two semantic types on the *meta-cognitive layer* serve for planning further learning activities as well as controlling past activities. They can be used for assessing both the relevance of subject matters and own difficulties. *Important* bookmarks (red) mark passages which seem particularly relevant to the learner. *Unclear* bookmarks (blue) point out passages which the learners have difficulties understanding and which therefore require further work. Once the subject matter is well understood, the bookmark can be removed.

The bookmarks of the structure layer offer much space for writing a title, whereas the meta-cognitive bookmarks serve as simple category markers without a title (Fig. 2). Several bookmarks can be attached to the same page. We assume that the bookmarking actions keep intuitive and simple albeit the certain amount of
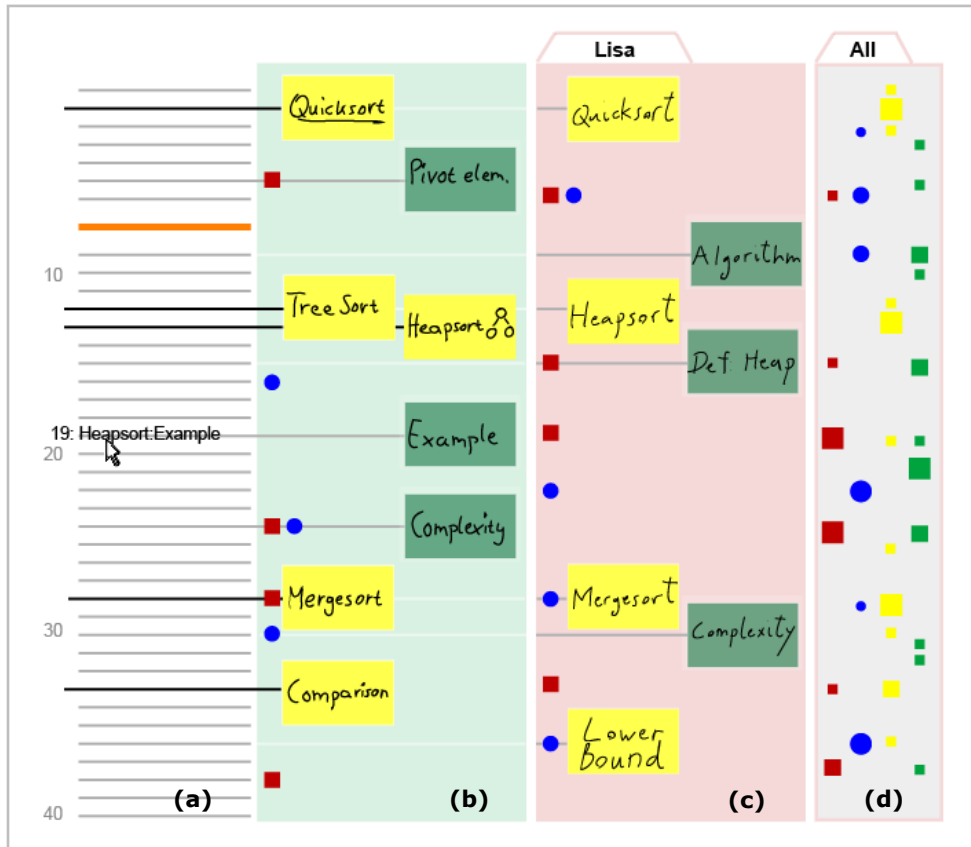
Figure 4. The visualization of own bookmarks (b), shared bookmarks of other members of the learning group (c) and an aggregate view of the bookmarks of all users (d). The pages of the (PowerPoint) document are indicated with horizontal lines on the left (a). More information on slide numbers and titles appear when hovering over this area.

Collaborative Visualization

Personalized Index of Contents
As Digital Paper Bookmarks are automatically synchronized with the electronic system, paper bookmarks can be integrated to and displayed within the corresponding digital document. Our collaborative document viewer includes a visualization of the lecture slides and the bookmarks (Fig. 4). This provides an abstract overview of the individual slides (4.a). The slide which is currently displayed in the software viewer is highlighted in orange. Beneath, the user's bookmarks are displayed (4.b), allowing discerning the document structure at a glance. Bookmarking pages on paper thus automatically creates a personalized index of contents including passage headings (yellow) as well as pointers to key passages (green), particularly relevant passages (red) and unclear passages (blue).

Sharing and Aggregation
Besides accessing one's own index of contents, users can view those of their learning partners. For this purpose, multiple learners can set up a group. Each member of this group then has the access privileges to view the bookmarks of the other group members. The bookmarks of one or several group members can be displayed at a time and are visible to the right of the own bookmarks (Fig. 4.c). This enables learners to critically examine their own understanding by comparing their own structure with those of other learners. Cognitive conflicts may arise and can lead to a modification of one's own bookmarks.

In addition to this within-group sharing, the bookmarking data of *all* users is automatically aggregated by the system. Anonymity is preserved as only the positions and types of the bookmarks are taken into considera-

abstraction imposed on the users by these four categories: On the one hand, marking documents with bookmarks of different colors is widespread in the paper world; on the other hand, the relatively small number of four categories still seems manageable. In order to help novel users to memorize the meanings of the different colors, small symbols are printed on the paper bookmarks.

tion, but not their handwritten labels. An aggregated view then visualizes data from all users indicating the type, position and frequency of bookmarks by colored markings of different sizes (4.d). Large red markers indicate that these passages are judged particularly relevant by a large number of learners. Large green rectangles mark key passages, etc. We plan to study if the handwritten bookmark labels can be aggregated as well. This would require that users choose the same labels although a paper-based interface is not able to suggest frequent labels used by other people, which is considered a key factor for the convergence of tags [3].

Evaluation

A pilot study gave encouraging feedback and indicates that Digital Paper Bookmarks seem to be very promising tools for learning settings. Nine randomly selected students attending an introductory computer science lecture participated to the study. Their tasks were to structure printed lecture slides with Digital Paper Bookmarks and to access specific passages in the electronic and the paper document later on. We observed the participants, conducted semi-structured interviews and made use of a questionnaire.

The results indicate that Digital Paper Bookmarks are very intuitive to create and modify (M=4.6 on a five-point Likert scale, SD=.5). All link gestures were correctly recognized by the system. Users judged Digital Paper Bookmarks as very helpful for finding specific pages both in their analogue version on paper (M=4.9, SD=.3) and in the software viewer (M=4.4, SD=.5). Several participants particularly valued the possibility to fade away from the given structure and instead to create an own structure of the document. A problem was that, depending on the orientation of the bookmark

w.r.t. the document page, users wrote labels in other orientations than the intended one. This could result in an incorrect visualization. Hence, a next version should automatically detect the text orientation on the bookmark. A subsequent study over a longer period of time will assess the asynchronous processes of sharing and subsequently modifying bookmarks.

Related Work

Prior research on the integration of paper and computing has considered sticking and attaching paper sheets as a means for linking and annotating underlying documents. In the PaperPDA [4], stickers can be used to create *hyperlinks* on paper. An augmented notebook of Mackay et al. [8] tracks handwritten *annotations* on Post-it stickers which are attached to a paper notebook. The system lacks mobility due to the specific hardware required. The same is true for the Designers' Outpost [6]. With this system, users can add physical Post-it notes to an electronic document on a whiteboard, but not to paper documents. To the best of our knowledge, PapierCraft [7] is the only one of the large number of systems relying on Anoto technology which leverages this technology for linking different paper sheets. Similarly to our system, users can electronically link two sheets by performing a "stitching" pen gesture. In contrast to our approach, PapierCraft is a general, non-collaborative command system and the stitching does not focus on the structuring or indexing of printed documents. Quickies [9] are paper Post-it stickers whose handwritten label is captured electronically. Quickies cannot be used for bookmarking and indexing documents as the underlying RFID technology for location sensing is not able to discern specific pages or positions within a document.

Electronic bookmarks became popular with web browsers, in which web pages can be bookmarked with individual labels. Traditional browser bookmarks are not collaborative. More recent social bookmarking tools (e.g. del.icio.us or www.citeulike.org) provide for the web-based sharing of bookmarks with other users. However, these bookmarks apply only to entire documents but not to within-document positions. A good reference for electronic bookmarks within individual documents is Adobe Acrobat, which offers a wide variety of annotation and marking tools for PDF documents.

Conclusion and Future Work

Our first prototype and a pilot study indicate that Digital Paper Bookmarks are a very intuitive concept to structure, index and tag documents. The combination of paper-based interaction with electronic sharing is particularly supportive in the case of learning settings, where the structuring of other users provides for a critical contrasting with the own understanding of the learning material.

In our subsequent work, we plan to compare Digital Paper Bookmarks with other paper-based means for indexing documents, such as tagging with handwritten symbols and specific buttons printed on paper. Moreover, we will evaluate the interaction technique and its collaborative use with a larger number of users. On the basis of these results, we will work towards supporting more electronic and printed document types and integrating Digital Paper Bookmarks with electronic social bookmarking. This could be a further step towards combining the paper and the digital worlds.

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