PERSONALIZATION TOOLS FOR ACTIVE LEARNING IN DIGITAL LIBRARIES

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INTRODUCTION

Libraries serve three roles in the learning process (Marchionini 1995, 66). First, they play a practical role in sharing valuable resources. Although this is a general expectation of users, the digital library revolutionizes this sharing role by allowing people to access materials simultaneously regardless of their physical location. Second, libraries serve a cultural role in preserving and organizing artifacts and ideas. In this sense, libraries serve as reservoirs of information sources for the education of generations. Third, libraries serve a social and intellectual role by bringing people and ideas together. Digital libraries offer diverse information resources extending beyond the physical space shared by groups of learners. In theory, digital libraries bring together people with different learning missions.

Studies related to learning methodologies and techniques have been conducted for centuries, including those done by philosophers and educators like Socrates. Learning is a process of knowledge construction in which the learner carries out many activities (Lorenzen 2001; Fitzgerald 1998). Active learning can be described as the ability of learners to carry out those activities effectively and efficiently while incorporating them into a process of their own education.

Consequently, learners are easily absorbing knowledge through their interaction. In active learning, learners take responsibility for their own education, and study strategies to accomplish their academic goals (Lee 1999). With respect to digital materials, there are three actions that create the tools for active learning: *active consuming*, *information gathering*, and *information seeking*. Active consuming is carrying out activities effectively with respect to different media types. These include active reading, active watching and active listening. Constructing the user's reference collection with ease is the main concept of the information-gathering portion. To provide intelligent support in a digital learning environment, information seeking facilities are needed to locate suitable materials. This paper describes how these three facilities can be supported in a personalized information environment for digital libraries.

Two schemas, material personalization and collection personalization, form the basis for the *personalized information environment* or PIE. Material personalization refers to constructing customized views of library materials. Collection personalization describes how to provide a different view of the library organization through personalizing retrieval and filtering facilities.

ACTIVE LEARNING WITH DIGITAL MATERIALS

Learning, which is a process of knowledge construction, is an inherited behavior of human beings. It generally takes place with interaction and access to resources around a user. Although learning is a talent that varies from person to person, everyone needs proper guidance and tools to acquire the knowledge that is needed for life long education (Fischer and Scharff 1998). Guidance is generally based on the experiences of others, and tools are built based on learning activities, including reading, listening, watching, searching, thinking, understanding, writing and speaking. Tools enable people to do those activities with corresponding information sources, and generally play an important role in the success of the learner.

Active learning is as the ability of learners to carry out learning activities in such way that people will be able to construct knowledge from information sources effectively and efficiently. These tools should extend beyond the traditional facilities of browsing and searching, and learners should be able to perform continuous engagement in acquiring, applying and creating knowledge and skills in the context of *personal requirements and interests*. At the same time, a modern digital society requires that the originality and copyright of scholarly information sources be protected (Brin et al. 1995; Gladney 1998).

Text, audio and video make up most of the media types present in digital materials. However, the majority of digital materials that individuals tend to use in learning are textual materials. When digital textual materials are made available for learning, the interface provides mixed benefits for reading. Learners are able to search and organize those materials easily but interfacing is not comfortable as reading print materials. In an active learning process, reading consists of not only looking at words and understanding but also related activities such as underlining, highlighting and commenting. This type of reading is called *active reading* and is one common behavior among serious learners (Marshall 1997, 131; Carroll 1987). When it comes to learning with video materials, passive watching, as with entertainment videos, is not adequate to provide effective interaction between the learners and the information sources. Video sources are more effective as learning resources when segmented and integrated with annotations from other media types. This type of viewing is *active watching* (Correia and Chambel 1999, 151-154). The same is true for audio materials used in learning. For example, when learners access audio lectures, seminars or speeches, they may prefer to add annotations and to suppress segments that are not very important in later revisions. We call this *active listening*. In an abstract interpretation, we combine these three activities, active reading, active watching and active listening together with digital materials to become *active consuming*. An important step of knowledge construction in a self-directed, active learning environment is active consuming. Therefore, the tools provided for such an environment, facilitate active consuming while safeguarding copyrighted material.

However, active learning using a digital collection covers more than active consuming activities. It must facilitate the construction of information artifacts that represent the learner's information gathering process. Practically speaking, learners cannot memorize everything they have gathered, but benefit from their own effective reference collection. Such user-defined artifacts on top of digital materials enhance the learner's thinking and understanding in the learning process, as well as being useful for writing, documenting and creating new audio/video materials. Traditionally, people have been using notebooks and some capturing devices (for example, tape recorders) to create their own reference sources. If the information sources are digital materials, new tools should allow the learners to integrate their selections from digital information sources in a metaphorically similar manner.

In order to provide intelligent support to achieve the expectations of active learning, it is also necessary to provide tools to locate suitable materials. “Active consuming,” “information gathering,” and “information seeking” are the three main requirements for active learning tools with respect to the digital materials.

PERSONALIZED INFORMATION ENVIRONMENT (PIE) AND DIGITAL LIBRARIES

PIE (Jayawardana 2001) in a digital library is a framework that provides a set of integrated tools based on an individual user’s requirements and interests with respect to his access to library materials. These tools can support active learning by integrating the user’s personal library and a remote digital library. The user will be able to carry out learning activities when browsing the digital library.

The learner, who is considered as an academic user of a digital library, performs active consuming activities, such as active reading, active watching and active listening when accessing multimedia library materials by using tools in PIE. Therefore, they can build personalized views on those materials while turning them into an easy-to-use reference collection. When information gathering, the user may create new artifacts, which are described as Notebooks, by integrating selected segments of library materials with their own comments. These segments would be text, images, audio or video depending on the type of original source. Thereafter, a personal library is used to maintain these views (Notebooks) on top of digital library materials. An integrated interface of the personal library and the digital library in PIE then allows the user to organize and modify the library materials according to their direction. Since the digital library is a vast, ever-growing collection of materials, it is necessary to include services, based on the user’s learning intentions. In PIE, these learning intentions are the user’s requirements and interests in the context of library usage. Based on those requirements and interests, filtering and retrieval tools are developed, improving their usage. The user is then able to seek suitable library materials more easily.

As previously mentioned, there are two schemas involved in PIE. Material personalization corresponds to facilities for learners to use library materials according to their individual requirements such as active consuming and information gathering. Technically, it describes the customization of multimedia library materials to define suitable views and how selected media segments from multimedia objects become part of Notebooks. Collection personalization, on the other hand, captures the learner’s learning context and interest from the material personalization in order to provide a personalized view of the organization of digital library. Collection personalization, then, includes personalized filtering and personalized retrieving.

In PIE, these two schemas of personalization benefit each other by creating the cycle of interaction. Therefore, it is possible to provide the three main active learning facilities in the PIE for the digital library. Figure 1 shows the architecture of tools in the personalized information environment.

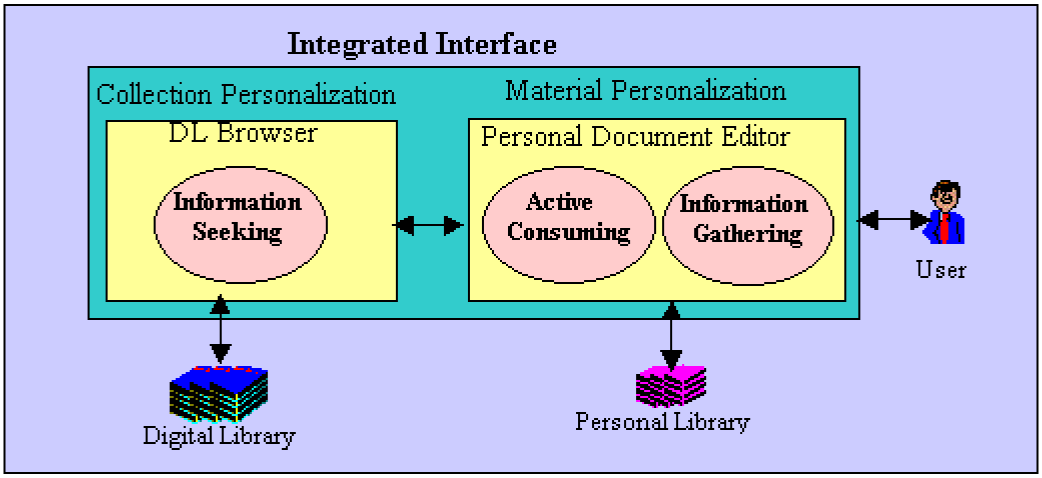

Figure 1: Architecture of Tools in the PIE

In this architecture, there are two main components called DL Browser and Personal Document Editor. DL Browser supports the collection personalization and Personal Document Editor for material personalization. Two Information seeking tools, personalized retrieving and personalized filtering, are provided in the DL Browser. On the other hand, tools for active consuming and information gathering are available in the Personal Document Editor. The integration of both the DL Browser and the Personal Document Editor provide an interface for the digital library.

TOOLS FOR ACTIVE CONSUMING AND INFORMATION GATHERING

As a part of material personalization, we carried out a survey in our university to find out how individual users learn in conventional libraries and what they expect in a digital environment. Although the access to the digital library differs from the conventional one, everyone agrees that the primary requirements and ultimate objectives of learning process remain as they are. In addition, the majority of users expect more than conventional Web browsing and bookmark facilities when accessing a digital library as part of the learning process.

Survey results summary

- Users expect special facilities for customizing, reusing or linking relevant segments in a reference book when using multimedia sources.
- What the user has collected through their interaction should be maintained in a personal space (personal library).
- The user should be able to organize the collected information according to their learning requirements.

· Rather than passive reading, watching and listening, the user tends to enhance these activities by annotating, segmenting, modifying and integrating library sources as a part of their knowledge construction.

After conducting this survey, an interaction model was designed for material personalization.

Design for user-interaction

Figure 2 illustrates how an active learner might interact with library materials. The digital library is a collection of digital objects organized on a computer system to provide library services. Digital objects are published materials, and have some copyright requirements (Brin 1995, 398; Gladney 1998). Since these materials belong to the library, they are the library's property. A personal document, on the other hand, is a document created by the user with selected segments from the digital library. He can organize and modify its contents just like an ordinary word processing file, in addition to his own annotations. Combining digital library browsing with personal documents enhances active learning.

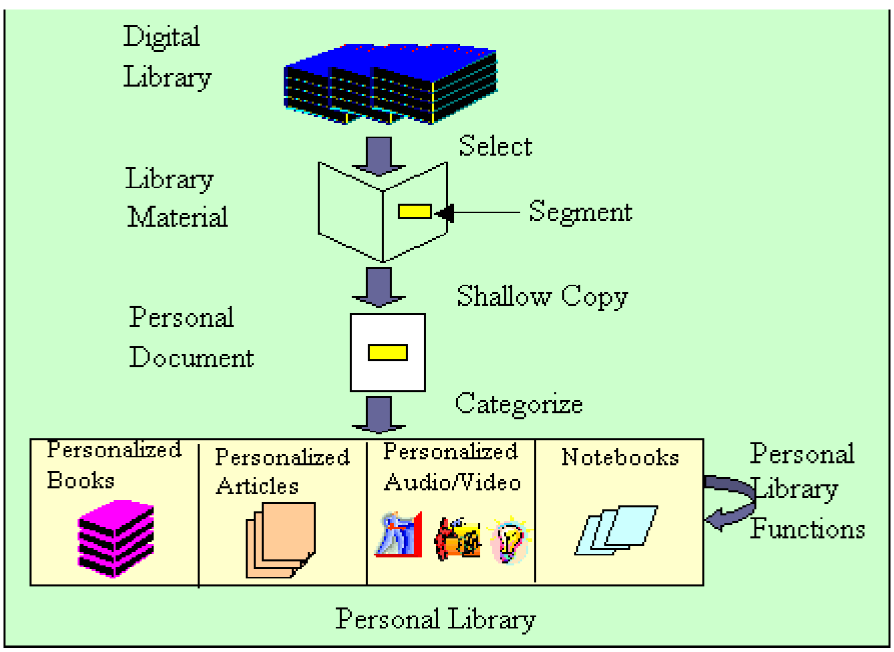

Figure 2: Interaction Design for Material Personalization

In this design, the learner can select materials from the digital library, and copy them into a personal document. This copy operation is performed using Shallow Copy. (Jayawardana et al. 2000, 77-84) The personal documents are categorized according to the following areas: Personalized Books, Personalized Articles, Personalized Audio/Video, and Notebooks. Personalized Books and Personalized Articles, which mainly support the learner's active reading process, provide personalized views of static library materials. Personalized Audio/Video supports active watching and active listening processes and gives personalized views of audio-visual library materials. The Notebook, which represents the learner's information gathering, allows the user to integrate different segments that can be text, images, audio or video together with annotations. Manipulation of those personal documents is carried out by personal library functions, which include annotating, segmenting, formatting, modifying, organizing and integrating.

Shallow Copy Technique

Shallow Copy is the main technique that is used to create Segments from the existing multimedia library materials. With Shallow Copy, only a pointer to the part to be copied is stored, and no physical copy of the material is made. In personal documents, shallow copied segments are used instead of simple hyperlinks. Since the internal representation varies with respect to media type, the design of shallow copy technique depends on the media type of the selected source.

Shallow Copy on Text Data

Since there are different text formats for different purposes, we identify three categories, namely open, print and proprietary. Open formats correspond to all text encoding such as HTML, XML and ASCII. Print formats such as Postscript generally contains both text and images together. Therefore, we consider them a special kind of image format. Proprietary formats, for example Microsoft Word, usually come with an application programmers interface (API).

A shallow copied text segment consists of three attributes: document identifier, begin offset address and end offset address. Each segment contains two declarations called physical and logical. The physical declaration of document identifier would be URL or URI of the source object and it becomes invalid when the object is not retrieved or located. In such circumstances, the contents of the logical declaration will be used to identify it. The logical address contains useful information that tracks the original document, irrespective of its physical location. For example, it would be the ISDN number for published material.

The begin offset address and end offset address contain values that can be used to retrieve the segment from the document. In open formats, the physical declarations of those offset addresses mainly contain the relative length with respect to character count. The relevant physical address calculation for print formats is based on the virtual coordinates (described in the next Section) and for proprietary formats it depends on the facilities given in the corresponding API. However, the logical address cannot be directly defined unless they are supported. For immerging standards like XML, it provides a mechanism to determine logical offset addresses using XLink (XML Linking Language) and XPointer (XML Pointer Language). XPointer defines addressing requirements for individual parts of an XML document and XLink can include those pointers to identify those parts in the target document.

Shallow Copy on Image Data

Image objects are also represented in a variety of formats such as JPEG, GIF, and BMP. The internal representation of these image objects vary significantly from each other and the platform (operating environment) also affects their representation. In this circumstance, it is difficult to have a unique mechanism to represent the shallow copied image segment irrespective of data type and platform. We used a virtual coordinate system to map them in order to calculate the offset addresses uniquely and it is maintained in a device independent form. The user interactively zooms in or out before marking the clipping area. The width and length of source image in the virtual coordinates are then included as an attribute of the image segment. The top left corner and right bottom corners are used as offset addresses. Figure 3 shows a specified image segment in virtual coordinates with offset addresses.

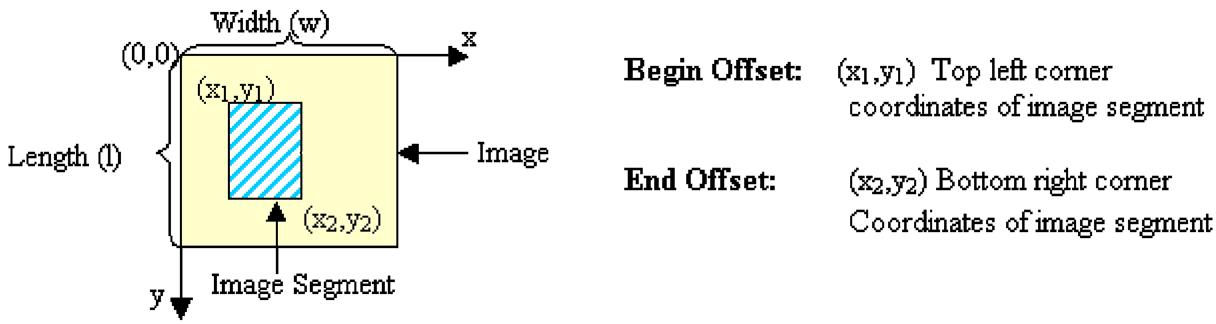

Figure 3: Virtual Coordinates Space for Image Formats

As described earlier, print formats such as Postscript are not processed as text files since they may contain images and their internal representation is printer oriented. Therefore, we used the virtual coordinate approach to describe the shallow segments taken from files of print formats. The Java 2D API provides direct facilities to implement a virtual coordinates panel of images in a virtual authoring. A browser for personal documents can directly retrieve those image segments through Java.

Shallow Copy on Audio/Video Data

The data type of audio/video data is completely different from text and image types, since the appearance of audio/video data depends on the time. Although there are varieties of data formats for their representation, both the audio and video data are function of time when they are played. Shallow Copy uses time as the user specified parameter to identify segments of audio and video library materials.

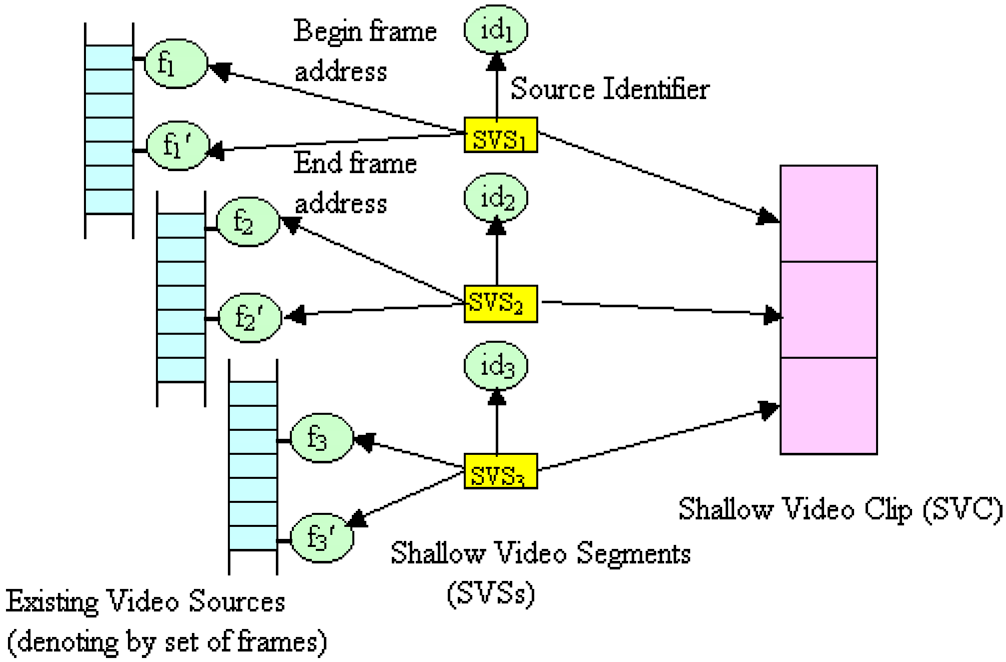

Figure 4: Shallow Video Clip

Figure 4 shows a shallow video clip (SVC) that consists of three shallow copied video segments. A shallow video segment (SVS) is selected from an existing video source, which corresponds to a series of frame sets. Hence, a shallow video segment consists of three attributes to identify original source video: source identifier, begin frame address and end frame address. The source identifier may contain the physical address of the source in the document base and any logical information about it. Since we can specify a shallow video segment based on timing information, the begin and end frame addresses could be identified using a function that maps the time to relevant frame number. An SVS can be specified as a function of time.

$$SVS_i = (id_i, [f\ (t_i),\ f\ (t_{i'})])$$

A shallow video clip, then, is a sequence of one or more shallow video segments.

$$SVC_r = \{SVS_1, [SVS_i]^*\}$$

When opening a personal document using the browser, the dynamic video sources are generated based on the information in the shallow video clips of the document. Such sources could stay in the temporary buffer during the activation time of the personal document but are not stored.

Java Media Framework facilitates a video editor for shallow copying and the browser for personal documents with shallow video clips and relatively easy API to cut and merge frame sets from video sources irrespective of different video data formats. To reduce the time taken for data transfer from the server (where video data sources are located) to client (where the personal document is opened), the Java Servlet API can be used to process the shallow video clip at the server side. In a similar manner, shallow audio segments can also be specified using timing information and can be generated dynamically on a temporary buffer using Java Media Framework.

This shallow copy technique safeguards the copyright requirements and the ownership of the digital library materials, since it does not physically move data. In addition, the shallow copy technique avoids the problem of data replications. In the case of multimedia data types such as audio/video data, which take a large amount of storage space, the shallow copy technique demonstrates a definite advantage. (Hewagamage et al. 2001)

Implementation

Personal Document Editor is the interface that integrates the user's personal library and the remote digital library to provide active consuming and information gathering. Its functionality and architecture are based on the interaction model for material personalization in Figure 2. It facilitates browsing and maintenance of all types of personal documents such as personalized books, personalized articles, personalized audio/video and Notebooks.

When the user opens static library materials through the DL Browser and if they want to carry out active reading activities, they first copy them to a personal document using shallow copy operation. Then the learner can actively read using the personal document editor. This allows formatting functions such as highlighting, bolding and underlining. The user can also delete unnecessary contents and add annotations to improve the readability. Figure 5 is the screen shot of a personalized article with its original article. The back window corresponds to the original article opened in the DL Browser and the front window shows the reformatted content that appears in the corresponding personal document.

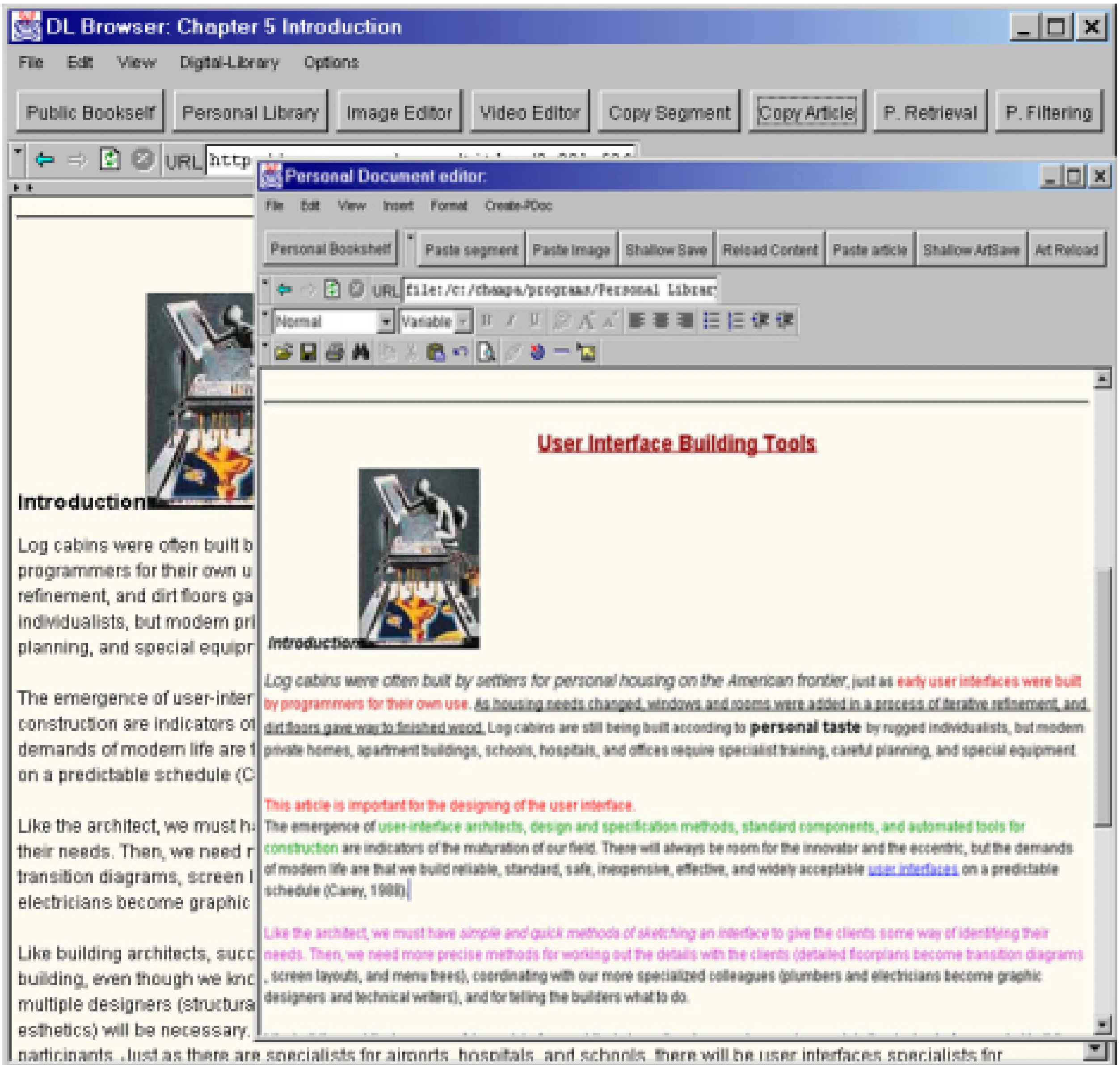

Figure 5: A Personalized Article

Here, when the user wants to customize the static images it is necessary to open them on a special window called Shallow Image Editor to map them on to the virtual coordinate space as described earlier. Using this editor, the learner can select any segment of the image according to their preferences. The editor also facilitates changing the size of the image segments when they are to be inserted into personal documents. Figure 6 shows a Shallow Image Editor in which the user has opened the image and marked an area to perform the shallow copy operation on it.

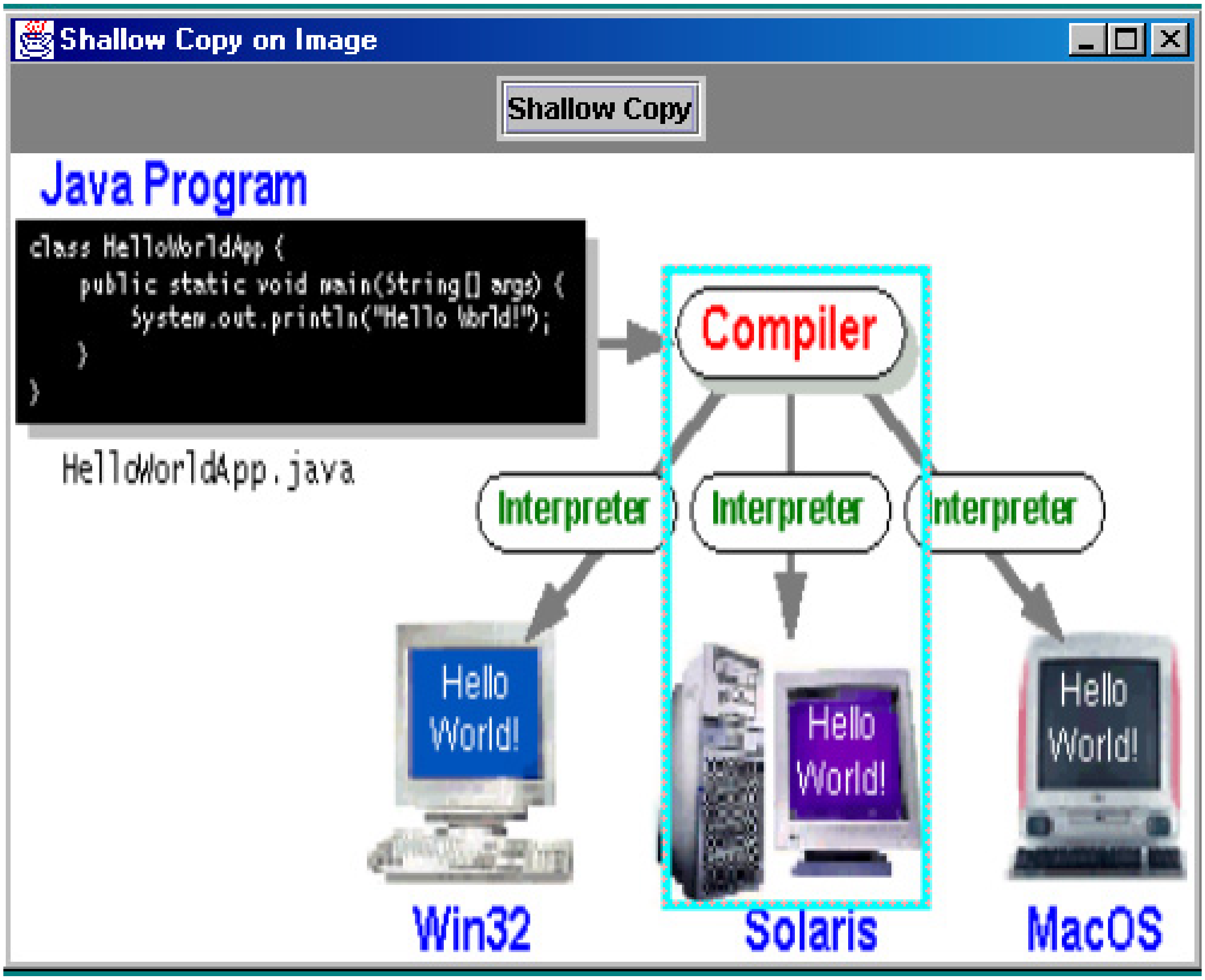

Figure 6: Shallow Image Editor

When the learner wants to create personalized audio/video clips from audio-visual library materials, a special editor called Shallow Video Editor is provided with the facility of shallow copying on audio/video data. Figure 7 shows how to create a personalized video clip by integrating different video segments from existing video sources on the Shallow Video Editor. (Hewagamage et al. 2001) In this case, the learner has to open the relevant source videos in the Shallow Video Editor to specify relevant video segments to be copied to a shallow video clip. The segments are then played using the control bar that appears below the picture frame and should identify the start and end times of corresponding segments. Once one or more segments have been specified, the shallow video clip can be created and played by pressing relevant buttons. If the user wants to keep the shallow video clip in the personal library, they insert it into a personal document. Then necessary meta information to rebuild the clip is written down on the personal document, but the actual data segments are not included in the personal library. In a similar way, for the creation of personalized audio clips, Shallow Video Editor can be used to open original source materials, and to create and play shallow audio clips. The difference is that the image frame is blank when audio materials are opened.

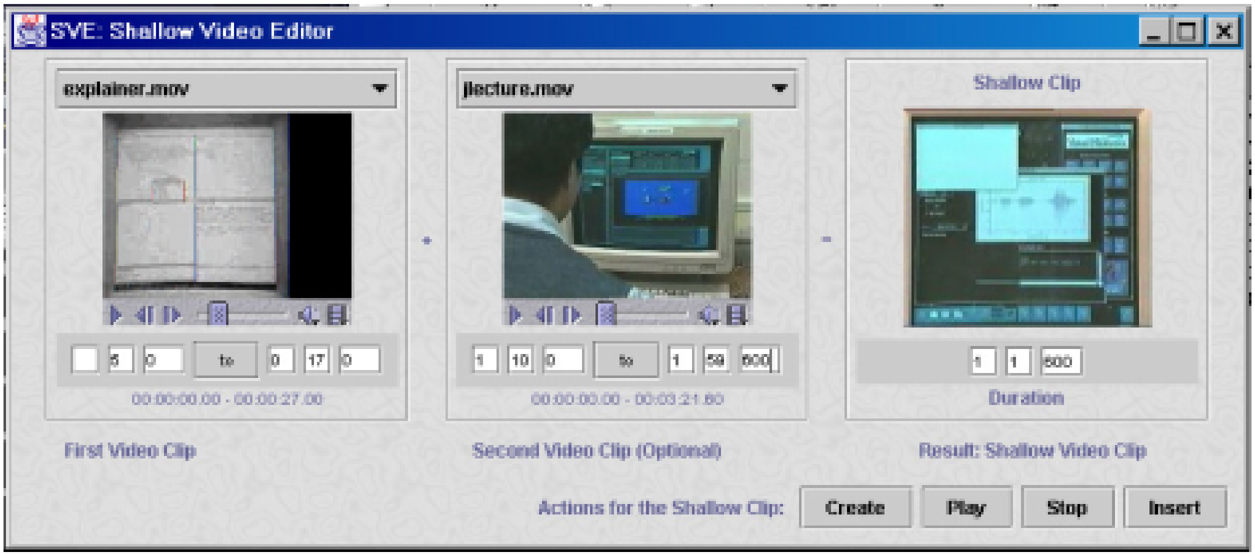

Figure 7: Shallow Video Editor

In our prototype system, when the user wants to add textual or image annotations to a personalized audio or video, a notebook type personal document should be created to place annotations in between the segments. At the same time, Notebook personal documents are used to gather information from different library materials. The Personal Document Editor lets the user create Notebooks containing both the personalized shallow segments from multimedia library materials as well as the user-defined annotations. Figure 8 shows a snapshot of Personal Document Editor with an opened notebook which contains shallow copied text, image and video segments together with user's annotations. When a segment from a library material is copied, a reference link is appended to its end allowing the user to navigate the original source at any time. Image, audio and video shallow segments should be created from relevant editors before inserting them into a notebook. In the current implementation, shallow audio/video clips are indicated by special icons. When the user selects them, they are played on a popup window.

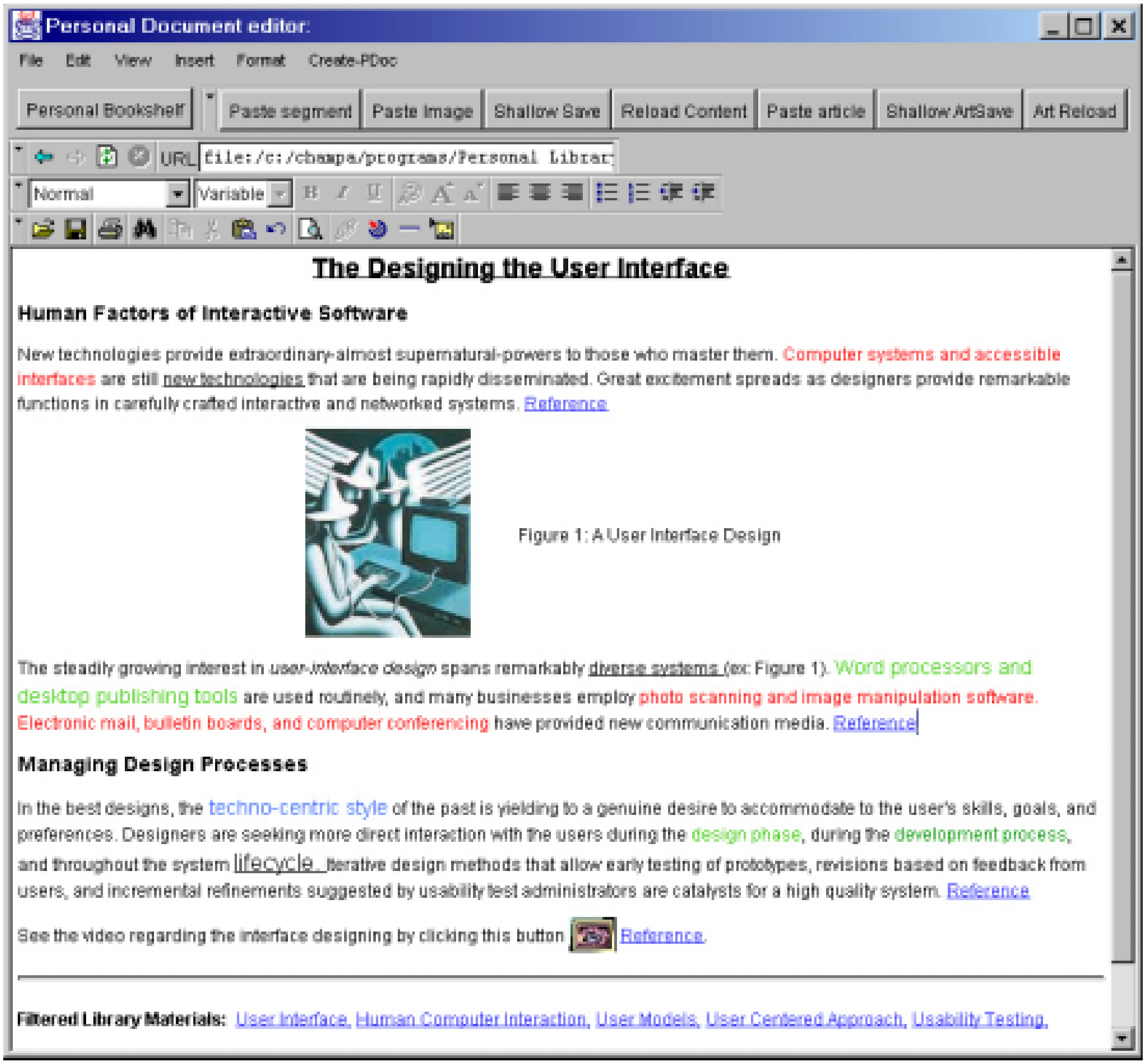

Figure 8: A Notebook

TOOLS FOR INFORMATION SEEKING

The main emphasis of information seeking is to allow people to locate relevant information sources in a diverse world of information. Tools for information seeking must be relevant to the user's learning requirements in order to enhance the learning process.

In PIE, tools for information seeking are based on the collection personalization, which is aimed to define a personalized view of the organization of library materials. This reduces the information overload encountered in a dynamic digital information environment. The success of this collection personalization mainly depends on the way in which the learner's information needs are captured and maintained during the usage of the digital library.

As described earlier, the personal documents provide a mechanism to personalize the library materials depending on the user's learning requirements and interests. Those personal documents represent how the user has acted in browsing the digital library. Therefore, interests can be identified by considering the contents of all personal documents and the current learning context can be identified by considering the original sources or links. Two types of knowledge, content-based knowledge and context-based knowledge are realized by analyzing the contents and links in personal documents. A separate profile is maintained for each personal document describing content-based knowledge and context-based knowledge. Using all these data, an interest profile is generated at regular intervals. Personalized retrieving and personalized filtering are the main benefits provided in collection personalization. All profiles of the personal documents, the interest profile and the history file (which contains the learner's access information) provide the required information for the success of the tools based on the personalized retrieving and filtering processes.

The content-based knowledge of a personal document represents a set of keywords, phrases and meta information about images, audio and video segments. The actual contents of each textual shallow segment and user's comments in a personal document are sampled to determine these keywords. The phrases are determined by analyzing the structure such as headings, sub-headings and section headings, and also the formatted text fragments. These phrases provide different semantics than the set of keywords of the relevant personal document. The semantic information about image, audio and video segments is determined by analyzing the meta information of corresponding library materials. In addition, if there are some comment segments associated with those audio-visual segments, they are used to determine corresponding keywords for audio/video data in personal documents.

The context-based knowledge of a personal document in its profile describes the corresponding contexts of a personal document in the digital library. These are identified based on the original sources of each segment in the personal document and also based on the hyperlinks placed inside segments. This contextual information is classified based on the media types of segments and used by personalized retrieving and filtering processes to identify the categories of library materials in the digital library properly.

Personalized Retrieving

In a digital library, a learner specifies a query using the retrieval tool given to search the library materials. Generally, such a query is a collection of words with Boolean conditions or a phrase with some semantic meaning. Queries are passed to a library search engine without any consideration of learner's current information needs, resulting in a questionable list of resources.

Personalized retrieving is an enhancement of normal retrieving facilities using the information found in profiles of personal documents and the user's interest profile. The user's learning context is determined using currently opened personal documents. It is done at two stages. First, when the user specifies a query to retrieve some information, the query is modified interactively using the information in profiles to satisfy their current information need. The corresponding contextual information in profiles is used to identify the relevant categories on which the searching has to be done. Secondly, the retrieved results are presented according to the preferences described in the profiles. Figure 9 shows a snapshot of the retrieval tool in the DL Browser.

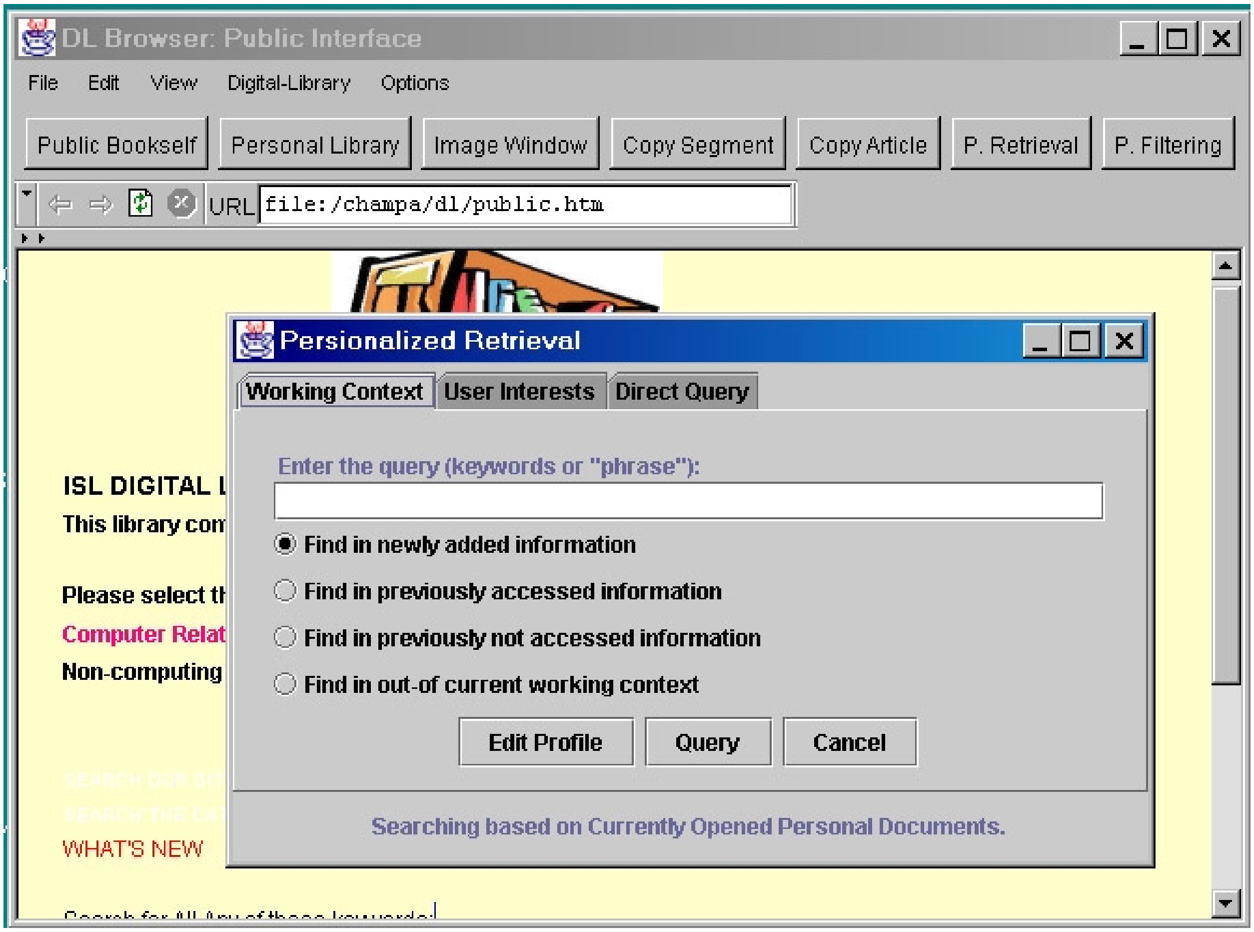

Figure 9: The Personalized Retrieval Tool in DL Browser

Personalized Filtering

Information filtering systems can help learners by eliminating the irrelevant information. They are mediators between the sources of information and the learners. Personalized filtering is also a process of filtering based on not only the long-term interests but also the short-term requirements. (Jayawardana et al.2001)

Generally, there are three stages in the filtering process: (a) obtaining the user's interests and requirements, (b) identifying the most suitable information sources, and (c) presenting those results to the user at the right time in a user-friendly way. Personal documents and their profiles work as the foundation for these three stages of filtering. Personalized filtering is carried out based on each profile as an automated background process whenever the profile is updated significantly. It can also be requested periodically by the learner. Keywords, phrases, meta information about images, audio and video, and contextual information in the profiles are used to obtain the learner's interests and requirements. The filtering process is performed based on these interests and requirements. The filtered library materials are recorded in the profiles themselves and they are presented to the user at appropriate time. In our current prototype system, such filtered library materials are listed at the bottom of personal document as shown in Figure 8.

CONCLUSION

Today, active learning is a highly discussed issue since it brings students into the process of their own education taking them beyond the role of passive listener and note taker, and allowing the student to take some direction and initiative in classroom instruction. (Lorenzen et al. 2001) Web technologies will grow and mature, and learning through the World Wide Web will become increasingly popular particularly in distance education systems. Teachers can distribute lecture notes and other required materials via the Web. Learners then get the opportunity to use learning materials freely and independently, collecting other related materials on the Web as well. (Dodge 1996)

When it comes to active learning with audio-visual digital materials, the interaction comes from listening and watching activities, and tools are necessary to enhance the process. Correia and Chambel (1999) present an interesting work on the active watching of video materials. It considers that annotations also have temporal and spatial dimensions when they are integrated with video data, though annotated segments could be different media types. An annotations set which contains all user specified comments in a separate file, is integrated when the video clip is played on a special player. Different annotation sets (with respect to different users and multiple versions) are maintained in a single video source. In our work, video annotations are temporally fixed but spatially distributed in a personal document. In some other studies such as Sgouropoulou et al. (1998) and Wilcox et al. (1997), there are descriptions of how different types of annotations are integrated with audio and video data. WebOrama is a multimedia annotation system illustrating client-server architecture for asynchronous annotation sharing, but it does not discuss user interface issues. Other authors, Davis and Huttenlocher (1995), and Furuta et al. (1997) also focus on the collaboration of shared annotations with hypermedia for learning activities.

The work discussed in this paper considers both active reading activities with static digital library materials and active listening/watching activities with audio-visual library materials. Active consuming is a composition of active reading, active listening and active watching. At the same time, active learning goes beyond providing annotations on library materials. Tools are provided that play an important role in improving activities in any learning environment. They are built on a single framework called personalized information environment (PIE). Library users can then construct views (personal documents) on top of library materials. Tools for information seeking, which capture meta information from segments in personal documents to improve searching and filtering, are used to locate library materials in a particular learning context.

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