SmartCourier: An Annotation System for Adaptive Knowledge Sharing

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Abstract. SmartCourier is a Web-based system for browsing electronic documents shared by a group of people. It allows users to annotate the documents with a freehand pen interface and share the annotations among users having similar interests. The system recommends shareable information such as annotations to users based on their inferred interests by using a collaborative filtering method.

In this paper, we briefly describe annotation as an information sharing method for awareness based on historical background and related researches. Then, we describe our experiment and discuss the use of SmartCourier systems for academic exhibitions and laboratories.

Introduction

Recently, the rapidly developing WWW environment has brought about major changes in information use and cooperative work. A great deal of creative work involving intellectual inspiration [7], such as research and learning as well as research on supportive network environments, has been performed. To manage appropriately computerized information for use as knowledge and to develop a use environment adaptive to the situation of each user is important. In this paper, we describe two SmartCourier systems that support adaptive information acquisition and knowledge sharing beyond explicit small groups of people. These systems work by extracting information on a user's interests from the annotation activity on electronic documents.

SmartCourier for JSAI2001 was developed first, and provides personalized information related to an exhibition tour, depending on situations such as participation and the interests of users at an exhibition site. It supports knowledge sharing among the participants and effective information acquisition. In this way, the developers of SmartCourier aim to accelerate circulation of knowledge and creation of knowledge for users participating in exhibition tours. This system provides adaptive services of information recommendation and annotation sharing. This is done by extracting users' interests from the annotation activities on the computerized proceedings provided at an exhibition site.

SmartCourier for Research Labs is a re-designed version of the first system based on the knowledge and results obtained by using the former system. This new version provides

adaptive paper recommendation, matchmaking of users having similar interests, and annotation sharing services. This is achieved by extracting context information such as interests and research purposes from researchers' annotation activity. The main differences between the original and the new version are improved usability and diversification of the user modelling method. Consequently, the new system supports effective information acquisition and knowledge sharing, and we aim to activate it for the research and learning community to stimulate intellectual inspiration.

In the first section, the annotation, related research, and positioning of this research are discussed. In the second section, we describe the intellectual inspiration support system that uses the annotations, SmartCourier for JSAI2001, which was used at the 15th Annual Conference of the Japanese Society of Artificial Intelligence (JSAI). In the third section, we discuss the problems encountered and how we re-designed the system based on the knowledge obtained from the results of using it. In the fourth section, we describe the intellectual inspiration support system for the research and learning activity community that we developed based on the re-design ideas. This system is called SmartCourier for Research Labs.

1. Annotation for knowledge sharing

1.1 Annotation

"Annotation" can be defined as the activity of adding secondary information to a source document. It can be used on source documents for different purposes such as explanation, illustration, translation, correction, and comment. It has to common features the different purposes, e.g., annotation provides secondary information contents for source documents, and has expressive constraints. Specifically, the relation between source document and annotation should be secured by spatial nearness and diagrammatic representation.

Annotation of documents has been popularised by the process of information documentation and sharing.

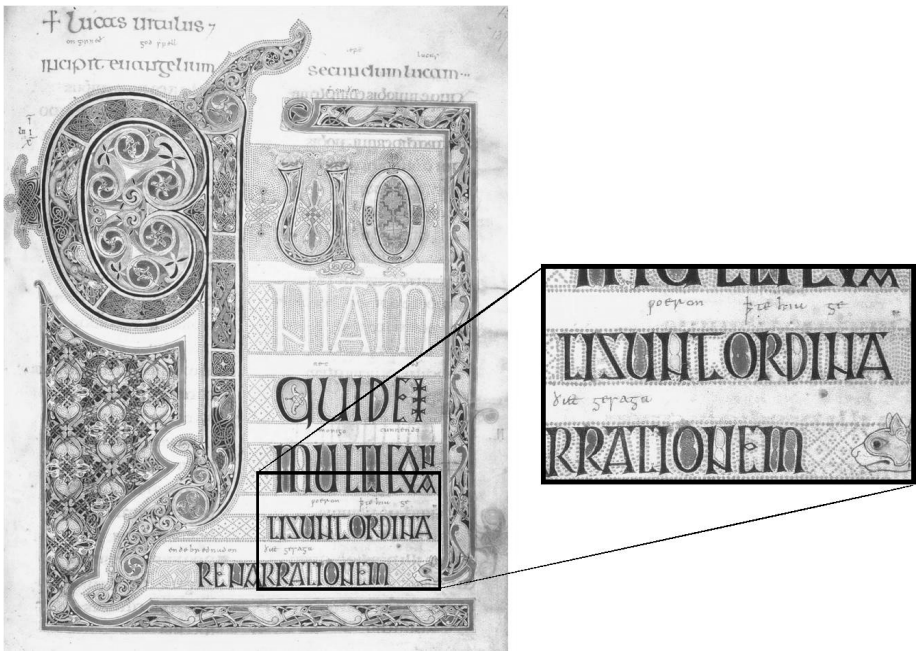


Figure 1. Example of interlinear glosses style annotation

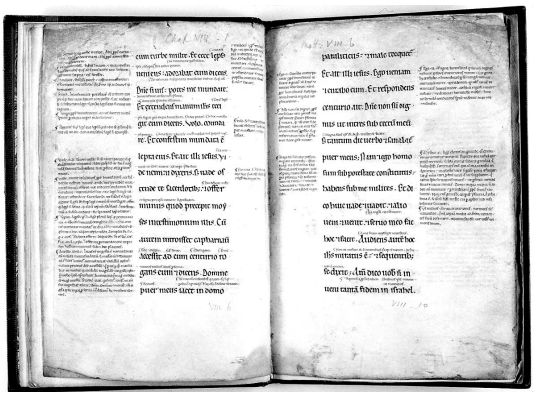


Figure 2. Example of column style annotation

Figure 3. Example of edited annotation

Figure 1 is an early example of literal translation from Latin into Old English as interline annotation in the Latin source document. Annotation such as the interlinear glossing style has a different expressive modality from that of replacing source documents with translated documents. That modality is adding supplementary information to enable comprehension source documents, while maintaining their uniqueness. Thus, it is effective for increasing their availability as unified sources of information shared between many persons, because the correcting of both kind of information by contrast is easily possible for each user, and the identity, accuracy, and legitimacy of source documents are also guaranteed. In addition, annotation can be called an effective expression form for finding supplementary information and its relation to a source at a glance. The latter can be observed by the difference in expression between the source documents and supplements, and the referent information in the source documents. Appropriateness and accuracy of information content are required for annotation to be effective as a shared source of information for each user. In figure 1, the Latin source documents date to about 700 and were written by Eadfrith, Bishop of Lindisfarne. Some 250 years later a priest, Aldred, added to a translation in Northumbrian Old English as an interlinear gloss the Latin documents so that accuracy for a reader is of Old English guaranteed. The sharing these documents is restricted to a privileged religious class with background knowledge near that of the priest who added the annotation, this was thought to be appropriate content of information.

Figure 2 is an example in which an interlinear gloss of translation (center part) and interpretive article (column) coexist. As the range of sharing documents was expanded and the number of readers increased, more comprehensive and detailed description corresponding to users with a variety of background knowledge levels was needed to helping them understand documents. This expression form of adding an interpretive article as column styled annotation that enabled providing much more information while accurately maintaining the source document becomes widely used.

Figure 3 offers an example in which two or more notes of explanation have been intermingled into documents. When the documents are shared among many users and each of them adds annotations, their contents are diversified according to different users' knowledge or opinions, and contents unnecessary for some readers are increased. To use shared information resources effectively, the editing of annotation, and opinion summaries, etc. are needed. This example is a summary of the annotation performed for every sentence by many annotators. The editor, He Yan, wrote annotator's summary describing the comments of other annotators such as Ma or Kong. He Yan was a special authority as the editor of both annotations and the source document. Then, readers can refer to annotations from many viewpoints of the document including that of the editor, and attempt to understand and interpret. Related information or interpretation of the document can also be chosen based on a suitable editor for readers' purposes.

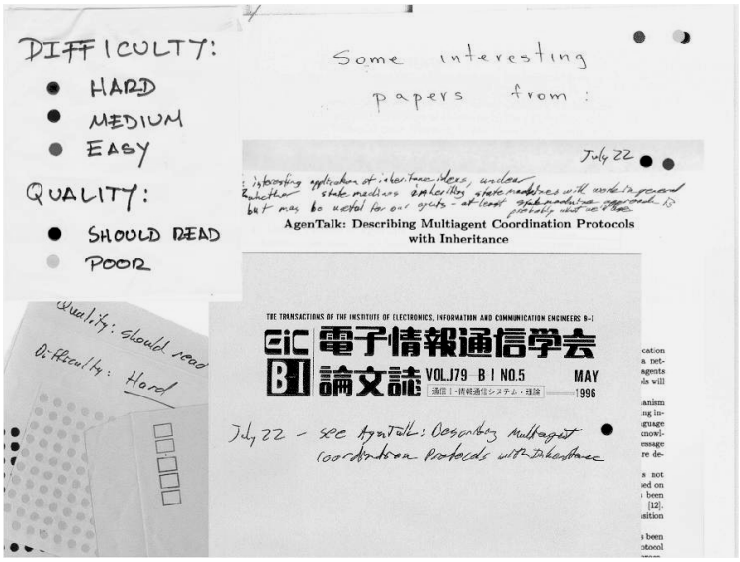


Figure 4. An example of information sharing by using annotation with evaluation indices

In modern times, flexibility of document sharing via paper medium with a writing instrument or development of the copy machine gave rise to the possibility of information sharing over distance with annotation. This also spread gradually, but was restricted by technical and economical conditions in the past. Appropriateness of shared information was maintained in a restricted range of writers and readers in past days. However, the unexpected expansion of that range brought about a reduction in appropriateness. Specifically, increases in the unnecessary information as a noise for users, such as annotations outside their area of interest, should be considered. When many users add their individual evaluations as annotations to a journal paper, if there are no similarity in evaluation signs and axes, understanding the evaluation of others is difficult. Then, the usefulness of annotation as shared information falls remarkably. As presented Figure 4, evaluation signs of the quality and annotations of the opinion were added and shared for a paper used as reference information in a laboratory to achieve the efficiency of information acquisition. By fixing an evaluation axis beforehand with stickers, the usefulness of annotated papers as shared information resources is maintained.

In the following paragraphs, we introduce related research proposed in the field centering on CSCW (Computer Supported Cooperative Work) about the problem accompanying the enlargement of the sharing range and the generalization of annotation. We also introduce the position of the awareness system SmartCourier in this field, which this paper proposes to clarify.

1.2 Annotation and user interface

There are two types of research related to annotation. One is based on the usefulness of annotation as shared knowledge, such as comments and ideas added on information resources such as lecture notes by users [2][5][13]. The other is based on the usability of pen and paper as interface on real books and documents [15]. In both types of research, annotation is understood as the activity of externalizing the relationship between users and documents by the user clearly adding information in a specified position on static document resources. Here, the term position indicates character strings and images that are subject to annotation, and added information indicates the meaning and existence of a relation in user-documents such as a mark showing the grade of importance of an item to likely users. GeoNotes [3] and TeamSpace [12] were research using positional meanings except annotation on documents.

Such kinds of annotation do not depend on a pen-based system. Many studies have been made of systems that install a text-tag at a specific position of the visible HTML on the web browser. These types include CoNote [5] and ComMentor [13]. However, the problem is that such methods inhibit various expressions containing information other than the text that is made possible by the free pen-based system.

The study of the computerized versions of documents that contain the typography[1] found in real books and texts, such as XLibris [15] and Adobe Acrobat®, attempts to increase the usability of electronic documents by making various expressions of pen annotation recordable, as an addition to the usual way of writing them down on paper. This kind of annotation has the advantages of overall visibility and a high visual effect because this intuitive input can be shown in high contrast to the document's typography, and this attracts the attention of readers. In this study, we adopt as the basic system handwritten annotation with the pen user interface, which has higher usability than HTML-based system.

Studies and software that emphasize usability, such as XLibris and Acrobat®, tend to focus on the personal use of annotations. On the other hand, in CoNote [5] and eClass [1], designed for educational activities, annotations on data documents, lectures and assignments, are considered useful shared information resources. Sharing this information through the Web between teachers and students has been shown to aid understanding and promote discussion of these documents among students [5]. NotePals [2] is another system that uses annotation for knowledge sharing in a group on a smaller scale. NotePals promotes sharing ideas and knowledge inside a group by sharing handwritten notations via Personal Digital Assistants (PDA), such as the PalmPilot®, equipped with a pen user interface.

Writing down notes on paper or a whiteboard has no limitation on the ways of writing and expressing, making it possible to represent a variety of expressions. Therefore such writing provides an effective complementary communication tool for small groups that share background knowledge such as common interests and purposes. Furthermore, applying this approach in a real-time communication environment that also incorporates audio and visual communications is useful for transmitting and organizing concepts that are difficult to explain clearly in text [4] [10]. However, memos and whiteboards are inappropriate as information resources that are continuously shared. This is because the annotations, as well as the information related to the background and intentions of representations written down on memos, are not available to users who do not have the common background knowledge and/or a real-time communication environment. For readers of books and documents, writing an annotation or memo is a familiar activity, and marker pen methods such as underlining or

[1] Typography is a general term of visual appearance on paper surfaces such as typeface, composition and form.

highlighting are empirically understood. However, the concrete differences between the meanings of such representations and those of other types of representations are unclear.

Marshall researched examples of annotations found in secondhand college books in the real world [8]. As a result, underlining, highlighting, boxing a sentence word (with a circle, square or parentheses), asterisking, marking an arrow, linking between markings, and, other notes and illustrations were obtained. Markings are used for recording important points, and notes are used for writing interpretations of sentences and answers to questions. For purchasers of secondhand books, the notes giving answers are valuable at a glance, but the meanings of symbols and marks showing the grade of importance are difficult to understand. Generally, evaluating the significance of an information resource is useful for efficient information acquisition. However, this kind of information is not effectively used as an information resource for sharing in terms of evaluation because the annotation is written in an individual free-hand form and subsequent readers cannot understand background knowledge such as the scale of importance and complete meaning of the annotation. The diversity of expressions and difficulty of sharing them are shown in our previous research [6].

1.3 General purpose of this research

Existing research related to annotation focuses on the personal use of electronic documents [15] and on supporting knowledge sharing by explicit small groups having shared background knowledge [1] [2] [5] [13]. Knowledge sharing by annotation is difficult due to the problem of interpreting annotations marked by free expression of comments and ideas as well as evaluation of importance made by users who have different background knowledge such as interests and purposes.

First in this research, we build a user model that automatically represents users' interests by the free expression of annotation on electronic documents. From the similarities found with this user model, we extract the potential communities that share interests. We then find the most appropriate forms of information acquisition and knowledge sharing, such as recommending electronic documents and sharing annotations. In this way, we support heuristic knowledge sharing among users who potentially share background knowledge such as interests. Furthermore, we aim at the activation of the research community, which involves intellectual inspiration.

2. SmartCourier for JSAI2001

In this section, we describe the SmartCourier for JSAI2001, mounted as a subset of the Digital Assistant system [16], that supported participants' site tours and communications at the 15th Annual Conference of JSAI, from May 22 through 25 in 2001.

2.1 System overview

Figure 5. SmartCourier for JSAI2001: in service at exhibition hall

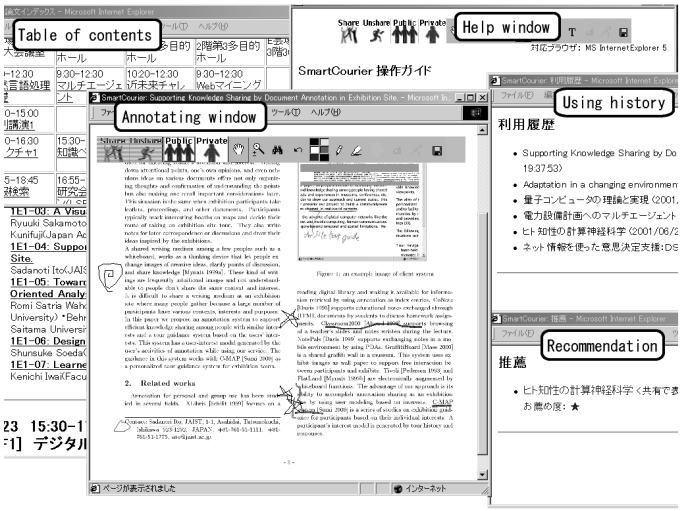


Figure 6. System images on video tablet

The Digital Assistant is a service that provides personalized information related to an exhibition tour according to the interests and browsing activities of individual participants. The purpose of the Digital Assistant is to support efficient information acquisition, knowledge sharing and community formation, and to promote knowledge expression and knowledge creation through participation in the exhibition tour. The system is composed of video tablets and large displays installed at information kiosk terminals in the hall, PDA terminals given to applicants, and Web services. For the same purposes of efficient information acquisition and knowledge sharing support, SmartCouriear for JSAI2001 mainly provided the service of facilitating handwritten annotation on electronic documents provided for the readers of proceedings. The source documents were provided via video tablets installed at information kiosk terminals and the Web (see Figure 5 and Figure 6). Users were able to chose and refer to theses from a list in the conference program provided with the Digital Assistant service. They could also leave annotations on the theses by using a free-hand pen interface. This system works on a Web browser with the basic functions of zooming in on and out of the presented papers and selecting the colors and sizes of pens and ways of writing and undoing. As functions to improve the reusability of annotations, we implemented ways of presenting a list showing annotation history and of retrieving annotations by using the shapes of strokes.

2.2 Functions of recommending papers and annotation sharing

At an exhibition site, communication among participants who have similar interests is an effective way to elicit intellectual inspiration. At a large site, however, the problem is this effect tends to be temporary. Because many participants having various interests pass through in a short term, the formation of communities among participants occurs by coincidental encounters. To overcome this problem, constructing a system for appropriate knowledge sharing of participants' interests and an environment that adequately supports communications is necessary.

Therefore, we developed a user-interest model from the reading history of computerized proceedings and the locations of annotations handwritten via a pen-interface. Moreover, we constructed the functions for annotation sharing among users with similar interests and for recommending unread papers based on users' interests. The purpose of these functions is to promote knowledge sharing and intellectual inspiration among the users present. This is made possible by efficient information acquisition, by recommending papers, and by asynchronous communication through sharing annotations on computerized papers among users with similar interests.

Furthermore, because some annotations could be inappropriate for sharing, users can select a public or private mode when they input them. Therefore, how the system is used depends on the user's purpose. The asynchronous communication among users is achieved by sharing the annotations written in the public mode.

2.3 System architecture and implementation

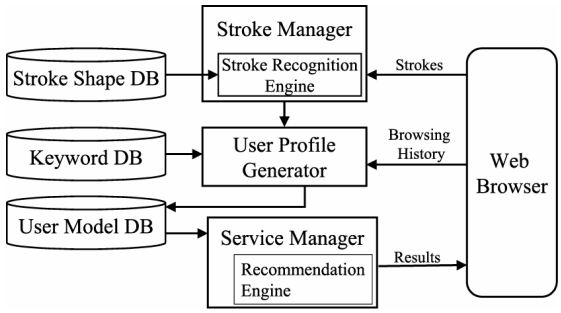
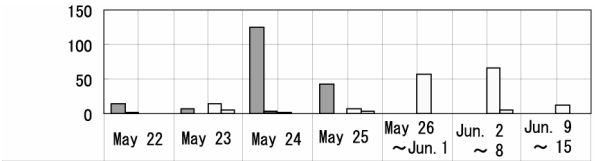


Figure 7. System overview



	May 22	May 23	May 24	May 25	May 26 ～Jun. 1	Jun. 2 ～ 8	Jun. 9 ～ 15
Use at hall	15	7	125	42			
Rec at hall	2	0	4	0			
Use via Web	0	14	1	8	57	66	12
Rec via Web	0	6	0	3	0	5	0

Figure 8. Number of times system started and annotation saved

This system consists of a server machine running databases and CGI programs and a JAVA Applet client running on a Web browser at the information kiosk terminals (see figure 7).

Two indexes were used for judging the similarity of user interests. One was to obtain a user's interests from his or her paper reading history. On the papers published in the proceedings, a keyword set indicating the realm as selected from the sponsor's examples is an established procedure. Similarity of interests among users was judged by the keyword set of the papers that the users read. A keyword vector was generated that indicates the user interests.

The other index was based on a common location of annotation. Users who left an annotation at the same location on the same paper are assumed to share interests, and the number of positional commonalities of annotation implies similarity of interests. From the size and shape of the stroke, we selected the stroke judged as the marking area of the document. If there was a duplicated part, we counted this as a positional commonality. For recognizing the shapes of strokes, we used the gesture recognizing algorithm of Rubine [14].

For the recommending and sharing function, we listed and displayed those annotated papers obtained with indices described above and the hypothesis that a paper that is read and annotated by users who have higher similarity has a higher importance. Each index was considered in isolation. Another sign that shows the degree of recommendation for every similarity index was then prepared. A user chooses an index sign and a recommendation list is displayed according to the index.

2.4 Results

The exhibition session used in our experiment was for four days. During that time, SmartCourier was started up a total of 189 times: 15 times the first day, 7 the second day, 125 the third day, and 42 the fourth day (see Figure 8). The total number of times annotation was saved was six. Also, the total number of times SmartCourier was started via the Web was 23, and annotations were saved 9 times. After the session, the number of times the system was started up the system via the Web was 57 times the first week, 66 the second week, and 12 times the third week. Annotation was only saved five times during the second week. Questionnaire was returned by 37 users of the Palm Guide on the Digital Assistant. Of the 12 respondents who used SmartCourier, 5 answered that it was effective, 1 answered ineffective, 5 answered neither and 1 did not answer. From the system log, we researched whether the recommendation function was effectively performed. The six requested paper recommendations were all performed with the user model constructed from the reference history, and none of the recommendations were made based on positional commonality. According to this result, no sharing of annotations occurred. This will be analyzed in the next section.

3. Discussion of problems and re-designing the system

In this section we clarify the problems from the performance result of SmartCourier for JSAL2001. We also explain how we re-designed the system to solve those problems.

3.1 Utility problem

The performance results revealed that the rate of using the system and the rate of recording the annotations were both low, despite the total number of times counted for starting up the system. Despite our desire, use of the system for recording ideas through participation was not as frequent as we had assumed. The problem was most likely due to the system being inferior to the paper medium in terms of portability because the information kiosk terminal available for this system was confined to the exhibition hall. For general annotation where intuitive and vague ideas are noted instantly, to have immediacy of recording in addition to reusability and a free expression form is important. In contrast, that a bigger machine is required in order to display images and texts is a problem. The reason for this problem is that the information kiosk

terminal is limited to being used on a desk. Therefore, we think constructing a high-availability system that is adaptive to various usage styles by adding the higher portability of an input device such as a PDA is necessary.

From interviews about why the number of recorded annotations was low, users answered that they did not notice that the save operation was required. This problem was that when the interface of a system is constructed based on a metaphor imitating actual pen and paper, the save operation, which is not inherent to this metaphor, is not intuitive. In this system, due to network requirements, an explicit save operation was obligatory. However, such a prolix operation should be processed inside the system, and the user interface must adhere as closely as possible to its model for the system to support an intuitive action such as annotation. Accordingly, we automated the save processing and adopted the method of saving the stroke data continuously.

3.2 Problem of user modelling

On this system, the recommendation service was provided by extracting user interest from the reading history of papers and the positional commonality of the annotations. However, no one used recommendation by positional commonality. In the recommendation system using the knowledge of others and the user model, providing quality recommendations there is certainly a problem when starting the service. For that, annotations were made as accessory data by a few developers before starting exhibit, but the positional commonality only used twice even when it included data, and it did not provide an effective recommendation service. This was caused by the problem that not enough use was obtained to make possible appropriate matching among users by simple positional commonality, even though about document 500 pages were opened during the short term of four days.

The availability of user modelling by positional commonality is assumed to be dependent on the purpose of the system and type of the objective documents. This system is effective, for instance when a user must know another's comments on a description of a specific paper, when the objective documents are used as a textbook over a long-term period, and when the paper's space is limited, such as on small maps and talk programs.

In the next system, user modelling by using keywords of the annotated text will be used at the same time as the constructing of the user model that captures the user annotation activity as more detailed segments.

4. SmartCourier for Research Laboratories

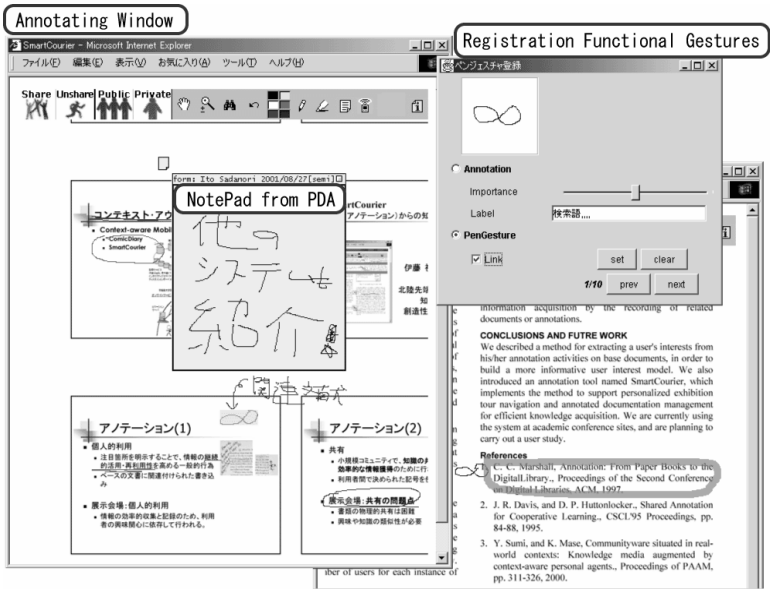


Figure 9. SmartCourier for Research Labs: system image

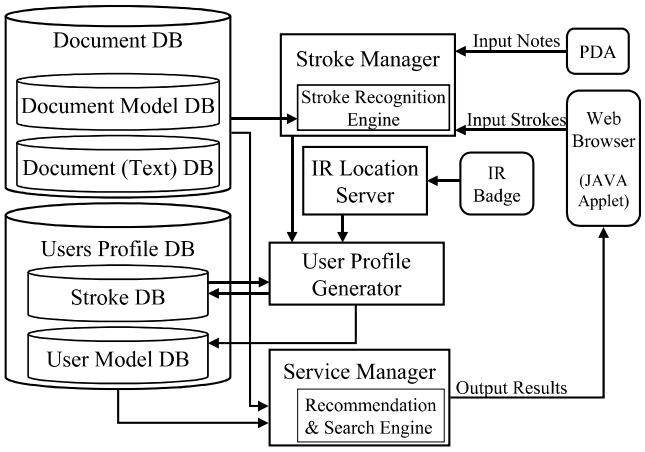


Figure 10. SmartCourier for RL: system overview

4.1 Purpose

SmartCourier for Research Labs provides on annotation sharing service, matchmaking of research coworkers who have close interests, and appropriate recommendation of related papers by extracting contexts such as interests and research purposes from annotation activities, subject to the research and learning activities of users. These services can support efficient information acquisition and knowledge sharing. Furthermore, we aim to activate intellectual inspiration of the research and learning community. This system is constructed of Web service and personal information input devices such as a video tablet that allows input with a pen and a PDA. From each terminal, users are able to read and share information resources and also receive information acquisition and knowledge sharing service based on their interests.

Writing down annotations on paper documents is a useful and common function in typical research and learning activities [8].

In the instance of a researcher's work, shared annotation is used as a method analogous to using papers with shared information resources. Prepared evaluation stickers are classified into a few grades by a paper's quality and difficulty. Then some comments are left and a sticker is

placed on the read paper in the shared stacks (see Figure 4). However, in the case of making annotations directly on shared documents, the acceptable area for writing them is spatially limited. Also to write down disapproving comments is psychologically difficult. Therefore, that self-consciously using a rule such as prescribed stickers restricts free annotations is assumed.

In the following section, we describe the adaptive knowledge sharing environment supporting research and learning activity by handwritten annotations (see Figure 9) keeping in mind the results of the pre-research and the observations such as portability and user modelling from SmartCourier for JSAI.

4.2 Summary of system improvements

For the problem of mobility that was revealed from the results of using the former system, the newer system provides a service in which a PDA （PalmPilot®） is positioned as a tag available to put on electronic documents, in addition to the stationary video tablet. For the knowledge creation activity, it has been repeatedly mentioned that the location where cooperating workers share the context (called "ba") is an important factor [11]. With this service, in addition to the highly mobile PDA terminal, information recording is supported at various sites. This is done by cooperating with the lecture room reservation system of our school (JAIST) from which we acquire information such as entering day, time and place, and lectures attended. From this information, the system supports use of annotation information by putting tags on lecture documents and their related documents, or the information is used for smoothing management on a simplified tag. For example, information sharing among users attending the same lecture at the same time, would allow organizing of the information according to the context.

Also, the problem of the save operation, an unfamiliar interface feature for the metaphor of pen and paper, has been solved by improving the program, by such means as changing the server to progressive connectable JAVA.

As for the problem of the user model's suitability, on systems not only subjected to non-consecutive massive groups but also to relatively small-scale consecutive groups, the same problem could occur when a great number of documents must be handled. Therefore, we adopted the following method to extract important keywords from marked texts and use a weighted keyword vector as the model of user interests according to the frequency of markings and the kinds of signs used (see next section).

4.3 System overview

This section describes some of the system modules (figure 10).

4.3.1 Development of document data base

In order to accurately extract texts based on markings by users, correspondence must exist between the external expression of the paper surface, which represents image information, and the internal expression representing texts and logical structure. The logical structure is the information indicating the absolute coordinate and area of each text item on the paper surface. These analyses and conversions are processed by heuristics from a PDF file (It is analyzed on the assumption that it is formatted for any journal, and its automatic processing depends on

whether it has version and text.) Also, to reduce the system overload in providing service, keywords are extracted when creating the database and the result is recorded as an internal expression. Here, keywords are nouns extracted from documents by using the Japanese language morphological analysis tool, Chasen [9]. Furthermore, overly general nouns are eliminated and technical terms are added to the analysis dictionary.

4.3.2 Personalization of the system and registration of pen gestures

We found in the previous research [6] that users choose particular kinds of pens and signs for marking depending on their purpose. The explicit use of expressions depending on situations could be an important indicator in developing the user model, but because uses depend on situations and are different for each user; recognizing this automatically is difficult. The degree of using annotations differs depending on conditions such as the user's desired immediacy of use. Therefore, some users could actively handle various expressions skilfully for document collecting and information management, while others might just underline important parts. This diversity is one reason why information sharing by creating and using rules, such as shared stickers and signs, is difficult. In this system, to suit various use styles and to develop a more appropriate user model, we deal with this problem by establishing the kinds of markings and meanings that can be registered in the system. The meaning of a marking has one of five ranks of importance, and phrases for searching can be freely defined. The indicator of importance is used for user modelling as well as for information searching by users. For instance, one might use this expression for searching: "a marking that was ranked as the most important (five of five) and defined by the phrase 'key technology'."

As functions for document resource management related to research and learning activities, dynamic functions can also be defined in addition to static semantics. Currently, this system has the function of dynamical link creation. Links are creating by starting up two Web browsers with this system and inputting two link signs defined by a user on different documents; this dynamically creates hypertext. (The first can be registered as the second sign is input.) Using pen gestures with linking functions is necessary to make this distinction clear when the pen stroke is distinguished by the digital ink as shape data. For the pen interface, we assumed that since there could always be some errors in either input or recognition, to have a method that allows input errors and that does not disturb the input operation is necessary. When dynamical functions recognize the pen input as a defined stroke, we adopt a method that displays reverse imaging around the stroke as well as the names of functions. If there is no problem with the display function, the display can be cancelled by continuous inputting, except for the reversed image.

4.3.3 Annotation recognition and user model

In order to represent the user-interest with the keyword vector, appropriately extracting the text subjected from markings of handwritten annotations on documents is necessary. Here, by using following the processes, texts are extracted from input strokes.

1. Location determination: eliminate strokes except for those inside the text area and the adjoining strokes.

2. Size and shape determination: eliminate strokes smaller than the font size. Eliminate strokes except for the default stroke shapes defined from the results of the pre-research or user-defined stroke shapes.

3. Marking area determination: determine the marking area of underlines and enclosing shapes.

4. Marking area correction: when the marking area such as parentheses and signs is not explicit, refer to the logical information of the document database, so that the entire continuous adjoining sentence is defined as the marking area.

5. Extracted text correction: when the marking area is discontinued on a word in the document model, that whole word is determined as a completed marking.

6. Re-marking area correction: when the determination shape is the same and also a single sentence from the logical structure of the document model, continuously input strokes are determined to be a continuous marking.

The text extracted with the processes mentioned above is determined as the text marked by users. From that, choose the ruled keyword at the database creation, and create the keyword vector to be the user interest model. At this time, if there is a defined stroke of importance input by the user, place a rating of its importance following it.

The matchmaking service lists the group of users having a higher similarity of user interest model, which is the calculated from the similarity of keyword vectors by a cosine correlation. In the paper recommendation service, the papers with marked as having a higher grade of importance are extracted by the user group having a similar user interest model. Then, unread papers are listed in order for those who receive this service. In the annotation sharing service, likely candidates are chosen by listing users who leave annotations of a higher grade of importance on recommended papers and by listing the history of writing by users introduced by matchmaking. Each index in the listing is treated in isolation. The display method is the same as that used by SmartCourier for JSAI2001.

4.4 Experiment

4.4.1 Purpose

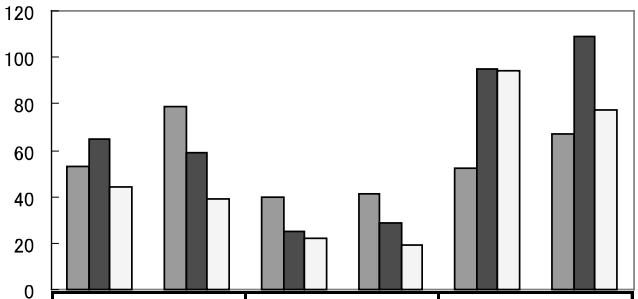
Two kinds of SmartCourier systems are proposed in this paper. They are aimed at supporting the activation of research and learning activity by intellectual inspiration through adaptive information sharing in an environment where an unspecified implicit community annotates documents. In this section, we examine the effect of such SmartCourier services as paper recommendation and matchmaking on the research and learning community.

4.4.2 Experimentation environment

An experiment was concluded with 20 experimental subjects in 5 groups: master course students belonging to laboratories A to D, where each group is an independent explicit group,

and group E, doctor course students with research associates of Lab A[2]. As documents for reading and annotation, we chose computerized proceedings of the 15th Annual Conference of JSAI, and the subjects used the system via video tablets or their own Web terminals. In the experiments, after explaining the functions of the system to the subjects, we had them select papers as subjective reading that was related to their own research, learning tasks, and interests. They could choose from all of the computerized proceedings without limitation. Then, we had them read those papers and add annotations[3]. Paper recommendations were made for ten papers and matchmaking for five people, which was limited. This information was provided to the subjects.

4.4.3Results and discussion



	recommendation		matchmaking		annotation sharing	
method	old	new	old	new	old	new
yes	53	79	40	41	52	67
no	65	59	25	29	95	109
unknown	44	39	22	19	94	77
total	162	177	87	89	241	253

Figure 11. Results of questionnaire in blind test

Table 1. Results of matchmaking

	unknown user	known user
inside the group	4	6
outside the group	24	7

The number of papers browsed by the experimental subjects was 75 of 231. That comes to an average of 3.75 papers read by each person (minimum 1, maximum 13). The number of twice-selected papers recorded was 17. This data illustrates that the experimental subjects engaged in information acquisition activity according to their individual interests. The total number of recorded annotations was 144 pages. That comes to an average of 7.2 pages noted per person. The average number of kinds of pen colors and signs used was 4. The kinds of pen input used were mainly based on object classification and semantic contents, such as definition, problem posing, related papers, and names of researchers. Six users left memos and illustrations in

2 Number of people in groups; A: 5, B: 4, C: 4, D: 3, E: 4. first year master course students: 9, second year: 7, doctoral course students: 2, research associates: 2. humanities course persons: 6, science course persons: 14.

3 For convenience in implementing the experiment, the available time for reading was limited to one day, but reading time could be extended on request. Also, subjects had to read and write in the same area as the information acquisition activity that is typically performed by them in research and learning.

addition to markings, and the contents of these were mainly comments on paper contents, indicating questions and noting the figures in papers.

The number of subjects who did not annotate documents in their usual research and learning activity was 6, and few of them used any specific kind of pen input according to the situation (2 to 1 kinds were used). There were big differences in the style of using the system between those 6 users and other users who annotate in their usual research and learning activities. We believe that adding additional functions, such as defining the importance of strokes and developing a user model from multiple information resources, provided significant utility. This is because such functions can increase the accuracy of the service while flexibly corresponding to the various requests of users.

The results of a blind test with the old and new methods are shown in Figure 11. As for paper recommendation using the new method, a total of 177 papers were recommended. The following evaluated result was acquired. Papers that are interesting and unknown, that cannot be acquired in general information acquisition, accounted for, on average, 4 papers per experimental subject. The number and ratio of valid recommendations appears to indicate superiority of the new methods.

For paper recommendations using the new method, the correlation of amount of annotation activity and appropriate number of recommendations was expected. However, the correlation coefficient was -0.10, because the keyword set extracted from the annotated areas was used for user modelling. In contrast, for groups of master course students A to D, but not group E, research associates and doctoral course students, the correlation coefficient was 0.50. In interviews with group E, the following comments were obtained. “Participated in the conference of JSAI2001, necessary documents (in the proceedings) have already been checked out”, “Not my field, but near my field.” Those comments indicate that although the number of annotations and browsing of papers was larger for this group, the evaluation for recommendation was low. That is to say, support from the recommendation system was limited for users whose research tasks and field are clearly set, and also for those who have sufficiently high information acquisition skills.

On the questionnaire asking whether the new or old method gave the most appropriate recommendation, 13 answered that the new method did, 2 answered the old method, and 5 answered no difference was noticed. About the new method, the following comments were heard “because many recommendations from other fields overlapped my interests even if only by a little,” “because I felt that the recommended papers were from a wider field than that of A (old method).” This is a good result in terms of this system's purpose of supporting intellectual inspiration. From subjects who answered that the old method was better, the following comments were obtained. “Its accuracy is higher than that of B (new method),” “because the information amount was narrowed down by A (old method).” However, this differs from this system's purpose because the old method recommends using positional commonality and regulated keywords on read papers, so one can that subjects who had a sense of purpose “to search other papers in my same field,” evaluated it as good. Opinions from experimental subjects answering that there was no difference, were “a paper that seemed to be good was recommended by both methods,” and “could not recognize any difference at all.”

On matchmaking and annotation sharing, no great difference between new and old methods was obtained in the results of the questionnaire. On matchmaking by the new method, about 41 of 89 respondents said that they were sharing the same or similar interests even if there was little sharing. At this time the service was provided with no confirmation of whether they already knew each other. Regarding this, one question asked whether they already knew the research subjects of the introduced users (see Table 1), and 28 of 41 respondents answered no. Furthermore, 31 of the 41 subjects who favourably evaluated the matchmaking were introduced from outside their group. Also, the number of people inside the same explicit group

who were introduced only reached 10. About experimental subjects outside their group, 24 of 31 those matched were unknown users, and although many experimental subjects did not know students and researchers outside their explicit group, many cases of matchmaking were successful outside that group. In these experiments, 6 of 20 subjects were students and researchers in the humanities. Concerning the relationship between humanities and science, matchmaking and paper recommendation were successful through papers involving socio-psychological content such as community and conversation analysis. No difference in humanities and science was found in the results of evaluating recommendation and matchmaking. This indicated that this proposed system could be used for knowledge sharing beyond explicit communities.

On annotation sharing with paper recommendation with the new method, an average of 1.3 people for annotation sharing, were listed with each recommended paper. Experimental subjects answered that useful information was given by others' annotations at an average of 3.4 papers. As impressions of participating in the experiment, many commented that other's annotations were useful for understanding the outline of papers; these comments included: “it was easier to skim recommended papers by consulting underlines.” On the other hand, there was an opinion that, “It was difficult to understand papers by only looking at others' markings.”

Taking a dominant position, a doctoral course student commented “not a noteworthy point” on the annotation of a master course student. On the contrary, other comments were, “the comment form the doctoral student made was helpful for preparing the proposal (of the master course student)” and “(the first year student) understood the purpose of the system in open testing by the second year master student.” Consequently, communication beyond that of people belonging to the same labs and courses was observed. The communication resulting from using the system began within the annotated papers, but no communication related only to the content of papers was observed. As mentioned in the examples above, communication focused on topics such as the activities and roles of experimental subjects in the real world. This time, the information inside the college influenced the expansion of conversation topics. In this sense, one can assume that keys such as expansion and continuity of conversation topics about the communication process represent different aspects. This can be seen, for example, in discussions about the different number of users and use conditions, such the location being inside the university or at an exhibition site. Supporting such communication among users is also significant from the viewpoint of activating community.

After the experiment, to evaluate the system as a whole, the question was asked, “As a system of stationary online annotation, do you agree with continued use of the system in the university?” Fifteen people answered “agree”, four people answered “undecided” and one person answered “disagree.” A supporter commented, “It is very interesting that from the data of papers I read, wide-ranging interests were beneath the implicit data and were presented in visible form. Actually, some papers that seemed uninteresting were introduced, but some of these were fairly interesting when I read them.” These statements indicate that the system is useful as a tool to obtain prior knowledge for communication with others. Others commented, “When fixing an order of priority for reading papers introduced in journals,” and “studying earlier research,” “it skimming was easy because important points were underlined,” “Seeing the reading history of someone who does research in a similar field is useful,” “It is temporally helpful that recommendations of other papers can be obtained from the system by reading a few papers.” These comments confirm that effective information acquisition from large quantities of documents is possible while taking advantage of favourable aspects mentioned. Some comments seemed to say that the system is more helpful for knowledge creation along with receiving intellectual inspiration on research and the learning process: “when designing

for ideas," and "seeking different approaches from my own ideas when my research comes to a deadlock," and "if it could be used at the library (on many documents)."

Also there was a comment, "simply seeing graffiti by others is interesting," on the contrary, an earnest opinion, "It would be interesting if I could know what points are consciously read by peer review judges of papers," was heard. Comments regarding the importance of the role of users on an existing explicit community were "comment from a doctoral course student was helpful," "it is useful to seek a paper from among similar papers recommended by senior students, when a student is preparing or working on a proposal." When applying the recommendation system in user model to the situation of educational guidance, we are concerned that situation requires some basis for maintenance and management of the model's quality, and also consideration reflecting how one's position with in the explicit community effects of recommendations will be necessary.

Four subjects were undecided about evaluating the system. Two of them answered that they doubted the accuracy of the recommendations, and the others answered that the interface did not seem complete. We checked the logs on browsing and recommendation of those two users who had doubts on the accuracy of the recommendation. Because their numbers of browsings and markings were very small, or they selected the papers of different fields from those of the other experimental subjects, they were unable to find user groups with a similar user interest model. However, this is a general problem of a recommendation system with a user model. Developing a system for the situation when there is little user information is a future task.

Two subjects who had doubts on the completeness of the interface commented that "the reaction speed is slow," and "want to input texts with keyboard." The slowness of the reaction speed is a future task of system improvement. Furthermore, at this time, the system is fully implemented under the pen metaphor, but there were many experimental subjects who can input more efficiently by keyboard than by pen. In order to develop a more practical system, a keyboard input is also essential.

The one subject who disagreed to continue using the system commented that, "it is unpleasant to be forced to use the system," this was because this subject does not usually annotate. Needless to say, installation of the system does not force anyone to use it. However, since the system applies user knowledge for recommendation, the effect of the entire system would be enhanced by many users providing high-quality information. In this regard, it could be said that if a big difference in the frequency of use exist among the users, the opinion of a "free ride" user would be undesirable. This needs to be considered in the future.

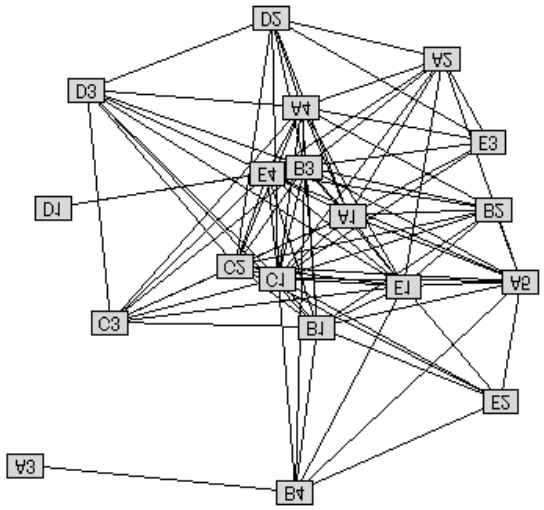


Figure 12. Graph out of implicit community (A~E in nodes mean each belonging explicit group)

From the results of our experiment, we have attempted to identify the existence of an implicit potential community. The incidence matrix of experimental subjects and papers that were recommended by using the system or chosen by users as interesting has been converted to an adjacency matrix of experimental subjects. Then, the networks formed by the interests of experimental subjects were graphed out.

The graph shows 16 cliques[4], and each clique is constructed by experimental subjects who belong to 3 to 5 groups. Hence, potential communities based on interests have been formed beyond the established explicit groups.

5. Conclusion

This paper described two kinds of SmartCourier systems that support adaptive information recommendation services and knowledge sharing. We developed a user model from the annotation activity on electronic documents. First, SmartCourier for JSAI2001 was designed to provide adaptive services with user modelling by the positional commonality of annotation. We considered this system's use and the result. Next, based on this consideration, we build a user model by using keywords extracted from the annotation activity. SmartCourier for Research Labs was designed to stimulate the research and learning community, which involves intellectual inspiration in research and learning activities.

The results of our experiment, demonstrated that the SmartCourier system, used as an adaptive information sharing environment through annotations, was effective in activating a larger community involved in intellectual inspiration beyond the existing explicit group. For matchmaking and annotation sharing, no qualitative difference between new and old methods was obtained from the results of a questionnaire. For recommendation, the new method was preferred by users who want more extensive knowledge, while the old method was preferred by users who demand accuracy and narrowing of information.

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References

[1] Abowd, G. D. Classroom 2000: An experiment with the instrumentation of a living educational environment. IBM Systems Journal, special issue on Pervasive Computing, Vol. 38, No. 4, pp. 508-530, 1999.

[2] Davis, R. C., Landay, J. A., Chen, V., Huang, J., Lee, R. B., Li, F. C., Lin, J., Morrey, C. B., Schleimer, B., Price, M. N., and Schilit, B. N. Notepals: Lightweight note sharing by the group, for the group. In Proceedings of the CHI '99 Conference, pp. 338-345. ACM Press, 1999.

[3] Espinoza, F., Persson, P., Sandin, A., Nystrom, H., Cacciatore, E. and Bylund, M. GeoNotes: Social and Navigational Aspects of Location-Based Information Systems. In Ubicomp 2001: ACM Conference on Ubiquitous Computing, pp. 2-17, 2001.

[4] Gale, S. Human aspects of interactive multimedia communication. Interacting with Computers, Vol. 2, No. 2, pp. 175-189, 1990.

4 Clique is a subgroup within a group, a subgraph that has 3 or more nodes, and density is 1.

[5] Gay, G., Sturgill, A., Martin, W. and Huttenlocher, D. Document-centered peer collaborations: exploring educational uses for networked communication technologies. Journal of Computer-Mediated Communication, Vol. 4, No. 3, 1999.
[6] Ito, S., Sumi, Y., Mase. K., and Kunifuji, S. Smartcourier: An annotation system for adaptive information sharing. Journal of Japanese Society for Artificial Intelligence, Vol. 17, No. 3, pp. 301-312, 2002(in Japanese).
[7] Kunifuji, S. Communication environment for intellectual inspiration. In Proceedings of the 2nd Symposium on Advanced Science and Technology, Future Communication, pp. 29-36, 1995(in Japanese).
[8] Marshall, C. C. Annotation: From paper books to digital library. In Proceedings of the 2nd ACM international conference on Digital libraries, pp. 131-140, 1997.
[9] Matsumoto, Y., Kitauchi, A., Yamashita, T., Hirano, Y., Matsuda, H., Takaoka, K. and Asahara, M. Morphological analysis system chasen version 2.2.9 manual. 2002.
[10] Mynatt, E. D. The writing on the wall. Human-Computer Interaction INTERACT '99, 1999.
[11] Nonaka, I. and Konno, N. The concept of 'ba': Building a foundation for knowledge creation. California Management Review, Vol. 40, No. 3, pp. 40-54, 1998.
[12] Richter, H., Abowd, G., Geyer, W., Fuchs, L., Daijavad, S. and Poltrock, S. Integrating meeting capture within a collaborative team environment. In Ubicomp 2001: ACM Conference on Ubiquitous Computing, 2001.
[13] Rscheisen, M. and Mogensen, C. Commentor: Scalable architecture for shared www annotations as a platform for value-added providers. In Stanford University Technical Report, 1994.
[14] Rubine, D. Specifying gestures by example. In Proceedings of ACM SIGGRAPH'91:Computer Graphics, pp. 329-337, 1991.
[15] Schilit, B. N., Price, M. N., Golovchinsky, G., Tanaka, K. and Marshall, C. C. As we may read: the reading appliance revolution. IEEE Computer, Vol. 32, No. 1, pp. 65-73, 1999.
[16] Sumi, Y. and Mase, K. Digital assistant for supporting conference participants: An attempt to combine mobile, ubiquitous and web computing. In Ubicomp 2001: ACM Conference on Ubiquitous Computing, pp. 156-175, 2001.