Supporting Student Collaboration for Image Indexing

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Abstract. We describe the Image Tagger system – a web-based tool for supporting collaborative image indexing by students. The tool has been used in three successive graduate-level classes on content representation. To fully satisfy the class' requirements and provide support for student indexing activities, it was designed and developed iteratively in accordance with the feedback and suggestions from the students as well as the instructor. The tool was well received by most students. They expressed a positive opinion toward collaboration support and thought it enhanced the overall learning experience in the class' image indexing project.

Keywords: Collaboration, Digital Library Education, Image Indexing, Metadata, Repositories, User Interfaces.

1 INTRODUCTION

Quality metadata remains a cornerstone of effective digital libraries. While social tagging systems, such as Flickr, are very useful for providing coarse labels (e.g., [9]) high-quality, consistent, labels still require trained professionals. We believe that metadata development tools are best be implemented as a digital repository. In addition, for teaching purpose, those tools should support collaboration among groups of students. However, existing repository tools such as Fedora DSpace, and Greenstone are not well designed for that.

We report on the design, implementation, and evaluation of a educational Image Tagger. This has been used in image indexing projects in three successive terms of a graduate-level course on Content Representation. The class' image indexing project is intended to make the students aware of the challenge and issues in representing non-textual materials such as images, give them experience in working with established controlled vocabularies currently used for image indexing, and allow students to work both individually and in a collaborative group mode. This indexing tool is an integral part of a larger repository system for both text and non-textual resources.

To customize the digital libraries to task-specific requirements, several researchers have adopted a user-centered design approach. In this approach, the objectives are to understand how the users perform their information seeking activities within the digital libraries scope and to expand the scope of the digital libraries to better support the tasks in context. Our project shared the same design philosophy. We believe that the best way to provide support for student collaboration can be achieved by involving the stakeholders early in elicitation and design phases. A few collaborative indexing systems have been developed e.g., [8, 11] but these systems are focused on free-text annotation we emphasize the use of controlled vocabulary in image indexing.

2 GOALS AND REQUIREMENTS

We are investigating effective ways to teach library and information science (LIS) students about repositories and metadata. Simultaneously, we aim to leverage such technology to improve the integration of digital library components into existing classroom. This leads us to the development of Image Tagger, a tool for supporting students' image indexing tasks. To achieve this, we have worked closely with the potential stakeholders -- the instructor and the students -- to develop the requirements and specify the design of the tool. One of the major requirements is to provide a facility that supports student collaboration in image indexing project. As the class usually conducted the indexing projects with the groups of online students, it was crucial that the working environment had to be specifically designed to support online collaboration. Lastly, as most LIS students had moderate computer proficiency, the tool had to be simple enough to use and required a minimum amount of installation.

We began an early version of Image Tagger prototype in fall 2005. The main users were LIS students enrolled in the class; the instructor (who is the second author on this paper) was also a key user, since she needed to monitor student activity and trouble-shoot indexing performance. The prototype was primarily intended to allow the students to view a set of images and index them with appropriate metadata through a web interface. In addition, the students should be able to search through images indexed by other group members through a simple interface. The feedback we got from the students during the first term was very positive; most of them liked the simplicity of the tool for doing their image indexing project. We have iteratively refined the prototype in the subsequent terms. The instructor provided us with requirements to make the tool a better fit for the class projects and to support instructional activities. Other requirements were gathered directly from comments and suggestions of the students after they had used the tool throughout the term.

At the end of each term, we anonymized and analyzed the recorded discussions of students when they were working on their group indexing assignment. This has helped us to understand student collaboration patterns and provided us with requirements that we later developed into the subsequent version of the prototype.

3 IMAGE TAGGER

Here, we describe the specific features of the current version of Image Tagger tool, focusing in particular on those aspects which have been essential for the class project. Particularly, we try to come up with collaborative indexing features, which are still lacking in existing digital library tools. Image Tagger was developed in a Java Server Pages (JSPs) platform using MySQL as a backend database. It consists of the following modules: login and authentication, image handler and storage, metadata generation, image metadata search, and group tools. The developer (first author) was responsible for the prototypes and providing technical support to the class.

We used a custom metadata set tailored for these photographic materials. The metadata fields include ID number, title (text included in photograph), textual description on the front and the back of the photograph's cardboard mount, city and country (derived from descriptions with preferred names derived from Getty's *Thesaurus of Geographic Names* (TGN) [3]), subject terms based on the *Thesaurus for Graphic Materials* (TGM) [4], subject terms based on the *Art and Architecture Thesaurus* (AAT) [2], and notes.

3.1 Individual Indexing

After students log in, they are directed to an assignment page which displays a set of 15 images the individual student is assigned to index. The purpose of the individual indexing assignment was to allow the students to become familiar with images' subject matter and the controlled vocabularies used for subject indexing and control of city and country names. In this way, the students would be prepared to contribute to a group indexing exercise. The system did not provide a direct link to access terms in the controlled vocabularies. Instead, the students are told where to access the thesauri via their web browser. The student can return to a particular image and modify the metadata as often as desired within the individual indexing portion of the assignment.

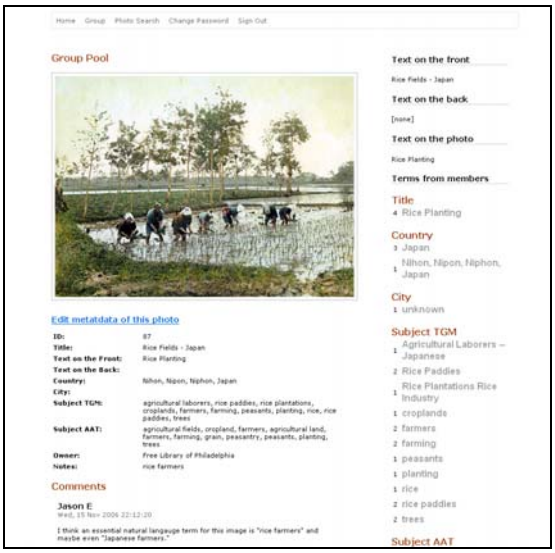

Figure 1. An example of a page for a single image with candidate terms suggested by group members and discussion about which of those terms should be selected.

3.2 Photo Pages with Overviews of the Group Members Individual Reponses

After completing individual indexing activity, the students are given access to their group's page. The group page displays thumbnails of the same set of images the students had previously indexed in their individual assignment. In this second stage, the members of each group work together to create the consensus metadata for their 15 images. To help the group manage their workflow, the thumbnail display includes visual cues showing the indexing status of each photo. A borderless image shows that the image had not been indexed yet. A dotted border indicates that the image is currently being indexed while a solid border indicates a completely indexed image with all metadata fields completed. To prevent group members from accidentally overwriting one another's works, an image could be indexed by only one student at a time. In addition to the group's image pool, this page also displays the recent comments made by group members on the particular images.

3.3 Displaying Common Indexing Terms

Clicking on a thumbnail in the group page directs the students to the image indexing page (Figure 1). This page displays a high-resolution image along with its associated metadata (if any). Group members are also able to discuss the indexing task by posting comments (lower left of figure). A major design consideration for image indexing page is to support students working toward consensus metadata. Image Tagger provides summaries of controlled vocabulary terms used by each group member to index a particular image (right side of figure). Each summary displays a list of terms used by the group members in their individual indexing assignments along with the frequency of use. In this particular example, rice paddies/Rice Paddies assigned from the Thesaurus for Graphic Materials (TGM) four times (twice with and twice without capitalization).

3.4 Exploring the Group's Indexing Terms

Additional information on subject term choices is provided to the group as two aggregated listings of all terms assigned to all 15 images — the subject term pool and subject term cloud. These two views are intended to help the students efficiently explore their group's indexing space. The subject term pool shows the subject terms the group members used in their individual indexing assignments. It inverts the image/term relationship, displaying a list of subject terms used by group members in alphabetical order. Each row contains a subject term, the images indexed with this term, and the names of the indexers. The list is organized according to the controlled vocabularies. The students can choose to view subject terms in either of the two controlled vocabularies – the Thesaurus for Graphic Materials (TGM), or the Art and Architecture Thesaurus (AAT). Figure 2 shows a screenshot of the subject term pool page.

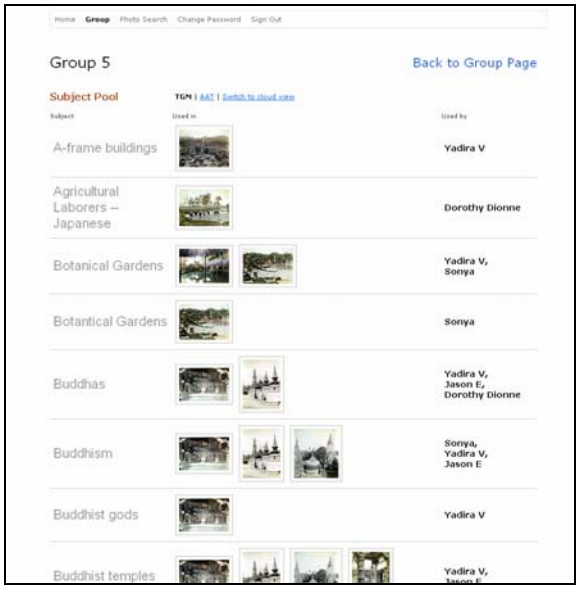

Figure 2. Subject term pool.

3.5 Searching Image Metadata

The students have access to a simple search interface with two search options available. One option is to search for one or more subject terms in the two subject fields (TGM and AAT). The second is to search for text in the remaining metadata fields, such as title, city, country, notes, etc. Once the query is submitted, the system will display the retrieved images along with the associated metadata.

3.6 Tools for the Instructor

Image Tagger also provides basic tools for the instructor. The instructor can keep track of the groups' progress and discussions using the same tools as the students, but with full access to all students' work. For example, the instructor can view the index metadata using a search interface or access the specific group page to inspect the students' discussion and indexing term assignments. The instructor can also view the activity log to see the participation rates of individual students. The activities tracked by the current system include sign in, sign out, annotate, and comment.

4 USE IN CLASS

4.1 Class Procedure

The Image Tagger tool has now been used in a class on Content Representation for three consecutive terms. The initial version was introduced in the Fall 2005 Content Representation on-campus class as a relatively simple tool that supported image metadata generation and subsequently (Spring/Fall 2006) in two online classes. In all three classes, collaboration was accomplished primarily via threaded discussion on Blackboard, although the on-campus class also was given time for in-class group discussions as well.

The project organization varied slightly from term to term. To simplify the scope of our discussion here, we will focus on the procedure used in the last two terms in which collaboration support was totally online. The image indexing project was designed as a combination of individual and group activity to give each student some experience with the challenge of image indexing, working with different established controlled vocabularies, and also with seeing how others dealt with the same issues. After an initial orientation, assigned reading, and writing assignment, individual students worked on the images with general troubleshooting discussion (discussion thread) and feedback from the instructor. By Week 7, all students had completed their initial set of 15 images and had begun the group indexing assignment. Students were organized into groups of 4-6 students, all of whom had worked on the same set of images. Each group had to work together to develop consensus metadata for each of their assigned 15 images.

There were about 30 students enrolled in each of the classes (Spring/Fall 2006). All were online students who resided in different geographic locations and time zones. Students had two or three different modes of collaboration available depending on the academic term. They could use assigned discussion threads in the Blackboard course shell, real-time/recorded group chat, or the comment field in the Image Tagger (in Fall 2006). By the time students began working on their individual projects, the course had covered the basics of general resource surrogation and image representation. They were given minimal guidelines – decide what was "index-worthy" in the image and then find a reasonable number of appropriate terms in the source vocabularies. The goal as stated in the assignment was to give the student the

full experience of facing an image without prior discussion of its content, difficulty, historical background, etc. and without extensive supervised indexing training. At the group indexing stage, students were expected to establish a consensus representation based on group discussion. Had there been time, this would have been followed by cross-group retrieval experiments.

At the end of the course, each student submitted a reflection paper commenting on the project and his or her experiences and insights. The students were not graded on the "correctness" of their individual or group indexing but on their understanding of the process and the issues involved in image representation they acquired.

4.2 Materials

The images used were taken from a collection of 19th century photographs of Asian countries, including India, China, Japan, and Thailand, held by The Free Library of Philadelphia. Most of them are black-and-white photographs. Image content included landscapes, architectural details, portraits, and local events. This material was used because the photos are of inherent interest, were out of copyright, and illustrated some of the challenges in using Western-centric controlled vocabularies.

4.3 Observations on Indexing Activity

We observed two different trends in the collaborative indexing activity. If there was any commonality of term use among group members (frequently assigned, even if some slight modification), the group consensus terms were taken from the most frequently used terms. Otherwise, terms were negotiated or new indexing terms were selected by the groups after discussion and exchange of views on the "best" level of indexing, "index-worthiness" of the image feature or concept, etc.

Most students found the assignment of terms from controlled vocabularies the most challenging part of the project. The subject matter of the images (19th century Asia) was unfamiliar to almost all students, and not well dealt with by the AAT and TGM, which have a known Western bias ([6] pp 84-91). Consistent with Jörgensen's "naïve" users [5], the students reported greater consistency and comfort dealing with generic objects and scenes (e.g., elephants, temples) and specific named entities (e.g., Kirifuri Falls at Nikko National Park) and more problems in agreeing upon abstract objects and concepts. The inclusion of a notes field in which they could describe the image in natural language terms, frequently informed by additional research, was an important adjunct to the controlled descriptor fields. Several students commented on the benefits of the group indexing module – if only to know what thought processes others followed when deciding what to index in a given image.

Tables 1 and 2 show the numbers of indexing terms used by each group. The students in both classes (Spring/Fall 2006) were assigned the same set of 15 images in their individual as well as group assignment. Quantitatively, students in both classes had similar indexing patterns overall. This might be explained by the fact that most students in both classes were unfamiliar with Asian culture. Thus, the choices of indexing terms were limited by their background knowledge of the subject matter.

We initially expected groups to consistently use a similar set of indexing terms. However, our preliminary analysis showed that the choices of consensus terms made by the two groups are quite different. Although the groups used similar numbers of indexing terms, the assignment of indexing terms between groups was not very consistent. We used Rolling's measure [10] to evaluate indexing consistency between groups. For example, an average Rolling's measure between Group 1 of Spring 2006

and Group 1 of Fall 2006 is 47.3% for TGM terms and 21.1% for AAT terms, while an average Rolling's measure between Group 2 of Spring 2006 and Group 2 of Fall 2006 is 52.1% for TGM terms and 51.1% for AAT terms. The result is similar to many studies of inter-indexer consistency that a high consistency level is hard to attain, even among trained indexers (e.g., [7]). Although the students tended to agree about the index-worthy image content, the exact indexing terms selected often differed.

Group	Spring 2006				Fall 2006			
	Max	Min	Mean	SD	Max	Min	Mean	SD
1	11	3	6.1	1.8	10	2	4.8	2.2
2	3	1	2.3	0.7	4	1	1.9	0.8
3	11	4	6.7	1.9	9	3	7.1	1.4
4	12	4	7.3	2.4	12	4	7.5	2.5
5	10	3	5.6	2.1	18	5	11.3	3.4
6	18	7	12.6	3.4	10	2	4.1	1.8
Overall	18	1	6.8	3.8	18	1	6.1	3.7

Table 1. Comparison of the number of TGM terms selected across groups.

Group	Spring 2006				Fall 2006			
	Max	Min	Mean	SD	Max	Min	Mean	SD
1	7	2	4.6	1.5	11	3	5.5	1.9
2	4	1	1.9	1.0	4	0	1.5	0.9
3	12	3	7.3	2.8	16	5	9.0	3.0
4	15	5	8.9	1.7	15	6	8.7	2.4
5	12	4	6.6	2.4	22	5	11.0	4.8
6	25	11	17.9	4.7	22	5	11.0	4.8
Overall	25	1	7.9	5.7	22	0	7.8	4.7

Table 2. Comparison of the number of AAT terms selected across groups

4.4 Observations on Collaboration

Since the collaborative indexing feature was recently implemented, the collaboration data was derived from the Spring 2006 class. The collaboration process focused on voting and validation of thesaurus subject terms. The groups used two different strategies to collaborate on indexing images. Some groups used a "divide-and-conquer" strategy by assigning subsets of images to individual group members and the assignees to decide on consensus metadata. Afterward, the group as a whole reviewed the consensus metadata, discussed any problems and made appropriate final changes. The second strategy was to work together on each of the 15 images. Group members were asked to specify indexing terms they would choose to include in the consensus metadata for each image and their rationale for choosing so. After the further discussion within group, the group voted and approved terms were selected. To validate specific subject terms, the common practice among the groups was to cite the external sources that they found relevant from their own research. This ranged from print and digital reference sources and tourist information in the Web to personal resources and experience (in each class at least one or two students had visited one or more of the sites photographed or was generally familiar with the geographic area). On a photograph of boats labeled "Houseboats—Thailand" discussed by three students:

#1 *If we use "shantyboats," we shouldn't also use "houseboats" because shantyboats is NT to houseboats. If we use "waterfronts" in AAT, we should also use it in TGM. We should choose one of "harbors" and "bodies of water"--"harbors" is narrower than "bodies of water." Whichever we choose, we should use it in TGM as well ("harbors" and "bodies of water" are both TGM terms).*

#2 *Are we certain that they are "Shantyboats"? I would be more comfortable w/ just using "Houseboats". Also, I agree with "Harbors", "Bodies of water" seems too broad to me.*

#3 *I'm not sure I agree here… at least on the "harbors" matter. I don't think we can tell from this whether we are looking at a river, a harbor, a bayou, etc. I'd prefer sticking with "Bodies of water." I feel confident that these are shantyboats (at least the vessels in the foreground are). However, because the AAT has "houseboats" as a preferred term from "shantyboats," and because it appears "shantyboats" is a primarily English word, I'm fine with using "Houseboats" for both.*

These examples provide clear evidence for the value of collaboration as a pedagogic tool reinforcing for principles of metadata development that had been discussed in class.

As there were multiple options for collaboration, each group was able to decide how to communicate. Asynchronous collaboration was used by most groups. This consisted of using Image Tagger's commenting feature to some extent and Blackboard Discussion to discuss and vote on indexing terms. Many groups began the discussion by copying all indexing terms available in the indexing page for different images and pasting them into a Blackboard discussion thread. After that, each group member would choose indexing terms and begin the discussion of the acceptability of the term for subject indexing of that image. In addition, the Blackboard Discussion was also used to communicate on group administration, e.g., breaking down the tasks, setting up a schedule, etc., as well as supporting extensive discussion for some groups. Students also shared external hyperlinks with one another. These links often contained useful information that could help them identify the images. One group put all terms into a set of Excel spreadsheets and circulated. A few groups used synchronous real-time chat as the primary channel of communication.

Group	Comments on Image Tagger		Posts on Blackboard	Total collaboration
	Total	Mean		
1	107	7.13	122	229
2	1	0.07	319	320
3	15	1.00	48	63
4	86	5.73	133	219
5	58	3.87	116	174
6	231	15.4	135	366

Table 3. A quantitative summary of student collaboration by group.

Table 3 summarizes collaboration based on the number of comments/discussions posted on Image Tagger and the Blackboard Discussion Boards. Most comments posted on Image Tagger's indexing page were related to subject-term voting and validation while discussions in Blackboard forum included subject-term discussion, group administration and other topics. Notice that Group 2 relied heavily on Blackboard forum for collaboration and Group 3, while having the smallest number of asynchronous collaboration, used real-time chat (data not shown).

Inter-group collaboration occurred occasionally and we did not restrict the students from access other groups' threaded discussion, thus they were free to read and even participate in the discussions (but not the group chat) outside of their own group. One example of inter-group collaboration started from the use of the subject cloud. One student looked through the cloud to explore what other people did in their indexing assignment. She discovered an image of the Fujiya Hotel in Miyanoshita, Japan, which was indexed by another group. Since she had been there, she commented on that image. Students also monitored discussions to catch any instructor feedback to specific questions from other groups in a type of vicarious learning.

4.5 Feedback and Evaluation

At the end of the project, the students participated in a discussion thread to talk about their experience with the tool and the project in general. Out of 14 students during Fall 2006 who participated in the discussion, 5 of them stated that they really liked working with the tool and did not see any problems with it. 2 of them reported the specific bugs that need to be fixed and the remaining 7 proposed possible features and improvements they would like to see in the future version. Overall, the students found the tool easy to use and support their collaboration process well. One student commented on the value of real-time discussion available to them in Blackboard as it worked best for their group's collaboration process.

From the instructor's point of view, the interface worked reasonably well in terms of monitoring student input and catching potential problems (e.g., appropriate content in metadata fields, appropriate use of TGN terms for city and country, addition of subheadings to TGM terms) early. The initial version of the activity log was somewhat useful in gauging the level of student activity but requires future work to make it easier to use and to provide a greater level of detail.

Although we initially provided a simple space to allow the students to post discussion on the page associated with a particular image, the functionality of a full-featured discussion board was still preferred by the students in the overall collaborative activity. Different modes of collaboration also affect the use of the tool and the group strategy. As we mentioned earlier, some of the group thought a synchronous collaboration, real-time chat, worked well for them and successfully made use of it for their collaboration, while the other groups preferred asynchronous collaboration over synchronous one for various reason.

5. CONCLUSIONS AND FUTURE WORK

We describe Image Tagger, a digital library tool built to support image indexing instruction in a collaborative context. Taking a user-centered design approach, the tool was developed iteratively in accordance with feedback and suggestions from the students and the instructor. The tool has supported image indexing class projects in three academic terms. Most students expressed positive opinions about the tool. They commented that Image Tagger and the indexing assignments offered them a unique learning experience. They learned by direct interaction with other students in their indexing group and from vicarious observation of the discussions of other groups. Moreover, many of them thought the tool worked well for virtual group work and helped them in their collaborative deliberations. The students made some suggestions, outlined below, for how to improve the tool based on the features they would like to see in the future.

The deliberation and decision process can be made more robust. One solution is to provide a voting interface directly for each candidate terms. For example, each candidate term might have a checkbox by its side. A checked status on a checkbox indicates that the students have voted to accept that term. In addition, the students might specify the rationale behind their votes. For example, the terms might be approved because they represent main objects or peripheral objects or describe certain events or concept in the image. Next, the terms might be chosen because of their ease of searching. If the terms are rejected, the students might supply specific reason for voting so. For instance, they might be too specific or too broad.

To fully support group collaboration, the other collaborative tools, such as real-time chat room, forum, and file sharing, were available to students via the Blackboard system. Because these tools were outside the Image Tagger environment, the students had to sort through multiple places to collaborate with their peers. In critiquing the current version of the tool, several students expressed their preference to be able to work in a unified collaborative environment. We hope to find ways to add these other collaborative services to Image Tagger. Finally, we are extending the Image Tagger to incorporate more administrative functions [1]. By continuing to emphasize student-friendly design we hope to develop a tool that will be effective for teaching students about the administration of repositories.

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