Collection Understanding

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ABSTRACT
Collection understanding shifts the traditional focus of retrieval in large collections from locating specific artifacts to gaining a comprehensive view of the collection. Visualization tools are critical to the process of efficient collection understanding. By presenting simple visual interfaces and intuitive methods of interacting with a collection, users come to understand the essence of the collection by focusing on the artifacts. This paper discusses a practical approach for enhancing collection understanding in image collections.

Categories and Subject Descriptors
H.3.3 [**Information Storage and Retrieval**]: Information Search and Retrieval – *information filtering*. H.3.7 [**Information Storage and Retrieval**]: Digital Libraries – *collection, user issues.* H.5.2 [**Information Interfaces and Presentation**]: User Interfaces - *interaction styles, graphical user interfaces (GUI), direct manipulation, evaluation/methodology.*

General Terms
Collection understanding, information visualization, digital libraries

Keywords
Collection understanding, streaming collage, ambient slideshow, variably gridded thumbnails, image visualization.

1. INTRODUCTION
Digital libraries provide novel means of information access to large collections of artifacts. Widely available digital imaging technologies have resulted in a dramatic increase in the number of collected artifacts. However, these large collections pose a challenge for the collection provider when trying to convey the actual collection's contents. Users cannot effectively understand what constitutes a large collection if they are unable to see what is in the collection in an efficient manner. Visualization tools are critical to the process of efficient collection understanding, not only for viewing the artifacts but also for understanding their metadata and content. By presenting simple visual interfaces and intuitive methods of interacting with a collection, users come to understand the essence of the collection by focusing on the artifacts.

Various methods have been used to express information about sought artifacts in large collections [43]. These retrieval methods include browsing using metadata [12, 43, 46], keyword/phrase searching on specific metadata fields [45], and finding similar artifacts through feature extraction [30, 38, 35] and text overlaid on video [9]. Directly searching on these collections traditionally returns pages of surrogates that serve as multimedia abstractions for previewing the artifacts. Users may browse these surrogates and select specific ones to see additional information (assigned metadata). These methods help users to find particular artifacts in the collection.

Collection understanding has a different focus. The goal here is to understand the entire collection by comprehending the "whole as a sum of the (relationships among the) parts." By "parts", we mean a subset of artifacts in the collection. Users should be able to iteratively specify subsets, visualize the resulting collection artifacts easily and derive their own understanding.

Screen space is a key factor in designing visualization tools for any collection. Displays are limited with respect to the number of artifacts that may be shown without scrolling or navigating to the next page of results. Scrolling is slow and navigating becomes very tedious for the user [47]. When the representative artifacts are separated and cannot be seen simultaneously on the same display, users become distracted from their main goal of collection understanding. When the result set is very large, users may find the process of examining the artifacts almost impossible, since they must traverse each page of surrogates. By using visualization techniques that eliminate manual scrolling, the process of browsing, and other user interface management tasks, collection understanding becomes the central goal.

2. COLLECTION UNDERSTANDING vs. INFORMATION RETRIEVAL
Information retrieval (IR) is traditionally used as a tool for finding specific artifacts. Users must be able to define queries by specifying values for metadata fields. IR interfaces facilitate this "find the needle(s) in the haystack" approach.

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Collection understanding is, in some sense, directly opposite to the IR approach. The users may have no prior knowledge of the metadata fields or values. Users first acquaint themselves with the actual artifacts and then come to understand what the metadata fields and values mean and how the collection artifacts vary based on dynamically generated criteria. Instead of having a pre-conceived notion of which artifacts to look for in the collection, users take an exploratory approach by defining their own metadata filters and forming their own structures for viewing the artifacts. Once they have acquired a general sense of the collection by metadata filtering and information visualization, they are better able to understand how metadata and artifacts interplay in forming the collection, and hence match their filtering criteria to the current situation.

Additionally, users are often faced with the dilemma of defining an artifact in an IR interface. Users have a general idea of what they are looking for but can neither define the condition(s) using IR terms nor express a specific description. Users are compelled to find a representation of their query in a form that can be understood by a system they perhaps find difficult and unnatural to use. Collection understanding facilitates a visual illustration of the artifacts over time and gives insight about how the collector chose to describe the artifacts using metadata. Users gradually learn the collector's choice of metadata and values by experience through interaction with the contents of the collection.

3. RELATED WORK

While collection understanding is a general idea, our initial work focuses on image collections. Several means of visualizing image collections have been explored previously [7, 8, 15, 36, 40, 43]. Photo browsers specifically manage collections of photographs. They often include home photo collections and introduce browsing techniques for novice users [22]. They allow users to easily digitize and organize their photographs into categories of events, based on metadata created by the user [22, 27], file names and directories [3], or the date and time [15] that the photos were taken.

Image browsers manage a more diverse collection of artifacts, including photographs [27], architectural drawings [12], and museum paintings [4]. They provide effective ways to retrieve artifacts [10] and browse large images [28] through novel user interfaces [4, 14, 39].

Collage is an effective tool for utilizing screen space, allowing a large collection of images to be viewed simultaneously. Collage has been used to provide a novel web browsing technique [23, 25, 26], form aesthetic and dynamic art pieces [13], create a group awareness tool [18], and show a physical information collage connected to an electronic information display [34].

Ambient displays do not require a user's undivided attention or continuous real-time interaction [32]. Rather, they display non-critical information [42] slowly in the background environment [19, 20]. Through chance encounters, they engage the user's attention without requiring direct focus [21].

Current work in IR interfaces also try to give participants a starting point for finding and browsing artifacts in the collection. The Flamenco image browser [12, 46] allows users to dynamically view metadata values using explicit exposure of hierarchically faceted metadata [12]. Thus users do not feel lost when they are given metadata feedback in the current query state. However, Flamenco focuses on externalizing the metadata to improve IR search. Therefore participants spend a great deal of time learning about metadata word descriptions of the collection and do not see (in their mind's eye) the actual artifacts of the collection. As participants become exposed to other faceted metadata, they must still click on the links, scroll and page through thumbnails to view the actual contents that constitute the collection.

The "berry-picking" model described by Bates [2] suggests ways to improve IR searches. According to Bates, IR searches are static one-time views and the results are a single output set. In the berry-picking model, participants use an incremental method for probing information where they learn how to refine a query based on previous result sets. With iterative feedback, users successively improve their search criteria by evaluating the efficacy of former searches. The final results are obtained from a series of incremental adjustments based on new insight found along the way, creating an emergent search strategy. However, Bates' model still focuses on improving probe searches. Although her model recognizes incremental learning based on previous results, collection understanding isn't about finding specific artifacts but coming to understand the essence of the whole collection.

4. CURRENT PRACTICE

Three main problems plague current digital library interfaces for querying large image collections: querying by metadata is ambiguous, browsing is predefined and inflexible, and scrolling through artifacts becomes burdensome.

4.1 Problems with Querying by Metadata

While creating metadata is time-consuming for collectors, querying metadata is currently the most commonly used method for accessing images. Users enter a metadata query and matching images (or their surrogates) are returned from the collection. However, the user is limited with respect to how the creator/maintainer defines the metadata. In addition, most metadata descriptions are vague. They contain few sentences and provide little information about the possible values that satisfy the metadata field. Instead, users are left to guess how the creator categorized the metadata and cannot query the image collection unless they know what is in the collection. This process of trying to decide how to begin a search is inefficient and hampers the users' intention to learn about the collection.

If the user is successful at deriving values for the metadata fields, the query results generated are specific to the metadata that the user entered and the user never sees similar artifacts in the collection that share some of the metadata values. Relationships among the image elements and the metadata are lost. The user obtains results based on knowing what the metadata values are, but doesn't gather any information about the remainder of the collection, losing the real benefit of understanding the entire collection.

4.2 Problems with Browsing

Browsing is another popular technique for image access, but browsing categories are usually pre-defined and static, forcing the user to follow a fixed structure with little flexibility for adapting to the user's needs. The user simply "points and

clicks", narrowing the collection to a subset of images. This technique is very time-consuming and may involve a large amount of pointing and clicking to get to the actual images.

Collection understanding is not focused on narrowing the view of a collection to a small subset of images. Instead of trying to find specific images, the user starts with some image(s) or the entire image collection, and then expands/narrows that view to more/fewer images from the collection, gradually deriving relationships about the complete collection. Users progressively learn about the collection through dynamic interaction with artifacts and metadata.

4.3 Problems with Scrolling through Thumbnails

When images are returned from a query, they are typically displayed using thumbnails across and/or down the screen [10, 15, 22]. Users scroll through the results and choose images of interest. With limited screen space, the user must scroll or page through these images to see more results. With either technique, the previous image matches are no longer in view and the user cannot see the entire result set. Thus, image viewing becomes a limiting task and the collection is more difficult to understand.

5. IMAGE COLLECTION UNDERSTANDING

Collection understanding is an attempt to view the artifacts that constitute the collection in an extensive sense. Users confronting a new collection are trying to learn about the general underlying theme of the collection, the features the elements have in common and the varying qualities that link them as a collection. By increasing their awareness and obtaining a comprehensive outlook, they hope to appreciate the collection builder's (or curator's) point of view about what the collection represents and which characteristics the elements share as members of the collection, so they may derive their own perception of the collection and steer subsequent collection-related tasks. Intuitive interfaces are needed that allow users to efficiently grasp the essence of the collection.

Typical access to image collections consists of querying metadata fields and being presented with responses that match the query. These metadata fields are descriptive fields that characterize the image such as time, title, photographer, medium, dimension and event [11]. They represent structured information to help manage the images in the collection and to facilitate image description and discovery [43]. However, results that match metadata are specific to the query and give no broad perspective as to what the collection actually contains. What are the actual artifacts in the collection? What determines whether an artifact belongs to this collection or not? What are the relationships among images that form a subset of the collection?

The curator can provide collection-level metadata describing the motivation for this collection, why the images were chosen for the collection, how the images were collected, and the factors that came into play to decide that these images should be collected together. However, this general descriptive metadata does not answer the question pertaining to the actual artifacts contained in the collection and it gives no concrete visual depiction of how sub-collections are related via various metadata values. Users should be able to see in their mind's eye what the artifacts are and vary the metadata values dynamically to see what subset of the collection would be returned.

Currently, our research is exploring the following three techniques for image collection understanding: streaming collages, ambient slideshows and variably gridded thumbnails. We used the Online Picasso Project [31] (a collection of Picasso's life and works from 1881-1973) as our test collection.

5.1 Using Streaming Collage for Collection Understanding

A collage is a work created by the combination of materials from different sources [33]. The artist's purpose in making collage is to evoke some idea or feeling from the audience based on the content of the collage and to invite observers to create their own associations and interactions among the elements that constitute the collage. By streaming collage, we refer to the changing content of the collage - the images are dynamically displayed so that the collage is constructed interactively in time [26].

Through streaming collage, users become aware of the images that constitute the general collection and their relationships. Figure 1 shows a still image of a streaming collage prototype. On the left, a window collages the images in real time and on the right, a metadata filtering form shows the metadata fields corresponding to the collage. Streaming collage places images in the window using the metadata values from the form, making the best use of limited screen resources. The metadata filtering form and the collage display can both be used to adjust metadata values. We refer to this process as metadata filtering – by gradually removing or adding values for the metadata fields, users come to a better understanding of the collection [1].

A user begins the process of collection understanding using either the entire collection (as in Figure 1) or specific images as the starting point. In the first case, the user may be visiting the image collection for the first time, perhaps not knowing any metadata fields or values. When the user selects the "Create Collage" option, the entire collection randomly collages on the display. Once the user spots interesting image elements, the metadata values are displayed to the user with a right-click of the mouse (Figure 1). The user may then select any of these fields to further filter the metadata, showing more images sharing this metadata value or, at the user's choice, not sharing this metadata value. Figure 2 shows the results of filtering the collection on the *media* metadata field for the value of *"oil on plywood"*.

In the second case, users begin with a subset of the collection sharing certain metadata values. From this subset of the collection, users may choose to either narrow or expand the image subset by dynamically changing the metadata values as they increasingly come to a better understanding of the collection. In both cases, the dynamically generated results are shown on the collage display. Additionally, users can select higher-resolution images of the thumbnails for further examination in a subcollection window (Figure 3).

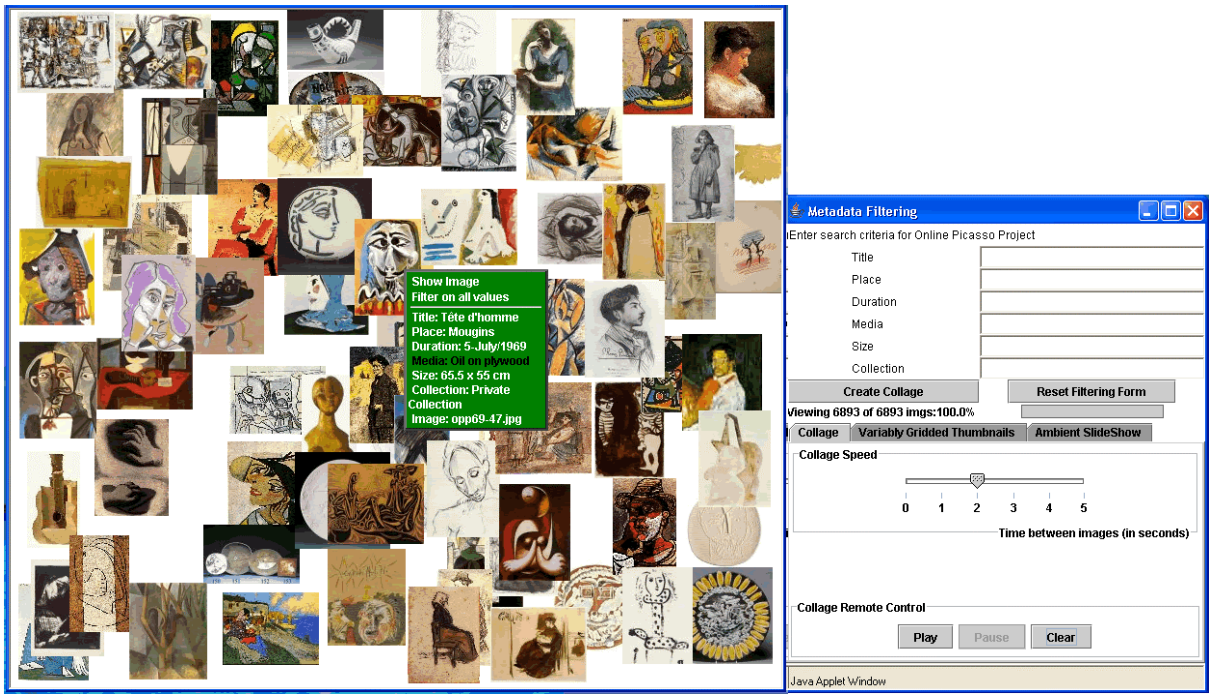

Figure 1. Using streaming collage for understanding the Online Picasso Collection.

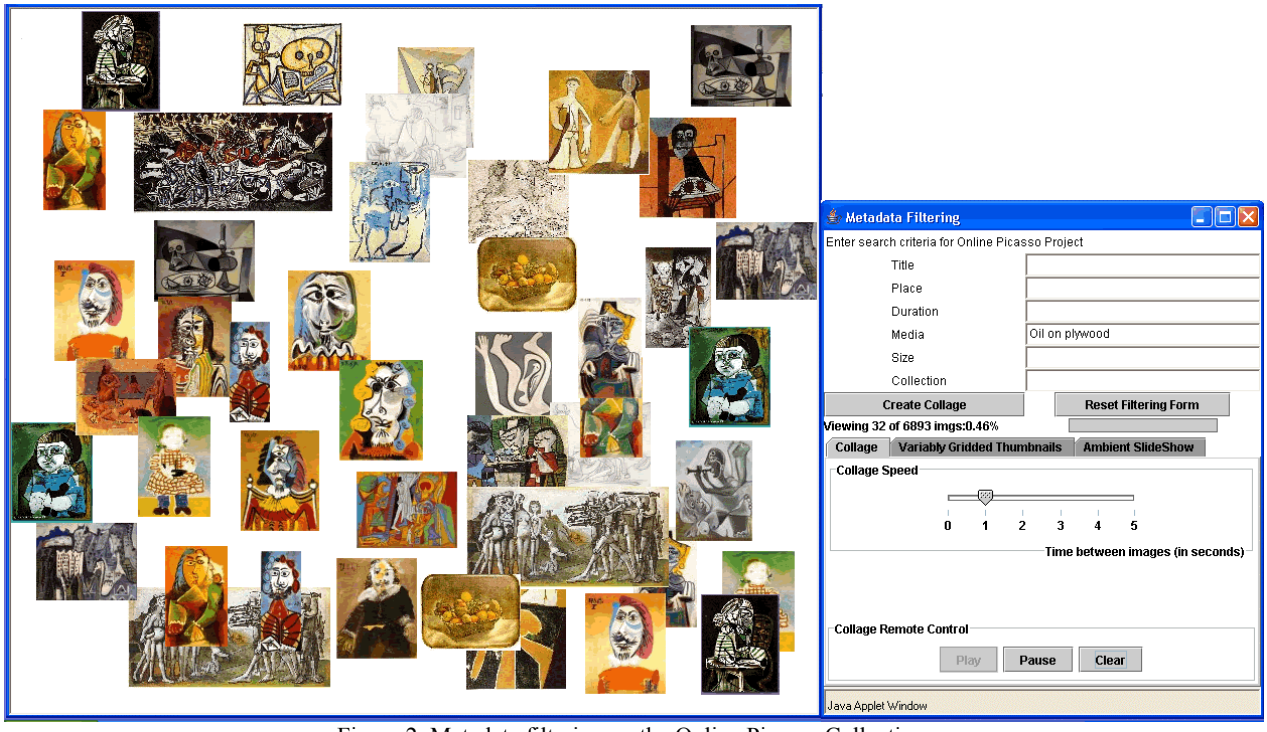

Figure 2. Metadata filtering on the Online Picasso Collection.

Figure 3. Creating a personal Picasso collection.

5.2 Using an Ambient Slideshow for Collection Understanding

Using an ambient slideshow allows users to select a subset of the collection for peripheral (or background) display. The images returned do not require a user's undivided attention or continuous real-time interaction [32]. Rather, they display in the background environment and engage the user's attention (through chance encounters) to learn about the artifact's membership in the collection. An ambient slideshow in the periphery of the environment slowly reveals the images in the collection and provides a simple mechanism to take a (possibly fleeting) look at the result set without requiring direct focus (Figure 4). When the collection becomes immersed in the environment in an ambient display, we envision that collection understanding will occur over longer periods of time as predicted by research on incidental learning [23].

Figure 4. Ambient Picasso.

5.3 Using Variably Gridded Thumbnails for Collection Understanding

Current image collections typically use a grid of thumbnails as a direct manipulation interface to retrieve the original artifact. Clustering images based on size and orientation maximizes efficiency of screen space [22]. Thumbnails can also be categorized based on feature extraction similarities and text captions to aid users in finding images [39]. By changing the default arrangement of the thumbnail images, users can scan the resulting image set to see parallels among images in the collection.

When using variably gridded thumbnails, a relevance measure is returned for each image based on the number of matches found within a particular metadata field. Figure 5 shows artifacts from the Online Picasso collection where the media is specified as "lead pencil & watercolor on paper" and the year as "1900". Any images completed in 1900 *and* containing lead, pencil *or* watercolor are returned with greater preference for images containing lead, pencil *and* watercolor. A color and a range of relevance values are stored for each bin. Images are placed into bins based upon their relevance value. Each grid element's background is colored to indicate the degree of relevance. Users can vary the number of bins to indicate the number of relevance categories for subdividing the images. As illustrated in Figure 5, images placed on yellow backgrounds have the greatest match, with relevance decreasing when background colors are blue, green, purple and orange. We will be using this visualization as a baseline with which to compare the streaming collage and ambient slideshow visualizations.

6. USABILITY STUDY

As with any software tool, or indeed any artifact, the energy that went into the development of the functionality of the collection understanding tool would be wasted if users are not able to carry out their tasks because the user interface is too obtuse. The usability literature indicates that usability evaluations are typically better if conducted by professionals who have not been involved in the design and development of the product [4]. Thus, the tool developers from Texas A&M approached the usability experts at the University of Texas at Austin to conduct an independent evaluation of the emerging tool. A usability study of the intuitiveness of the streaming collage prototype was conducted and the findings are described below.

6.1 Context

The following describes a preliminary user test of the collection understanding tool. It is the first in a series of usability evaluations, ultimately to include further end-user testing in the lab with various user audiences, a heuristic evaluation [36], field testing in a university classroom, and perhaps a usability walkthrough [4].

6.2 Participants

The evaluators selected 15 graduate students from the University of Texas at Austin to participate in the preliminary study. None of the students who were recruited for the study had prior experience using the tool nor did they have any formal training in art history or Picasso. The investigators recorded sessions through hand-written notes and video.

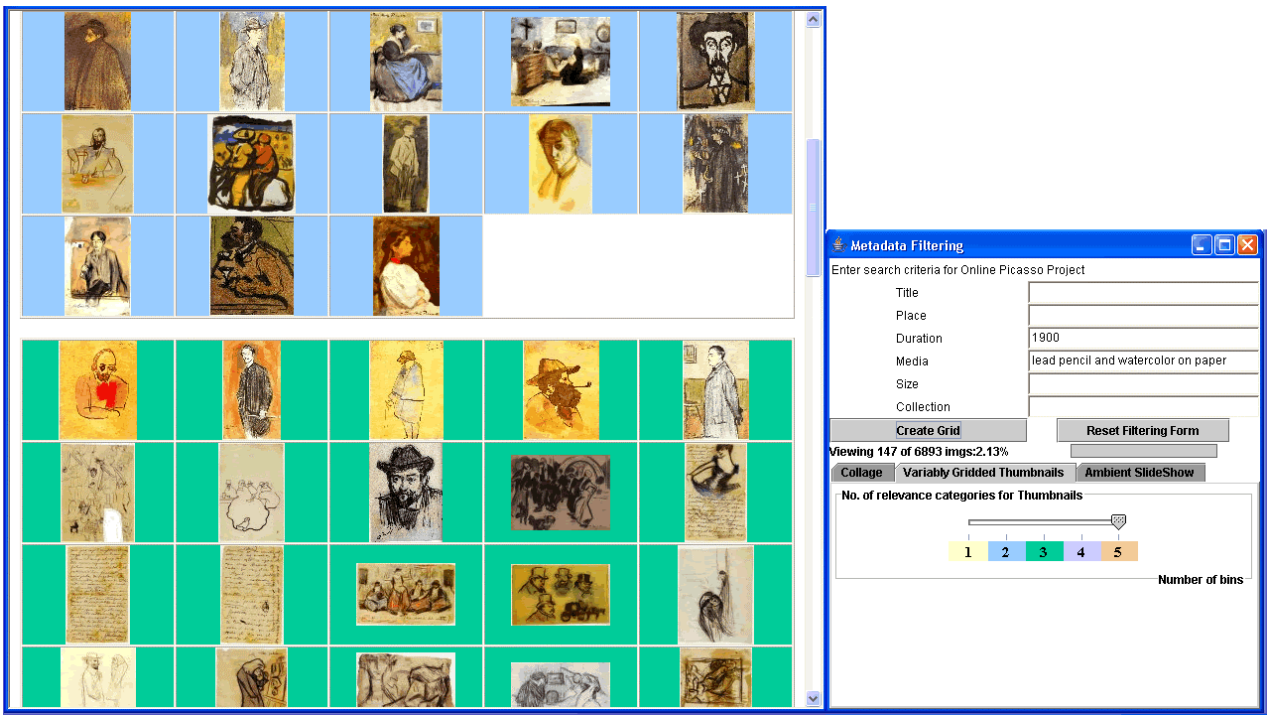

Figure 5: Variably Gridded Thumbnails for the Online Picasso Collection.

6.3 Tasks

After receiving a short scripted introduction, each participant was asked to begin working (without any training or direction) with the tool on his or her own for 10 minutes. During this period users were encouraged to "think aloud" and discuss their expectations [28]. At the completion of the 10-minute period, the participants each wrote a description of their comprehensive impression of the collection. Participants were instructed to write about the collection rather than the tool.

Participants were then asked to complete a set of tasks. The tasks were selected based on the designers' description of a typical collection understanding experience and were those actions deemed critical to facilitating the proper use case scenario. The participants were encouraged to work without guidance except for periodic prompts from the experimenters to verbalize their thoughts as they worked.

6.4 Results

The results of the initial tests indicate that users are not able to effectively "walk-up and use" a majority of the tool's functions, however when given directed tasks they were more successful.

No directed tasks. During the phase in which they worked with no direction, more than half of our participants never created a collage without any filter values and an overwhelming majority attempted to type their own metadata values before ever beginning a collage. All of our participants attempted to type values into the search criteria fields at some point during test. Most users began the test by attempting to derive search criteria on their own based on their understanding of Picasso and his work. This left many users frustrated as their initial attempts at "*querying the database*" resulted in few if any returned results. Clearly, the presence of the metadata fields on the right attract the attention and action of novice users based upon their prior experience with IR-style interfaces.

Even when users were able to get images to appear in the display space, many seemed hesitant to attempt to manipulate these images. Nearly half of our test subjects never right-clicked on images in the display space, thus never had an opportunity to review the metadata attributes for any images. Additionally, a third of the users never once attempted to manipulate images as they appeared in the display space and only two users who right clicked on an image clicked on the terms in the menu to populate the search fields on the filtering form.

Directed tasks. Users met with much more success when they were asked to complete discreet tasks. Upon being instructed to filter for images with no search criteria, all of our users were successful at creating a collage of the entire collection. Similarly, all but one of the test subjects successfully right-clicked on the images once instructed to view an image at full size.

Summary. These results indicate the current interface lacks intuitive controls and affordances for novice users, but that these users can quickly recover once they receive appropriate cues about how to properly manipulate the tool. These cues could easily be built into the interface design either through explicit instruction (e.g. help, or via an instructional mode) or more subtly by implying the phases of collection understanding in the interface.

7. FUTURE WORK

The current usability study was largely formative [15, 16] and tested only those intuitive interface attributes that were deemed essential to creating a collection understanding experience as described by the designers. In the future, we will test a wider knowledge range of audiences. In addition, we have evaluated only the streaming collage prototype. We will carry out further studies on collection understanding using ambient slideshows and variably gridded thumbnails. The collection understanding tool will be modified to reflect the lessons learned from these studies.

8. CONCLUSIONS

Collection understanding shifts the traditional focus of retrieval in large collections from locating specific artifacts to gaining a comprehensive view of the collection. Users visualize the collection using dynamic interaction to create their own understanding of the collection. As users narrow or expand their view, they acquire the general gist of why the artifacts belong to the collection and what characteristics the component elements share. When users interactively filter the contents of the collection and perceive varying viewpoints of the artifacts, they are then inspired to derive their own relationships among the elements and come to a fuller understanding of the collection.

Through novel visualizations, users will be able to efficiently understand what specific collections have to offer. Collection insight will increase and enhance information access, making digital collections more valuable knowledge assets. In a world populated by thousands of digital libraries, a collection understanding tool of demonstrable, empirical, strong usability, can be used profitably by digital librarians and users alike to efficiently characterize and evaluate the holdings of various collections.

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