# Faceted Metadata for Image Search and Browsing

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## ABSTRACT

There are currently two dominant interface types for searching and browsing large image collections: keyword-based search, and searching by overall similarity to sample images. We present an alternative based on enabling users to navigate along conceptual dimensions that describe the images. The interface makes use of hierarchical faceted metadata and dynamically generated query previews. A usability study, in which 32 art history students explored a collection of 35,000 fine arts images, compares this approach to a standard image search interface. Despite the unfamiliarity and power of the interface (attributes that often lead to rejection of new search interfaces), the study results show that 90% of the participants preferred the metadata approach overall, 97% said that it helped them learn more about the collection, 75% found it more flexible, and 72% found it easier to use than a standard baseline system. These results indicate that a category-based approach is a successful way to provide access to image collections.

**Keywords:** Image Search Interfaces, Faceted Metadata

## INTRODUCTION

Image collections are rapidly coming online, and many researchers have developed user interfaces for browsing and searching such collections. Probably the most familiar image search interface today is that used by Web image search engines, in which users enter keyword terms, and images are shown in a table ordered by some measure of relevance. These systems can be effective for searching for very specific items, but do not support browsing and exploratory tasks well [7, 9, 10]. Many research systems approach image retrieval by analyzing images in terms of visual properties such as color and texture. However, results of usability studies call into question the usefulness of image searching according to low-level visual properties [10, 15].

In contrast, and perhaps counter-intuitively, ethnographic studies indicate that professionals who look for images on a regular basis (e.g., journalists, designers, and art directors) want to browse and search images using textual category labels [1, 5, 7, 10]. Despite this, few image search engines provide the ability to navigate images by rich category sets, and those that do often have unwieldy interfaces [10].

We have developed an interface for large image collections that allows users to navigate explicitly along conceptual dimensions that describe the images [8]. The interface uses hierarchical faceted metadata (described below) and dynamically generated query previews [14], seamlessly integrating category browsing with keyword searching. To arrive at the current design, we conducted several rounds of usability studies and interface redesign. This paper presents the results of a new usability study whose goal is to directly compare the faceted category design to the current most popular approach to image search. Conducted with 32 art history students using a fine arts image collection, the study found strong preference results for the faceted category interface over that of the baseline, suggesting this to be a promising direction for image search interfaces.

We now describe related work, the faceted metadata, the category-based interface design, the baseline interface, and the study design and results, concluding with a discussion of the larger lessons that can be drawn from this effort.

## RELATED WORK

The bulk of image retrieval research falls under the rubric of "content-based" image retrieval; this term refers to systems that perform image analysis in order to extract low-level visual properties, such as color and texture [12, 13] or object segmentation [4]. Some systems also incorporate information extracted from associated text [17]. A good summary of content-based image retrieval can be found in [18].

There has been a great deal of research on these systems, but only a small subset of the past work has included usability studies. Rodden et al. [15] performed a series of experiments whose goal was to determine if and how organization by visual similarity is useful, using as features global image properties (colors and textures) and the spatial layout of image regions. Their results suggested that images organized by category labels were more understandable than those grouped by visual features.

Ethnographic studies of image search needs have indicated that there is a great need for more conceptually rich image search. In a study of art directors, art buyers, and stock photo

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researchers [7], Garber & Grunes found that the search for appropriate images is an iterative process: after specifying and weighting criteria, searchers view retrieved images, then add criteria, add restrictions, change criteria, or redefine the search. The concept often starts out loosely defined and becomes more refined as the process continues.

Markkula and Sormunen [10] reported on a field study of journalists and newspaper editors choosing photos from a digital archive in order to illustrate newspaper articles. Journalists stressed the need for browsing, and considered searching for photos of specific objects to be a "trivial task". Selection of search keys for general topics was considered difficult; journalists emphasized the need for photos dealing with places, types of objects, and themes. The journalists had access to an "advanced search" interface that allowed them to search on many different features at once, but its format, which consisted of about 40 entry forms and drop-down boxes, was seen as too complex, and was rarely used. Thus, although they had the desire to do searches on multiple categories, the interface discouraged them from doing so.

A query study also supports the notion that users want to search for images according to combinations of topical categories. Armitage and Enser [1] analyzed a set of 1,749 queries submitted to 7 image and film libraries. They classified the queries into a 3-by-4 facet matrix; for example, *Rio Carnivals* fell under *Geographic Location* and *Kind of Event*. They did not summarize how many queries contain multiple facets, but showed a set of 45 selected queries, to which they assigned an average of 1.9 facets per query.

The system proposed by Garber & Grunes [7] is the interface most similar to our approach. The interface operated in two modes: (i) showing metadata associated with a target image, and presenting images in an order reflecting the number of categories they had in common with the target image; and (ii) allowing the user to select a set of category labels, and showing sample images for similar categories (e.g., showing images labeled *New England*, *Africa*, and *Egypt* when the category label *Florida* is selected). Hierarchy information was not shown, and no information was provided about how many images are available in each category. Focus groups observing the demonstration were very enthusiastic about it, but no followup work appears to have been done.

## METADATA

Here we define and illustrate the notion of faceted metadata.

### Faceted Metadata

Content-oriented category metadata has become more prevalent in the last few years. Many individual collections already have rich metadata assigned to their contents; for example, biomedical journal articles typically have a dozen or more content attributes attached to them. Metadata for organizing collections can be classified along several dimensions:

- The metadata may be *faceted*, that is, composed of orthogonal sets of categories. For example, in the domain of fine arts images, possible facets might be themes (military, religious, etc.), artist names, time periods, media (etching, woodblock, ceramic, etc.), geographical locations, and so on.
- The metadata (or an individual facet) may be *flat* ("by Pablo Picasso") or *hierarchical* ("located in Vienna > Austria > Europe").
- The metadata (or an individual facet) may be *single-valued* or *multi-valued*. That is, the data may allow at most one value to be assigned to an item ("measures 36 cm tall") or it may allow multiple values to be assigned to an item ("uses oil paint, ink, and watercolor").

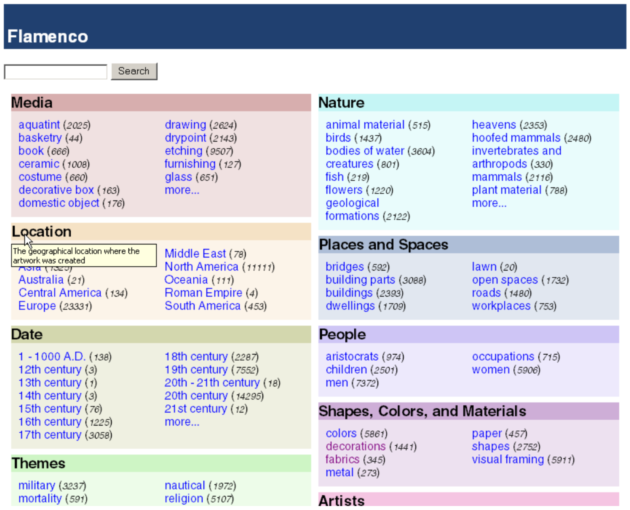
There are a number of challenges associated with metadata, including choosing the most appropriate descriptors for a given collection and assigning metadata descriptors to items that do not have any metadata assigned. Researchers are investigating these problems (e.g., [17]), but there are in fact many existing, important collections whose contents already have hierarchical metadata assigned.

### Collection Preparation

The collection under study consisted of approximately 35,000 images out of the more than 82,000 images in the Thinker collection of the Fine Arts Museum of San Francisco (metadata was available only for a subset of images). This collection contained standard arts metadata facets, including artist names, types of media, and dates, but had little in the way of content-based metadata. That is, it lacked metadata categories that describe the appearance of items or the images depicted in them, as in the case of paintings. However, many of the images did have sentential or phrasal descriptions of their contents. For example:

- *A man riding in cart drawn by two horses.*
- *Soup can, not in traditional colors: i.e. green lid, purple and orange lettering, etc.; Campbell's condensed tomato soup in purple, aqua and orange on purple background.*

We developed an algorithm to semi-automatically convert these descriptions into a set of metadata categories assumed to be useful for students and scholars of art history. This was done by comparing the words in the descriptions to their higher-level category labels in WordNet [6], and retaining a subset of the most frequently occuring categories. Some categories tended to correspond to highly ambiguous terms (e.g., "arm", "head" and other body part terms) and so were discarded. Other ambiguous words (such as "punt") only had one sense in the collection and so could be retained. Although some labels were incorrectly assigned, this algorithm worked surprisingly well. We did not directly ask our usability study participants about whether they trusted the metadata categories, but most independently volunteered comments. The majority of participants expressed pleasure at seeing content descriptors in addition to the traditional descriptors of who, what, and where. However, about one-quarter of the participants commented on a confusing or



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Search

Media

aquatint (2025)
basketry (44)
book (666)
ceramic (1008)
costume (660)
decorative box (163)
domestic object (176)
drawing (2624)
drypoint (2143)
etching (9507)
furnishing (127)
glass (651)
more...

Location

The geographical location where the artwork was created

Asia (1325)
Australia (21)
Central America (134)
Europe (23331)
Middle East (78)
North America (11111)
Oceania (111)
Roman Empire (4)
South America (453)

Date

1 - 1000 A.D. (138)
12th century (3)
13th century (1)
14th century (3)
15th century (76)
16th century (1225)
17th century (3058)
18th century (2287)
19th century (7552)
20th - 21th century (18)
20th century (14295)
21st century (12)
more...

Themes

military (3237)
mortality (591)
nautical (1972)
religion (5107)

Nature

animal material (515)
birds (1437)
bodies of water (3604)
creatures (801)
fish (219)
flowers (1220)
geological formations (2122)
heavens (2353)
hoofed mammals (2480)
invertebrates and arthropods (330)
mammals (2116)
plant material (788)
more...

Places and Spaces

bridges (592)
building parts (3088)
buildings (2393)
dwellings (1709)
lawn (20)
open spaces (1732)
roads (1480)
workplaces (753)

People

aristocrats (974)
children (2501)
men (7372)
occupations (715)
women (5906)

Shapes, Colors, and Materials

colors (5861)
decorations (1441)
fabrics (345)
metal (273)
paper (457)
shapes (2752)
visual framing (5911)

Artists

Figure 1: The opening page shows a text search box and the first level of metadata terms. Hovering over a facet name yields a tooltip (here shown below "Location") explaining the meaning of the facet.

misfiled classification; these issues did not appear to disrupt the flow of the participants' searches nor did they negatively affect their evaluation of the system. The leaf-level category labels were manually organized into hierarchical facets, using breadth and depth guidelines similar to those in [2].

## INTERFACE DESIGN

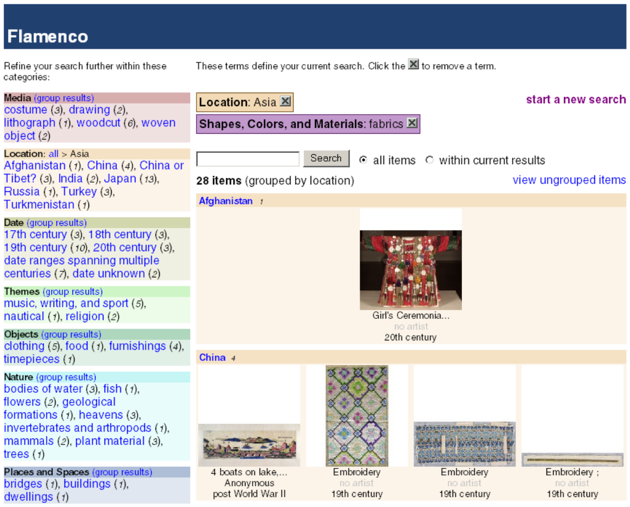
### The Faceted Category Interface

*Unifying Goals*

Our design goals are to support search usability guidelines [16], while avoiding negative consequences like empty result sets or feelings of being lost. Because searching and browsing are useful for different types of tasks, our design strives to seamlessly integrate both searching and browsing functionality throughout. Results can be selected by keyword search, by pre-assigned metadata terms, or by a combination of both. Each facet is associated with a particular hue throughout the interface. Categories, query terms, and item groups in each facet are shown in lightly shaded boxes, whose colors are computed by adjusting value and saturation but maintaining the appropriate hue.

In working with a large collection of items and a large number of metadata terms, it is essential to avoid overwhelming the user with complexity. We do this by keeping results organized, by sticking to simple point-and-click interactions instead of imposing any special query syntax on the user, and by not showing any links that would lead to zero results. Every hyperlink that selects a new result set is displayed with a query preview (an indicator of the number of results to expect).

The design can be thought of as having three stages, by rough analogy to a game of chess: the opening, middle game, and endgame. The most natural progression is to proceed through the stages in order, but users are not forced to do so.



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Refine your search further within these categories:

Media (group results)
costume (3), drawing (2), lithograph (1), woodcut (6), woven object (2)

Location: all > Asia
Afghanistan (1), China (4), China or Tibet? (3), India (2), Japan (13), Russia (1), Turkey (3), Turkmenistan (1)

Date (group results)
17th century (3), 18th century (3), 19th century (10), 20th century (3), date ranges spanning multiple centuries (7), date unknown (2)

Themes (group results)
music, writing, and sport (5), nautical (1), religion (2)

Objects (group results)
clothing (5), food (1), furnishings (4), timepieces (1)

Nature (group results)
bodies of water (3), fish (1), flowers (2), geological formations (1), heavens (3), invertebrates and arthropods (1), mammals (2), plant material (3), trees (1)

Places and Spaces (group results)
bridges (1), buildings (1), dwellings (1)

These terms define your current search. Click the ☒ to remove a term.

Location: Asia ☒
Shapes, Colors, and Materials: fabrics ☒

start a new search

Search ● all items ○ within current results

28 items (grouped by location)

view ungrouped items

Afghanistan 1

Girl's Ceremonia...
no artist
20th century

China 4

4 boats on lake,...
Anonymous
post World War II

Embroidery
no artist
19th century

Embroidery
no artist
19th century

Embroidery ;
no artist
19th century

Figure 2: Middle game (items grouped by location).

*Opening*

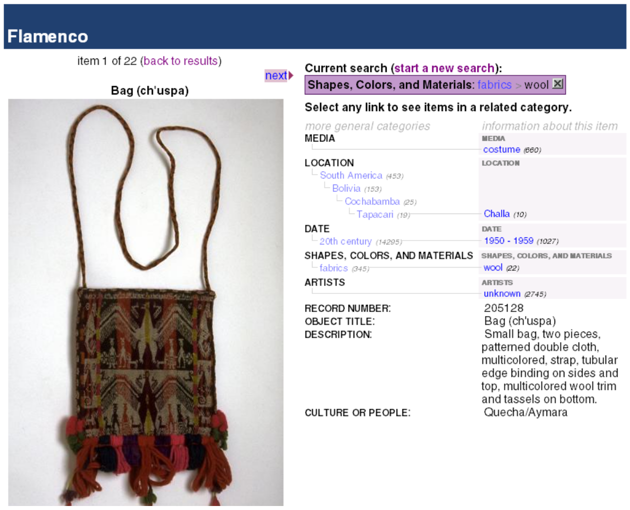
The primary aims of the opening are to present a broad overview of the entire collection and to allow many starting paths for exploration. The opening page (Figure 1) displays each metadata facet along with its top-level categories. This provides many navigation possibilities, while immediately familiarizing the user with the high-level information structure of the collection. The opening also provides a text box for entering keyword searches, giving the user the freedom to choose between starting by searching or browsing.

Selecting a category or entering a keyword gathers an initial result set of matching items for further refinement, and brings the user into the middle game.

*Middle Game*

In the middle game (Figure 2) the result set is evaluated and manipulated, usually to narrow it down. There are three main parts of this display: the result set, which occupies most of the page; the category terms that apply to the items in the result set, which are listed along the left by facet (we refer to this category listing as The Matrix); and the current query, which is shown at the top. A search box remains available (for searching within the current result set or within the entire collection), and a link provides a way to return to the opening.

The key aim here is organization, so the design offers flexible methods of organizing the results. The items in the result set can be sorted on various fields, or they can be grouped into categories by any facet. Selecting a category both narrows the result set and organizes the result set in terms of the newly selected facet. For instance, suppose a user is currently looking at the results of selecting the category *Bridges* from the *Places* facet. If the user then selects *Europe* from the *Locations* facet, not only is the category *Europe* added to the query, but the results are organized by the subcategories of *Europe*, namely *France*, *Italy*, and so on. Generalizing or removing a category term broadens the result set. Selecting an individual item takes the user to the endgame.



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item 1 of 22 (back to results)

next

Bag (ch'uspa)

Current search (start a new search):

Shapes, Colors, and Materials: fabrics > wool ☒

Select any link to see items in a related category.

| more general categories | information about this item |
|---|---|
| MEDIA | MEDIA<br>costume (660) |
| LOCATION<br>South America (453)<br>Bolivia (153)<br>Cochabamba (25)<br>Tapacari (19) | LOCATION<br>Challa (10) |
| DATE<br>20th century (14295) | DATE<br>1950 - 1959 (1027) |
| SHAPES, COLORS, AND MATERIALS<br>fabrics (345) | SHAPES, COLORS, AND MATERIALS<br>wool (22) |
| ARTISTS | ARTISTS<br>unknown (2745) |
| RECORD NUMBER: | 205128 |
| OBJECT TITLE: | Bag (ch'uspa) |
| DESCRIPTION: | Small bag, two pieces, patterned double cloth, multicolored, strap, tubular edge binding on sides and top, multicolored wool trim and tassels on bottom. |
| CULTURE OR PEOPLE: | Quecha/Aymara |

Figure 3: Endgame view of an individual item, with contextualized links for expanding the query in several conceptual directions.

### Endgame

The endgame (Figure 3) shows a single selected item in the context of the current query. Next to the item, the query terms are displayed, together with an innovative hybrid-tree layout that shows all of the metadata terms assigned to the item and their locations within their hierarchies. This layout combines a simple attribute list in the right-hand column, where the most specific assigned terms can be quickly read off, with an outline tree view in the left-hand column, where each term is situated in its context within the metadata hierarchy. Selecting a metadata term switches to a new query showing all the items associated with just that term.

This view exposes metadata terms of interest, while also making it easy to navigate *laterally* through the collection. After refining a query in the middle game, a user can head in a totally new direction by choosing an image and then expanding the search from a related category in the endgame.

### Keyword Matching

Each item is associated with the text of all its metadata, as well as any additional collection-specific text. The result set formed by a keyword search then contains all items whose text contains the keyword. Keyword search terms can be freely intersected with metadata query terms. In response to a keyword search, an additional panel appears at the top of the middle game display. This disambiguation panel lists all the metadata terms that contain the search key, with the search key highlighted in color wherever it appears. The user can select one of these terms to replace the keyword query term with a particular metadata term, or ignore the panel and continue to browse, leaving the keyword term in their query.

### Intermediate Listings

When a query yields too many items or subcategories to show at once, an intermediate page is shown, listing all the subcategories and suggesting that the user choose one. Subcategories are listed in columns and grouped alphabetically.

| System | Collection | Results<br>Per Page | Show<br>Cats? | Used<br>Before |
|---|---|---|---|---|
| Google | Web images | 20 | No | 27 |
| AltaVista | Web images | 15 | No | 8 |
| Corbis | Photos | 9–36 | No | 8 |
| Getty | Photos, art | 12–90 | Yes | 6 |
| MS Office | Clip art, photos | 6–100 | Yes | NA |
| Thinker | Fine arts images | 10 | Yes | 4 |
| Baseline | Fine arts images | 40 | Yes | NA |

Table 1: Comparison of features in popular existing image search interfaces. Show Cats? indicates whether hyperlinked categories are shown when images are selected; Used Before indicates how many study participants had previously used an interface.

### Implementation

The system is built using Python, MySQL, and the WebWare toolkit[1]. All components of the interface are dynamically generated, based on the facets and facet values defined in a relational database. Query previews are generated using the SQL `COUNT(*)` and `GROUP BY` operators to count the number of items that fall into each subcategory.

## The Baseline Interface

Today many users are familiar with keyword-based image search, as embodied by Web image search engines. Table 1 compares some of the features of 5 image search engines: Google Image Search, AltaVista Image Search, Corbis, GettyImages, and MS Office Clipart, in addition to The Thinker, the search engine currently available for the art history collection used in our study.

When the user selects an image for detailed viewing, three systems (Getty, MS Office, and The Thinker) show related topical category labels, hyperlinked to act as queries (e.g., showing the categories *Flowers* and *Nature* next to an image of poppies). The categories are not explicitly faceted or hierarchical, and are usually not shown in any meaningful order.

To create a fair comparison of search interfaces, we built an image search system that is representative of the best aspects of the six image search engines in Table 1. When in doubt we usually opted to make the baseline resemble Google Image Search, due to its familiarity to the user population.

The starting page for the baseline interface provides an entry form for typing in search terms, an illustrative image, a two-sentence description of the collection (mimicking the starting page of The Thinker), and some information on how to search the collection. If multiple search terms are entered in the query, they are implicitly ANDed, as this practice has become widely adopted due to Google's use of it. Only one participant (in the pre-test) asked about doing advanced Boolean queries. Adjacent words enclosed in quotation marks are treated as phrases. Stemming is not done, both because of the confusion it can cause [11], and because Google does not use it.

[1] www.python.org,www.mysql.com,webware.sourceforge.net

After the user enters search terms, a linked list of pages of search results is shown, along with a description of how many images were found as a result of the query. The images are displayed in a table of 10 rows of 4 images each, in alphabetical order according to image title[2]. The user can click through a page at a time, enter a new query in the search form that appears at the top of each page (the default is to search the entire collection), or click on a particular image to see more detail.

In the detailed view, a larger version of the image is shown along with a listing of its associated metadata. In addition, the baseline has a feature that makes it more powerful than the other keyword search systems. It shows a hyperlinked list of category labels that translate into queries on the corresponding category label in the faceted category interface. For example, if an image has been assigned the category label *Bridge* in the faceted category interface, the detailed view of that image in the baseline interface also includes a hyperlink to a query that retrieves all items in the *Bridge* category. The categories are shown in alphabetical order, but no preview is shown of the number of items in the category. Thus, here the baseline interface departs from the Google design in order to incorporate functionality roughly equivalent to the category views provided by the other systems in Table 1.

Since the baseline interface does not need to compute query previews, it is much faster than the faceted category interface. Using our records of actual queries performed during the studies described below, we measured the average processing time for the category interface to be an order of magnitude longer than that of the baseline interface.

### Prior Work

To develop the target interface, we followed standard interface design practice. Beginning with the domain of architectural design, we did an ethnographic study of how architects search for and use images as inspiration for design [5]. This was followed by a cycle of low-fidelity prototyping, informal usability testing, and redesign. After this, we conducted two rounds of development and two usability studies. These studies were useful for answering questions about various design features, and determining whether users would respond well to navigation of multiple simultaneous hierarchical facets. However, up to this point we had not compared the design to a more standard baseline, to determine if this richer method of search would be preferred and more effective over a more standard interface. Hence this paper presents the results of a new study to answer the question: is this design better than the current state of the art in image search interfaces?

## USABILITY STUDY

### Participants

Working with participants who are interested in the collection in question has been found to be especially important in search usability studies [3]; this has been our experience as well. We chose to use a fine arts collection for this study because it was possible to recruit art history students and people who have recently taken art courses as the study participants. Data from 32 participants was used in the analysis. (A pre-test was conducted on three participants and data for two outliers was discarded.) The participants were all regular users of the Internet, searching for information either every day or a few times a week. They searched for images online less frequently, with the majority searching for images less than once per week. Table 1 summarizes their familiarity with various image search systems; four people had previously used the Fine Arts image collection with its official Web interface, The Thinker.

### Apparatus

Participants received a $15 gift certificate for participating in a session that lasted about 1.5 hours. We tested all the participants in a lab setting, using Internet Explorer 6 on Windows 2000 workstations with 21-inch monitors set at 1280 by 1024 pixels in 24-bit color. Data was recorded with multiple methods: (a) server logs, (b) behavioral logs (time-stamped observations), and (c) paper surveys after each task, each interface, and at the end of the session. One or two experienced usability analysts conducted the sessions; when two were available, one analyst took written notes while the other facilitated the session. We collated data from all the sources to create a complete record of each test session.

### Design and Procedure

The study used a within-subjects design. Each participant used both the faceted category interface (henceforth FC) and the baseline interface; each interface was the starting view for half the participants. The interfaces were assigned neutral names (“Denali” for FC and “Shasta” for Baseline).

In earlier studies we walked participants through the features of the experimental interfaces. By contrast, and to better mimic the situation that occurs in practice, in this study participants were not introduced to the features nor told anything in advance about the systems other than that they both accessed the same collection of 35,000 fine arts images. We did inform participants that keyword searching was available in both interfaces and briefly explained the text search syntax (the use of quotation marks to delimit phrases).

Throughout the study, subjective ratings were reported on a 9-point Likert scale, with 1 meaning “strongly disagree”, 9 meaning “strongly agree”, and 5 meaning “neutral”. Because we have found that participants tend to be generally positive about the current interface, we adopted a wide range in order to have a more sensitive testing instrument.

[2] It is difficult to determine the ranking algorithm used by the Web search engines; presumably it is a function of the match of the query terms to the words near the images where they are found. The other systems do not seem to have a ranking function; three systems allow grouping according to broad categorical features such as color vs. black-and-white or media type.

### Tasks

The tasks were designed to reflect the contents of the collection and the art history background of the students. Participants completed four tasks on each interface, two structured and two unstructured:

1. (3 min, unstructured). Search for images of interest.
2. (11-14 min, structured). Gather materials for an art history essay on a given topic. Complete 4 subtasks, ranging from very specific to more open ended, e.g.: (i) Find all woodcuts created in the United States; (ii) choose the decade for which the collection seems to have the most images of U.S. woodcuts; (iii) select one of the artists who worked during this period and show all of his or her woodcuts; (iv) choose one of the subjects depicted in these works and find another U.S. woodcut artist who has treated the same subject in a different way.
3. (10 min, structured). Compare related images in order to write an essay, e.g.: Find images by artists from two different countries that depict conflict between peoples.
4. (5 min, unstructured). Search for images of interest.

Task 2 used metadata categories clearly visible in the start page and matrix of FC. However, we carefully framed the wording of Task 3 so as not to reflect the wording of a particular facet. Each of Tasks 2 and 3 had two versions; study design was balanced in terms of which queries were assigned to each interface. At the end of the session, we asked participants whether they felt the structured queries were equally difficult; 30 out of 32 stated that they were equivalent. As a double-check, we looked at the difficulty ratings in the post-task questionnaires for the different tasks; we found no significant differences between the two task sets (both $t$'s $< 1.7$, both $p$'s $> 0.05$).

### Results

It is difficult to evaluate browsing tasks, since there are no correct answers and since the goal is not necessarily to minimize time used. Thus the tasks and measures were designed to test the following hypotheses about FC:

1. Participants will experience greater search satisfaction and success in FC than in the Baseline, feel greater confidence in the results, produce higher levels of recall, and encounter fewer dead ends.
2. Overall, FC will be perceived to be more useful and flexible than the Baseline.
3. Using FC, participants will feel more familiar with the contents of a collection.
4. Participants will use FC to perform multiple-facet queries during their self-directed searches.

#### *Task Satisfaction and Success*

After each structured task, participants completed a short questionnaire. Using FC, participants felt significantly more confident that they had found all of the relevant images in the collection (Task 2: $t(62) = 2.18$, $p < .05$, Task 3: $t(62) = 2.03$, $p < .05$) and significantly more satisfied with the results (Task 2: $t(62) = 3.78$, $p < .001$, Task 3: $t(62) = 2.03$, $p < .05$) than when they used Baseline (thus supporting hypothesis 1).

We evaluated participant success in retrieving all the relevant images for part (a) of Task 2, which was to find all woodcuts created in the United States or all aquatints created in France. In Baseline, 57% of the participants conducting the aquatints task retrieved all the relevant results; in FC, 81% of the participants were successful. For the woodcuts task, 21% of those using Baseline and 77% using FC managed to retrieve all the relevant images (thus supporting hypothesis 1). The differences were caused in part by the Baseline users not querying both singular and plural forms of words.

Participants indicated that they more often found themselves at a dead-end or empty results when using Baseline; this difference was not significant (Task 2: $t(62) = 1.41$, $p = .163$, Task 3: $t(62) = .499$, $p = .619$). However, during the structured tasks participants actually did receive empty results in Baseline 82 times, while in FC, they received empty results only 26 times (thus supporting hypothesis 1).

For search success, we also looked at how many items users opted to bookmark in each system and the usefulness ratings (on a scale from 1 to 10) for those items. In Baseline, participants rated 266 items with an average rating of 8.1; in FC, participants rated 215 items with an average rating of 7.9. In Baseline, participants may have been able to rate more items because the processing speed was so much faster than in FC. The differences in item ratings were not significant ($t(481) = 1.12$, $p = .26$).

As indicated above, all tasks were assigned time limits, but participants were allowed 3 extra minutes on Task 2 when using FC because of its slower response time.[3] Participants could complete a task before the time limit had expired. We did not encourage participants to rush through the searches; instead, we asked them to search as they normally would.

Participants spent an average of 9 min 30 s on Task 2 using Baseline; in FC, the time spent on this task averaged 12 min 6 s. For Task 3, participants spent 7 min 45 s in Baseline and about 9 min in FC. These differences were significant (both p's $< .05$), but may be caused by the slower processing time, and the fact that system errors occurred during 5 of the 32 sessions with FC; restarting the system added time to the tasks. Thus FC did not result in faster usage times; however, we had not hypothesized that it would, given that success in browsing tasks is not reflected by faster completion times.

#### *Post-Test Interface Comparison*

In the post-interface assessment, much stronger differences emerged. Immediately after completing the fourth task on

[3] For Task 2, the average processing time per step was 0.3 s for Baseline, but 3.7 s for FC. For Task 3, this was 0.37 s for Baseline, but 4.3 s for FC.

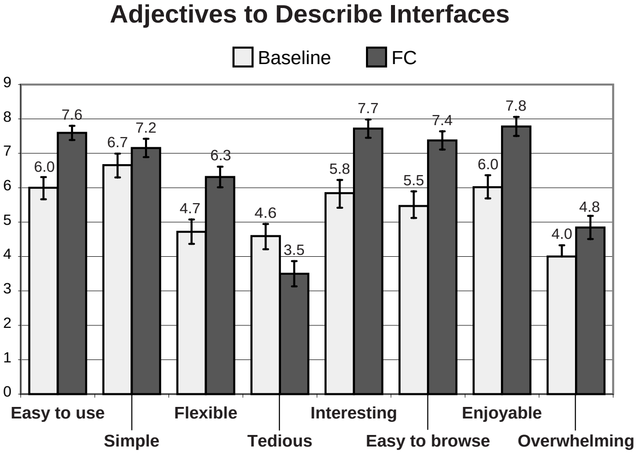

Figure 4: Post-interface assessments. All results were statistically significant at $p < .001$ except “simple” and “overwhelming”; “tedious” was significant at $p < .05$.

an interface, participants completed an interface evaluation. FC received more positive ratings than Baseline for nearly every measure, as shown in Figure 4. Noteworthy ratings are those for “easy to use” and “easy to browse.” Given FC’s complex screen design, it is remarkable that users assigned it an average rating of 7.6 for “simple.” Similarly, the fact that FC was not rated to be significantly more “overwhelming” than Baseline ($t(62) = 1.79, p > .05$) testifies to the success of the design. Participants indicated they were more likely to use FC in the future ($t(62) = -3.75$, $p < .001$). They also felt more familiar with the collection ($t(62) = -2.17$, $p < .05$). These results support hypotheses 1, 2, and 3.

The order in which interfaces were viewed had a strong effect on these ratings. When FC was viewed first, the interface ratings for Baseline were considerably lower than when Baseline was the first interface shown ($t(26) = 2.67, p < .01$). The ratings for FC were not significantly affected by being viewed after Baseline ($t(26) = -0.27, p = .783$).

Participants were also asked to compare Baseline to FC and indicate which interface they preferred for different situations (see Table 2). For finding images of roses (a simple, single-facet task), about 50% preferred Baseline. However, for every other type of searching, FC was preferred: 88% said that FC was more useful for the types of searching they usually do and 91% said they preferred FC to Baseline overall. Those who preferred the Baseline commented on its simplicity and stated that the categories felt too restrictive.

### *Facet Usage*

Facet usage in the structured tasks was driven largely by the task content, causing participants to focus on Date, Location, Media, Artist and Theme. However, for the unstructured searches, usage was more evenly distributed across all the facets. Artists (17%), Date (15%) and Location (15%) were the most used facets on the start page, but 111 starts occurred in the other facets with percentages ranging from 5% to 12%. For refining queries, again Artist (20%), Date (14%), and Location (19%) were most used, but the other facets were used for 6–11% of the refining actions (n=139). In the endgame, participants opted to create a new query by clicking on Artist 39%, Media 29%, and Shapes 19% of the time (n=21).

| Which interface would you rather use for these tasks? | Baseline | FC |
|---|---|---|
| Find images of roses | 15 | 16 |
| Find all works from a certain time period | 2 | 30 |
| Find pictures by 2 artists in the same media | 1 | 29 |
| Overall assessment: | Baseline | FC |
| More useful for your usual tasks | 4 | 28 |
| Easiest to use | 8 | 23 |
| Most flexible | 6 | 24 |
| More likely to result in dead-ends | 28 | 3 |
| Helped you learn more | 1 | 31 |
| Overall preference | 2 | 29 |

Table 2: Post-test preferences for the Baseline and Faceted Category (FC) interfaces.

The number of facets used simultaneously was also of interest to us, since this is a unique aspect of FC. Participants constructed queries from multiple facets in the unstructured tasks 19% of the time and in the structured tasks 45% of the time, thus supporting hypothesis 4. However, when browsing only a single facet, participants frequently used “search within results” to refine their searches (15% for unstructured, 50% for structured).

### *Qualitative Observations*

Users of the Baseline commented favorably on its simplicity and similarity to Google image search, but also noted that the category hyperlinks made it much easier to use.

Many participant reactions to FC followed a pattern. When shown the starting page, more than half explicitly remarked on it, noting that it was “well-organized” and gave them “ideas about what to search for”. The query previews were a key ingredient for 9 users, who offered unsolicited comments on this feature’s usefulness: “The collection seems more complete because I can tell how many are available in different categories from the front page.”

Once participants tried their first queries, more than half of them commented negatively on the speed. Some wondered aloud about the cause of the slowness, a few said it was “frustrating” and “annoying”, and one person commented, “At this point, I would go to a different search engine.” In the middle game, more than half of the participants explicitly remarked on the matrix, saying favorable things such as that it “prompted” them about where to go next. They also generally liked seeing the images grouped into categories: “It does a lot of the work for you, the searching and the categorizing.” Three were confused about how the matrix functioned: they thought it was a repetition of the first page and did not realize they could use it to refine their existing query. All other participants did understand the matrix and stated they felt more confident in the results they obtained by browsing. Participants liked having category links in the endgame of both interfaces, but 9 out of 32 explicitly commented on the level of detail in FC, stating that the information here was "useful" and "very clear", "guiding" them through a search.

As participants continued to use the interface, they became more comfortable with it. As an example interaction sequence, one participant began Task 3 (to compare images on conflict between people) by clicking on *military* at the start page, then refining from an intermediate page to choose *war*. Since there were 824 results, he refined his search further by doing a keyword search within results for *sword*, reducing the number of images to 74. He grouped the results by *artist*, since the task called for him to contrast works by two artists. Then he began clicking on images and started formulating his thesis: "This is the Napoleonic view of war—the camera is really far away. Men look like ants and you don't see war itself, the death, just the preparations." It occurred to him that 20th-century depictions of war are more graphic. He grouped his 74 results by date and quickly found images by Goya that "zoom in on the misery and suffering" of war.

At the end of the session, participants expressed enthusiasm for the FC interface, wanting to know when it would be available for them to use. One participant said, "I wish I had this when I was writing papers." The participants found it "interesting", "enjoyable", and "easy to customize" their searches using the FC interface.

## CONCLUSIONS AND FUTURE WORK

We have designed an image access interface that allows users to navigate a large collection using hierarchical faceted metadata in a flexible manner. Despite the fact that the interface was often an order of magnitude slower than a standard baseline, it was strongly preferred by most study participants. These results indicate that a category-based approach is a successful way to provide access to image collections.

We are in the process of developing algorithms to make the query preview generation faster. This is important for future attempts to make the method scale to collections that are one or two orders of magnitude larger. We also plan in the future to perform studies comparing this approach directly to similarity-based approaches, as well as studying the effects of adding personalization, history, and relevance feedback functionality to the design, and investigating the efficacy of the method on text collections.

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