Subject Access to Images and Exploratory Search

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Abstract. As traces of social life and material culture of the past, non-art images are carriers and prompters of memory. They are important sources for social and cultural history and, at the same time, valuable cultural heritage resources. Cultural heritage information systems (CHISs) very often rely on basic search and browsing features to provide access to information related to non-art digital images. However, these forms of access are not very helpful for non-expert or casual users, who usually move through the information space in an exploratory way. Although significant strides have been made to understand exploratory search activities, there are still some open issues when it comes to the user interface (UI). After briefly reviewing concept-based indexing techniques applied to images, this paper explores some of the questions related to UI design and provides insights into how to develop a browse-and-search framework to enhance exploratory search tasks.

1 Introduction

Like words, images convey meaning, but in a way that has nothing to do with the written or verbal language. Indeed, as the old adage says, a picture is worth a thousand words. Yet, in today's online environment, most indexing is precisely carried out using words, and search engines are predominantly keyword-based. What is more, there may be differences between the indexing system and the search system, resulting in the so-called vocabulary problem and a semantic gap [14].

Most information nowadays available on the Web is non-indexed. As a result, the only feature available to users to find out what they are looking for is free-text searching. This happens through a simple search input box, usually placed at the top right of the page. Here users can enter their queries using keywords. As a response, the system returns a set of matching results, usually sorted by relevance according to some similarity measure. This access pattern is the primary mode of searching offered by cultural heritage information systems (CHISs) and underlies a search model that targets users who have specific information needs in mind and well-defined search tasks to perform [18].

Since users are accustomed to Web search engines and their performance in returning results, retrieval latency plays an important role in the users' satisfaction: the higher the latency, the lower the quality of the results perceived by the

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users [12]. However, there are many different kinds of search, ranging from simple lookup tasks, such as known-item search in bibliographic databases, to informal browsing. When users have ill-defined, fuzzy or broad information needs, their behavior falls on the right side of the range. Users engage then in a particular type of information seeking process known as exploratory search (ES).

That ES implies learning and investigation tasks has long been implicitly recognized in the literature: "the query is satisfied not by a single final set, but a series of selections of individual references and bits of information at each stage of the ever-modifying search. A bit-at-a-time retrieval of this sort is here called berrypicking" [5] (p. 409). The berrypicking model aptly describes the dynamism and evolving nature of both search focus and information needs. Its non-linear and segmented path is a good graphical representation of how each piece of new information encountered along the way can result in new ideas and directions to follow. A berrypicking search seems to be an almost informal way of seeking information, albeit not restricted to informal methods only.

Rather than being designed according to the traditional direct search paradigm, CHISs should take a more user-oriented approach and implement navigation models that are capable of supporting those users who find unnatural to begin a search using keywords. These systems should also support those users who employ informal methods, by offering browsing functionalities going far beyond those based on the organization of the collection or context metadata, which do not reflect the image subject(s).

A complementary approach would be to offer a multidimensional browsing space where the subject terms describing what the image is *of* (description) and *about* (identification) are organized according to their paradigmatic relationships. Berrypicking is perhaps the most common strategy that users follow in ESs. Recent research has focused on the features required to best support ES patterns: White and Roth [32] have outlined the challenges of developing an ES system to support ES activities. Briefly, the set of features required for such a system includes: (1) an overview of the information space covered by the system, (2) meaningful representations of results, (3) support for query formulation and refinement, (4) faceted browsing and filtering, and (5) track-keeping of search path and history.

In recent years, faceted search (FS) has emerged as a key feature for enhancing the user search experience. Combining keyword search with faceted navigation has proven very effective as it lets users begin with a simple query and then refine search results by facets [16,28,33]. FS has also turned out to be a useful model to support ESs [32], although a few changes are still needed to make it more compliant with ES requirements.

The remainder of this paper is organized as follows: Sect. 2 gives an overview of concept-based indexing techniques applied to images; Sect. 3 focuses on how the concept of facet has been variously interpreted in different domains; Sect. 4 takes a look at hierarchical and faceted systems; Sect. 5 deals with search interaction patterns; Sect. 6 discusses the key characteristics of an exploratory tool for non-expert users; finally, Sect. 7 closes the paper and touches on future work.

2 Subject Access to Images

Photographic images have been the subject of attention of various disciplines, both old and new. Not only have these disciplines played a major role in increasing public awareness of the great social, historical and cultural significance embodied in such "documents of reality", but they have also developed specific categories and interpretative tools to understand the language of that specific means of expression (Fig. 1).

Fig. 1. Embroiderers (group portrait), Cormóns (GO, Italy) 1899. (Gorizia Archdiocese [Digital] Photographic Archive, C00034).

Over the last few years, libraries, archives and museums (LAMs) have tried to support non-expert users by providing innovative ways of searching and browsing that go beyond the query-response paradigm. Content-based indexing has offered in this regard an alternative way of exploring and engaging with digital cultural heritage resources [27]. At its most basic level, content-based indexing allows users to search for images by means of visual features such as color, shape and texture. However, these are low-level features, with limited descriptive power as regards the semantics of an image. A more suitable approach to improve retrieval is suggested by research conducted in domains like medical informatics, wherein visual content is combined with text-based data [2].

Unlike content-based indexing, concept-based indexing represents *subject matter* through descriptive terms taken directly from natural language, as is the case of social tagging, or through corresponding descriptors chosen from a controlled vocabulary. The latter is a far more formal way of representing topicality and involves various aspects of standardization that are of pivotal importance for CHISs. Vocabulary control is one of the key steps of this process as it is only by using a common terminology that any potential semantic gap existing between indexers and users is bridged and retrieval achieved.

In the case of library systems, concept-based indexing is usually carried out by human indexers. It begins with determining what a document is *about* and

goes on with a conceptual analysis and translation into a controlled terminology. However, it must be said that what *about-ness* really is remains controversial. From a very pragmatic point of view, about-ness can be considered as a variable, mainly affected by the type of language used: referential language refers to the objective reality, hence sentences are about their subjects, while representational or emotive language communicates or excites feelings [26] (pp. 46–48).

While determining the subject of a text according to the so-called grammar model (a careful examination of virtually any sentences making up the text) is somewhat problematic, determining the subject of, say, a photographic image is in general relatively straightforward as its referent or its genuine essence is "la chose nécessairement réelle qui à été placée devant l'objectif, faute de quoi il n'y aurait pas de photographie" [4] (p. 120). However, the referent is not enough to grasp the whole meaning of a photographic image. In Henry Ziegler's portrait of his cousin Gaspard, the pocket watch shown by the sitter might now suggest a simple reflection on the flow of time, while for a contemporary observer it meant the long time of the pose typical of early photographic processes [6]. This intended meaning is, in Barthes' words, *studium* [4] (pp. 47–48), which typically requires skills and knowledge other than those possessed by the layperson. Another much more problematic concept coined by Barthes is *punctum*. This is something present in the image that immediately jumps out at the viewers as unusual or unexpected and triggers in them a feeling, thought or memory. Therefore, *punctum* belongs entirely to the sphere of the beholder's subjectivity [4] (pp. 48–49). Barthes' considerations seem to offer a good basis for reconsidering the most common concept-based approaches currently underlying subject indexing of images as they provide for a differentiation between intersubjective and subjective meaning.

A complementary, albeit different, approach reported in the vast literature on image indexing is that of German art historian Erwin Panofsky [22]. His *Studies in Iconology* (1939) has had a strong influence on art history research and proven to be a valuable method for analyzing the subject of a work of art. In his model, Panofsky identifies three layers of subject matter in a work of art: (1) primary or natural subject matter (pre-iconographic description); (2) secondary or conventional subject matter (iconographic identification), and (3) intrinsic meaning (iconological interpretation). At the first level, perception yields factual meaning, i.e. referential meaning (objects, events), but psychological nuances (expressional meaning) can possibly emerge as well. At the second level, referents are related to the relevant frame of conventional values (social, art historical etc.). Finally, the third level is concerned with the essential or intrinsic meaning of an image, which is grasped by widening the analysis to the religious, social, historical and philosophical context in which the work of art was created. At this level, a work of art is understood to be symptomatic of a worldview (*Weltanschauung*) [22] (pp. 5–8 and 14–25).

Panofsky's model has been largely deployed in image indexing, albeit modified to merely fit instrumental and pragmatic needs. Indeed, what was originally conceived as a unitary process geared towards understanding the inner

essence of a work of art that encompasses the whole continuum of the interpretive spectrum has been regrettably turned into no more than a set of procedural guidelines mainly focused on the pre-iconographic and iconographic levels (see for example [19]). For this, as well as other reasons, Panofsky's model (1939) has been recently criticized and challenged by some scholars, who have called for a rethinking of the theoretical and practical foundations of image indexing (for example [10]). However, when going back to the apparently banal example given by Panofsky in the *Introductory* of his *Studies* (1939) – a natural event of the everyday life – one cannot overlook the fact that it was purposely chosen "to exemplify the **minimal** [bold mine] features of visual communication and representation", and to serve as a "baseline from which to measure more complex" forms of "visual representation" (cf. [21], p. 26). Therefore, it is not a matter of doing Panofsky's model anew or simply to scale it down from the level of iconological interpretation to that of the minimal features of non-art imagery. Rather one should acknowledge that there are methodological differences in approaching the problem of subject indexing of images and that the building blocks of a heuristic model for subject access to non-art imagery are to be laid on the basis of the analysis of images that represent events of everyday life like the one described in Panofsky's model.

Shatford Layne's contribution to image indexing, on both the theoretical and practical level, appears to address many of the issues surrounding this point [25]. Her framework for analyzing the subject of an image consists of: (1) a description in generic terms (*generic of-ness*), (2) identification in specific terms (*specific of-ness*), and (3) interpretation (*about-ness*). The main limit of this framework becomes immediately clear when analyzing Fig. 1. The content of this photographic image is actually readable only at the first two levels: (1) women and children (generic of-ness), and (2) embroiderers (specific of-ness). The third level of meaning, i.e. the meaning to which the image referent alludes, is problematic because there is no readily available information in the image pointing to some underlying message. If one wants to find out such message, they have to rely upon the help of sources other than the image itself, which may not be readily available, or even exist at all.

As far as art images are concerned, about-ness is core to subject analysis, especially when symbols and allegories are at work, or when it is stated or clearly apparent. However, when this is tenuous and ambiguous, because the interpretation is heavily dependent on the observer's subjectivity, it can be even omitted altogether. About-ness then is the constitutive factor that differentiates art images from non-art images. However, since non-art images are not only a representation of reality but also, in Barthes' words, prompters of *punctum*, it follows that: (1) the analysis of non-art images should not be limited to the generic-to-specific continuum of the spectrum making up the description and identification of the reality depicted in an image in order to fit it into categories according to some schema; (2) it is appropriate to provide additional or alternative points of view, i.e. access points to the who, what, when and where that are right **there** (*there-ness*) **in**, rather than **about**, an image. If neither the interaction between

studium and *punctum* nor the rules for knowing the *punctum* can be established in advance, then the analysis of the content of non-art images should take place solely at the of-ness level. And the related subject metadata created by indexers should adequately reflect the outcome of this analysis at the level of detail as required for the so-called minimal features of non-art images.

As regards this issue, it was considered appropriate to conform to the version of *Subject Matter* presented in [15], comprising the following sub-categories: *description*, *identification*, and *interpretation*. Additionally, although [15] provides everything necessary to develop a search interface, the way in which the descriptive content was structured for the project in question is quite different as it features both natural language descriptions (to support direct keyword search) and subjects based on bibliographic conventions. Indeed, the relevant subject terms selected by the indexer were first translated into the appropriate controlled vocabulary, and then organized into a compound subject (string), whose citation order follows the syntax of the indexing language.

The indexing language used for the project in question consists of: (1) a controlled vocabulary, (2) a syntax (citation order), and (3) sentences (indexing strings). In technical terms, this type of indexing is called *pre-coordination* as the relationships between concepts are established in advance, i.e. at the indexing stage. In pre-coordination, indexing offers a twofold advantage: (1) context, and (2) browsability. The latter can be implemented either as a hierarchy of strings (to meet the needs of expert users) or as a multidimensional space (to meet the needs of non-expert users). Pre-coordinated strings can be parsed according to the categories underlying the citation order for the sake of creating a multifaceted space of information that allows for post-coordination. Last but not least, pre-coordination is a helpful feature for improving proximity searches and ranking metrics [1].

As for Barthes' *punctum*, the analysis of the who, what, when and where present **in** an image is the responsibility of the beholder. Since in the era of Web 2.0 viewers are free to assign to visual content whatever tag in their opinion expresses the feelings, thoughts or memories arising in them when seeing an image, it is assumed that folksonomies and tag clouds are, among other things, capable of gathering about-ness statements as intended by Barthes.

3 The Concept of Facet

Facet analysis (FA) was originally conceived as a method for conceptual analysis of semantic elements based on a given set of principles and rules [8], [9] (pp. 299–326). From this standpoint, a *facet* simply represents a type of concept. Information scientists have (re)discovered facets only quite recently. Indeed, the large-scale application of FA to information architectures designed for the Web dates to early 2000s. From then onwards, facets have become the standard way in which e-commerce websites organize their content [28]. However, it must be said that the notion of facet underlying this ever-growing trend goes far beyond the original meaning and is indicative of a major conceptual shift wherein

a "generic term used to denote any component of a compound subject" [23] (p. 88) has in the end become any attribute of a resource. This widespread understanding of facets seems to reflect the way in which FA has been received in Northern America. Two cases in point are the *Faceted Access to Subject Terminology* (FAST) project by OPACs 2.0, featuring Endeca Guided Search [7], and the principles set out in the ANSI/NISO Z39.19-2005 (2010) standard, where one reads that: (1) the possible attributes or facets of a resource are subject (*indexing string*), author, location, form, language; and (2) the concept of facet basically corresponds to that of attribute in the computing field.

Unlike these examples, the notion of facet borrowed here follows that of the mathematician and librarian Ranganathan. Accordingly, indexing focuses on what an image depicts, while FA is the technique wherein terms or concepts of the same type (facets) are identified and grouped together. Therefore, the browse and search interface is the result of an analytical process in which facets (subject metadata) and the corresponding values are identified using natural language. Facets and values are then validated against the subject indexing tool devised for this project, which is also used as a conceptual grid to identify basic categories during the first steps of FA.

4 Information Exploration Architectures

There are two main ways of organizing information: hierarchical and faceted. A *hierarchical structure* consists of a classed system organized according to a top-down approach, starting from the most generic concept – the most top-level class – and then dividing it into sub-classes of increasing specificity. In general, a subject can be divided and subdivided according to different characteristics and levels of specificity. However, in practice, both division and specificity should reflect the distinctions and level of analysis by which the subject matter is, so to speak, naturally structured. For this reason, it is more convenient to develop a system on a pragmatic basis, rather than a philosophical one. The best approach is to compromise and seek the right balance between literary and user warrant. On the one hand, the structure should basically conform to the way in which the subject matter is represented in the relevant literature, but on the other hand it should be accessible in much the same way as users search for this type of information in the related literature and in online settings.

A good example briefly illustrating the pros and cons of this approach are those images whose subject falls under the category *Building*(s). Its hierarchical arrangement is divided by place first, and then by building type and building parts, respectively. Put it another way, three characteristics of division are applied to this class in the following order: Place – B. type – B. parts. This, on the one hand, results in the inevitable scattering of the subordinate attributes (*distributed relatives*), but on the other hand it represents the prescribed and predictable sequence by which concepts are not only sorted but also accessed (*citation order*). In this respect, if the main concern is to first find buildings in a given area, and then their types and components, the citation order will perfectly

match the users' interest. On the contrary, if the initial focus is on types, in order to collect every piece of relevant information, users have to browse every single place. Therefore, when deciding on the order in which the attributes should be placed, one should carefully consider which order is more likely to fit the needs of the intended users, as well as which aspects are of primary importance and which ones can be distributed instead [9] (pp. 8–12). There are usually many aspects (facets) potentially relevant to users. Locking them into a rigid arrangement favoring one facet over the others results in a one-dimensional approach, and hence in a unidirectional search, that is very limiting.

Unlike the hierarchical approach, the faceted one relies on a bottom-up technique called facet analysis (FA). The process begins with grouping individual concepts into classes on the basis of some common characteristic. So far, nothing new in this. FA is not very different from the classic principle of logical division according to which each class is derived from the application of a single characteristic of division at a time. However, as already mentioned, some reasonable compromise or balance between literary and user warrant is necessary when choosing the characteristics for each class. Such characteristics are called facets and identify the properties used to model the information space of interest [29] (pp. 12–13). Facets are also referred to as conceptual dimensions of data or faceted metadata [33]. This approach seems to be a somewhat natural way of organizing information, since it offers the ability to accommodate on the same level all the facets (dimensions), or at least, the most relevant ones.

5 Search-and-Browse or Browse-and-Search Interface?

There are search situations in which non-expert users come with fuzzy information needs in mind. Since they lack background knowledge about the domain in question, the first problem to be tackled is how to help them get a better understanding of the domain and its conceptual organization. In practical terms, this means to find out what type of exploratory system is needed to achieve this goal.

It is assumed that the ultimate goal of exploratory search (ES) is to foster learning and investigation by combining analytical strategies (direct search) with browsing [18,32]. Many applications make use of faceted search (FS) as a key technique for supporting ESs as FS combines these two components in a seamless fashion [28]. But how are these components combined together? And, what is more, how is the interaction between the two worked out? In a typical scenario, FS would begin with a keyword search: users have to formulate their information need as a query. Non-expert or naive users perform core exploratory tasks and issue short general queries returning large result sets [3]. This is when faceting is implemented to enhance the display of search results. Facets offer guidance to users in: (1) exploring the search space from different perspectives, and (2) narrowing down the result set based on relevant facets and associated values. This search-and-browse interaction pattern seems to be suitable for borderline lookup tasks [3].

Non-expert or casual users interact differently with cultural heritage information systems (CHISs) [20,30,31]. Coming without a specific information need

in mind, or with no need at all, these users just look around aimlessly, driven by the desire to discover something interesting, engaging or exciting. They interact with the information space in an exploratory fashion using browsing features first [30]. Therefore, to present a digital environment that is not only familiar and intuitive to a large majority of users, but also capable of providing handy orientation from the very beginning, is paramount.

A core assumption underlying browsing models is that metaphors based on physical spaces and resources are highly favored by both novice and expert users. These metaphors are likely to closely match users' mental models because they feel engaged in well-known physical environments such as the physical layout of a library [5,24]. In fact, as shown in the Flamenco interface [33], faceted systems are multidimensional exploratory maps and, at the same time, spatial models where information is organized in much the same way as books are classified and placed on library shelves. Users get an overall view of the information space covered by the system, and then browse the content as if they were walking through the library shelves.

Faceted classification – taken in its strict meaning – represents a promising approach to the organization of information and construction of browse-and-search systems that may help newcomers in their initial interaction with digital cultural resources (cf. [8]). Moreover, faceted techniques can prompt the exploration tasks of casual users who approach digital cultural heritage content with the hedonic intent of finding something amusing, entertaining or enjoyable, and eventually discover that learning is fun too.

6 The Browse-and-Search Interface

The screenshot below (Fig. 2) shows the latest version of the user interface for an ongoing digital cultural heritage project called *Percorsi della memoria*, versione 2.0 [Paths of Memory, version 2.0] [11]. Its design largely follows the guidance and recommendations put forward for the *Flamenco Search Interface Project* [33], except for the faceted metadata. The center of the page is occupied by the set of results returned after selecting *Forme* > *Generi artistici* [Forms > Artistic genres]. The main faceted navigation system is located on the left side of the page. Its structure was built from the bottom up by first analyzing the subject terminology according to the grid of basic categories identified using the subject indexing tool devised for this project. The inner structure of each facet was subsequently organized using facet analysis. All facets are hierarchical, except for *Luoghi* [Places].

This system represents a knowledge structure that provides users with an overview of the information space based on its top-level semantic facets (the number of items contained in each facet is displayed next to the facet name). Clicking a facet displays the next level (checkbox/sub-facet pairs). In this case, the query preview shows not only the counts but also all the sub-facets nested under a facet, which are displayed after selecting the checkbox. Finally, the value level is reached by clicking the sub-facet (here the counts always refer to the

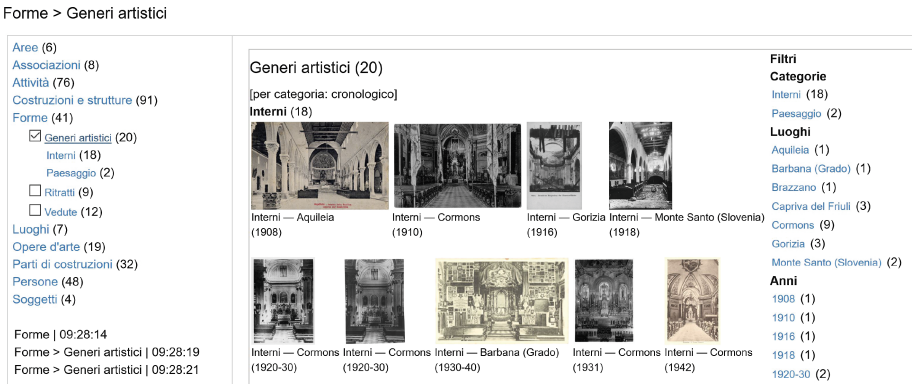

Fig. 2. Screenshot of the exploratory interface of *Percorsi della memoria*, version 2.0: set of results returned after selecting Forme > Generi artistici [Forms > Artistic genres]. Images are grouped by genre type and arranged in chronological order. On the right side of the page, there are facets that allow one to refine the set of results, and hence to contextualize the subject explored. The main faceted navigation system is located on the left side of the page.

number of matching results). When clicking a value, results are limited to those matching the corresponding value, as happens with a WHERE constraint, while selecting a checkbox/sub-facet pair allows the disjunctive selection of multiple values within a facet (ORed set).

The set of thumbnail images and captions displayed on the middle of the page is arranged in ascending chronological order to create a historical sequence of data. Many sets resulting from the selection of a sub-facet are instead classified according to the values present within each sub-facet. These categorized overviews are ordered alphabetically, while each sub-group is arranged chronologically. Since the size of the set is large, an additional faceting feature has been added: on the right side of the page, there are terms related to category type, time and space, which allow one to refine the results, and hence to contextualize the subject explored. This feature is always available to users so that they can filter sets exceeding 10 results.

Two additional key features are: (1) the user exploration path, which is shown at the top of the page; and (2) a separate line in the list below the main faceted navigation system displaying each exploration step (this list may serve as an exploration history as well). Last but not least, the interface remains the same throughout the user's journey. This browse-and-search framework model will be used for other similar collections of digital images such as the photographic collection of the Italian indologist Luigi Pio Tessitori [13].

7 Conclusion and Future Work

Non-expert or casual users browse digital cultural content prompted by a desire of finding something amusing, engaging or just interesting. In this regard, it is clear that better tools are needed to support this exploratory seeking behavior. Faceted classification seems to offer a good basis for developing browsing spaces where an initial journey for fun may become a journey for learning. The middle game phase of the information-seeking process tends to be the most problematic for users [33]. According to Jackson and colleagues [17], it is exactly in this phase that focused search plays a crucial role. However, further research is needed on how to insert direct keyword search in the middle game phase. It is expected that useful findings will emerge from a dedicated qualitative survey of user behavior which is still ongoing. Although the system described in this paper is still being developed, a working demo is available from http://www.cataloguing-science.org/public/issrgo/ui.php.

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