Personalized Faceted Navigation for Multimedia Collections

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Abstract

Existing multimedia information retrieval systems provide users with insufficient support for efficient searching for and browsing in multimedia content. Several possible solutions were proposed, such as using faceted metadata search or semantic clusters of search results. We describe the possibilities of using enhanced faceted navigation with support for personalization, collaboration and Semantic Web technologies for multimedia information retrieval. Furthermore, we propose a method of faceted browser adaptation with support for dynamic facet generation based on an automatically acquired user model.

1 Introduction

Existing multimedia retrieval systems in general and image retrieval systems in particular do not enable users to search for and browse in diverse multimedia content (i.e., image, video or audio files) efficiently. Most existing search and sharing systems, such as Flickr, Google or MSN Live Search, use either keyword/tag-based search or similarity search with some sample images (based on low-level image properties). Furthermore, many existing systems use an advanced search interface, which allows users to specify more complex queries for images (e.g., size, filetype). Video sites such as IMDb and MovieLens take complexity to another level by offering (multistep) interfaces with many text fields, drop-down menus and multi-choice listboxes.

Several studies have already indicated that typical search queries are short (up to four words) [9] and that advanced search is impractical to use for many users [1]. While existing systems are generally good when searching for very specific items, they do not support browsing and exploratory tasks sufficiently [16]. A field study of journalists and newspaper editors selecting photos for newspaper articles conducted by Markulla and Sormunen reported that "professional users" needed to search on multiple categories [10], yet found an elaborate advanced search interface with about 40 input forms unusable. Moreover, the multimedia domain (on the Web) is a dynamic open information space as many images, videos or music files are continuously added, modified, rated, tagged. Thus, user diversity and the evolution of user characteristics over time also play an important role.

Due to limited capabilities of existing systems in terms of search efficiency, usability, collaboration support and personalization, new approaches were proposed to address information overload and insufficient search and navigation support. In this paper we build upon several proposed approaches and describe an enhanced adaptive faceted semantic browser, which is built around the faceted navigation paradigm [8] and user adaptation [3], by taking advantage of Semantic Web technologies (ontologies in particular) [12] and adaptation based on an automatically acquired user model. Section 2 describes related work. In section 3 we describe the proposed method of faceted browser adaptation. Section 4 explores adaptive faceted navigation in the context of multimedia information retrieval. Lastly, we draw conclusions in section 5.

2 Related Work

Several approaches were proposed to improve upon existing multimedia information retrieval systems with focus on interface usability and search engine capabilities.

The keyword-based IGroup image search engine presents search results in semantic clusters thus alleviating problems with short, general or ambiguous search queries [15]. IGroup clusters the original result set into several clusters and provides users with an overview of the result set by means of representative cluster thumbnails and names, which users can choose for further navigation. Thus, IGroup improves usability and makes users' search query formulation easier by providing both query suggestion and browsing by textual category labels.

Donald Geman discussed a somewhat similar approach based on "query-by-visual-example" and a Bayesian relevance feedback model, where users interactively choose the most similar images out of a set of sample images and the system matches the "visual query" against other images [6].

The importance of a combined browse and search interface was stressed in [17]. The proposed Relation Browser++ (RB++) was specifically designed for large digital libraries and (multimedia) information collections with evaluation on a video library. RB++ enables users to explore the information space via several categories (facets), displays relationships between facets and provides additional dynamic filtering of search results.

Authors in [16] proposed a faceted browser that allows users to navigate along (textual) conceptual dimensions. They stress the importance of user interface usability and divide the search process into three phases. The *opening* gives users a broad overview of the scope, size and content of the collection, the *middle game* allows users to narrow down the result set by refining the search query, the *end game* shows the final search result and allows users to navigate laterally through the collection.

The overall user response to these approaches was positive – nearly all users preferred them over a baseline approach/interface. Nevertheless, several of the approaches suffer from scalability and information overload issues. E.g., the faceted browser in [16] had an average response time of 3.7s vs. 0.3s for the baseline approach. Furthermore, neither of these solutions provide personalized features based on individual users' characteristics.

3 Method of adaptive faceted navigation

The enhanced faceted semantic browser extends the typical request handling of a faceted browser with additional steps that perform specific tasks (see Figure 1). We extend the processing of search results with support for their annotation and adaptation (Figure 1, center right). For this we employ external tools that evaluate the relevance of individual search results, e.g., by means of concept comparison with the user model [11]. Subsequently, we reorder the search results or annotate them with additional information. For example, in the movie domain, we can display the suitability of a movie, based on its estimated relevance to the user's preferences, as background color or via emoticons.

To facilitate automatic user modeling, we log events that occurred as results of user interaction with the browser and the current logical display state the browser interface via an external logging service [2] (Figure 1, bottom right).

Facet processing is extended with the adaptation, annotation and recommendation of facets and restrictions (Figure 1, bottom left), which improve orientation and guidance support, reduce information overload and alleviate some disadvantages of faceted classification. If the set of available facets is insufficient, we use dynamic facet generation to add new facets at run-time on a per user basis (Figure 1, center left) thus allowing the user to refine the search query and improving support for open information spaces.

3.1 Facet adaptation, annotation and recommendation

Facet adaptation processes all facets and adapts them at run-time to the specific needs of individual users. We first determine the relevance of facets and restrictions based on in-session user behavior (i.e., user clicks), on the user model (i.e., user characteristics described by their *relevance* to the user and the *confidence* in their estimation in the range $\langle 0, 1 \rangle$) and based on global statistics (i.e., all user models).

Let $L_U(X) = relevance_U(X)$ be the local relevance of facet X for user U and $R_U(V) = relevance_U(V) * confidence_U(V)$ be the relevance of restriction V. We define $C_U(X)$ as the cross relevance of X determined as the average local relevance for all users V weighted by their similarity to user U (1), and $G(X)$ as the global relevance of X defined as its average local relevance for all users (2).

$$C_U(X) = \frac{\sum\limits_{V \in users} (dist(U,V) * L_V(X))}{|users|}, U \neq V \quad (1)$$

$$G(X) = \frac{\sum\limits_{V \in users} L_V(X)}{|users|} \quad (2)$$

To evaluate the user similarity $dist(U,V)$ we employ external concept comparison tools [11]. Alternatively, similarity can be evaluated as the sum of differences between the relevance of specific concepts between users (3).

$$dist(U,V) = \sum_{X \in facets} (L_U(X) - L_V(X))^2 \quad (3)$$

We define $T_U(X)$ as the temporary in-session relevance of facet X determined as the percentage of user clicks on facet X from the total number of clicks (4). Static relevance $S_U(X)$ defines the relevance of facet X based on the user model and the respective *confidence* in the relevance estimation (5). Dynamic relevance $D_U(X)$ defines the total relevance of facet X based on the user model and in-session user behavior (6).

$$T_U(X) = \frac{Clicks(X)}{TotalClicks} \quad (4)$$

$$\begin{gathered} S_U(X) = L_U(X) * confidence_U(X) + \\ (C_U(X) + G_U(X)) * (1 - confidence_U(X)) \end{gathered} \quad (5)$$

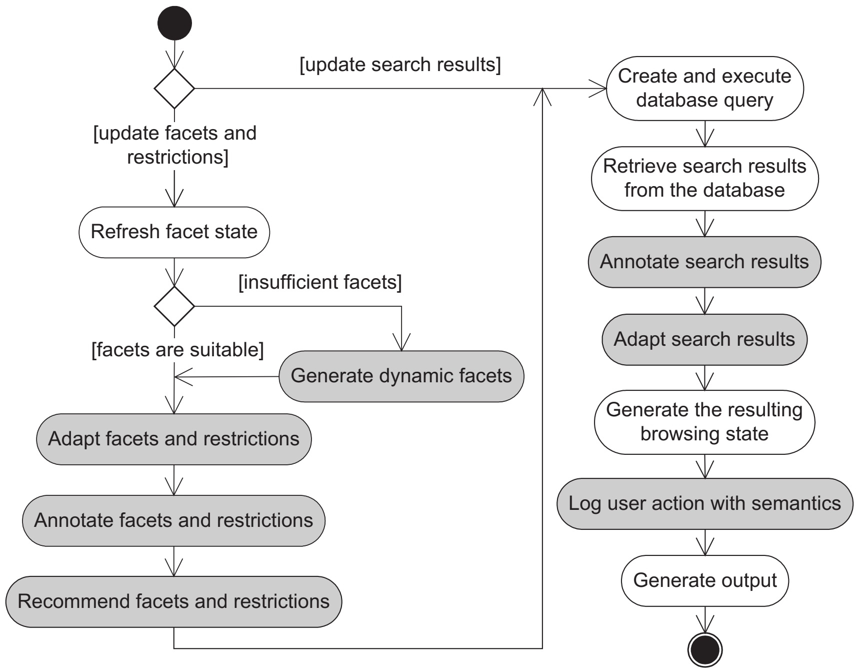

Figure 1. Request handling of the enhanced faceted browser, extensions shown in gray.

$$D_U(X) = S_U(X) + T_U(X) \tag{6}$$

The successive adaptation process uses the computed relevance in these steps:

1. *Facet ordering* – all facets are ordered in descending order based on their relevance with the last used facet always being at the top (i.e., most relevant).

2. *Active facet selection* – the total number of active facets is reduced to 2 or 3 most relevant facets since many facets are potentially available. Inactive facets are used for queries but their contents are not restored, disabled facets are not used at all. Both inactive and disabled facets are still available per user request.

3. *Facet and restriction annotation* – active facets are annotated with tooltips describing the facet, numbers of instances satisfying each restriction and the relative number of instances satisfying each restriction by means of font size/type.

4. *Facet restriction recommendation* – the most relevant restrictions in a facet are marked as recommended (e.g., with background color or "traffic lights").

3.2 Dynamic facet generation

During facet generation we examine the attributes of the desired instances as defined in the domain ontology. For example, for images, we examine attributes of the domain concept *Image* and its associate concepts, e.g., *Location* denoting the place where the image was taken. Next, we select eligible candidates from the relevant attributes of instances and construct facet descriptions based on metadata from the domain ontology. Lastly, we determine a suitable presentation method for each new facet and forward the resulting set of new facets to the following facet adaptation stage.

The selection of suitable candidate attributes for facet generation first evaluates the attributes of the target instance type (i.e., direct attributes), e.g., *Image* and next the attributes of associated types (i.e., indirect attributes), e.g., *Location*. Since it is not desirable to generate all possible facets, efficient attribute selection is crucial in order to select the most suitable attributes. We evaluate the aggregate suitability of individual attributes based on:

- *In-session user behavior* – user navigation and facet selection. For example, if a landscape photo is selected as the desired image type, additional facets associated with *Location* are likely to be generated in order to allow the user to further refine her query.

- *Attribute relevance* – high attribute relevance in the user model denotes good choices for facet generation.

- *Global attribute relevance and facet usage* – the overall "popularity" of facets and attributes increases the likelihood of a facet being generated for a specific user. The preferences of similar users have higher weights.

Since dynamically generated facets are created from either direct or indirect attributes of instances, they are presented differently. Figure 2 illustrates proposed facet types (bold text is used for recommendation, tooltips and instance counts for annotation):

- *Direct facets* – top-level facets based on direct attributes of the target instances (images), e.g., object, keywords, image type.
- *Nested facets* – facets that in addition to (or instead of) a set of individual restrictions contain a set of *child* facets, e.g., a facet that contains facets for the type of place, popularity and climate of the location where a photo was taken.
- *Indirect facets* – top-level facets based on indirect attributes of the target instances, e.g., the resolution of the camera used to take the photo.

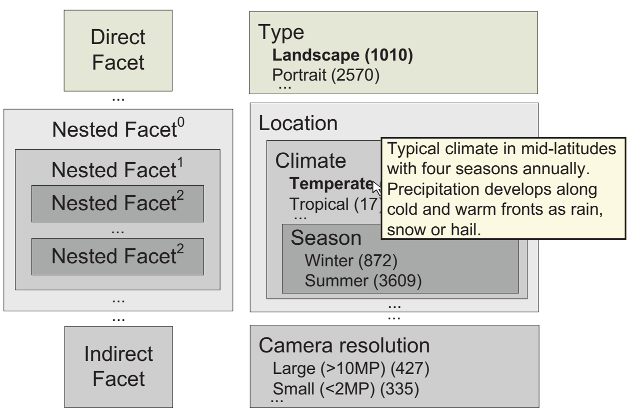

Figure 2. Facet types (left) and adaptation examples (right).

Direct attributes of target instances are always presented by means of direct facets. If only one indirect attribute of an associated instance type is presented an indirect facet is used. If multiple indirect attributes of the same type are presented a nested facet can be used so that each nesting level corresponds to one level of attribute indirection.

4 Adaptive Faceted Browsing for Multimedia

The enhanced faceted semantic browser offers a combined interface for both searching and browsing and is suited for effective viewing and navigating in large open information spaces represented by an OWL ontology. It can also be used as an information retrieval tool where the search query is visually created by means of navigation – selecting restrictions in the set of available facets, which are dynamically adapted to users' needs. Figure 3 shows the sample GUI of a software tool – *Factic*, which we developed to evaluate the described method. Furthermore, using the proposed adaptation method and some of its possible extensions we can provide users with advanced browsing, searching and visualization features as described below.

Adaptive views. Users can choose from several visualization options by selecting one of the available views – simple overview, extended overview, thumbnail matrix or detailed view, which display increasingly more detailed information about individual search results (ontology instances). The attributes of the displayed instances are adaptively chosen based on their estimated relevance derived from the user model. Moreover, the faceted browser can show instances of different types so that the user can seamlessly switch from browsing/searching for e.g., images to videos, then to actors and back to images.

Information overload prevention. Based on facet and restriction relevance we reduce the number of accessible items in order to allow users to find relevant facets and restrictions more efficiently without having to scroll several screens down. The selection of appropriate facet types and displayed restrictions is performed based on their relevance in the user model and based on the current in-session user behavior so that it matches both long-term user interests and short-term user goals. For example, if a user starts searching for images, only facets for the object, image type and location would be displayed while others concerning copyright or price would be available on demand.

Query refinement. By using additional facets created by dynamic facet generation, users can refine their queries beyond what would be possible with statically defined facets. Furthermore, these are combined with additional functions often used in advanced search such as OR, NOT or braces.

For example, if some users were interested in images related to a given theme they would select it as the object of the image in a static facet resulting in images related to the given theme. By using a dynamic facet generated from the domain ontology (i.e., one that was not anticipated by the system's creator), users can instead select images taken, at specific types of places (e.g., *wooden* bridge) or in specific conditions (e.g., night at full moon) thus receiving a more relevant set of images related to the given theme.

Orientation support. Since faceted classifications and large information spaces tend to be complex and hard to understand, we annotate facets and restrictions with additional information to improve user orientation. Annotation includes the number of instances that satisfy a restriction

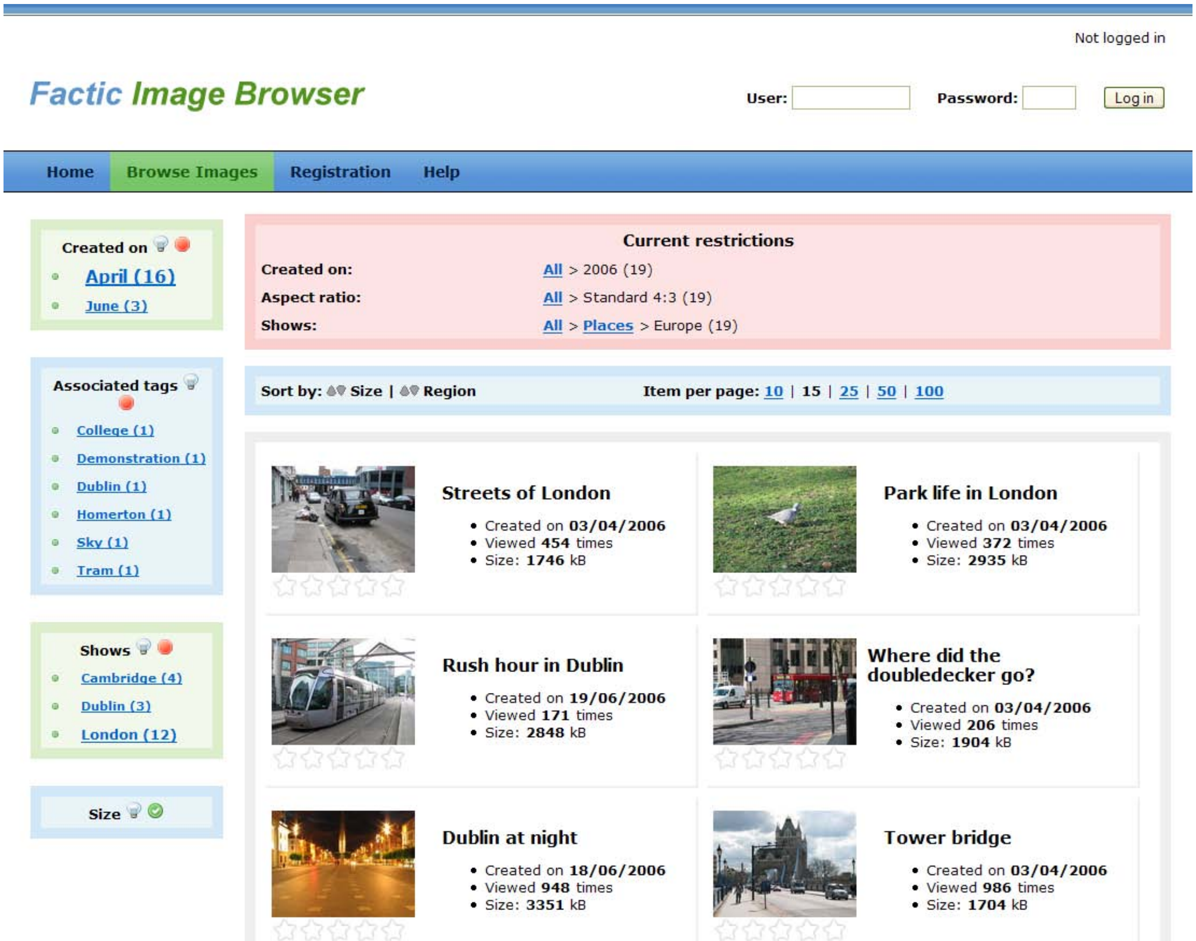

Figure 3. Example GUI of our adaptive faceted browser Factic.

and a textual description of their meaning. Individual restrictions can be further annotated with background color indicating, e.g., their relation to users' field of interest.

For example, individual search results are annotated using background color, based on their relation to a given set of movies (e.g., already seen or the author's own creations) by means of an external concept comparison tool [11].

Guidance support. To improve user guidance, we first order the set of available facets based on their estimated user relevance thus recommending the most relevant facets. Next, we evaluate the relevance of individual restrictions and recommend the most relevant ones based on the user model, e.g., by means of background color. Moreover, we can recommend the most relevant search results by using external ordering tools [7, 11] to evaluate their relevance against the current user model and query.

Social navigation and recommendation. We take advantage of social networks of users (e.g., contributors) in two ways – we define additional facets based on social network data and also extend the *cross relevance* evaluation model, which considers user similarity, with special weights based on different social relation types between users.

Hence, users can access facets, which select only content, e.g., created, viewed, tagged or rated by their peers. Furthermore, we recommend individual facets, restrictions and search results also based on (user defined) profiles which assign different weights to different types of social relations. For example, an "at work" profile would assign high weights to colleagues while ignoring private friends thus promoting task oriented collaboration. An "at home" profile would weight family, relatives, friends or users with similar hobbies higher thus focusing on private relations.

Visual navigation and presentation. In order to improve the understandability of the domain and the available data a visual presentation method may be more suitable than pure text. Visual navigation in clusters [5] provides users with the necessary "global" overview of the respective information subspace selected in a faceted browser. Likewise, a seamless transition between an adaptive textual view with support for faceted navigation and a visual view, representing the selected information subspace (e.g., based on clusters), with successive visual navigation can provide users with a more intuitive browsing experience.

5 Conclusions

We presented a novel method of dynamic facet generation with successive facet adaptation as an enhancement for generic faceted browsers. Our approach is suitable for open information spaces (e.g., multimedia collections) as it not very susceptible to changes which are a distinguishing characteristic of open information spaces.

We evaluated selected parts of the proposed method in two other application domains – scientific publications (project MAPEKUS, `mapekus.fiit.stuba.sk`) and online job offers (project NAZOU [11], `nazou.fiit.stuba.sk`). Since the proposed method relies heavily on user characteristics stored in a user model, we evaluated the adaptive faceted browser *Factic* [14] as part of the personalized presentation layer proposed in [13] and integrated it with the respective tools aimed at automatic user action logging and characteristics acquisition [2].

Initial experiments indicate that adaptation significantly reduces the required processing time due to the lower number of active facets and thus faster refresh times. However, the number of clicks increased since the right facets were not always active and thus had to be manually enabled. Restriction recommendation further reduced the required time and even the number of necessary clicks because it allowed users to skip several clicks by directly recommending the suitable restrictions within a restriction hierarchy.

Our approach relies on the availability of an ontological description of the application domain with a faceted classification (i.e., metadata). Though at least some metadata for multimedia are usually available, if no metadata are available, automatic means of faceted classification construction can be used to (semi)automatically annotate content [4].

Future work will include the design and evaluation of additional method enhancements, especially dynamic facet generation, social navigation in the faceted browser and recommendation based on user relationships. Furthermore, integration with additional external tools for visualization, concept comparison, instance ordering and relevance evaluation, and the successive evaluation with more users and usage scenarios is of interest.

Acknowledgment. This work was partially supported by the Slovak Research and Development Agency under the contract No. APVT-20-007104 and the Scientific Grant Agency of Slovak Republic, grant No. VG1/3102/06.

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