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Visual Abstraction and Ordering in Faceted Browsing of Text Collections

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ABSTRACT

While faceted navigation interfaces can assist users in exploring an information collection, there is yet little support for users in choosing a relevant item from the set of items returned from a filtering process. In this paper, we propose using a multi-dimensional visualization as an alternative to the linear listing of focus items. We describe how visual abstraction based on a combination of structural equivalence and conceptual structure can be used to deal with a large number of items, as well as visual ordering based on the importance of facet values to support cross-facets comparison of focus items. This visual support for faceted browsing has been developed for visual exploration of text collections.

ACM Classification Keywords

H.5.2 Information Interfaces and Presentation: Graphical user interfaces

FACETED NAVIGATION - PROS AND CONS

Faceted navigation is a proven technique for exploration and discovery of an information collection [3]. Apart from being well-studied in many research work e.g. [12, 4, 2], its usefulness is attested by the popular uptake in many commercial websites. At the core of faceted navigation is a set of flat or hierarchical facets, which are categories characterizing items in a large collection [3]. Each facet has one or more facet values and each item may be associated with a subset of these values [1]. As such, this navigation paradigm requires rich metadata expressing relationships between facet values and information items. Users' selections of facet values result in either conjunctive or, more commonly, disjunctive queries executed on the dataset. The matching items (or focus items [1]) are then displayed as results of the filtering process.

We were interested in user experiences with existing faceted user interfaces (UIs), therefore we invited three persons who were familiar with faceted browsing to participate in **contextual interviews**. They were asked to demonstrate their recent use of a faceted UI to achieve a real task of their own.

One accessed the www.komplett.ie website to buy a PCI-Express graphic card, one used the www.yelp.com website to look for Vietnamese restaurants in New York, and the last one went to www.daft.ie to find a room in Galway whose rent should cost less than 400 euros. They explained their interactions while we were observing. Afterwards, each of them discussed what were good about these websites and what could be improved. The users' feedback is as follows:

- The facets in these websites were highly appreciated as they were relevant and helpful to narrow down the search. One subject in particular was not happy with the default set of facets, as they did not reflect his most relevant criteria, therefore he always used the "Advanced Search" option which provided all available facets.
- Comparison of items across different facets is very important for making decisions. To avoid missing the best matches, users had to look at different combinations of facet values inherent in the focus items. Sorting by one facet at a time was thus not considered effective.
- Facets are not equally important. Some facets are more important than others (e.g. neighborhood can be more important than room type).
- Having to go through a long list of focus items is time-consuming. While disjunctive queries allow displaying a wider set of items matching one or more values of a facet, users needed to look into the details of each item to figure out which values of a facet an item matched. This is in line with results from a study on faceted UI [5], which showed that while users spent equally much time on the query, the facets and the results on the first results page, they focused entirely on the items on the second and third results pages. This suggested that after choosing the facets to narrow down their search, users still needed to spend a considerable amount of time to look for a specific item.

The above feedback begs the question if properties of focus items can be visually displayed in such a way that users can make a better informed decision faster than having to traverse all pages of results and looking at one item after another. This question is also relevant to visual text analysis research. While the websites chosen above by the subjects were commercial websites catering for different products, they shared many similarities with faceted UIs for text collections, such as the one studied in [5]. This means that in faceted browsing of texts, filtering interactions also result in document items returned in a list, usually sorted by overall relevance, and users still have to traverse through many results pages to select a particular document for further anal-

ysis. The key limitation is the lack of an aggregated view showing how each focus item relates to each of the facet values. While certain issues were raised about faceted UIs [3], they tend to focus on the display of a large number of facets, e.g. which facets to show (adaptively) when there are many. The issues identified here regarding focus items representation have largely been left untouched. Based on the users' feedback, we argue that their experiences with faceted UIs can be improved if the following design desiderata are met:

- Each focus item should have a compact representation expressing its correspondences to facet values.
- Users should be able to perform cross-comparison of focus items over different values of one or more facets.
- The display can be visually abstracted to deal with a large amount of focus items.
- Users should be able to interactively reorder facets based on their preferences, resulting in different displays of focus items.

As such, we propose using a multi-dimensional visualization, one dimension for each facet value, as an alternative to the linear result listing paradigm. In the rest of the paper, we provide the context and then the proposed solution.

CONTEXT

Our proposed solution is developed within the context of a filtering mechanism to support exploration of a text collection in a personalized manner. The design of the initial prototype IVEA [10] is based on Shneiderman's visual information-seeking mantra "*Overview first, zoom and filter, then details-on-demand*" [8]. It employs multiple coordinated views to guide users through this workflow. The core element in IVEA is a simple user-defined ontology encapsulating their sphere of interest. Various statistics about the relationships between documents and entities in the ontology are visually presented to facilitate the exploration.

PROPOSED VISUALIZATION

We proposed in [11] the initial idea on a matrix-based multi-dimensional visualization, which was inspired by FOCUS [9] and TableLens [7], to show the correspondences between documents and a taxonomy of entities of interest to users. This visualization, in effect, supports filtering similarly to faceted navigation in that users can select entities from hierarchical facets and then documents relevant to those entities are displayed. Since hierarchical relationships between entities are taken into account, selecting a class will result in the automatic inclusion of all of its direct instances and recursively, all of its subclasses. Thus, facet selection for filtering can be done at different levels of granularity and multiple facet values can be selected in a single operation. In the matrix, rows represent selected entities, columns represent documents containing at least one of those entities, and each cell shows the relevance value (TF-IDF based score) of a document with respect to an entity via its height. Here each entity is linked to a user-defined set of associating terms. As such, abbreviations, linguistic variations, conceptually related terms and synonyms can be taken into account. This is important, since in many cases, documents' authors adopt a

rhetorical writing style by choosing different wordings, and use them as a semantic camouflage with the intended purpose of influencing readers into accepting misleading interpretations of the information being presented.

To decide a cell's height, we use k-means clustering to identify three clusters of relevance values, and the maximal values of the three clusters are used as thresholds. The vertical part of the cross-hair highlighter helps to focus on which entities a document contains and its horizontal part helps to show the distribution of an entity in a collection. Users can also remove facet values by right-clicking on an entity and the whole respective row is removed from the visualization.

Although it meets two of the design desiderata, the visualization provides no visual abstraction to cater for a large number of documents and no interactive ordering of facet values to enable users to easily compare items across different facet values (entities). Next we present the proposed solution. Here, documents are information items and concepts/entities of interest to users are facet values.

VISUAL ABSTRACTION OF DOCUMENTS

Relationships between documents and a set of concepts can be represented by a bipartite graph $G = (D, C, E)$ whose vertices belong to two disjoint sets D representing documents and C representing concepts. If $d_i \in D$ is relevant to $c_j \in C$, then there is an edge $(d_i, c_j) \in E$ connecting them, whose weight is the relevance of d_i with respect to c_j .

Given the typically available screen resolution, too much data is confusing and limiting information manipulation. Therefore, it is important to collapse visual information when desired so that it takes up less screen space and users can focus on what is being shown more effectively. This need is equivalent to interactively collapsing and expanding vertices in the set of documents and the set of concepts so that the view is collapsed and expanded accordingly. In this respect, two mechanisms are provided: semantic zooming and document grouping, which can be combined in use.

The semantic zooming feature provides different levels of abstraction based on the hierarchical relationships among entities (facet values). The hierarchy attached with the matrix allows users to dynamically drill down or roll up to achieve views at different conceptual levels of detail, as indicated by the collapsible glyph in Fig.1, to focus on particular subgroups. This, in effect, is the aggregation of vertices in the set of concepts C , hence replaces edges that connect documents to instances of a class with edges that connect documents to that class only. For instance, the bigraph in Fig.2 shows the relationships between 5 documents and 4 concepts. Assuming that concepts c_1, c_2, c_3 are instances of a class, they therefore can be grouped into a single concept c_{123} representing that class. Any document that contains any or all of the three concepts c_1, c_2, c_3 is considered as containing the concept c_{123} . Thus, the resulting bigraph has fewer edges, as shown in Fig.2, whereby all documents now connect to the concept c_{123} instead of to the three concepts individually.

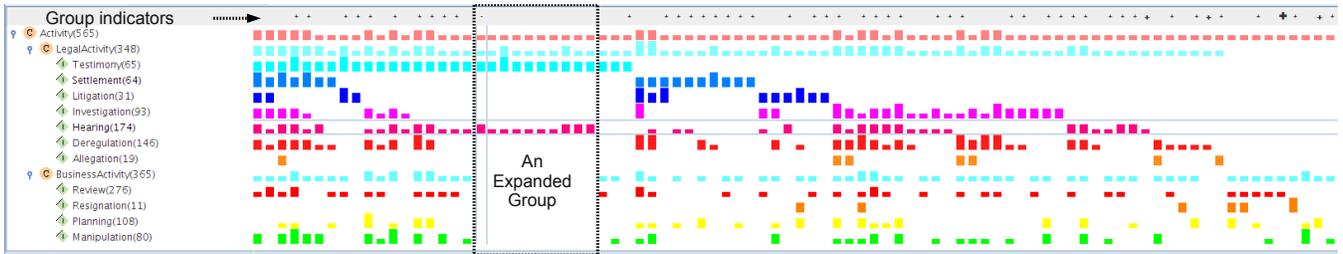


Figure 1. Document Grouping

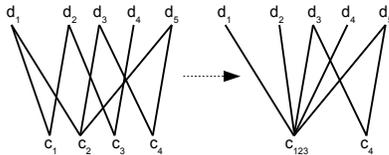


Figure 2. Semantic Zooming Bigraphs

While semantic zooming can abstract away a lot of details, the number of documents in a relatively large collection can still be too much to be effectively displayed on a limited screen space. Here the document grouping feature provides further abstraction based on the notion of Structural Equivalence of individuals in social networks [6], defined as below.

Definition Objects a, b of a category C are *structurally equivalent* if a relates to every object x of C in exactly the same way as b does [6].

This notion is used to partition objects in a set into classes of structurally equivalent objects, which leads to the ability to derive a reduced set of categories in which belonging objects are considered equivalent. When these objects are individuals in a social network, the set of derived categories represents “maximal relationally homogeneous groups” [6]. Here we treat documents and concepts as objects and adapt the Structural Equivalence notion as per below.

Definition Given a set of concepts $C = \{c_1, \dots, c_n\}$, the set of structurally equivalent documents with respect to C consists of documents that contain all elements of C .

In other words, documents d_i and d_j in D are structurally equivalent with respect to C if there exist edges (d_i, c_k) and $(d_j, c_k) \in E$, for $k = (1, \dots, n)$. As such, given a set of entities C , we can identify a set of structurally equivalent documents with respect to this set and treat them as a group. This, however, has two limitations: (1) The requirement for documents to be structurally equivalent is strict in that they need to contain **all** elements of a given concept set, therefore the number of documents satisfying this requirement will not likely be large and (2) only one group can be identified given a set of entities, which is not significantly helpful in dealing with a large collection. Thus, our approach is to consider the powerset of C (excluding the empty set) and find groups of structurally equivalent documents with respect to each of

those subsets. For example, there are four concepts c_1, c_2, c_3, c_4 , and five documents relevant to them in such a way that is represented by the left bigraph in Fig.3. Here documents d_1, d_3, d_5 contain c_2, c_4 and not any other concepts. Therefore, these three documents can be put together into a group d_{135} as shown in the right bigraph.

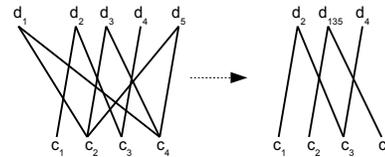


Figure 3. Document Grouping Bigraphs

This approach enables more flexibility with regard to the levels of granularity at which information is viewed and manipulated. As in Fig.1, although the screen space is limited, the visualization can still cope with a large set of documents. Here, the filtering process results in 565 relevant documents. However, since 50 structurally equivalent groups are identified, only 76 columns need to be shown, as only one (randomly chosen) document of a group is initially displayed on the matrix, while other documents that do not belong to any groups are still displayed as a regular column each. In fact, if there are n selected facet values, only a maximum of $2^n - 1$ columns are needed for the initial display. The column of the representative document of a group has a '+' sign on top, which is a visual cue to indicate that there are more documents containing exactly the same set of entities. We also use k-means clustering on different group sizes to find three clusters of sizes and use the maximal values of the three clusters as thresholds. Thus, the size of the '+' sign can indicate the relative size of a group. Hovering over a '+' sign will pop-up the exact number of documents in that group. This visual cue overcomes the need to show numeric values, which require varying spaces and can distort the consistent layout of the matrix. Clicking on this representative column will make visible all documents in a group and its visual cue changes to '-' as shown in Fig.1. Clicking again on the representative column will hide other documents in that group. This “focus+context” interaction simplifies the comprehension of the visual display of a large number of documents without users having to examine a matrix containing a large number of columns, since the initial display does not depend on the actual number of focus items (documents).

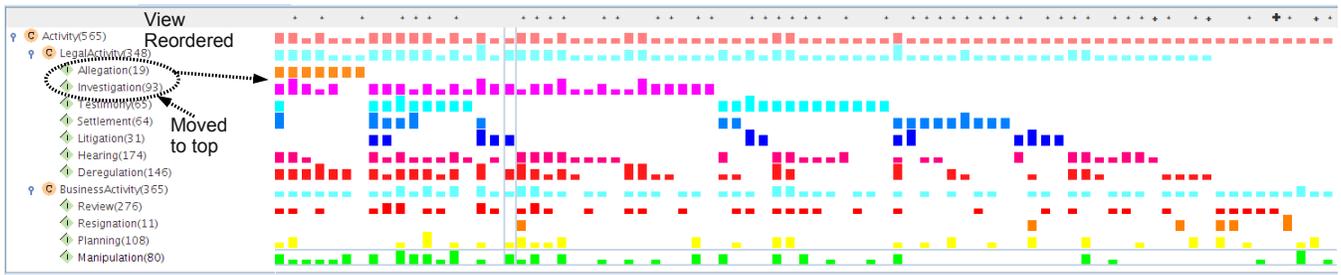


Figure 4. Facet Reordering

VISUAL ORDERING BASED ON FACET VALUES

As previously mentioned, not all facets are equally important. For each user, there is an order of importance of facet values accordingly. Therefore, we consider facet values that are placed on top are more important than those below them. Thus, documents and groups of documents are reordered based on their correspondences with facet values. As in Fig.1, in the facet “LegalActivity”, the value “Testimony” has the highest position, therefore documents and groups of documents that are relevant to “Testimony” are moved to the left and those that do not are moved to the right. Within these two groups, they are subsequently ordered by their relevances to the second value, “Settlement”. This ordering is done similarly until the last facet value. This ordering can be efficiently achieved using a bitmap of a document or a group of documents, which is constructed by assigning a 1 bit if a document/group of documents is relevant to a facet value, a 0 bit otherwise, and the first facet value corresponds to the highest order bit. For instance, the left-most document in Fig.1 corresponds to the value “1111111011001”, highest among the derived bitmap values. Furthermore, users can interactively reorder facet values while exploring a text collection. As shown in Fig.4, in the facet “LegalActivity”, if the values “Allegation” and “Investigation” are considered more important, they can be moved (via drag-and-drop) on top. The view is changed accordingly as a result. We believe that this visual ordering based on facet values enables users to easily compare focus items, in this case documents/groups of documents, across facet values in a meaningful way.

DISCUSSION

Initial users’ feedback on this visualization support for faceted browsing has been positive. They do acknowledge the need to get used to it, due to its differences from the more familiar display paradigm of linear listing of focus items. Although this is developed in the context of documents as information items, we believe it can be applied to other kinds of information items, since apart from temporal and spatial facet values which require separate timeline and map displays, most facet values are categories that can be visually encoded using iconic representations as in the proposed visualization.

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