Facettice: Integrating Faceted Navigation and Concept Lattices for Visual Data Exploration

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ABSTRACT

We present a novel interface for the exploration of multivariate data by integrating faceted search and interactive concept lattice visualizations. Concept lattices are Hasse diagrams showing hierarchical sub-concept relations in multidimensional data and result from a preceding Formal Concept Analysis. A concept lattice can be interpreted as the navigation space of exactly all possible results for a search that is based on conjunctive queries between terms. With *Facettice* we describe the two complementary visualizations *Facet Lattices* and *Big Smart Lattice* supporting interactive faceted search while visualizing and navigating in the concept lattice space. The design of our two visualizations is based on three integration goals which describe how faceted search can benefit from concept lattice visualizations and vice versa.

Index Terms: H.5.2 [Information Systems]: Information Interfaces and Presentation—User Interfaces;

1 INTRODUCTION

We designed *Facettice*, an interface integrating faceted navigation with interactive concept lattice visualizations. Few search tools provide extended visual and interactive representations of the search process, but the search process can benefit from visualization techniques to explore the structure of both the result set and the queries [6].

Faceted search and navigation is an intuitive technique to search in and browse large datasets by specifying a set of search terms (*query*). Then, objects are retrieved which are classified under those terms [9]. Search terms can be added and removed iteratively from the query in order to refine the set of retrieved objects (*results*). The extent of the result *shrinks* when a search term is added to the query and it *grows* when a term is removed. These specific subset relationships between query result sets can be represented by a concept lattice. Concept lattices have been introduced in the context of Formal Concept Analysis (FCA) by Ganter and Wille [5] in order to calculate an implicit classification of attributed objects. Concept Lattices are directed acyclic graphs where each node (*concept*) corresponds to a set of objects (*extent*) satisfying a set of attributes (*intent*). Consequently, a concept lattice can be interpreted as representation of the whole search space, meaning all possible queries on a dataset. Each subset relation between results (concepts) is a path the user travels while refining his query. However, concept lattices quickly become very large and only a few techniques have been proposed to visualize and navigate within them.

We argue that faceted search and the visualization of concept lattices are complementary techniques. Facettice consists of two complementary views, the *Big Smart Lattice* representing the current search context of the user and *Facet Lattices* that visualize how each facet and its classes are expressed in the dataset. Both visualizations are based on concept lattices and are interactively connected by brushing and linking. The following list shows our three goals in integrating Faceted navigation and concept lattices:

Visual Space — Concept lattices represent the search space of faceted navigation. An overview of any search space can be useful to visualize the current search context, the browsing history and the distribution of search terms in the current context.

Reduction of Complexity — Facets and multi-valued attributes decrease complexity of large data sets by grouping and abstracting attributes. This can be used to decrease the complexity of lattices. Facets can be used to reduce the complexity of lattices by distinguishing and filtering attributes.

Query Preview — Query preview in faceted search is limited to seeing only one step ahead, but concept lattices show all subsequent attribute combinations and their result sets. Faceted search can benefit from such a better query preview.

Although, the connection between faceted search and FCA is not new [8, 3, 9], to the best of our knowledge no approach has been made to explore the potential of a further integration. Camelis is a faceted browser that uses concept lattices as internal data structure to calculate related search results, but the interface uses common lists and trees [4]. Priss focuses on the fact that concept lattices can represent attribute taxonomies [8] but the system has never been implemented. The largest integration has been made by Ducrou et al. [1] with two concept lattices, each one for a different set of attributes, equal to facets. The user can select concepts in order to filter objects and the second lattice is adapted to the resulting set of objects. Similarly, D-Sift [2] enables the user to select attributes from a list whose values are then shown in a concept lattice. Besides very basic interaction, neither of both approaches present adequate visualization capabilities to present and distinguish facets or to show the impact of single attributes, for example.

In the remainder of this paper we describe the design of our visualizations and how they are used to explore a data set of tagged visualizations. We conclude with a discussion and refer to future work. The data we use for demonstration is a collection of 716 visualization projects classified under 13 facets such as *data type*, *visualization type*, *interaction possibilities* and so forth [7]. Projects are tagged by an average of 5 attributes, which are color coded by their facet.

2 BIG SMART LATTICE

The Big Smart Lattice (BSL) represents the user‘s current search context within all possible search results. Since concept lattices become very big, we only show the concepts (search results) the user has visited.

A concept of the BSL is shown in Figure 1a and varies in size depending on the number of contained objects. The surrounding corona segments represent attributes (search terms) associated with this concept and are divided in an upper and a lower semi-circle. The upper one shows attributes which define this search set by a conjunctive query. Figure 1a shows a result set of 4 objects when selecting the terms *2D*, *3D*, and *Science*. Relations leaving from these attributes lead to the corresponding concept when this at-

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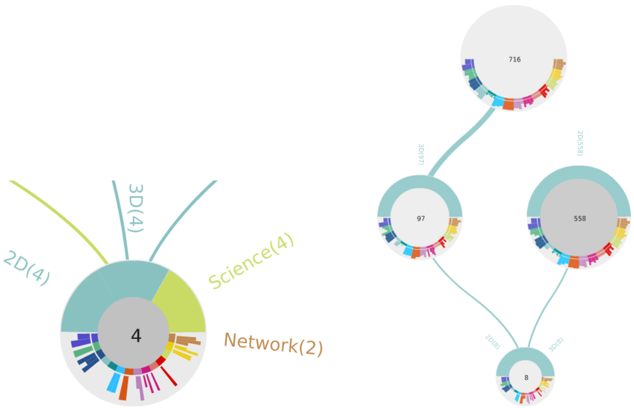


(a) Concept Detail (b) Lattice after 3 queries

Figure 1: (a) Detailed view of a concept in the Big Smart Lattice, which applied search terms (upper corona segments) and possible further query terms (lower corona segment)

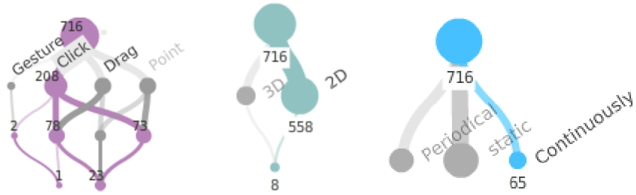
tribute is removed from the current set. Bars on the lower side of the concept circle show all the search terms which can be used to make the current concept more specific. Bar length indicates the number of objects in the concept associated with that term. There are still two objects classified under the term *Network*, indicated by the number in brackets. Clicking on such a bar creates a new concept below the current one with the *Network* term added to the upper circle of the new concept. The new concept contains two objects.

Figure 1b shows a BSL with the initial query (left concept) and two subsequent query refinements. The top most concept is the set of all objects in the data set and the lower concepts show the distribution of attributes within this set. After the user has clicked on the *3D* attribute from the turquoise facet (*visualization dimensions*), 97 objects are found matching this term. Then the user selected *2D* from the same facet and yield eight visualizations using both visual impositions. He finally removed the term *3D* and is then able to compare the two sets of 2D and 3D visualization as well as their intersection.

3 Facet Lattices

While the BSL distinguishes facets by color and uses bars for query preview, Facet Lattices present one concept lattice per facet. The three lattices in Figure 2 show individual concept lattices for the attributes from the facets *Interaction*, *Dimensions*, and *Update Rate (of the visualization)*. Again, the top concept contains the number of all elements classified under this facet and the lower ones show all existing search terms, indicated by labels, and combinations of them, shown by the subconcept relationship. The visual strength of the relations indicate the proportion of similar objects between two concepts. All Facet Lattices are interactive and connected to the BSL by interaction. Highlighting a concept highlights all super and sub concepts in the color of the facet. If the user clicks on a concept, all attributes which define that concept are added to the current query of the the BSL, and eventually a new concept is created in the BSL. Finally, Facet Lattices adapt to represent the distribution of their facet values in the new search result set. The same happens when the user creates a new concept in the BSL or revisits an existing concept.

The three lattices from Figure 2 contain several interesting patterns; Lattice (a) contains four attributes where most objects are classified under *Click* and the fewest with *Gesture*. Combinations of *Click*, *Drag*, and *Point* are often used together, but no result exists that combines all four interaction techniques. Lattice (b) shows two attributes which appear together in eight objects out of 716.



(a) *Interaction* (b) *Dimensions* (c) *Update Rate*

Figure 2: Three Facet Lattices for three facets showing patterns such as distribution and correlation as well as expression of search terms in the data set.

Note that Lattice (b) is principally the same as the BSL in Figure 1b, because in the BSL the user has selected only attributes from the same facet (*Dimension*). Finally, Lattice (c) shows no correlation among its attributes. Facet Lattices show many different patterns of distribution, correlation, extent and expression of the attributes in the dataset, but describing them all is beyond the scope of this paper.

4 Conclusion and Future Work

In this paper we described Facettice, a novel search interface consisting of two complementary visualizations, Big Smart Lattice and Facet Lattices. The goal was to integrate faceted search with concept lattices to facilitate navigation and to visualize large multivariate data sets. Faceted navigation allows to explore large data spaces step by step while concept lattices provide us with an idea of conceptual structures in the data. Since concept lattices have only be used in a very limited way for visualizing multivariate data, we believe that Facettice can be a first step towards a larger exploitation of FCA for visualizing multivariate data. We are investigating further visualization designs and interaction methods for concept lattices to make them more understandable to novice users. We also plan to conduct a user study to better understand how people are able to understand and handle concept lattices.

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