Semantic Cloud: An Enhanced Browsing Interface for Exploring Resources in Folksonomy Systems

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ABSTRACT
Popular Web folksonomy systems such as *Delicious* or *Flickr* allow users to create web contents and annotate them with a set of freely chosen keywords (tags) in order to organize them for later retrieval. Unfortunately, existing user interfaces of folksonomy systems have limited browsing capabilities and do not exploit tag semantics sufficiently for browsing linked data. In this paper, we present *Semantic Cloud*, an approach for exploring data in folksonomy systems based on a hierarchical semantic representation of the tag-space, which is obtained by analyzing folksonomy data.

Categories and Subject Descriptors
H.3.3 [Information Search and Retrieval]: *Information filtering.* H.5.2 [User Interfaces]: *Graphical user interfaces; Interaction styles; User-centered design;* H.5.3 [Group and Organization Interfaces]: *Collaborative computing; Web-based interaction;* H.5.4 [Hypertext/Hypermedia]: *Navigation*

General Terms
Experimentation, Design, Human Factors

Keywords
Tags, Folksonomies, Tag Clouds, Browsing Interface.

1. INTRODUCTION
In recent years, the development of 'Web 2.0' or 'Social Web' applications has led to an increase in user participation on the World Wide Web as users themselves are now able to easily create and share contents. Services such as Flickr and YouTube enjoy great popularity for uploading and presenting photos or videos and social bookmarking tools like Delicious have facilitated saving and sharing of website references online. Along with the increasing amount of user-generated content on the Web, a new form of manual content classification – *social tagging* – has been established, which is directly performed by users in order to organize their contents for later retrieval by either themselves or others. Tags can be freely chosen from users' own vocabulary and thus, in contrast to predefined taxonomies or ontologies, the folksonomy, i.e. the classification vocabulary in folksonomy systems, emerges automatically in the process of annotating and classifying [17].

Although many users – especially in social bookmarking systems – create and annotate mainly for their own purpose, they still produce a collective value, thus, helping other users to retrieve and browse user-generated contents. For searching and exploring content, users can enter search tags directly into traditional search interfaces as well as select them from dedicated interface elements such as tag clouds. In tag clouds visual features such as font size, font weight and intensity are utilized in order to visualize the tag space. Usually a small selection of the most often used tags within the system is displayed. This rough overview is particularly helpful for unspecific retrieval tasks and serves as a starting point for browsing, when users have no initial appropriate tag to start searching or browsing. Using the tag cloud implies less cognitive and physical workload than thinking of a search tag that defines the thematic field one likes to explore and entering it into the search field [15]. After having found an initial tag and associated resources users can start browsing using the interlinked structure of resources and tags or make use of related tag lists offered by most folksonomy systems. In context with these browsing structures, 'serendipity' is a term often used [11], referring to possible unexpected findings during browsing tags.

However, determined and structured ways of exploration are hardly provided and user interfaces of folksonomy systems often fail to sufficiently support users in finding appropriate search tags and creating efficient queries for discovering interesting contents. For users, it is difficult to gain a full impression of tags used in the overall system or within their field of interest as tag clouds as well as related tags cover only a very small subset of popular tags. Furthermore, users are often confronted with general semantic problems of folksonomies [5, 7], e.g. different spelling or lexical forms, homonymous or polysemous tags, "basic level problem", etc. leading to incomplete or unexpected results. Given this uncontrolled nature of tags, it might seem difficult to solve these problems. But folksonomies hold inherent semantic structures which can be extracted and used by means of tag co-occurrence analysis and clustering. In this context, various approaches have already been researched and presented. However, there are only few works applying them to concrete user interfaces for folksonomy systems.

In this paper, we present a similarity-based browsing interface for enhanced exploration in folksonomy systems. We enhance tag-cloud based user interfaces by semantically arranging related tags that are determined by co-occurrence analysis of folksonomy data and applying

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hierarchical clustering for multiple topic cloud exploration. Our prototype was evaluated in a short-term user study and yields promising results.

2. RELATED WORK

Besides the usual alphabetic and random arrangements of tags in tag clouds semantic arrangements have been studied by researchers recently. Schrammel et al. [14] describe a series of experiments of clustered presentation approaches indicating that semantically clustered tag clouds can provide improvements over other layouts in specific search tasks. Task-related performance for visual exploration and tag cloud perception was also assessed by Lohmann et al. [13]. The results showed differences in task performance for different layouts, leading to the conclusion that interface designers should carefully select the appropriate tag cloud layout according to the expected user goals. Hassan-Montero and Herrero-Solana [8] choose a layout similar to common tag clouds but each row of the tag cloud includes tags of a different main topic field. Fujimura et al. [3] present an approach for creating overviews of large scale tag sets by mapping them on a scrollable topographic image, where central tags are located in 'highest' regions and related more special tags are placed around in 'lower' regions. Hoare and Sorensen [9] describe an information foraging tool based on 2-dimensional proximity-based visualizations. Their layout technique is based on a graph-theoretic force-directed visualization.

Approaches that extract relatedness of tags directly from folksonomy data are usually based on the assumption that tags are related when they occur in a similar context. Tag relatedness has to be determined statistically on this broad basis of data by considering the whole set of annotations. Mika [12] describes how the original graph representing the complete annotation structure can be transformed in order to obtain a tag co-occurrence graph including the co-occurrence counts for each pair of tags. Several approaches have been proposed that adapt or extend absolute co-occurrence in order to obtain more balanced results of tag similarity by calculating relative co-occurrence and using different types of metrics [1, 2, 8].

Grahl et al. [6] as well as Gemmell et al. [4] present algorithms for establishing hierarchical structures from folksonomies that can provide a basis for more structured browsing or personalized navigation, respectively. Specia and Motta [16] apply a non-exclusive agglomerative clustering method in order to map groups of tags onto ontological concepts. Further work makes use of a divisive k-means algorithm [8] in order to provide a semantically ordered tag cloud or suggest clustering the tag space using graph-based clustering, splitting the co-occurrence graph where the edges are weakest [1].

In our work, we avoid typical limitations and problems in exploring tagged data by enhancing and integrating existing interface concepts and applying proposed approaches for extracting semantics to a concrete browsing interface. A hierarchical semantic arrangement of tags is used for supporting the creation of complex queries, i.e. queries that can be built from tags at different levels of the tag hierarchy. Finally, our interface provides an integrated UI approach for query refinement and results for complementing missing interactivity support in existing systems.

3. SEMANTIC CLOUD

3.1 Overview

Semantic Cloud (SC) integrates and enhances main concepts of current interfaces in one single interaction structure: tag clouds as a means of initial orientation within the overall tag space, related tags as a way of browsing related items and refining queries and manual tag search for specific information needs. For avoiding the typical problems and limitations of classic folksonomy retrieval interfaces, SC is based on a semantic arrangement of tags, i.e. similar tags are physically located near to each other in contrast to the alphabetic or random arrangement of classic tag clouds. Once a user has found a tag which seems interesting to her, she can easily find other potentially interesting tags by scanning neighboring tags. Secondly, instead of one single limited tag cloud, an extensive structure of multiple topic clouds is proposed which can be explored hierarchically. This way, users can get a fast overview of topics in a small representative overview tag cloud but retrieve more focused tag clouds with a higher semantic density on demand for creating more specific queries. The classic 'related tags' list is therefore directly integrated into the tag cloud. Finally, the interface showing tag cloud and results at the same time allows for simultaneously composing queries from the tag cloud, consulting results and refining the query afterwards. Additionally, query tags can be added by manual input.

3.2 Exploiting Tag Semantics

SC is internally based on a semantic representation of a folksonomy tag space that contains information about the semantic relatedness of tags needed for a semantic arrangement of tags within the tag cloud, as well as the hierarchical structure of thematic groups of tags. It can be acquired by analyzing a representative set of annotation data, i.e. calculating tag similarity and clustering tags.

3.2.1. Data Sample

For our user study we extracted a sample set of Delicious bookmarking data consisting of 870,500 annotation triples on 119,817 distinct URLs with 42,373 distinct tags. In order to obtain characteristic structures and relations, the data set was initially filtered by deleting rarely used tags and not representative annotations. Potentially representative annotations can be identified easily in a collaborative tagging system such as Delicious by consulting the frequency of how often a specific tag was used for annotating a specific resource. Rarely used tags may be meaningful only to some users while often used tags can be assumed to be commonly agreed on as a fitting description for that resource.

3.2.2 Tag Similarity Analysis

In order to determine the semantic relatedness of tags, we calculate the normalized co-occurrence for each pair of tags using the cosine similarity metric applied to tags being vectors defined as follows: Tag t_i is an n-dimensional vector with n being the number of total distinct tags in the data set and $t_i[k]$ being the absolute co-occurrence count of t_i and t_k, i.e. the number of resources tagged with both tags. The relatedness of two tags can then be computed as follows:

$$\operatorname{sim}(t_i, t_j) = \frac{t_i \cdot t_j}{|t_i| * |t_j|} = \frac{\sum_{k=1}^{m} t_i[k] * t_j[k]}{\sqrt{\sum_{k=1}^{m} t_i[k]^2 * \sum_{k=1}^{m} t_j[k]^2}}$$

Within an assessment of different similarity metrics including absolute co-occurrence (1), the Jaccard-coefficient (2) and a cosine metric applied to tag vectors (3) featuring their occurrences on resources, the chosen metric (4) turned out to produce most appropriate results, i.e. most effectively identifies tags as related. This counts especially for tags with a small number of occurrences in the data set. This is due to the fact, that the metric not only considers directly co-occurring tags but also their context [16]. It can therefore also identify relations between tags which do not occur together on a document of the (not necessarily complete) data set used for analysis.

Metric 1	Metric 2	Metric 3	Metric 4
food cooking **recipe baking** blog **dessert** reference **vegetarian** howto blogs **foodblog** health **chocolate** **nutrition** **vegan bread** **diet cake** diy tips **cookies** **vegetables** **soup** fun **breakfast**	**recipe cooking** **food baking** **dessert** **vegetarian** **foodblog** **chocolate vegan** **bread nutrition** health **diet cake** **cookies** **vegetables soup** **breakfast** **desserts** **pumpkin** **foodblogs cheese** blogs **chicken** **dinner**	**recipe cooking** **food gourmet** **foodblog** **cookbooks drink** **recipies drinks** **alcohol** **vegetarian** **kitchen vegan** **baking** useful **meals dessert** **bread cook** **healthy** **reference veg** **chocolate** **cupcakes** blog	**recipe cooking** **food baking** **breakfast** **dessert appetizer** **vegetarian** **casserole cheese** **bread pie pasta** **sauce dinner** **soup foodblog** **salad dough** **mexican beef** **tofu crockpot** **desserts beans**
Rating: 18	Rating: 24	Rating: 24	Rating: 26

Table 1. Related tags for 'recipes' in the data sample calculated with different similarity metrics

The evaluation in order to determine the most appropriate metric (Table 1 and 2) for the analysis of the data set was based on a manual inspection of fifteen random sample tags, which stem from different thematic fields and have different frequencies of use in the overall annotation set. The rating was based on whether the found tags were semantically or lexically similar or strongly related (2 points), whether they were related (1 point) or whether the indicated relationship was only accidental or very general (0 points).

	Metric 1	Metric 2	Metric 3	Metric 4
Rating	213	309	301	361
Mean rating	14,2	20,6	20,1	24,1

Table 2. Rating of similarity metrics.

3.2.3. Clustering

Given the similarity values for all pairs of tags, the tag space can be clustered into thematic groups, i.e. groups of highly related tags. For this task, we use an agglomerative hierarchical clustering algorithm, similar to the approach used by Gemmell et al. [4]: Starting with each tag being a single cluster, in each iteration, the most similar clusters are joined until there is only one cluster left. Inter-cluster similarity is calculated with the centroid method, which computes the average similarity between every tag in the first cluster with every tag in the second cluster [10]. Representing the clustering process in a binary tree, any structure of clusters and sub-clusters can be obtained, as the tree can be cut according to a minimal threshold of cluster similarity or a maximum number of clusters. Figure 1 depicts an example of a hierarchical structure, which could be reasonably split into 4 top-level clusters below the grey line. The resulting clusters can again be decomposed into a set of sub-clusters.

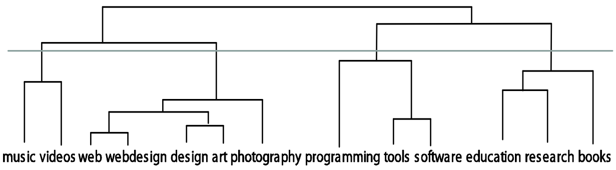

Figure 1. Dendogram of the cluster hierarchy for a small subset of sample data.

This algorithm was chosen as it has several advantages over other known clustering algorithms. On the one hand, it works unsupervised and without any prerequisites, i.e. it is neither necessary to give a selection of desired topics (initial cluster-centers) nor to define a final number of clusters. On the other hand, the result is very flexible and leads to the hierarchical structure of clusters and sub-clusters needed for the interface: A first level of clusters forms the high-level topics, each represented by their most popular tags in the representative overview tag cloud of the interface; their sub-clusters form the lower levels of the cloud, which can be consolidated hierarchically. In our work, the selection of clusters and sub-clusters, i.e. the determination of cutting thresholds, from the clustered tree was performed manually to extract most reasonable semantic groups for evaluating the interface concept. An automatic approach is yet to be developed.

3.3 The Semantic Cloud User Interface

The User Interface of SC (Figure 2) is logically divided into three areas, which stay visible all the time: tag cloud, results and tools (adjustment, reset/back buttons etc.). The tag cloud area initially displays a first overview of most popular tags. Due to each topic, i.e. top level cluster, being represented in equal measure, this overview is more balanced than in traditional tag clouds, where tags are chosen by absolute popularity. Topics are divided spatially and by color into different semantic regions. As usual, variation in font size indicates the popularity of the tags. An internal semantic arrangement of tags is achieved using graph visualization with force directed layout based on the described similarity metric. Zooming into topics, i.e. viewing sub-clusters can be carried out by clicking on a magnifier icon which is placed in the center of each semantic region in case this region contains further sub-regions. So, once a primary field of interest was found via the most general tags, a specific thematic field can be brought into focus by obtaining a new semantic tag cloud with a higher semantic density and more specific tags. The hierarchy of semantic tag clouds can include several levels (Figure 3). Tags can be selected either by clicking on them within the respective semantic region or by using the manual tag input field for further refinement or a new search.

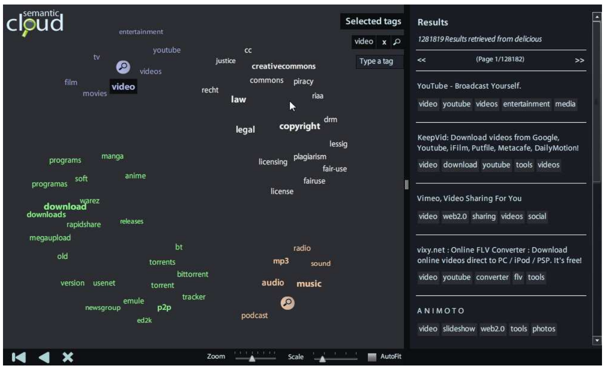

Figure 2. The User Interface of ‘Semantic Cloud’.

Furthermore, tags can be selected from the results list, which displays a set of popular tags with each found resource. All selected tags are highlighted in the tag cloud (if available in the currently displayed cloud) and furthermore appear in a compact list to the right of the cloud. They can be deselected directly within the cloud as well as in the list. An additional option provided in the list is (re)locating a specific query tag within the cloud by using the magnifying glass besides each tag. This can be particularly helpful when users have entered a query tag themselves and directly want to consult and select related tags without browsing the tag cloud hierarchy manually. Basically, queries are composed from the selected tags by applying the AND operator. Whenever the query selection is changed, the result list is updated. Hence, users are able to dynamically remove or replace tags while getting immediate feedback for their actions. They can consult results immediately and adjust their query if results are not yet appropriate. They can change focus of search at any time by replacing tags for related tags.

Figure 3. Hierarchical exploration in Semantic Cloud.

4. EVALUATION

4.1 Test design and user study

In order to evaluate the concepts behind SC we conducted a user study (based on the previously described data set) comprising 9 participants (2 female, 7 male) aged between 22 and 33. Having a computer science background, all participants were secure in using a computer and Web browser. While the traditional tag cloud concept was well-known to all of them, none of them regularly used browsing structures of folksonomy systems for finding contents. We used the Delicious user interface as a baseline for the evaluation, i.e. tested Delicious vs. SC. A set of three tasks was assigned to the participants, which had to be solved first by using the Delicious interface and then the alternative approach SC. This setup (“within-subjects testing”) was chosen for first creating a basic common understanding on current browsing interfaces and afterwards letting users judge about both interfaces in comparison based on their impressions from the tests. The tasks were chosen to simulate an undetermined browsing scenario: Users were first asked to look for any website they would find interesting and afterwards – more specifically – for a website presenting any interesting ‘cooking recipe’ and any website dealing with ‘music’ respectively[1]. Afterwards users were asked to assess both interfaces regarding three usability criteria on a five-point Likert scale[2]: whether it was easy to understand the interface (Q1), whether the system was supportive in solving the test tasks (Q2) and whether it was pleasant to use the system (Q3). In a fourth question (Q4), participants should state whether they would use the interfaces for in real life scenarios, i.e. whether they would estimate it useful. This rating was statistically analyzed and finally used to draw a conclusion, if the SC user interface concept is a significant enhancement compared to the standard user interface structures of folksonomy systems. For understanding possible interface order effects besides asking users to ‘think aloud’, they were also interviewed for their reasons while rating the interfaces.

4.2 Results

For analyzing the answers of the final questionnaire, we calculated the mean (μ) and standard deviation (σ) for each question and system. Moreover, the paired student’s t-test was applied in order to test the statistic significance comparing Delicious and SC: For each question, the null hypothesis predicated that the mean rating for both interfaces was equal and differences only due to chance. It was rejected for a probability lower than 0.05, which was the case for question 2, 3 and 4. Only in case of question 1 the null hypothesis was not rejected, thus, the differences are not significant. All in all, the empirical results (overall average scores) indicate enhanced support and user

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[1] Subjects are chosen such that they are comparably present in the tag clouds of both user interfaces to ensure an adequate starting point.

[2] http://en.wikipedia.org/wiki/Likert_scale

experience of the new interface (μ=4.16, σ=0.825, for Delicious: μ=2.94, σ=0.94). More expressive explanations why the systems were rated in a particular way could be inferred from the comments of participants. Basically, both interfaces were assessed easy to understand and no major problems occurred during testing. However, the thinking aloud protocol revealed limitations of classic interfaces as expected. Users criticized the limited number of related tags which forced them to enter tags manually in order to refine their queries. Regarding the SC Interface, the users stated that the interface was more supportive since providing more tags and respective related tags to select from. Also, the breakdown of topics was estimated useful as well as the possibility to edit queries all the time. For Q3, users stated, that SC was visually more attractive and transparent due to use of color and spatial semantic arrangement.

4.3 Discussion

For a full practical deployment of the concept, there are still some problems that need to be resolved. This primarily concerns the clustering method, which has to be enhanced in order to be executed fully automatically. A manual selection of clusters became necessary to achieve a satisfying result for evaluating the user interface concept. Furthermore, in future research cross-topic exploration needs to be enhanced. The current concept is limited in this regard as a query covering two topics (e.g. travel and photography) has to be either set up by exploring two semantic clouds one after the other or by entering tags manually. Here, it would be beneficial to either have very general tags displayed within every cluster using a non-exclusive clustering method or to develop an approach for simultaneously exploring multiple different topics. A non-exclusive clustering approach would also be beneficial in case of fuzzy cluster borders, where tags relate to different topics in the cloud. Moreover, users that participated in the evaluation suggested several ideas for improvement, ranging from small extensions, e.g. additional information on results, towards larger challenges like including a more extensive set of tags 'behind the scenes'.

5. CONCLUSIONS

In this paper, a new user interface approach called *Semantic Cloud*[3] was presented. It allows users to explore the tag space of a folksonomy system within a hierarchical structure of semantically arranged tag clouds representing different topics and their subtopics. This way, users are able to gain a fast impression of general topics as well as detailed insights into the tag space of their special field of interest, i.e. finding appropriate search tags. Observations, user comments and questionnaire answers in a user study indicate that users were more satisfied in using Semantic Cloud, than existing wide-spread user interface concepts for folksonomy systems.

[3] http://semanticcloud.sandra-siegel.de/

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