TagSpheres: Visualizing Hierarchical Relations in Tag Clouds

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Abstract: Tag clouds are widely applied, popular visualization techniques as they illustrate summaries of textual data in an intuitive, lucid manner. Many layout algorithms for tag clouds have been developed in the recent years, but none of these approaches is designed to reflect the notion of hierarchical distance. For that purpose, we introduce a novel tag cloud layout called *TagSpheres*. By arranging tags on various hierarchy levels and applying appropriate colors, the importance of individual tags to the observed topic gets assessable. To explore relationships among various hierarchy levels, we aim to place related tags closely. Three usage scenarios from the digital humanities, sports and aviation, and an evaluation with humanities scholars exemplify the applicability and point out the benefit of TagSpheres.

1 INTRODUCTION

The usage of tag clouds to visualize textual data is a relatively novel technique, which was rarely applied in the past century. In 1976, Stanley Milgram was one of the first scholars who generated a tag cloud to illustrate a mental map of Paris, for which he conducted a psychological study with inhabitants of Paris, aiming to analyze their mental representation of the city (Milgram and Jodelet, 1976). In 1992, a German edition of "Mille Plateaux", written by the French philosopher Gilles Deleuze, was published with a tag cloud printed on the cover to summarize the book's content (Deleuze and Guattari, 1992). This idea to present a visual summary of textual data can be seen as the primary purpose of tag clouds (Sinclair and Cardew-Hall, 2008). But the popularity of tag clouds nowadays is attributable to a frequent usage in the social web community in the 2000s as overviews of website contents. Although there are known theoretical problems concerning the design of tag clouds (Viégas and Wattenberg, 2008), they are generally seen as a popular social component perceived as being fun (Hearst and Rosner, 2008). With the simple idea to encode the frequency of terms to a given topic, tag clouds are intuitive, comprehensible visualizations, which are widely used metaphors (1) to display summaries of textual data, (2) to support analytical tasks such as the examination of text collections, or even (3) to be used as interfaces for navigation purposes on databases.

In the recent years, various algorithms that compute effective tag cloud layouts in an informative and readable manner has been developed. One of the most popular techniques is Wordle (Viégas et al., 2009), which computes compact, intuitive tag clouds and can be generated on the fly using a web-based interface.[1] Although the produced results are very aesthetic, the different used colors do not transfer information and the final arrangement of tags depends only on the scale, and not on the content of tags or potential relationships among them. Some approaches attend to the matter of visualizing more information than the frequency of terms with tag clouds – most often to compare textual summaries of different data facets.

In this paper, we present the tag cloud design *TagSpheres*, which endeavors to effectively visualize hierarchies in textual summaries. The motivation arose from research on philology. Humanities scholars wanted to analyze the clause functions of an ancient term's co-occurrences. Querying the large database, the scholars often face numerous results in the form of text passages. When only plain lists are provided to interact with the results, the discovery of significant text passages and the analysis of the contexts in which the chosen term was used becomes laborious. To support this task, we provide summaries of text passages in the form of interactive tag clouds that group terms in accordance to their distance to the search term. So, the humanities scholar gets an overview and is able to retrieve text passages of interest on demand.

[1] http://www.wordle.net/

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Figure 1: Wordle of Edgar Allan Poe's *The Raven*.

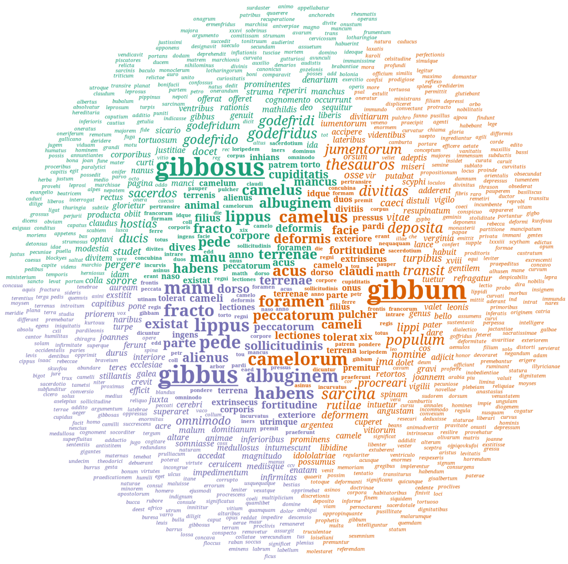


Figure 2: TagPie supports the comparison of co-occurrences of the Latin terms *gibbus*, *gibbum* and *gibbosus*.

We designed TagSpheres in a way that various types of text hierarchies can be visualized in an intuitive, comprehensible manner. To emphasize the wide applicability of TagSpheres, we list several examples from the digital humanities, sports and aviation.

2 RELATED WORK

Although tag clouds rather became popular in the social media, research in visualization attended to the matter of developing various layout techniques in the last years. A basic tag cloud layout is a simple list of words placed on multiple lines (Viégas et al., 2007). In such a list, tags are typically ordered by their importance to the observed issue, which is encoded by font size (Murugesan, 2007). An alphabetical order is also often used, but a study revealed that this order is not obvious for the observer (Hearst and Rosner, 2008). Later, more sophisticated tag cloud layout approaches that rather emphasize aesthetics than meaningful orderings were developed. A representative technique is Wordle (Viégas et al., 2009; Jo et al., 2015), which produces compact aesthetic layouts with tags in different colors and orientations, but both features do not transfer any additional information. A Wordle showing the most important terms in Edgar Allan Poe's *The Raven* is given in Figure 1.

Various approaches highlight relationships among tags by forming visual groups. In thematically clustered or semantic tag clouds, the detection of tags belonging to the same topic is supported by placing these tags closely (Lohmann et al., 2009). Traditional, semantic word lists place clustered tags successively (Schrammel and Tscheligi, 2014). More sophisticated layout methods often use force directed approaches with semantically close terms attracting each other (Cui et al., 2010; Wang et al., 2014; Liu et al., 2014). After force directed tag placement, tag cloud layouts can be compressed by removing occurring whitespaces (Wu et al., 2011).

Some methods generate individual tag clouds for each group of related tags, and combine the resultant multiple tag clouds to a single visual unity afterwards. An example is the Star Forest method (Barth et al., 2014), which applies a force directed method to pack multiple tag clouds. Other approaches use predefined tag cloud containers, e.g., user-defined polygonal spaces in the plane (Paulovich et al., 2012), polygonal shapes of countries (Nguyen et al., 2011), or Voronoi tesselations (Seifert et al., 2011). Newsmap uses a treemap layout (Shneiderman and Plaisant, 1998) to group newspaper headlines of the same category in blocks (Weskamp, 2015). Morphable Word Clouds morph the shapes of tag cloud containers in order to visualize temporal variance in text summaries (Chi et al., 2015). For the comparison of the tags of various text documents, a ConcentriCloud divides an elliptical plane into sectors that list shared tags of several subsets of the underlying texts (Lohmann et al., 2015). Due to the rather independent computation of individual tag clouds – which often leads to large whitespaces in the final composition step – the above mentioned methods can be seen as sophisticated small multiples. A rather traditional small multiples approach is Words Storms (Castellà and Sutton, 2014) that supports the visual comparison of textual summaries of documents.

Tag clouds also have been used to visualize trends. Parallel Tag Clouds generate alphabetically ordered tag lists as columns for a number of time slices and highlight the temporal evolution of a tag placed in various columns on mouse interaction (Collins et al.,

Table 1: Characteristics of TagSpheres usage scenarios.

domain	digital humanities (see Section 4.1)	sports (see Section 4.2)	aviation (see Section 4.3)
task	analyzing the clause functions of the co-occurrences of a search term T	comparing the performances of teams in championships	observing all direct flights from an airport or a city
H_1	search term T	best performing teams	departure airport/city
$H_2,\ldots,H_n$	co-occurrences in dependency on the word distance to T	teams grouped by decreasing performance	direct federal (H_2), continental (H_3) and worldwide flights (H_4)
n	4	6, 8	2..4
$w(t)$	number of (co-)occurrences of t	number of a team's appearances	inverse distance weighting between departure and arrival airports/cities
$p(t)$	equally labeled tag of a higher hierarchy level	same team if already placed on a higher hierarchy level	previously placed tag of the same country/continent
strong tag relations	equally labeled tags	same teams if placed on multiple hierarchy levels	departure/arrival airports/cities
weak tag relations	spelling variants	N/A	airports/cities of the same country/continent

2009). In contrast, SparkClouds attach a graph showing the tag's evolution over time (Lee et al., 2010). Other approaches overlay time graphs with tags characteristic for certain time ranges (Shi et al., 2010).

Only few approaches generate multifaceted tag cloud layouts in a single, continuous flow that includes the positioning of all tags belonging to various groups. RadCloud visualizes tags belonging to various groups within a shared elliptical area (Burch et al., 2014). In Compare Clouds, tags of two media frames (MSM, Blogs) are comparatively visualized in a single cloud (Diakopoulos et al., 2015). To support the comparative analysis of multiple tag groups, TagPies are arranged in a pie chart manner (Jänicke et al., 2015a). An example showing the comparative visualization of the co-occurrences of Latin terms is shown in Figure 2.

Although techniques like TagPies or Parallel Tag Clouds are capable of visualizing sequences of tag groups, none of the mentioned approaches endeavors to visually encode generic hierarchical information intuitively in a single, compact, aesthetic tag cloud. TagSpheres – presented in this paper – are designed to fill this gap.

3 DESIGNING TAGSPHERES

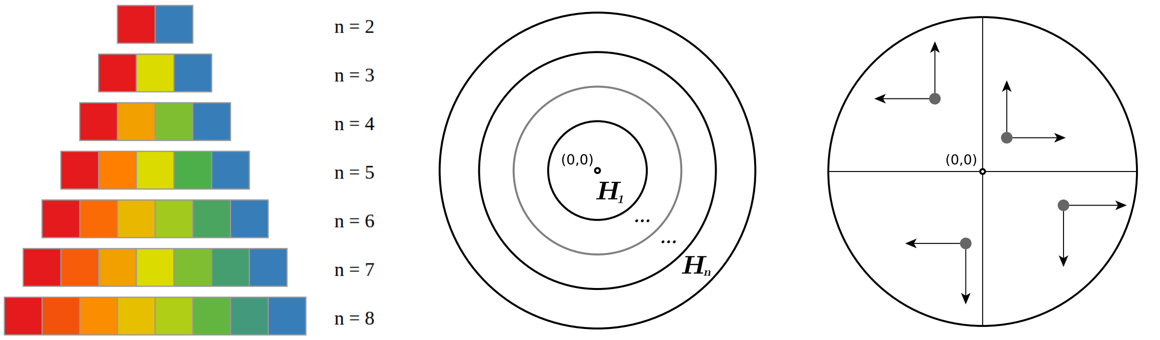
The central idea of TagSpheres is the visualization of textual summaries that comprise hierarchical information. This paper provides three usage scenarios that exemplify hierarchies in textual data (see Section 4). An overview of the characteristics of these examples is given in Table 1.

Given n hierarchy levels $H_1,\ldots,H_n$, the top hierarchy level H_1 contains tags representing the focus of interest of a usage scenario. All other tags are divided into $n-1$ groups in dependency on their hierarchical distance according to the observed topic, or to the tags on H_1. Each tag t in TagSpheres has a weight $w(t)$ reflecting its importance, and an optional predecessor tag $p(t)$ representing a relationship to another tag that was placed before t and usually belongs to a higher hierarchy level. In dependency on the observed topic, it might be necessary to place the same tag on several hierarchy levels to encode the change of a tag's importance among hierarchies. In such cases, predecessor tags help to visually link these tags.

3.1 Design Decisions

When designing TagSpheres, we use the following, well-established design features for tag clouds:

- **Font Size:** Evaluated as the most powerful property (Bateman et al., 2008), font size encodes the weight $w(t)$ of a tag.
- **Orientation:** As rotated tags are perceived as "unstructured, unattractive, and hardly readable" (Waldner et al., 2013), we do not rotate tags to keep the layout easily explorable.
- **Color:** Being the best choice to distinguish categories (Waldner et al., 2013), various colors are assigned to tags belonging to different hierarchy levels. As TagSpheres encode the distance to a



(a) Resultant color maps for $n = 2, \ldots, 8$ hierarchy levels.
(b) Using spheres for the tags of different hierarchy levels.
(c) Vectors for occlusion check to guarantee hierarchical coherence.

Figure 3: TagSpheres layout algorithm details.

(a) Placing all tags of H_1.
(b) Placing a tag without predecessor.
(c) Placing a tag with predecessor.

Figure 4: Determining tag positions using an Archimedean spiral.

given topic, the usage of a categorial color map is inappropriate. Unfortunately, suitable sequential color maps as provided by the ColorBrewer (Harrower and Brewer, 2003) produce less distinctive colors even for a small number of hierarchy levels, so that adjacent tags belonging to different hierarchy levels are hard to classify. Following the suggestions given by Ware (Ware, 2013), we defined a divergent cold-hot color map using red for the first hierarchy level and blue for tags belonging to the last hierarchy level n. To avoid uneven visual attraction of tags, we only chose saturated colors that are in contrast to the white background. Example color maps for up to eight hierarchy levels are shown in Figure 3(a).

3.2 Layout Algorithm

In preparation, the tags are sorted by increasing hierarchy level, so that all tags within the same hierarchical distance to H_1 are placed successively. The tags of each hierarchy level are ordered by decreasing weight to ensure that important tags are circularly well distributed.

To avoid large whitespaces, a problem addressed by Seifert (Seifert et al., 2008), our method follows the idea of the Wordle algorithm (Viégas et al., 2009) – permitting overlapping tag bounding boxes if the tags' letters do not occlude – to determine the positions of tags. So, we obtain compact, uniformly looking tag clouds for the underlying hierarchical, textual data. To ensure well readable tag clouds, we use a minimal padding between letters of different tags.

As shown in Figure 3(b), we aim to visually compose tags of the same hierarchy level in the form of spheres around the tag cloud origin at $(0,0)$. Initially, we iteratively determine positions for the tags of H_1 in the central sphere using an Archimedean spiral originating from $(0,0)$. An example is given in Figure 4(a). For each tag t of the remaining hierarchy levels $H_2, \ldots, H_n$, we also use $(0,0)$ as spiral origin, if $p(t)$ is not provided (see Figure 4(b)). If $p(t)$ is defined, we use the predecessor's position as spiral origin (see Figure 4(c)). As a consequence, hierarchically related tags are placed closely and visually compose in the form of rays originating from $(0,0)$ as shown in Figure 8. In contrast to other spiral based tag cloud algorithms, we avoid to cover whitespaces with tags of hierarchy level H_i within spheres of already processed hierarchy levels $H_1,\ldots,H_{i-1}$. Dependent on the quadrant in the plane, in which a tag shall be placed, we search for already placed tags intersecting two vectors originating from the dedicated position as illustrated in Figure 3(c). If no intersections are found, we place the tag. This approach coheres all tags of a hierarchy level as a visual unity outside the inner bounds of the previously processed hierarchy levels' spheres.

3.3 Interactive Design

Implemented as an open source JavaScript library, TagSpheres can be dynamically embedded into web-based applications. With mouse interaction, we enable the user to detect hierarchically related tags quickly. Thereby, we distinguish between strongly and weakly related tags, which are defined in dependency on the underlying usage scenario (see Table 1). Related tags are shown on mouseover (see Figure 5). For strongly related tags we use a black font on transparent backgrounds having the hierarchy levels' assigned color. In contrast, weakly related tags retain their saturated font color, but gray, transparent backgrounds indicate relationships.

TagSpheres provide a configurable tooltip displayed when hovering or clicking a tag to be used, e.g., to list all related tags and their weights. The mouse click function can be used for displaying additional information. e.g., to link to external sources, or to show text passages containing the chosen tag.

4 USE CASES

TagSpheres are applicable whenever statistics of unstructured text shall be visualized in the form of a tag cloud and a decent hierarchy among the tags exists. This section illustrates usage scenarios of TagSpheres for text-based data from three different domains: digital humanities, sports and aviation.

4.1 Digital Humanities Scenario

Within the digital humanities project *eXChange*,[2] historians and classical philologists work with a database containing a large amount of digitized historical texts in Latin and ancient Greek. Usually, humanities scholars pose keyword based search queries and often receive numerous results, which are hard to revise individually. As a consequence, the generation of valuable hypotheses is a laborious, time-consuming process. To facilitate the humanities scholars' workflows, we develop visual interfaces that attempt to steer the analysis of search results into promising directions.

TagPies – also developed within the *eXChange* project – are tag clouds arranged in a pie chart manner that support the comparison of multiple search query results (Jänicke et al., 2015a). Using a TagPie, humanities scholars analyze contextual similarities and differences of the observed terms – an example is given in Figure 2. Whereas the tags of the same groups are placed in the same circular sectors in TagPies to support their comparative analysis, the intention of TagSpheres is the visualization of hierarchical information. This supports approaching a further research interest of the humanities scholars: the analysis and classification of a term's co-occurrences according to their clause functions. For this purpose, the scholars required four-level TagSpheres displaying the following tags:

- H_1: search term T,
- H_2: co-occurrences of T with word distance 1,
- H_3: co-occurrences of T with word distance 2, and
- H_4: co-occurrences of T with word distance 3 up to word distance m.

The font size of T on level H_1 encodes how frequent the search term occurs in the underlying text corpus; the font sizes of all other terms reflect their number of co-occurrences with T in dependency on the corresponding distance. On H_4, font sizes are normalized in relation to the distance range $m-2$. A tag on hierarchy level H_i receives a predecessor tag if the corresponding term occurs on one of the previous layers $H_{i-1},\ldots,H_1$.

A use case provided by one of the humanities scholars involved in the *eXChange* project shall illustrate the utility of TagSpheres to support the classification of a term's co-occurrences by their clause functions. Analyzing the co-occurrences of ***morbo*** (disease), terms in similar relationships to the given topic were discovered and classified (see Figure 5). In large distances, the humanities scholar found objects in form of affected parts of the body, e.g., head (*caput*), soul (*animo*) and limbs (*membrorum*), affected persons, e.g., son (*filius*), woman (*mulier*) and king (*rex*), and related places, e.g., Rome (*romam*), church (*ecclesia*) and *villa*. Closer to *morbo* (most often with distance 1 or 2), typical attributes and predicates can be found. Whereas attributes describe the type or

[2] http://exchange-projekt.de/

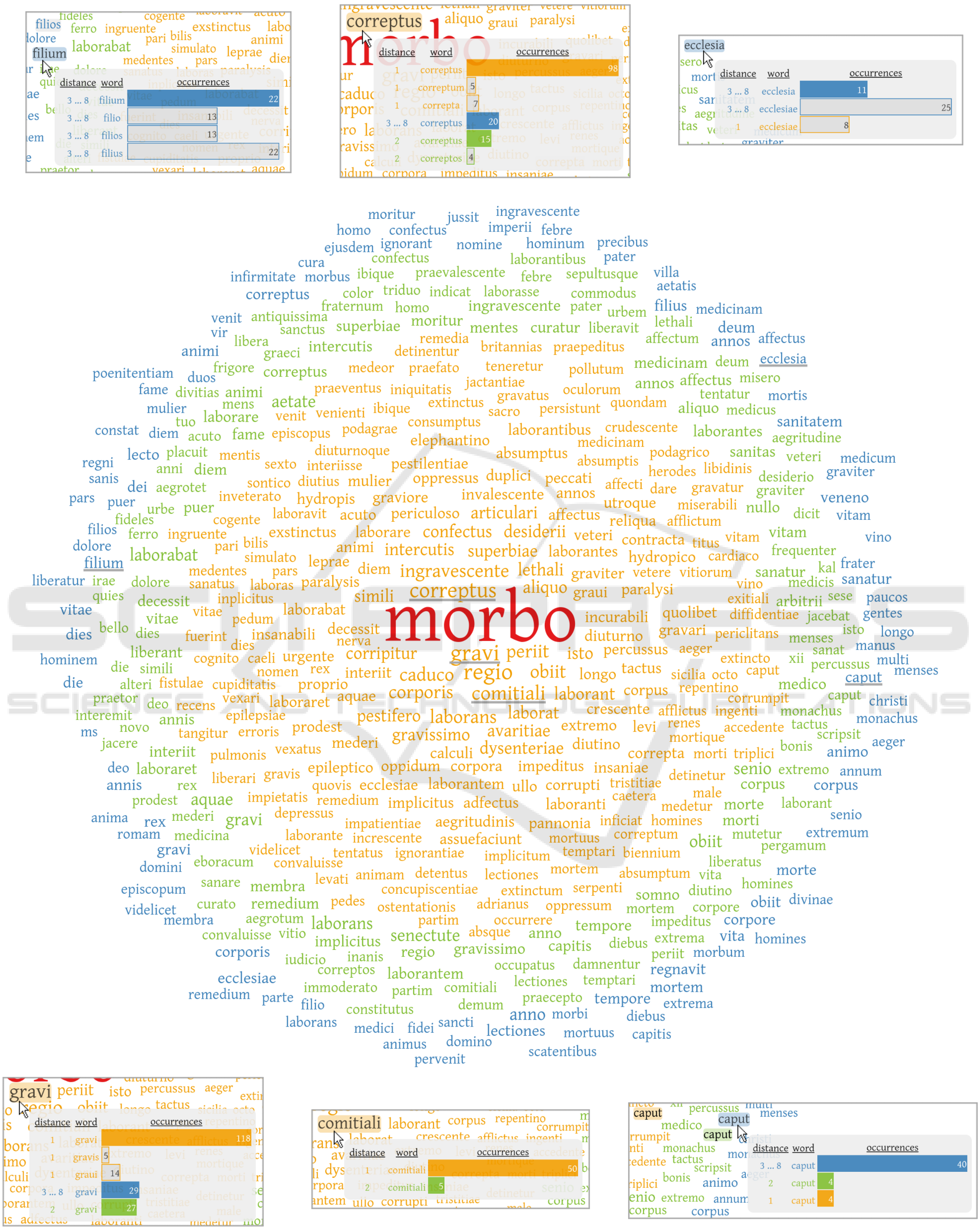


Figure 5: The analysis of co-occurrences of the Latin term *morbo* (disease) on word distance.

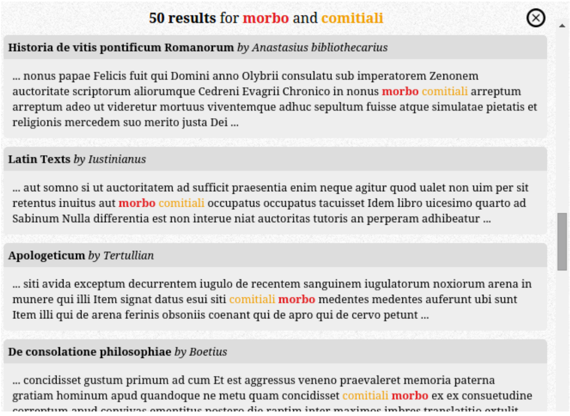


Figure 6: Close reading of text passages containing *morbo* and *comitiali* with word distance 1.

intensity of the disease, e.g., pestilential (*pestifero*), heavy (*gravi*), deadly (*exitiali*) and acute (*acuto*), the occurring predicates illustrate the disease's progress, e.g., seize (*correptus*), dissappear (*periit*) and worsening (*ingravescente*). Adjacent to *morbo*, specific terms for "moral" diseases, e.g., greediness (*avaritiae*), arrogance (*superbiae*) and lust (*concupiscentiae*), and actual diseases like jaundice ([morbo] *regio*), leprosy (*leprae*) and two common names for epilepsy (*[morbo] comitiali, [morbo] sacro*) occur.

In this usage scenario, the interaction capabilities of TagSpheres are tailored according to the needs of the humanities scholars. Hovering a tag opens a tooltip showing the term's number of occurrences on all hierarchy levels as strongly related tags. Additionally, variant spellings or cases of the term are listed with their corresponding frequencies as weakly related tags to support the analysis process. An important requirement for the humanities scholars was the discovery of potentially interesting text passages, but they desired a straightforward access to the underlying texts in general. This so-called *close reading* is often reported as an important component when designing visualizations for humanities scholars (Jänicke et al., 2015b). TagSpheres support close reading by clicking a tag, which displays the corresponding text passages containing the search term and the clicked term with the chosen distance. An example for text passages containing the adjacent terms *morbo* and *comitiali* is shown in Figure 6.

4.2 Championship Performances

This scenario illustrates how TagSpheres can be used to comparatively visualize performances in championships. An example is given in Figure 7 that illustrates the success of football clubs ever played in England's first league. Here, we use the average rank at the end of the seasons to cluster 68 clubs into eight hierarchy levels, and font size encodes the number of appearances.

Figure 7: Performances of English first league football clubs from 1888/89 – 2014/15.

For another example, we processed a dataset containing the results of all national teams ever qualified for the FIFA World Cup. We receive the following six-level hierarchy:

- H_1: FIFA World Champions,
- H_2: second placed national teams,
- H_3: national teams knocked out in the semifinal,
- H_4: national teams knocked out in the quarterfinal,
- H_5: national teams knocked out in the second round (second group stage or last 16), and
- H_6: national teams knocked out in the (first) group stage.

The nations' names are used as tags and font size encodes how often a national team partook a championship round *without* reaching the next level. Therefore, most nations occur on various hierarchy levels. If a tag t for a nation to be placed on H_i was already placed at a higher hierarchy level $H_{i-1},\dots,H_1$, we use the corresponding tag as predecessor $p(t)$.

Figure 8 shows the resultant TagSphere. Especially this scenario illustrates the benefit of using the positions of predecessor tags as spiral origins for successor tags. In most cases, the various tags of a nation are closely positioned. Hovering a tag displays the all-time performance of the corresponding national team for all championship rounds in a tooltip. Expectedly, *Brazil* and *Germany* achieved very good results, especially in the last championship rounds. In contrast, *Italy* was often knocked out in the first round, but in case of reaching the semifinal (8x), *Italy* often became

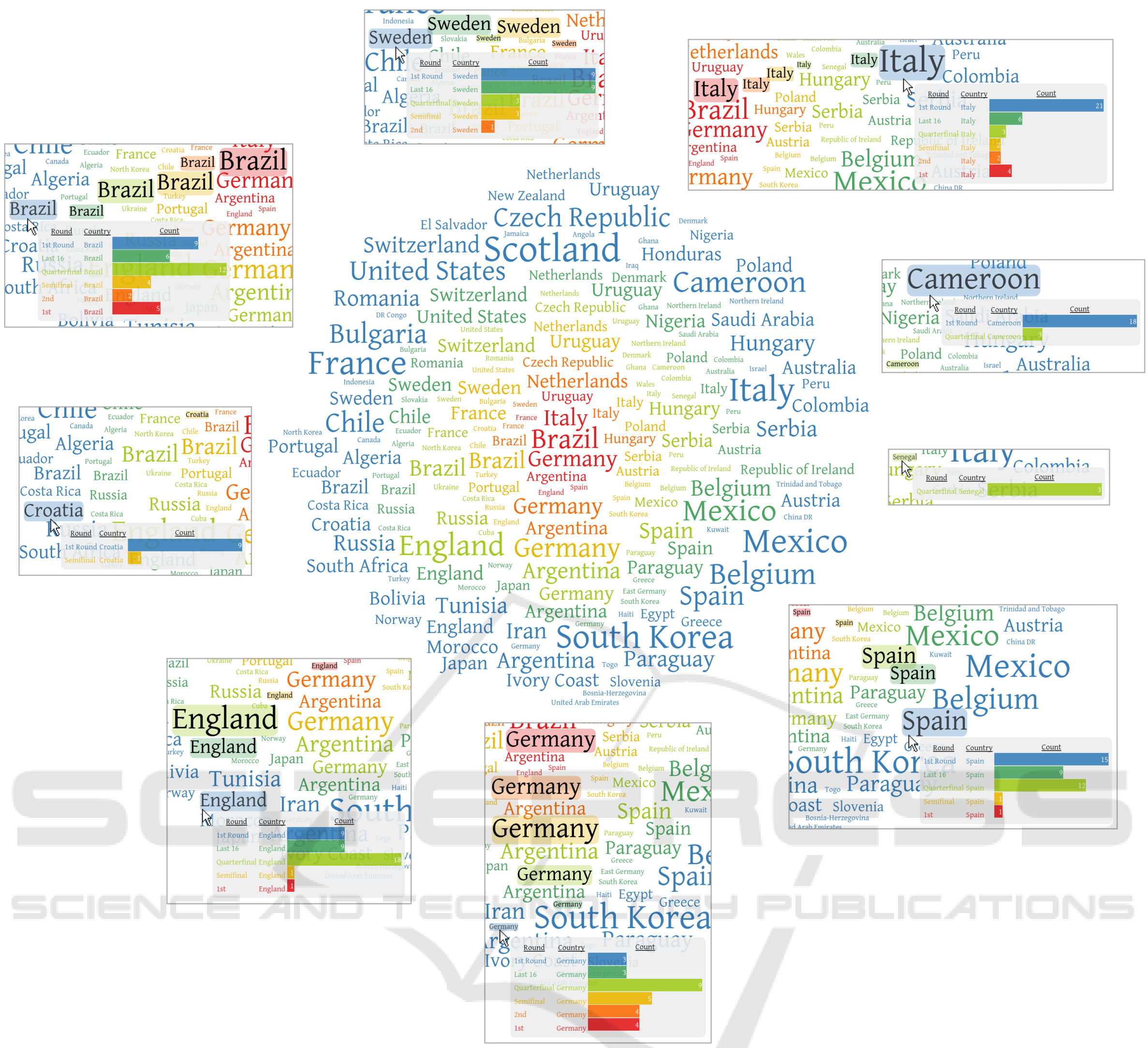


Figure 8: Performances of all nations qualified for the FIFA World Cup.

FIFA World Champion (4x). *England* and *Spain* show nearly equal performances. With the same number of appearances (38x), both nations reached the semifinal only twice. Few nations have a 100% success rate in the group stage. Qualified three times for the FIFA World Cup, *Senegal* always reached the quarterfinals. Most nations, e.g., *Sweden* and *Cameroon*, show the expected pattern “the higher the championship round, the smaller the number of appearances.”

4.3 Airport Connectivity

To analyze the federal, continental and worldwide connectivity of airports, we derived a dataset from the OpenFlights database,[3] which provides a list of direct flight connections between around 3,200 airports worldwide. With the selected departure airport d (or city) on H_1, all other airports (or cities) reachable with a non-stop flight cluster into three further hierarchy levels:

- H_2: airports/cities in the same country as d,
- H_3: airports/cities on the same continent as d, and
- H_4: all other reachable worldwide airports/cities.

As tags we chose either airport names, the provided IATA codes,[4] or the corresponding city names. In this scenario, font size encodes the inverse geographical distance between the departure airport $d = \{lat_d, lon_d\}$ and an arrival airport $a = \{lat_a, lon_a\}$. To keep the deviation to the actual distance as small as

[3]http://openflights.org/data.html

[4]http://www.iata.org/services/pages/codes.aspx

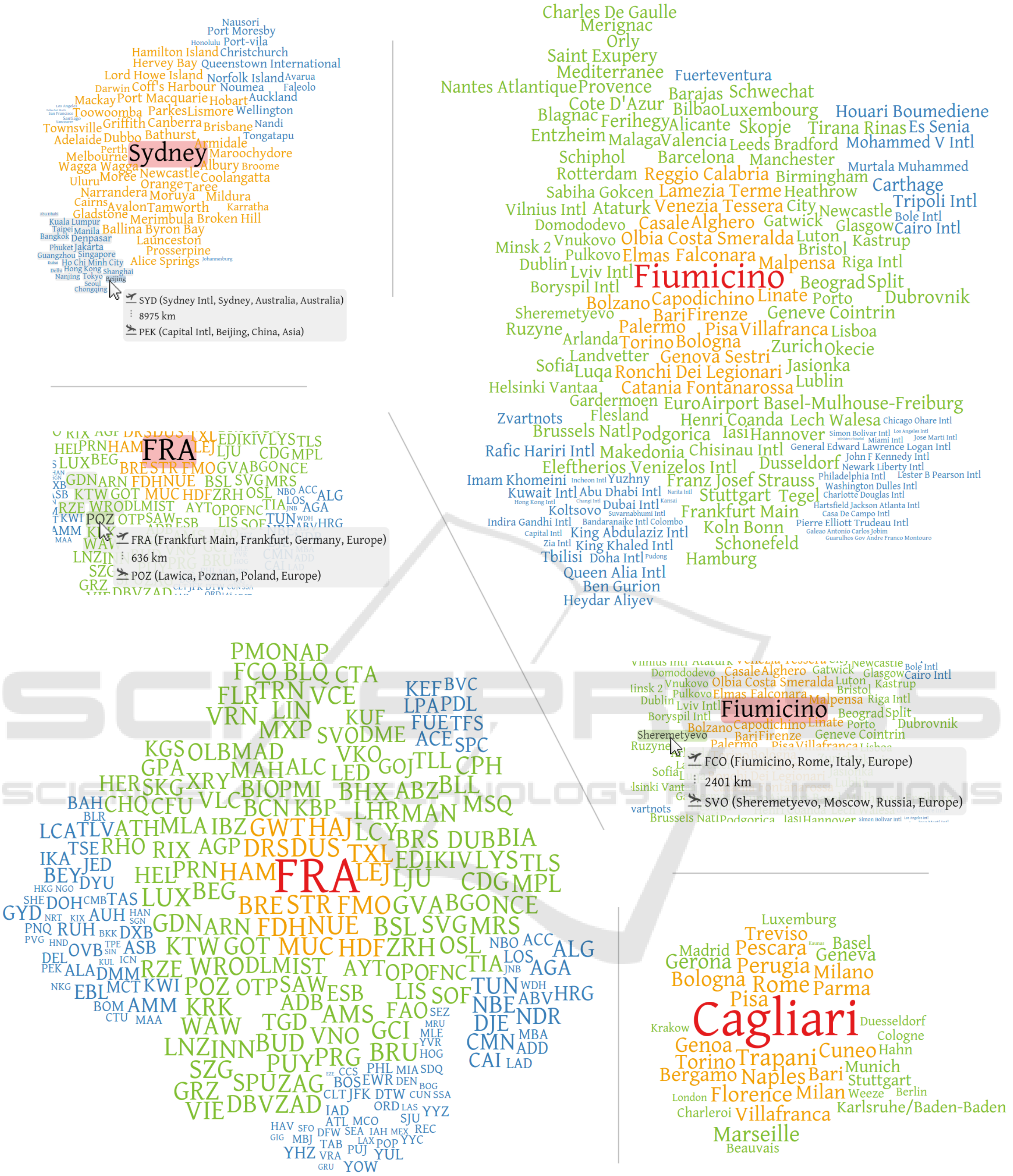


Figure 9: Direct flight connections from airports in Sydney, Rome, Frankfurt and Cagliari.

$$G = 6378 \cdot \arccos\left(\sin(lat_d)\cdot\sin(lat_a) + \cos(lat_d)\cdot\cos(lat_a)\cdot\cos(lon_d - lon_a)\right) \quad (1)$$

possible, we apply the great circle distance G (Head, 2003), defined by Equation 1. Predecessor tags are used to place airports or cities of the same country or continent closely. For a tag t to be placed on H_3, we choose the first placed tag with the same associated country as predecessor, if existent; for H_4, we choose the first placed tag with the same associated continent. Thus, a predecessor tag $p(t)$ in this scenario always belongs to the same hierarchy level as t.

Figure 9 shows TagSpheres for non-stop flights from various airports or cities. All examples show that airports/cities of the same countries/continents are placed closely in clusters. For Sydney, no tags are placed on H_3, and for Cagliari, no connections to airports outside Europe exist. When the user hovers a tag, the corresponding connection and the travel distance are shown in a tooltip. Clicking a tag redirects to Google Flights[5] listing possible flight connections.

5 DISCUSSION

The original motivation to design TagSpheres was to support humanities scholars in analyzing the clause functions of a search terms' co-occurrences (see Section 4.1 for details). Some aspects of evaluating the design during the corresponding *eXChange* project are outlined below. Furthermore, we discuss general limitations of TagSpheres.

5.1 Evaluation

To ensure creating a valuable interface for our targeted user group, we closely collaborated with the humanities scholars in the design phase aiming to transform their notion of hierarchical distance as appropriate as possible. This included project workshops and regular meetings, where we demonstrated current prototypes, and the humanities scholars were able to suggest their ideas on the design, the interactivity and the embedding of TagSpheres into their research environment. Finally, we conducted a small evaluation with seven humanities scholars (five female, two male) – five of them were members of the *eXChange* project. Due to that small number of participants, diversified research interests and the exploratory nature of the humanities scholars' tasks, a formal user study with performance data was not viable. To encourage the participants to intensely work with TagSpheres, we allowed them to query the database with terms of their own interest (preference data). A survey on close and distant reading visualizations designed for humanities scholars discusses in detail that quantitative, systematic evaluations are hardly realizable in digital humanities projects (Jänicke et al., 2015b).

In a questionnaire, we asked the humanities scholars for subjective ratings on several aspects concerning TagSpheres. They needed to choose a value on a Likert scale from 1 (very bad) to 7 (very good), and we also asked them to justify their decisions. The results are shown in Figure 10.

[5]https://www.google.com/flights/

Before developing TagPies (Jänicke et al., 2015a), we performed a case study on state-of-the-art tag clouds where we found out that the aesthetics of tag clouds plays an important role for humanities scholars. The aesthetics of TagSpheres was generally perceived as good. Very important for us were the opinions of humanities scholars if our design would intuitively transmit their notion of hierarchical distance. Only two scholars were undecided, but four scholars gave the best rate stating that TagSpheres are *"easily understandable."* Especially, the chosen colors *"clearly visualize the word distance between co-occurrences and the search term."* As the tags are shown in different colors and varying font size, we further asked for the readability of tags, which was mostly justified positively. Although the humanities scholars stated that *"all important co-occurrences of the search term are visible at first glance,"* it was hard for them to detect often closely positioned similar or related terms on different hierarchy levels. But all participants stated that the provided means of interaction facilitate this task and overall foster the understanding of the visualization and the explorative analysis of results. Finally, the utility of TagSpheres to support the humanities scholars in examining research questions regarding the clause functions of a search terms' co-occurrences was also rated as good.

5.2 Limitations

The main objective of the presented layout algorithm is to combine a hierarchical information of textual data with the aesthetics of tag clouds. In contrast to the usual approach to always initialize an Archimedean spiral at the tag cloud origin $(0,0)$ when determining the position of a tag, the usage of prede-

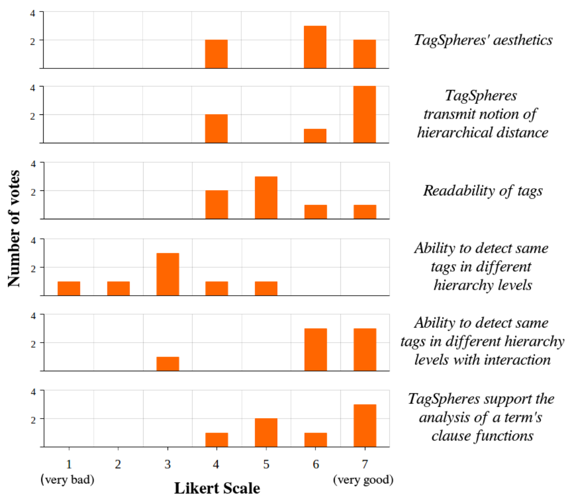


Figure 10: TagSpheres questionnaire results.

cessor tags as spiral origins slightly affects the uniform appearance of the result in some cases (e.g., see Figure 9). Occasionally, little holes occur, and – at the expense of visualizing the hierarchical structure of the underlying data – the tag cloud boundaries get distorted.

The proposed hot-cold color map used to visually convey hierarchical distance generates well distinguishable colors when the number of hierarchy levels is small. For a larger number of hierarchies as displayed in Figure 7, closely positioned tags of different levels may become visually indistinct, especially when only few tags belong to a certain level.

The current TagSpheres design does not take the distribution of tags throughout different hierarchy levels into account. In use cases with a steadily increasing or decreasing number of tags per hierarchy level it gets possible that a considerable proportion of the color maps' bandwidth is used for a comparatively small portion of tags. An assignment of colors taking the density distribution of the tags' weights into account could overcome this issue.

6 CONCLUSION

We introduced TagSpheres that arrange tags on several hierarchy levels to transmit the notion of hierarchical distance in tag clouds. We accentuate relationships between different hierarchy levels by placing hierarchically related tags closely. Applied within a digital humanities project, the design of TagSpheres was evaluated as aesthetic and intuitive, and the humanities scholars emphasized the utility of TagSpheres for their work. Further usage scenarios in sports and aviation outline the inherence of hierarchical textual information in various domains and the usefulness of TagSpheres as they provide an interesting view on this type of data.

Despite few listed limitations, TagSpheres might be applicable to a multitude of further research questions from other areas. Also imaginable is the combination of TagSpheres and TagPies to support the comparative analysis of different textual summaries with hierarchical information.

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