



The contribution of our development is making Tag Clouds no longer be simply considered as a social signaler [8], but a dynamic and interactive tool for geo-visualizations through textual data. For instance, we can examine and discover trends or patterns in geo-referenced data by dynamically displaying a set of tags on a geographical region; or, we can also analyze the correlations between different regions by linking tags which share the same attributes on them. This consideration, which has not been focused in existing Tag Clouds (e.g. [8-18]), as a result, can make our *Taggram* a promising choice for geovisual analytics, relevant to current research directions on visualizations, as proposed in [19].

The remainder of this paper is as follows: Section 2 presents related work as the background for our developed technique. Section 3 provides general analyses for the design of *Taggram* in the viewpoints of InfoVis. Section 4 will then give an example for our current *Taggram*'s implementation. And finally, we conclude our paper and present future directions in section 5.

## 2. Related Work

### 2.1. Collaborative Tagging and Tag Clouds

One of the main features provided in social network software (SNS) is sharing personal data in form of annotation and collaborative tagging [20]. This simple form for data sharing has been attractively accepted by SNS users, where Tag Clouds is amongst the most common supported visualizations. Tag Clouds has been known since 2002 through its implementation in Flickr<sup>1</sup>. Since then, there have been many investigations into this kind of visualization.

According to Hassan-Montero and Herrero-Solana [10], Tag Clouds was suggested for information retrieval interfaces, since the visualization promisingly supports the overview of indexed and clustered data. However, this has not been the focus of recent research on Tag Clouds, as a matter that users seem not to notice it as a data analysis tool but a kind of decoration: a social signaler [8]. Following that, researchers on Tag Clouds mainly concentrate on how to nicely fit the tags onto a view (i.e. drawing algorithms [11][12]) for SNS usages (in form of their evaluations on usability studies [13-18]).

In detail, those studies on Tag Clouds drawing algorithms mainly concern the static placement of tags on screen, in 2D. In this case, the authors proved that users prefer the alphabetical order placement best [15], and are interested in and affected by tags' font size, then font weight [14][16], while color and position of tags play lesser roles (e.g. in the case of clustering tags, or centric

based placement of tags) [17][18]. However, all of those Tag Clouds designs are more or less the static form of text decorations on SNS applications (normally in form of HTML-based web) [11]. Consequently, it does not reflect all common features of a visualization tool (among which interaction for exploration is a necessity).

Furthermore, since Tag Clouds is normally placed at fixed rectangular regions on SNS interfaces, existing tag clouds are only designed for rectangle-based regions, except the one developed by Seifert *et al.* [12] where tags can be placed into convex polygons.

Following that, the motivation for the investigation into Tag Cloud-based visualizations is general concepts and strategies for the placement of tags in arbitrary-shaped regions (including concave and complex polygons), and the ideas of supporting interactively selecting the tags for presentation following user actions.

### 2.2. Geo-Tagged Visualizations

As mentioned, existing Tag Clouds techniques are about the placement of tags on application interfaces for attraction (aka social signalers [8]). However, in reality, visualizations with texts are much more than that, benefiting by the meaningful relationships of textual data (semantic, linking, comparison, searching, and so on - see more on [21]). In this regard, tag clouds and many features of tag words must be taken into account dealing with specific contexts to arrive at suitable forms of Tag Cloud-based visualizations. In the context of geospatial data, tags therefore can be organized to support representing geo-referenced information. This is necessary, since according to Jo and Ryu [5], spatial information (e.g. place where an event occurred, place where a report referred to) is always the very centric data that human beings do normally recall when referring to any story. As a result, text-based spatial information can be used to change the ways Tag Clouds are available in SNS.

In fact, the use of geo-referenced information is not new in Tag Clouds' research. In [9], Jaffe *et al.* suggested placing tags on general purpose maps, namely Tag Maps, for the exploration of geotagged photos. Based on their ideas, Slingsby, Wood, and their colleagues [22][23] took advantage of mash-up tools (LandSerf GIS<sup>2</sup>, KML, Google Earth<sup>3</sup>,...) to present tags and tag clouds on maps as labels separately linking to maps or floating on them. Similarly, Dörk *et al.* developed Tag Clouds as a view, namely a VisGet, for the coordinated view of geo-referenced tags linking to general purpose maps [24].

The development of those techniques has provided first concepts for the browsing and exploration of geo-

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<sup>1</sup> <http://www.flickr.com>

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<sup>2</sup> <http://www.landserf.org>

<sup>3</sup> <http://earth.google.com>

referenced information through tag clouds. However, in those cases, they simply attach general tag clouds to general purpose maps, while text visualization strategies are not well considered. As analyzed by Jo and Ryu [5], navigating on fixed geometric maps for the exploration of some textual data while all maps features are incoherently displayed seems not to be a sufficient solution. User actions in zooming in and out on those maps for the overview or detailed exploration are not always beneficial. It is sometimes a redundant task, and even not applicable in linking related (historical) user's actions. Besides, using maps with detailed data will occupy presentational space as well as computer resources (rendering time, memory).

Therefore, geo-tagged data to be visualized on maps should not be simply organized as the separate or floating clouds attaching to general purpose maps as in existing techniques [9][22-24]. Instead, we should analyze the shapes of the regions to provide additional visualizations for the presentation and exploration of geo-tagged data on maps, adapting to the trend of general InfoVis in trading off shape and area adjustments with other abstract visual data [25].

### 3. General Issues on Taggram Design

The goal for this novel visualization is to be able to organize and represent a number of tags in association with a geographical region. But in contrast to conventional cartographic labeling problem, where texts are placed on maps at places close to the objects to be labeled, tags in this technique are planned to be freely positioned within the associated region.

In general, we are interested in the issues of tag clouds and cartography for the development of *Taggram* with the following considerations:

- Concerning the geographical region, only its spatial feature (the shape) is taken into account for the design of the technique.
- Concerning tags, for our geo-data visualization, they can be freely placed, but must be inside the geographical region, so that different tag clouds can be distinguishable for different regions.
- Tags are to be flexible in size, color, orientation, and transparency, where the constraint of those attributes is to maintain the relationship and the meaning of the displayed cloud.
- The number of tags is not necessarily fixed, but might vary depending on the actual shape of the region or the exploration process.

With the above considerations, there would be three main problems to take into account for the development of this Tag Cloud-based visualization on maps: (1) the analysis of the geographical region to find appropriate positions to place the tags, (2) the mechanisms for the

association of the tags with the positions, and (3) the strategies for handling a large number of tags, larger than the number of available positions.

#### 3.1. The Analysis of the Geographical Region

As the shape of the geographical region is arbitrary, it is insufficient to use existing Tag Clouds drawing algorithms [8-18] for the placement of tags. In fact, in those existing techniques, tags are often linearly placed one after another (alphabetically) or symmetrically arranged around a simple (rectangular) region; while in this situation of arbitrary-shaped area, tags depend heavily on the available spaces of the region.

Therefore, given a geographical region, the first problem in designing *Taggram* is a method for finding suitable positions/places on the region so that tags can be attached to. There would be two strategies to solve this problem. First, we can subdivide the whole geographical region into subareas. Each subarea will be a place for a tag. In this regard, placing tags now means to solve the area labeling problem. There, the challenges will be the matters of how to subdivide the region, and into how many subareas? The second solution strategy is identifying the positions following the topological form of the region (e.g. the geometrical skeleton). In this case, placing tags means to solve the problem of point labeling, and the challenge now will be how to specify the appropriate positions along the skeleton.

The most difficulty in such analysis of a geographical region is due to the shape of the region, since normally available spaces along the geographical area can be very narrow, and the region may be formed with holes or concave shapes (for instance, star-shaped), while tags are generally comprehensible when horizontally shown (which requires wide in width spaces and short for the height).

#### 3.2. Mechanisms to Relate Tags to the Positions

The second issue for *Taggram* design is how to relate tags onto the region. Given a set of subareas/positions and a set of tags, which tag should be associated with which location?

One strategy can be sorting both tags by size and subareas by size, and then relating the biggest tag to the biggest area, and so on. Another alternative is sorting all tags by size, or alphabetically, then starting from the central position of the whole region (e.g. identified by its skeleton) to place the biggest tag, and finding new positions along the axis to relate the sorted tags step by step. The challenge here will be the size of a tag (its bounding box) may not always adapt to the size (shape) of the subareas or the available space around the related position (e.g. tag can be longer, not bendable along the subarea...).

### 3.3. Handling More Tags than Available Positions

As the number of tags is not necessarily fixed, but might vary depending on the actual shape of the region or the exploration process, the third issue in designing *Taggram* is how to nicely handle different numbers of tags, especially when the tags are much more than the available positions.

In fact, for comprehensibility, a common design of Tag Clouds normally supports presenting less than 150 tags in a cloud (e.g. 30 tags [12], 93 tags [11], 76 tags [18], or about 100 tags [17]), while the number of tags in a geographical unit can be varying up to hundreds or thousands of tags, but available positions may be just about dozens of places. As a result, tags must be selected to be shown on screen.

Considering this problem following existing Tag Clouds' research [15][16], we know that people do often scan the cloud for the highlighted tags rather than read all of them to find information. There, just some tags are meaningful in a tag cloud. Consequently, selecting some tags (e.g. a dozens of tags) and showing them dynamically or interactively can be the straight forward solution. Besides, the matter of computer resources for visual rendering is also taken into account for this issue.

Therefore, one solution can be rendering a tag, finding the next suitable place for the next tag, and adding more tags on demand (interactive selections). The process stops when no more suitable place is found, or after a number of iterative steps. Another alternative is rendering all tags for the estimated positions, and then doing post-processing to place the remaining ones, e.g. using the particle-based labeling approach [26].

### 3.4. Further Remarks

To support visualizing *Taggram* interactively or dynamically, tags are expected to be organized in the way that the updated ones (on new positions) can preserve the form of the old ones in the cloud. In addition, semantic relations between tags must also be taken into account for such design of *Taggram*. With meaningful textual relationships [21], tags can be highlighted, organized by groups, or linked together or to specific cartographic objects. In this case, browsing and exploring on *Taggram* can be done through brushing and linking techniques. This assists the user in classifying, comparing, or jumping into relevant data on maps, while not eliminating the default zoom-and-pan interfaces if available.

The challenge here will be how to preserve such coherent view of the visualization while still keep the relational meaning of the updated tags. Since in contrast to many other popular cartographic features (color, texture...), where aspatial data can be easily encoded on any-shaped area, tags when examined for re-placing on a

new location may not be always accomplishable, as its expected size can be, for instance, greater than the available space on the new area.

## 4. Current Taggram's Implementation

In this section, we provide an example of *Taggram* in presenting some demonstrated geo-tagged data on maps. It has been developed to illustrate a strategy of mapping the tags onto the arbitrary-shaped geographical region along the main vertical axis indicating the skeleton of the region, and a mechanism to update its view according to user interactions. Anyway, before describing our approach in detail, we take a look at the application scenario of our demonstration.

### 4.1. Application Scenario

As one characteristic of *Taggram* is supporting browsing geo-referenced information without taking general purpose maps into account, geographically-detailed data such as exact roads, buildings, and other geographical point-of-interests are not necessarily presented in the general view of maps in *Taggram*. This is also relevant to the ways people conduct spatial reasoning for places, about which just high-level areas of towns, cities, states, countries, and continents are prominently indicated [5].

For tagged data, we demonstrate to show the most popular tags (keywords with highest frequencies) from geo-tagged photos in Flickr, retrieved through its API<sup>4</sup>. In general, geo-tagged data can be extracted by combining web-services and geo-services (such as GeoNames<sup>5</sup>, Panoramio<sup>6</sup>,...). This, in combination with text extraction techniques for websites, blogs, online news (e.g. through GeoRSS [27]), and geo-databases, will provide more opportunities for research and applications in text and visual analytics scenarios.

### 4.2. The Overview of Our Approach

According to Tag Clouds evaluations, in arbitrary tagged data exploration, people often pay attention to tags with bigger font sizes, and contrast colors [16][17], and the center of the cloud will be the place tags normally get most noticed [17]. Therefore, our strategy is placing the most focused tags from the center of the geographical region. Besides, as presented in [15], tags are most easily comprehensive if organized in alphabetical order. As a result, we will arrange tags alphabetically on the region.

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<sup>4</sup> <http://www.flickr.com/services/api/>

<sup>5</sup> <http://www.geonames.org/>

<sup>6</sup> <http://www.panoramio.com/>

Following that, the general ideas for our approach, concerning the discussed problems (section 3), will be:

- 1) Analyzing the geographical region to find out the center of the region as well as its geometrical form (the main vertical skeleton).
- 2) Sorting the tags alphabetically. Placing the median of the sorted-list tags at the center of the region, and the next ones along the skeleton.
- 3) The remaining tags are displayed on demand (interactively) or automatically updated on screen, where the general view of *Taggram* always remains coherent.

The overall implementation of *Taggram* is summarized in Alg. 1.

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**Algorithm 1. Overall implementation of Taggram**

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Given an initial set of tags and a geographical region

1. Sort tags alphabetically and identify the first tag to be placed
  2. Find the center place of the region
  3. Place the first tag at the region's center
  4. Follow the vertical skeleton of the region
  5. **while** a new position can be found **do**
    - 5.1. Select the next tag to be shown
    - 5.2. Identify the new position based on the skeleton and the size of the tag
    - 5.3. Place the tag on the new position
  6. Handle the remaining tags
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**4.3. Placing Tags on the Region**

The center  $(c_x, c_y)$  of a geographical region is computed based on its boundary's points, following Bourke's formulae [28]:

$$c_x = \frac{1}{6A} \sum_{i=0}^{N-1} (x_i + x_{i+1}) (x_i y_{i+1} - x_{i+1} y_i) \quad (1)$$

$$c_y = \frac{1}{6A} \sum_{i=0}^{N-1} (y_i + y_{i+1}) (x_i y_{i+1} - x_{i+1} y_i)$$

where  $(x_i, y_i)$  are the consequent points in a polygon of  $N$  points, and  $A$  is the area of that polygon:

$$A = \frac{1}{2} \sum_{i=0}^{N-1} (x_i y_{i+1} - x_{i+1} y_i) \quad (2)$$

In case there are many separated polygons (with area  $A_j$  and center  $c_j$ ) in a geographical region (e.g. map of US), the center place will be the weighted center of mass:

$$C = \frac{\sum A_j c_j}{\sum A_j} \quad (3)$$

The size and position of a tag to be placed depends heavily on the relative distance of the examined area (to

place the tag) to the center of the region as well as its available space. There, we examine tag's font size and its bounding box to get the most suitable place in the available space.

The biggest and the expected smallest sizes ( $s_{max}$ ,  $s_{min}$ ) for tags in *Taggram* are computed based on the expected number of tags  $n$  to be placed and the region's area  $A$ .

$$s_{max} = \theta \sqrt{A/n}$$

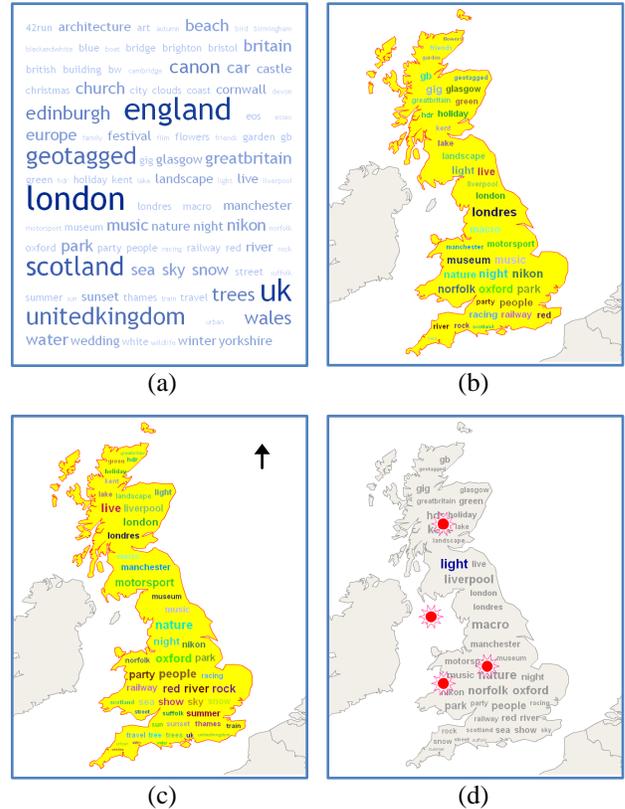
$$s_{min} = \varphi \sqrt{A/n} \quad (4)$$

where  $\theta$  and  $\varphi$  are pre-estimated (e.g. 0.66 and 0.33 in our implementation) so that the scale ratio *scale* between tags can be computed:

$$scale = \sqrt[n]{s_{max}/s_{min}} \quad (5)$$

In this manner, tag's sizes are updated when a new tag is examined for the next placement:

$$s_{currentTag} = s_{previousTag}/scale \quad (6)$$



**Figure 2. An example of our demonstrated Taggram: (a) the most popular tags retrieved for “United Kingdom” (using Flickr API), (b) tags are placed along the main vertical skeleton of UK’s map, (c) tags’ positions are updated as Taggram is scrolled up, and (d) some interesting Flickr’s geo-tagged places are highlighted as the tag “light” is selected**

Nevertheless, tags' sizes and positions are flexibly adapted within a predefined threshold (we allow a tag to be scaled up to 70% of the examined size, and inside a wider checking box) so that many tags can be shifted inside the arbitrary form of the region.

When sorting tags alphabetically, we suppose that tags' sizes do not represent their frequencies (as in most of conventional Tag Clouds). Therefore, the first tag to be placed at the region's center is tag  $i = n/2$ , amongst  $n$  sorted tags. The next tags to be selected will be tags  $i-1$  and  $i+1$  to show above and below tag  $i$ , along the main media axis of the region. Further tags are iteratively selected ( $i-2$ ,  $i+2$ ...) for the next places, until no more tag or no more new position is determined.

The demonstration of *Taggram* presenting the most popular tags retrieved for "United Kingdom" using Flickr API is presented in Fig. 2.

#### 4.4. Handling the Remaining Tags

To handle the remaining tags, we support two strategies in current *Taggram* implementation: (1) interactively showing the updated tags through a fisheye menu adaptation, and (2) dynamically presenting all the tags, in turn, on screen.

**4.4.1. Fisheye menu- based interaction.** As tags closer to the center of the region get more focuses [17][18], the idea of the implemented *Taggram* is relevant to the concept of "focus in context". Therefore, in order to remain the tags placement strategy, as well as to provide a coherent view for the users in easily comprehending and exploring geo-data, *Taggram* is implemented as an adaptation of a fisheye menu [29].

As tags are sorted and displayed alphabetically, interaction in *Taggram* is performed simply, relevant to the action of scrolling mouse or arrow keys on traditional menu contexts. We design the navigational exploration on *Taggram* with the supports of PC-equipped inputs through two main functions:

- Using arrow keys (up, down) or mouse's scroll button to shift up and down the updated focused tag, which is the one close to the central one. As tags move across the top-end or bottom-end of the displayed region, they will disappear, and new ones (which have not been shown in the previous step) are added to the opposite ends of the geographical area (bottom- or top-side).
- For a faster scrolling, mouse's scroll button keeps pressed, and tags are updated as mouse is moved up and down.

In doing so, instead of just using text boxes [30], we have added an alternative to the conventional ways of searching and exploring textual data on maps. Besides, similar to many other cartographic techniques, tags when

visualized with colors, transparency, orientation... can be meaningful for the analysis of geo-data, benefiting by their specific relationships [21]. Some illustrations are shown in Fig. 2c-d.

**4.4.2. Dynamically displaying the tags.** What if the user does not interact with the tags (i.e. scrolling) but still needs to see all the tags in the cloud? We follow the concept of "passive interaction". Passive interaction (in fact, it is a special case of dynamic visualization) means that the user does not need to actually interact with the interface for data exploration. Instead, the interface is unconsciously updated, and s/he can incidentally get information through its current view, and switch to the interactive process when needed [31]. This kind of dynamic visualization is supplemented to the above interaction implementation in the same manner.

## 5. Conclusion

In this work, we present a design for a novel textual geovisualization technique. The *Taggram* emerges from the ideas of Tag Clouds visualization on maps, taking advantages of geospatial information of tagged data, and characteristics of map visualizations.

The important contribution of our *Taggram* is making Tag Clouds no longer just a social signaler or a decoration of texts on SNS, but a geovisual analytics option for the presentation and exploration of geospatial data, which can be textually abstracted in geo-referenced context.

Tags positions are computed and displayed inside arbitrary shaped region, which has not been investigated in existing tag clouds drawings. And fisheye menu adaptation can be exploited for a demonstration of focus-in-context tags, while tags can be flexibly displayed on screen according to user interactions (with mouse and keyboard). During the interaction process, geo-tagged data can be explored and navigated following user actions on tags and their brushing-and-linking data.

The technique has been developed for the exploration of geo-tagged data on maps. However, in reality, as abstract textual data can be extracted from many geo-databases, we intend to extend *Taggram* to integrate into contexts of exploring online news, online blogs, and so on. In addition, concerning visualization aspects, future work will be the investigation into user studies for usability as well as in testing tags against other cartographic encodings, and the implementation of *Taggram* in 3D interfaces.

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