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Visual Mashup of Text and Media Search Results

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Abstract

There is a growing trend of enabling users to view diverse sources of data in an integrated manner, called visual mashups. This paper addresses the problem of how to visualize diverse data sources in a single integrated display when geographical meta-data is not available or advisable to use to combine the data sources. A visual mashup of web, image, video, news, blog and tagging search results is introduced. The presented solution makes it possible to visualize relationships between the different data sources, which would be difficult to show in a series of mini-displays arranged in a grid layout.

1. Introduction

According to Wikipedia [15], a "mashup" is a website or application that combines content from more than one source into an integrated experience. The data used in a mashup is usually accessed via an Application Programming Interface (API) or RSS / Atom feeds. The goal of a mashup is bring together in a single place data sources that tend live in their own data silos. Thus, data mashups can be understood as breaking down the "silo" structure of diverse information and integrating them into a new useful form. Major companies, such as Google, eBay, Amazon, AOL, Windows Live, and Yahoo, provide APIs to encourage "creative uses" of their data assets.

There at least two distinct ways for visually combining diverse data sources in a mashup visualization: a) multiple mini-displays for each data source can be created that are then shown and "combined" in the same holding page; b) a single display can be created that combines the multiple data sources. On the one hand, the former solution is simple to create by placing the mini-displays next to each other in a two-dimensional grid. A key limitation of such an approach is that is difficult to visualize relationships between the different data sources. On the other hand, the "single display" solution requires meta-data that can be used to integrate the different data sources. A common type of meta-data used is geographic location information (geo-tagging), which makes it easy to combine and superimpose diverse data sources on a map. Thus, map-based mashups, such as the combination of Google Map data with real estate listings [4], are the most common form of mashup visualizations [7].

This paper addresses the problem of how to create a visual mashup of web, image, video, news, blog and tagging search results, where geo-tagging data is not available or advisable to use. Specifically, a visual display will be presented for combining abstract data types that do not have an obvious spatial mapping, which is a key challenge in the field of Information Visualization [1].

This paper is organized as follows: section 2 reviews related work. Section 3 describes searchCrystal, a toolset for visually comparing diverse sets of data. In section 4, a visual mashup of web, image, video, news, blog and social tagging search results is presented. Section 5 discusses how searchCrystal makes it possible to compare different human "knowledge production" processes.

2. Related work

Related work can be distinguished based on how the diverse data sources are visually integrated. As noted, the first common option is to use a grid layout to combine multiple small displays for each data source; the second one is create a map-based mashup if geographical data is available to relate the different data sources.

Grid Layout: It is common for mashups that display web, image, video, news, blog and social tagging search results or data feeds to place each data type in a separate display on the same holding page (netvibes.com [5], pageflakes.com [6], searchMash.com [8]). This makes it possible to view the different result sets in a single web page, instead of having to visit multiple web sites or formulate multiple search queries. As noted, the grid layout do not support the visualization of relationships between the different data types, without requiring users to actively interact with the different data displays and "brushing" interactions to be supported.

Map-based: As mentioned, map-based mashups are the most common form of mashup visualizations where diverse data sources are combined in the same display. Examples are real estate listings (housingmaps.com [4]), crime data (chicagocrime.org [2]) or images taken at specific locations (flickrmap.com [3]) that are superimposed on maps generated by using the Google or Yahoo Map API. Map-based mashups do not have to solve the difficult problem of how to map abstract data into an understandable visual form. The geographical meta-data dictates how to map the data, resulting in a data display that is ideally suited to leverage a user's ability to rapidly perceive spatial relationships, such as how the data clusters at specific locations. Thus, it should come as no surprise that map-based mashup are the largest category of mashups being created (more than 40% of the mashups listed at programmableweb.com [7]).

3. Crystal Tools

In this paper, the *searchCrystal* toolset is used to visualize web, image, video, news, blog and tagging search results in a single integrated display. searchCrystal is an extension of MetaCrystal [10], which was developed to visualize the overlap between multiple engines searching for the same data type. MetaCrystal in turn is based on InfoCrystal [9], which makes it possible to formulate and visualize Boolean as well as Vector-based queries in the same visualization. These "Crystal" tools have in common that they can visualize the overlap between any fuzzy sets. They have also been developed based on the same key design principles: a *radial layout* is employed to ensure that items found by the same number of engines are mapped into the same concentric ring and the greater the number of engines that find an item, the smaller an item's distance from the center. Further, *shape*, *size*, *color*, *proximity* and *orientation coding* are used to indicate how many and which engines retrieved an item and in which rank positions. The "Crystal" family of tools are discussed in more detail in [10, 11, 12].

3.1. searchCrystal

searchCrystal has the capability to visualize relationships between the items in the different result sets being compared as well as the overlap structure of the sets. Its layout algorithm has been extended so that images and videos can be shown in a space-efficient way while preserving the "ordered" nature of their result lists (see subsection 3.1.2 and Fig. 3). searchCrystal has additional capabilities, which are outside the scope of this paper.

searchCrystal makes it possible to simultaneously submit the same query to a web, image, video, news, blog and social tagging search engine, respectively. Next, the result sets for the different data types are compared, where the great majority of items will be found by only one engine since different data types tend to be indexed in different "database silos."

3.1.1 Integrating Different Types of Search Results

The question needs to be addressed what information other than geo-tagging can be used to "synchronize" the different data sources to create a useful single display. The Uniform Resource Locator (URL) can be used in the case of the web, blog and social tagging search results, since they all use URLs that can appear in each other's result sets, whereas image and video URLs are usually not mixed into web, blog or tagging results. Further, video results tend to be stored on video hosting services, such as YouTube or GoogleVideo. Thus, the majority of video URLs will point to a small number of hosts. However, the host address can be used to relate and organize the web, image, blog and social tagging results, since they can all be stored on the same host. searchCrystal makes it possible to visualize the "host structure" of the results being compared by drawing connecting lines between items that reside on the same host (see Fig. 2). The radial layout used by searchCrystal facilitates the visualization of such structural relationships.

As noted, it is possible for web and social tagging (and to a lesser extent blog and news) search results to have result items in common, especially if more than the customary top 10 results are compared. If an item URL appears in both result lists, then this greatly increases the probability that the item is relevant, especially if it is highly ranked in both lists [13]. Thus, searchCrystal can be used to infer which items are more likely to be relevant. searchCrystal guides user toward potentially relevant items, since they tend to cluster toward the center of the display. At same time, users easily scan the top items that are only retrieved by a single engine.

3.1.2 Layout of Image & Video Thumbnail

searchCrystal consists of a series of linked views to help guide the user toward relevant information [10, 11, 12]. One of these views is the Cluster Bulls-Eye view, which is extended in searchCrystal, because it is best suited to visualize relationships and the overlap between search results with diverse data types. Specifically, its layout algorithm is modified to support the display of visual thumbnails of images, videos and websites in a space-efficient way.

The Cluster Bulls-Eye tool uses polar coordinates to display the found items: the *radius* value is related to the number of engines that found the item and the average of its rank positions in the lists that contain it; the *angle* reflects the relative ratio of an item's rank positions. This causes items retrieved by the same number of engines to

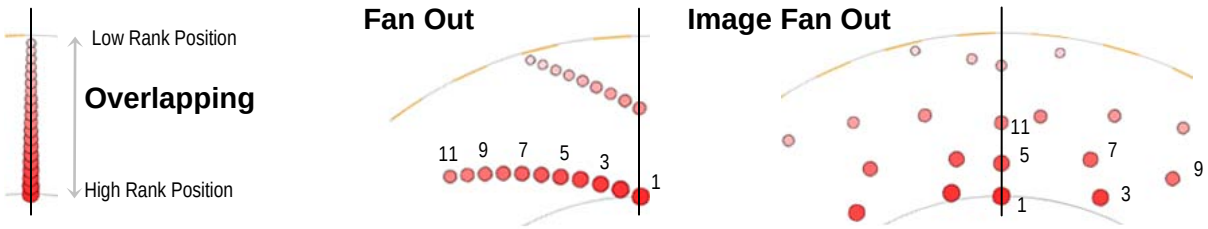

Fig 2: (Left & Middle) items found by a single engine are ***fanned out*** in the Cluster Bulls-Eye view so that they do not overlap. (Right) the fan out direction away from the input line is alternated so that the degree of overlap between images is reduced.

cluster and to be contained in the same concentric ring (see Fig. 2). The use of size coding helps to guide users toward the top items found by a specific number of search engines. In addition, the star-shaped input icons, which are located at the periphery of a crystal, influence an item's position. They act as "magnets" that pull an item toward them based on its rank position in the input lists that contain it.

As noted, when comparing sets with diverse data types, the great majority of items will be found by only one engine, especially for the image and video search results. Items found by a single engine represent a special case in the Cluster Bulls-Eye. Their angle value would be equal to the angle of the related star-shaped input icon with respect the display center. Thus, these items would cluster and overlap on a straight line as shown in Fig 1 (left). Instead, their angle is incremented so that items do not overlap and their total angle remains within a specified range, causing items to *fan out* in a compact way away from the line defined by an input icon, as shown in Fig. 1 (middle). The "fanning out" of items, which are only contained in a single input list, does not change an item's distance from the display center. For images and videos, the "fanning" solution is extended so that the direction away from the "input line" is alternated, as shown Fig. 1 (right).

This "alternate fanning" approach ensures the visual thumbnails for items, which are in subsequent rank positions in the result list, are mapped further apart in the Cluster Bulls-Eye display than if the direction is not alternated. The visual thumbnails are still tightly packed, yet they tend to overlap in such a way that users can see a large enough part of an image. If users place the mouse over a partially occluded image, then the whole image becomes visible. By moving the mouse over the partially occluded images, the full images are coming into and going out of view, enabling users to quickly to explore a large number of images. Further, users can adjust the size of the visual thumbnails to decrease the overlap between adjacent thumbnails.

4. Visual Mashup

Fig. 3 shows how searchCrystal can be used to create a "visual mashup" of the web pages, images, videos, news and user tagged pages found when searching for "Tim O'Reilly" on March 9, 2007. First, the labels next to the input icons, which are located at the periphery of a crystal, show that the top 10 results for the Google, Google Images, Google Video, Google News and Delicious search engines are compared in the interior of the crystal.

Second, the Google and Delicious results have three URLs in common. The item closest to the center is stored on the "oreillynet.com" server and it is the number one result for both Google and Delicious. This suggests that this item has a high probability of being relevant, since Spoerri [13] has shown that the more engines that recommend the same item, the greater the probability that the item is relevant (called the "Authority Effect"). Further, the higher up an item is placed in the result lists, the greater its likelihood of being relevant (called the "Ranking Effect"). The other two items both found by Google and Delicious are hosted on the "radar.oreilly.com" server.

Third, the fact that *all* found items are visible in the Cluster Bulls-Eye view makes it possible to draw connecting lines between the items that have the same host address. As noted, web, image, blog and social tagging results can be stored on the same host. The item that is closest to the center of the Cluster Bulls-Eye display is selected to be the "hub" from which the pinkish lines emanate to connect items with the same host (see Fig. 2). Now, a connecting line can help to corroborate the relevance of connected items. For example, if a web page is found by both a web and social tagging engine and it has a pinkish connecting line to an image, than this image is more likely to be relevant and related to the content of the web page that connects to it. Fig. 2 (middle) shows that the web page "o'reilly – what is web 2.0" is connected to the third and fourth results in the image result list. Both images are relevant and highly related to the content of the "Web 2.0" page, especially the "Web 2.0 Meme Map" (see Fig. 3, bottom middle and where cursor is visible).

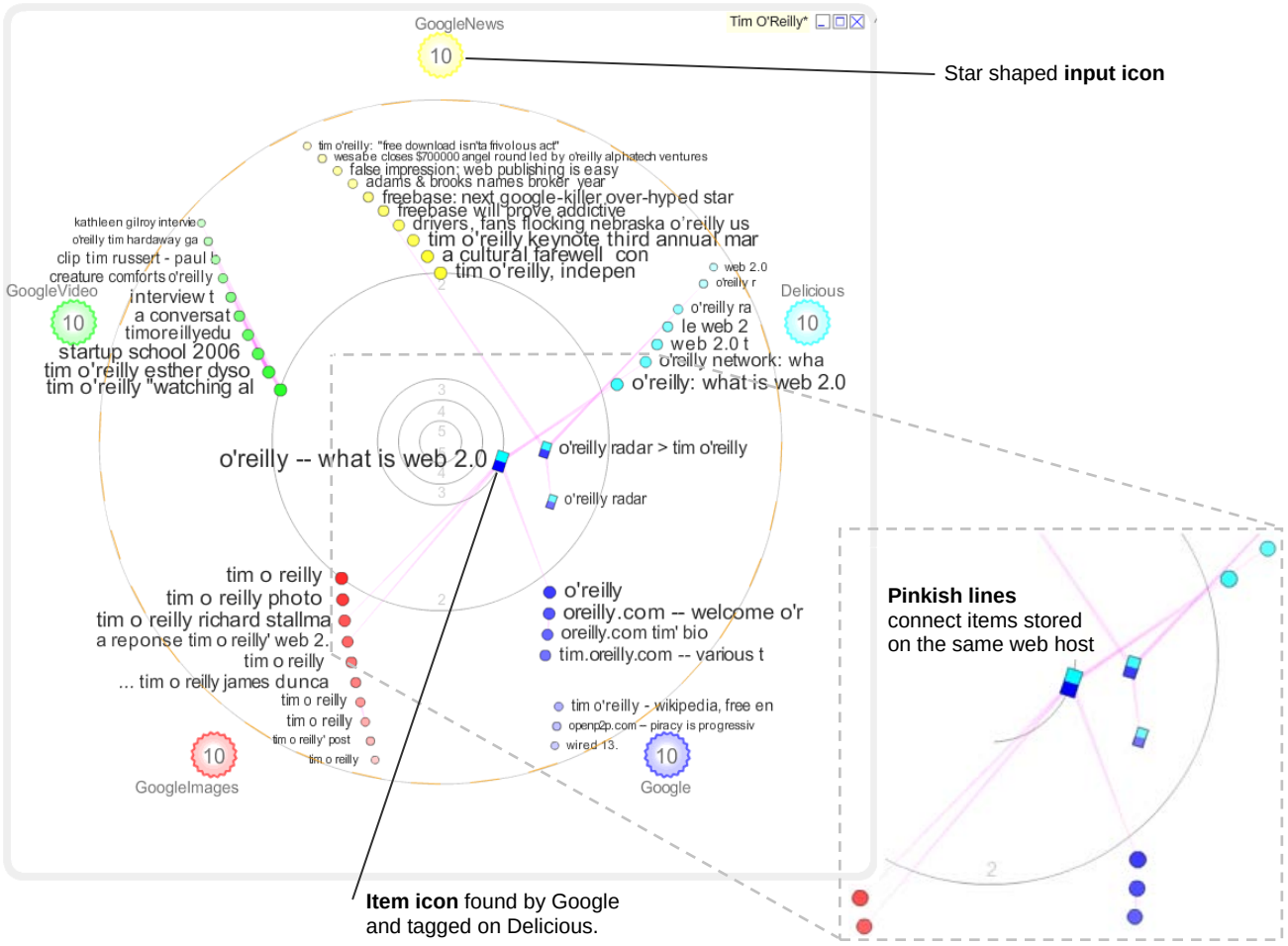

Fig 2: Cluster Bulls-Eye visualizes the overlap between the web, images, video, news and tagging results for the search query "Tim O'Reilly." The pinkish lines connect items located on the same server. (Bottom right) shows a magnified portion of the display to make the connecting lines better visible.

Fourth, images, videos and websites can be represented by visual thumbnails, which are placed to minimize the complete occlusion of thumbnails and maximize the number of images that can be recognized although they are partially occluded (see Fig. 3). The size of a visual thumbnail is scaled based on its rank position in the lists that contain it. The lower the list position, the smaller the image size. Fig. 3 shows visual thumbnails of images, videos and websites.

Fifth, searchCrystal supports "focus+context interactions so that users can expand or contract specific concentric rings in the Cluster Bulls-Eye display. Fig. 3 shows the result of applying a focus+context action so that the ring, which contains the items found by single engine, is expanded to spread out the images and make them better visible. If the user places the cursor over one of the concentric rings, the shape of the cursor changes to indicate that a "focus+context" action can be applied. The user needs to select and drag the ring to achieve the desired expansion or contraction of a specific portion of the display. Once the mouse is released, the size of the visual thumbnails and the title (fragments) are recomputed to maximize the information density of the display.

5. Discussion & Future Research

searchCrystal enables users to create a "multi-media" snapshot of a person, company or topic of interest. An advantage of such an integrated display is that it makes it possible to see the overlap and relationships between the different sources of data that reflect different social processes for organizing information and producing knowledge. Web search engines analyze the external hyperlinks included in web pages and use in part the link structure of the Internet to infer the relevance of web pages. Similar to citations in academic papers, the number of incoming links to a web page can be interpreted as a reflection of the page's value. Social tagging engines use the bookmarking and tagging efforts of its community to

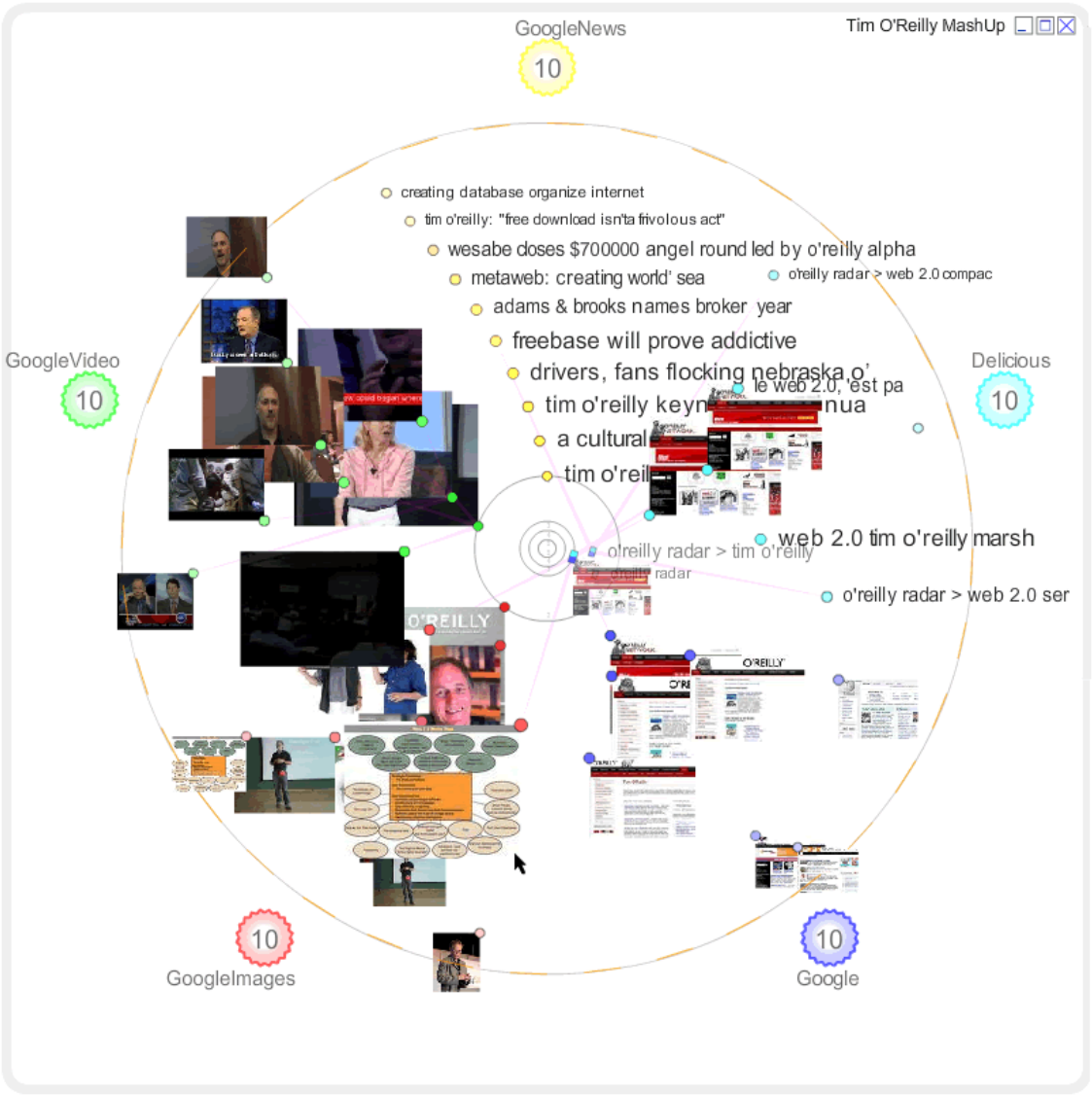

Fig. 3: Visual Mashup of the web pages, images, videos, news and user tagged pages found when searching for "Tim O'Reilly". Visual thumbnails of images, videos and websites (when available) are shown.

infer the relevance of bookmarked URLs. People bookmarking web pages and applying personal tags is a different process of organizing information, and ultimately producing knowledge, than people including external hyperlinks on web pages. Further, in a regular meta search, the result sets of different search engines, which search for the same data type (i.e., web pages) and use related information retrieval methods, are being compared and merged. searchCrystal makes it possible to compare independent human processes of "knowledge production" to find and present potentially relevant information, such as web pages, images or videos, to address a user's information need.

In this paper, an example has been presented that illustrates the "mashup" of the results of single search engines. However, searchCrystal can easily display the "meta search results" of multiple engines for a given data type, instead of just using the output of a single engine.

Future research will investigate if data type specific visual icons can be used in a searchCrystal display to make it easier to spot specific data types. For example, it would be helpful to if the item icons related to images or videos could reflect the visual nature of their content and whether the content is static or time-based.

searchCrystal can easily accommodate the visualization of different types of relationships by using

connecting lines, which can have different colors to reflect the different relationship types, such as web host structure or topical relationships. The visual thumbnails of websites, if they are available, can help users identify pages that are stored on the same web host. Users can use simple pattern matching to detect similar website thumbnails, although the visual thumbnails need to be sufficiently large to enable to users to gain insights into the web page content.

A user study [14] has been conducted to determine if novice users can use the RankSpiral and Cluster Bulls-Eye displays to find the documents that are most likely to be relevant. Specifically, it was shown that novice users can use the provided visual cues, such as the icon's shape and position, to decide which icons to explore first to find highly relevant documents. This ability is a prerequisite for users being able to make effective use of searchCrystal's full functionality. The user study also showed that novice users could identify highly relevant documents more rapidly and accurately by using the RankSpiral than the Cluster Bulls-Eye tool. A user study is currently being prepared to test if users can identify a sufficient number of known relevant documents and the Cluster Bulls-Eye tool will be compared with a standard ranked list display. It will be tested if the searchCrystal interface will lead to improved search performance, better user satisfaction and greater confidence in the relevance of the selected documents.

6. Conclusions

This paper addressed the problem of how to visualize diverse data sources in a single integrated display when geographical meta-data is not available or advisable to use to combine the data sources. It was shown how searchCrystal can be used to create a visual mashup of web, image, video, news, blog and tagging search results. searchCrystal is able to visualize diverse data related to the same query as well as relationships between the different data sources, such as which items are stored on the same web host. This would be difficult to achieve in a series of mini-displays arranged in a grid layout.

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7. References

[1] Card S., Mackinlay J. and Shneiderman, B. (Eds.) (1999). Readings in Information Visualization: Using Vision to Think. San Francisco: Morgan Kaufmann.

[2] Chicagocrime at http://www.chicagocrime.org

[3] Flickrmap at http://www.flickrmap.com

[4] Housingmaps at http://www.housingmaps.com

[5] Netvibes at http://netvibes.com

[6] Pageflakes at http://www.pageflakes.com

[7] Progammable Web at http://www.programmableweb.com/

[8] searchMash at http://www.searchMash.com

[9] Spoerri, A. (1999). InfoCrystal: A Visual Tool for Information Retrieval. In [1], pp. 140 – 147.

[10] Spoerri, A. (2004). Visual Editor for Composing Meta Searches. Proceedings of the 67th Annual Meeting of the American Society for Information Science and Technology (ASIST 2004), pp. 373 – 382.

[11] Spoerri, A. (2004). Coordinated Views and Tight Coupling to Support Meta Searching. Proceedings of the 2nd International Conference on Coordinated and Multiple Views in Exploratory Visualization (CMV 2004), pp. 39-48.

[12] Spoerri, A. (2004). RankSpiral: Toward Enhancing Search Result Visualizations. Proceedings IEEE Information Visualization Symposium (InfoVis 2004), p. 18.

[13] Spoerri, A. (2005). How the Overlap Between the Search Results of Different Retrieval Systems Correlates with Document Relevance. Proc. of the 68th Annual Meeting of the American Society for Information Science and Technology (ASIST 2005).

[14] Spoerri, A. (2006). Visualizing Meta Search Results: Evaluating the MetaCrystal toolset. Proceedings of the 69th Annual Meeting of the American Society for Information Science and Technology (ASIST 2006).

[15] Wikipedia Mashup_(web_application_hybrid) page at http://en.wikipedia.org/wiki/Mashup_(web_application_hybrid).