InfoWater: An Interactive Technique to Support Browsing of Conference Papers

Nicole Harris, Rachel Knickmeyer, Marleigh Norton, Olufemi Olumoko

GVU Center

Georgia Institute of Technology

Atlanta, GA 30332-0280

{nicole, rknickm, marleigh, folumoko}@cc.gatech.edu

ABSTRACT

The majority of text and document visualizations focus on one method to view information, causing them to limit the amount and quality of information that can be viewed. This paper describes a method to get an overview and detail view of large amounts of document data all at once based on a timeline schema. Through the combination and modification of previous existing visualizations, InfoWater gives a timeline overview of the history of information visualization and the main research focus areas during those times. Through the use of a lens schema, it also allows for viewing the inclusion and exclusion of authors and documents in specific information visualization subject groups, and focusing in on a specific author and/or document.

Keywords

lenses, brushing, text+document, overview+detail, timeline
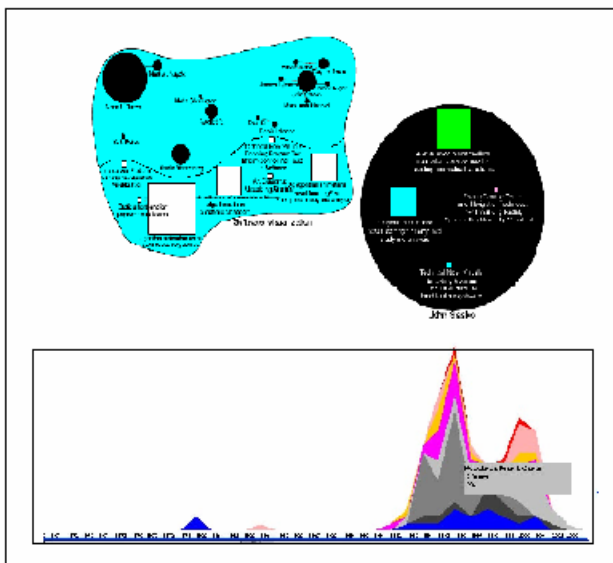
SCENARIO

Figure 1: Overview

Jeremy is a computer science graduate student considering taking a course in information visualization. He's heard from a friend that it's a good course, but wants to know a bit more about the area of study before he decides whether or not to register. Googling on "Information Visualization" provides many links, one of which is to an application called "InfoWater" (see Figure 1), which he decides to check out.

The first thing Jeremy sees is a ThemeRiver, with time plotted along the X axis and number of documents published along the Y axis. From this, Jeremy quickly sees that information visualization is a field that is about thirty years old, with a large rise in popularity in the last ten years. He decides to explore further and runs his mouse over the river. Mouseover balloons pop up, telling him the names: Overview & Detail, the World Wide Web, Software Visualization…

That last sounds interesting, so Jeremy investigates further by dragging from the river to the empty part of the screen above the river. This creates a blob on the screen labeled "Software Visualization". He sees objects labeled with people's names and document titles. He quickly sees that the most heavily referenced document in the field is called "Algorithm animation using 3D interactive graphics". Algorithm animation must be an important part of software visualization, Jeremy thinks.

Next, Jeremy looks at the names. He is surprised to see the course's professor there. The professor's icon is fairly large, so the professor must be well published. To find out more about the professor, Jeremy drags the professor onto the display, where it expands and shows all of the papers the professor has published. Yes, this professor seems to really like software visualization.

Jeremy looks back at the original display and notices that the professor's icon has a bunch of little icons stemming out from it. Those must be his graduate students, thinks Jeremy. Jeremy is then surprised to see his friend James there. James was the friend who had recommended the information visualization class to him in the first place. Perhaps Jeremy's first source of information was not as unbiased as he had thought. Good thing he found InfoWater!

INTRODUCTION

Over the past thirty years numerous papers have been written in the field of Information Visualization, enough to create an interesting visualization problem in its own right. How can one visualize the field of Information Visualization itself? This project seeks to answer that question by focusing on some high level tasks one might want to accomplish with a dataset of papers in this field.

The first task was to create a general overview of the evolution of the field since 1970. This would allow users to, at a quick glance, get a general feel for how the field has evolved over the years as well as determine the topics that were popular during various times. In addition, we wanted to allow users to be able to examine documents in different topics more closely, and see how papers and authors were related to each other by shared references and co-authorships. Finally, we wanted to include the utility of examining the intersection of various subjects with each other.

Why would such a utility be useful? There are a variety of reasons why users might want a program to view documents in this fashion, most of which are reflected in the user tasks mentioned above. In particular, the strength of our system is the ability to view how topics have evolved over time and also express relationships between authors, documents and information visualization subject groups. How we accomplish these tasks will be explained in detail in the following sections: Overview of the InfoWater system, ThemeRiver, Puddles and Merging Puddles.

PREVIOUS WORK
Zooming Interfaces – Grokker and Zoomology
Grokker is a data-mining tool that specifically searches the web and large databases. Used for knowledge mapping and information visualization, it displays information such that the user has access to multiple perspectives, which can be seen in relation to each other (grokker.com). Grokker does this by grouping information visually, in labeled nested circles (or squares), allowing the user to dig deeply through a large hierarchy to find the desired information [1]. Each downward drill through the sub-circles is performed very quickly so as to not lose or disorient the user thereby keeping him aware of his position.

Zoomology, with a layout similar to Grokker, is used to compare two data set trees by merging them into a single overview, displaying the sets in twin windows. Comparison occurs through size and color of the nodes displayed. Zooming down through the nodes with top-down navigation displays child nodes for evaluation as well. [12]

Spring Tension
Tension models are used to display the relationship between data in such a way that more closely related items are shown closer together than ones with very little relation or none at all. Spring tension is frequently used in graphs, which result in displaying clusters of closely related data.

ThemeRiver
ThemeRiver is a visualization that allows users to see a large number of documents' relationships or trends over time. It is based on a river metaphor where information flows from left to right becoming wider and narrower depending on the amount of information to be displayed at each time period. Individual themes within the river are usually represented with unique colors and remain in the same river concept becoming broader and narrower throughout time, depending on its strength or weakness.

Though ThemeRiver is beneficial for a basic overview of theme strengths, it fails immensely when trying to view details of a portion of the information. This is because the current information infrastructure for timeline views cannot handle the exploding scale of information and its associations. Even zooming in on a specific time period (which ThemeRiver does not support) would yield only a limited amount of the desired information. Thus, a system such as InfoWater (described in detail in the "InfoWater" section) is needed to automatically build the correlations and relationships between pieces of data. [2].

Lenses
Lenses give users the ability to interact with a more focused area of data allowing them to manipulate and dig through the data on their own. This implies that lenses carryout operations that change the user's view of the data through progressive refinement. Each lens can be both movable and arbitrarily shaped.

Magnifying lenses [9] and [10] give a zoomed in view of a specified data set. With these lenses, the user sees both the view of the original data plus an enlarged view of a specified region with details that were not presented in the original view. Using two lenses that zoom in on different types of information, you can also overlap the lenses to zoom in on a combination of information. Lenses can display the zoomed in data in two types of forms: distorting the data at its entirety in order to show a larger view of the specified data, or showing the specified data off to the side preventing image blockage or distortion.

Brushing
The common technique of brushing occurs when there are multiple views of the same data. By selecting or highlighting a case in one of the views, the other views highlight the same case. This is very helpful in gaining different perspectives about the data case. [8]

PROCESS
Identifying the Tasks
In developing InfoWater, we began with the user. We envisioned users much like ourselves, new to the field of information visualization. What would such a user want to know that could be found in the data? Our first thoughts were very specific tasks:

- Locate a particular paper
- Learn more about a particular subject
- Find references for a research paper

While these are important tasks, we felt that these needs were already being adequately met by modern search engines. We began to look at the problem from another angle: what else might users want to know that search engines could not tell them? We switched from search tasks to browsing tasks, envisioning a naive user who knew very little about information visualization, not even enough to use a search engine, since they would not know the relevant search terms. This led us to a very different set of tasks:

- What are the concepts of information visualization?
- Which documents are the most important?
- Who are the leading researchers in the field?

Triangulation
Next, we used the triangulation design technique to brainstorm visualizations. We each separately sketched out a visualization which we thought would serve our user tasks. The ideas which came back:

- A ThemeRiver mapping time and subject
- A zooming interface in the style of Grokker with authors and documents
- A direct manipulation visualization with a time line at the base in which lines could be dragged to the main screen to provide more detail
- A scatterplot-like visualization that showed clusters of documents along a timeline

Each visualization had its strengths: the ThemeRiver provided an excellent overview of the concepts of information visualization and how they changed over time. The zooming interface provided information about documents and authors broken up into small enough chunks to not overwhelm the user, the direct manipulation visualization provided a nice interaction between overview and detail views, while the scatter plot expressed relationships as clusters well. We quickly saw a way to combine these visualizations to utilize all of the strengths: the direct manipulation technique was applied to the ThemeRiver to pull out the zoomable objects.

Refining the Idea
As we worked on the idea, more ways to combine the functionalities occurred. Merging multiple objects into Venn Diagrams of subjects seemed useful, as well as using spring tension modeling to convey information about the relationships of the entities. Zooming itself was dropped in favor of mouseovers, which we considered less disorienting to the user. The water metaphor was adopted to help describe the different aspects of the system. One of the last features to be added was a brushing technique in which mousing over a documents would cause it's authors to be highlighted and vice-versa. This feature came out of internal testing. As we created the prototype, we had trouble with losing track of who wrote what. Brushing seemed like an elegant solution.
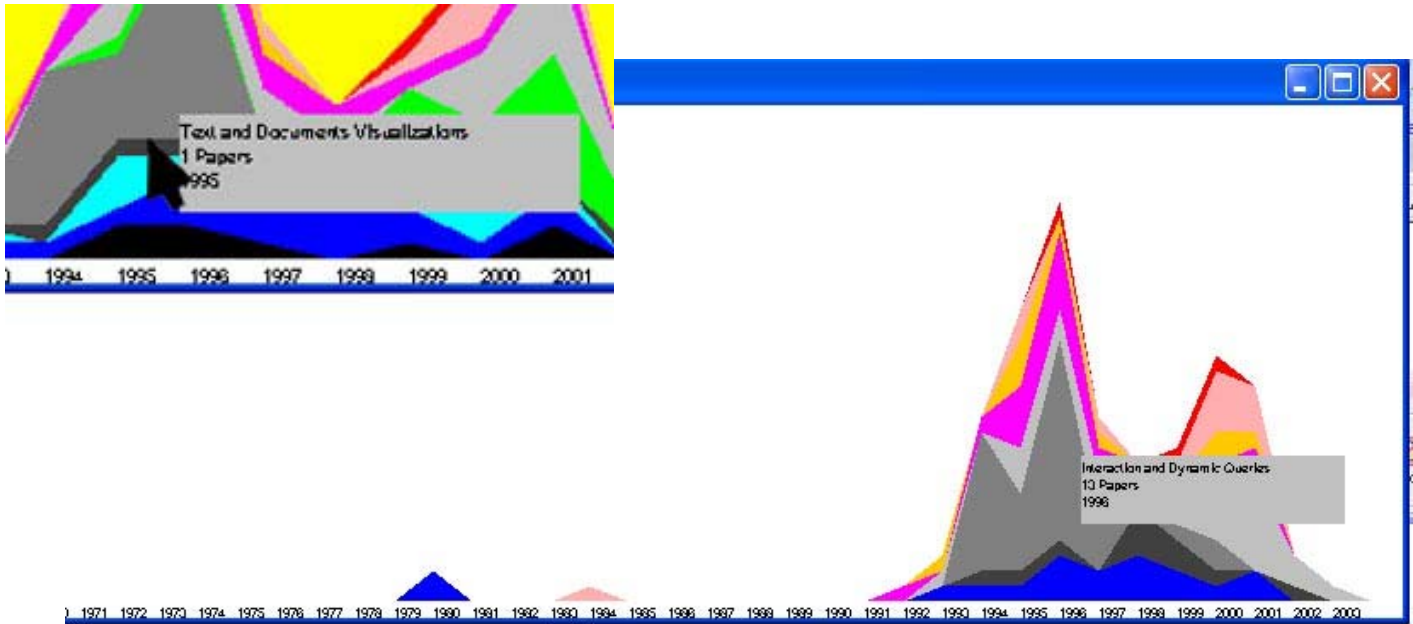
INFOWATER
Overview
The purpose of our system is to visualize data from over 10 years of the Information Visualization Conference. The dataset consisted of an XML file containing over 700 articles/books, and included descriptors (when available) such as the title, source, authors, date, abstract, keywords, URL, and references for each article/book. Our goal was to provide a tool that allowed users to effectively explore the large dataset in certain ways that allowed them to answer some important and specific questions about the data, and could help them make useful discoveries.

The specific user tasks we focused on include:

- Overview: As the dataset contains numerous papers and books covering a variety of topics and subjects, we wanted to be able to provide users with a useful overview of the data, by providing them with information such as the range of topics/subjects covered, the popularity of several information visualization subjects, and the various paradigm shifts that have occurred over the years.

- Focus/Detail: In addition to the general overview, we were concerned with allowing users to obtain more detailed information on specific subject, authors, and documents. This should be very useful in helping users locate specific information and make interesting and important discoveries/observations.

- Associations: Another task we addressed was providing users with information concerning existing relationships between authors and documents, within or between specific information visualization subject groups. As such, users would be able to determine if a particular author A is associated with another author B, or he can determine the various subjects that a particular document is associated with.

- Comparisons: By using different visual attributes, we also wanted to make provisions for users to make useful comparisons between different subjects, authors, or documents. Comparisons of authors or documents within and between specific information visualization subject groups were also addressed in the visualization.

InfoWater
The visualization is based on a water/river metaphor and is composed of two main views. One view consists of a "ThemeRiver" that shows the number of information visualization conference documents published in each of the listed subject groups, across a specific timeline. The other view consists of the individual water/river puddles,

which provide information on the authors and documents that

Figure 2: ThemeRiver

reside in each of the subject groups. Please note the "ThemeRiver" and "Puddles" are described in more detail in subsequent sections of this paper.

Multiple views are utilized in the visualization in order to effectively address the diversity of user tasks with which the visualization is concerned.

Implementation

The tool is primarily built using Java for both the front end (using the Swing library) and back end components (using Xerces Java XML parser libraries). As specific portions of the system is still undergoing development, Macromedia Director® is currently being used to demonstrate some of the tools functionality (in particular, the puddle view and user interaction with the puddles). In addition, a Java applet is currently being used to demonstrate some prospective spring tension functionality in the visualization (this is described in the "Authors" and "Documents" sections of this report). However, we expect the complete system to be a stand-alone Java application.

Mapping Keywords to Subjects

As stated earlier, our visualization will provide users with information relating to numerous information visualization topics/subject groups. As such, each article or book in the dataset has to be encapsulated into its appropriate subject group(s). Since the original dataset did not categorize each article/book into specific subject groups or topics, we manually traversed the dataset for each article's keywords, and simultaneously updated a mapping file that held specific article keywords, and the associated subject to which the keywords mapped (subjectively determined). So for instance, article keywords like focus+context, distortion, detailed views, etc, all mapped to the subject group: "Focus and Context / Overview and Detail". Similarly, keywords like information retrieval, data mining,

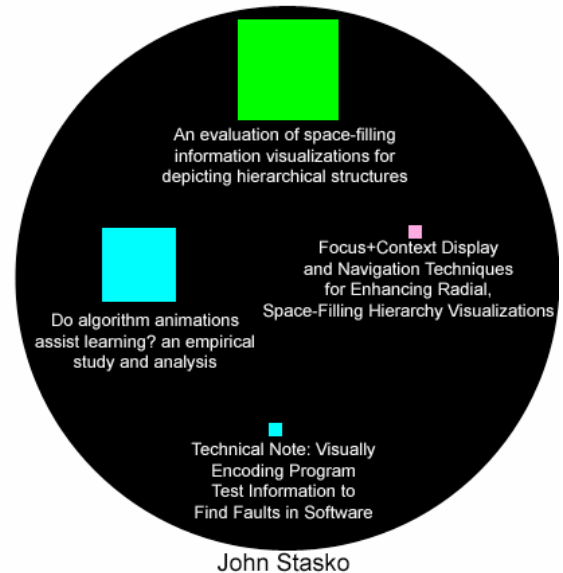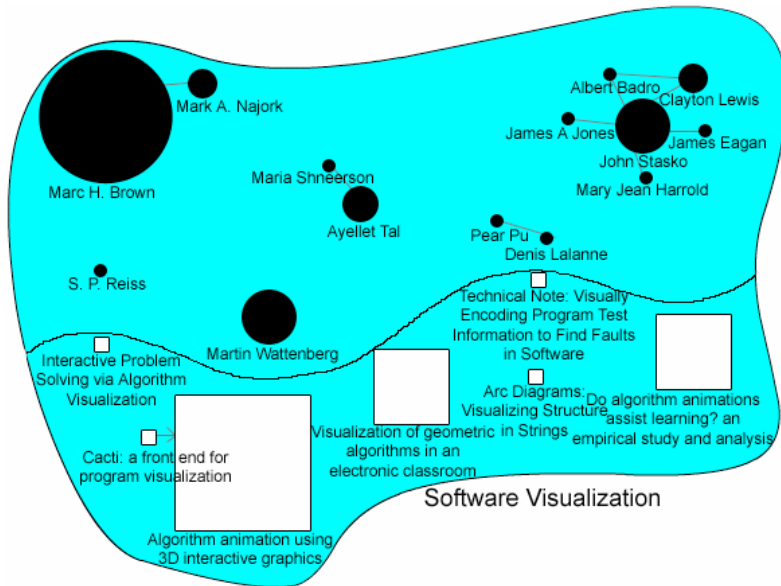search engine, query result, etc, mapped to the subject group: "Search".

While traversing the dataset, for particular data cases where the existing keywords were vague, too broad, or insufficient, appropriate keywords were included (at our discretion) by utilizing the information contained in the abstract, title, and source of the article to decide the most appropriate subject group that the particular article fell under. Articles that could not be effectively encapsulated under any subject group were designated under the subject: "Other".

ThemeRiver

As stated earlier, one of the critical tasks we wanted to include in the InfoWater system was an overview task. Searching and browsing seemed like obvious tasks for a text and document viewing system, but overviews are less common despite providing interesting views and information about the dataset.

Our solution to this problem is to include a ThemeRiver that displays the evolution of Information Visualization topics over the time period of interest. ThemeRivers as a technique are excellent for identifying trends, patterns and relationships in a dataset. The authors in [3] and [6] use this approach to visualize thematic variations over time in a set of documents. One example they present shows the thematic shift of speeches by Fidel Castro.

Our ThemeRiver was implemented in Java using Swing and 2D Graphics. The general algorithm scans the list of documents and creates a polygon where the y coordinates are based on the number of papers published in that subject by year as well as the ordering of the polygons. We sort the polygons by the earliest begin date (i.e. the earliest date of a paper published in that subject). A screenshot of our ThemeRiver is shown in Figure 2.

Software Visualization

John Stasko

In our case, we use the River to highlight the shifting topics over the field of Information Visualization. Our design

Figure 3: Puddles

includes using a range slider to allow users to focus on a particular time period, for example, the papers published during the 1990s. The current system prototype does not include this utility, however, we anticipate that a full implementation of the system would include the slider.

The ThemeRiver in and of itself, while providing a nice overview of the field, was not enough to give users detailed information about the topics. We include mouseovers to give users detailed information while maintaining the overall context of the river. As a user moves the cursor over an individual topic "rivlet" extra information is displayed including the topic name, the year currently under the mouse, and the number of papers published that year in that topic. A screenshot of this is shown Figure 2.

In order to examine a single topic such as "Interaction and Dynamic Queries" as shown in Figure 2, we introduce the concept of "Puddles". A user may click and drag an individual rivlet out of the river and display it as a puddle in the Puddle Canvas, which will be described in detail in the following section.

Puddles

To keep the metaphor constant, the magnifying lenses used in InfoWater have been deemed puddles and are shaped as one would imagine, in globular fashion. There are two different lenses giving different views depending on what the user chooses to focus on. The first lens displays a

rivlet, or one subject pool, in a large puddle with a color matching the rivlet from the river. This puddle displays two

pertinent pieces of information: all authors and all documents published within the subject. The second lens results from clicking on an author within the first lens. This lens magnifies by animating data out of the subject puddle and displays it beside the original, enlarged to show all the documents that specific author has published, see Figure 3. Two subject puddle lenses can also be dragged to overlap one another. This can result in two puddles with a merged middle section containing authors and documents that fell in both subject puddles. Labels are provided directly under respective puddles and their internal author and document bubbles.

In order to allow all desired information to be viewed, the maximum number of main subject puddles that can be displayed is three. This number is important as merging more than three puddles will make it difficult to display all the data such that it can be viewed easily. In addition, screen real estate is not currently large enough, on average, to accommodate four puddles and be able to expand at least one author into its own puddle.

Authors

Each subject puddle will hold a collection of authors who have published articles in the given subject group (note the subject puddle will also hold a collection of documents, which are described in the next section). The authors will be represented as circles with their names shown under their corresponding circles.

Size coding will be used to give users some measure of how active a given author is in the particular subject of interest, as the size of their circle will correspond to the number of information visualization conference papers (in the dataset) of the given subject that she has authored, weighted by the number of times these papers have been referenced. Hence, under the subject group "Focus and Context/ Overview and Detail" we can expect an author like "Ben Bederson" to have a noticeably bigger circle than some of the others in the group since he has been active in this particular area.

The placement of each author circle encodes the relationships between authors, based on their shared publications. Authors who frequently publish together will be placed closer together, while those who have never published together will be far apart. InfoWater uses an open source spring tension algorithm developed by Sun Microsystems [5].

Used together, the size and placement mappings can quickly reveal interesting information about the data. The "big names" of information visualization leap out as their author circles dominate the screen, while clusters of names correspond to a particular laboratory or university. In our dataset, we have found that a large circle surrounded by many small circles generally indicates a professor and her graduate students.

At any given time, users will be able to drag a particular author's circle out of the subject puddle onto the display canvas, thereby isolating its information from the rest of the data (note that this does not explicitly remove the author from the subject group, as it is only a copy of the author's puddle that will appear on the canvas). This sort of functionality is useful for viewing specific author information. The individual author puddle will contain a collection of all the documents (in the dataset) that the author has published (these will be color-coded by subject). Interaction with the documents is described in the next section ("Documents").

Documents
Each subject puddle will also hold the collection of documents that fall under the group (i.e., one of the documents keywords mapped to the subject). The documents will be represented as squares, and based on available screen real estate, abbreviated forms of the title of each document may appear under the square representing the document. As with the author circles, size coding will also be used, this time as a measure of the popularity or even importance/usefulness of a particular document. This is approximated as the number of times the document is referenced. Placement is also calculated in a manner similar to that of authors. In this case, instead of co-authorship, documents are drawn toward their references.

At any given time, the user can mouseover a particular document to obtain a floating window that reveals more specific information on the document (title, source, authors, publication year, abstract, etc). If an online version of the document is available, double-clicking on the document will pull up the particular article in a web-browser. Reference arrows will also be visible on mouseovers such that an arrow from a document A to a another document B, will indicate that document A references B (i.e., document B is present in document A's reference list). Both outward and inward (referenced by) references will be shown when applicable (different colors will be used for the inward and outward reference arrows).

Merging Puddles
One of the strengths of InfoWater comes from merging puddles. The puddles can be dragged on top of one another, which causes the puddles to overlap. This creates a Venn diagram of subjects. For example, if Subject Puddle A were dragged on top of Subject Puddle B, the documents which addressed both subject A and subject B would move to the region of intersection. Documents on subject A or subject B would stay in their respective puddles, though the spring-tension algorithm would cause them to adjust to the new boundaries due to the reduced number of documents. Each document appears only once in the resulting merged puddle. Up to three puddles can be merged at a time, creating 7 regions.

In merged puddles, authors are treated a bit differently than documents. Where documents appear only once in the merged puddle, authors can appear multiple times, up to once per regions. Authors follow their documents. If the author published multiple documents, which move to different regions of the merged puddle, the author icon divides and a part goes to each region.

TOOL CRITIQUE
Our proposed visualization tool has its set of strengths and weaknesses, some of which are outlined below.

Strengths of InfoWater
- Relationships: One of the best features of the tool is its ability to express relationships well. By merging puddles, users can easily identify those documents that relate to multiple subjects, and as such can use this to filter out specific documents of interest (i.e. the act of merging puddles is a dynamic query in itself). The intersection region of the merged puddles themselves will often hold documents that are closely related in some way. In addition, the spring tension model to be employed in the visualization will effectively show relationships between authors (in particular groups of authors that publish together). This can even lead to interesting observations of existing relationships, for instance, that between a professor and his/her graduate students. In such cases, Professors will usually appear as big author circles, and their graduate student will appear as small circles (since it is likely they have not published much relative to the professors) surrounding the professor. Such a view can also reveal how over time a professor's previous graduate student went off

to become a professor/researcher himself and publish papers with his own entourage of graduate students.

- Multiple Views: A particular strength of the tool is that it provides the user with multiple views of the dataset. The ThemeRiver provides he user with a nice overview in terms of the popularity and growth/decline of certain information visualization subject groups over the years. However, as it is likely that users will also want more detailed information on specific subjects while performing a variety of tasks, the puddle view provides a nice focus/detail view on demand (i.e., the user drags on a specific subject in the ThemeRiver to create the subject puddle), that users can utilize and interact with when necessary. This seamless presentation of overview and detail views on the same screen allows users to seamlessly move between the two, and it provides effective support for the user in performing a variety of analysis and exploration tasks.

- Direct Manipulation: Interaction is key in a lot of information visualization tools, and as such, a positive aspect of the system is its provisions for a lot of user interaction with the data. Users can view subject puddles, merge certain puddles together, separate out specific authors from subjects, etc all by directly manipulating the object of interest. Smooth animations are also used to provide constant feedback to the user that the software is responding properly. The above techniques can help engage the user in the interaction, and support the formulation of a deeper understanding of the dataset.

- Subject Growth/Decline: The ThemeRiver can provide an effective representation of the amount of activity taking place in the various subject groups over time (where activity is being measured as the number of information visualization conference papers published in that subject). As such, trends like the sudden growth or decline of activity in an area, or the time when certain topics were born/died out, can easily be determined. It is also possible to see interesting patterns such as those information visualization subjects that died out for a number of years and suddenly experienced resurgence.

Weaknesses of InfoWater
- Scale: As the river and puddles can occupy a lot of screen real estate, the visualization can become problematic for very large datasets. There will be considerable difficulty in representing all the documents and authors that fall in a puddle for very large (high density) subject groups. The documents would likely have occlusion problems and the reference relationships may look like a tangled ball of twine. Also, intersection regions (when documents are merged) may not be large enough to effectively contain all the documents that fall in the region (while maintaining appropriate size proportions) without a very careful exploration of effective accommodation techniques. Currently, the tool seems to be best suited for moderately sized subject pools of 30 items per puddle or less.

- ThemeRiver Subject Representations: Directly related to the scale issue, is that of being able to effectively encode a large number of subjects with distinct colors. Ware [13] believed that there are twelve specific colors that can be used to differentiate between categories of nominal variables (red, green, yellow, blue, orange, brown, purple, black, white, pink, cyan, and gray). As such we easily run out of colors to use for the ThemeRiver (as well as for documents which are color coded by subject) such that the categories can easily be differentiated visually.

- Keyword to Subject Mappings: As stated earlier, the keyword to subject mappings were primarily based on our subjective assessment (as there were no available standards to base it on). Consequently, this may not conform to a lot of users internal models of the information and as a result may get a lot of "irrelevant" documents (relative to them) in certain subject puddles. It is true that users could simply update the mapping file at will to reflect the changes they desire but this can be very tedious and time consuming especially when it involves having to manually step through the dataset and observe/update article keywords (as was required for the development of this visualization). In addition, we desire that the user's primary concern and involvement is with the visualization and using it to support her tasks, and not having to update keyword to subject mappings.

- Sub-Subjects/Subtopics: The visualization does not provide any information on subtopics that may exist within subject puddles (for example "Fisheye views" within "Focus and Context"). In other words, it does not break subjects down into subtopics. As such, some significant effort may still be required of the user to locate specific articles/groups of articles within large subject pools as the subject could encompass a wide range of subtopics. A hierarchical structuring of subjects and subtopics in the visualization would be very useful for navigation to specific information, and for viewing existing relationships of authors within subtopics, in addition to within subjects. This will most likely require the addition of zooming capabilities, which could potentially make the tool more powerful.

- Does not Support Search Tasks well: As we have already stated, we did not design InfoWater for search tasks, so any sort of specific locate task will be difficult using this tool.

Problems with the Data

The ThemeRiver worked nicely and does show the progression of subjects over time as we expected, but there were some issues with missing information in the data set. Many of the entries had missing keywords, or keywords that did not mesh with the keyword to subject mapping we had constructed. Because of this failing, a large portion of the papers were categorized as "Other". Figure 4 shows an image of the river with the "Other" papers included.
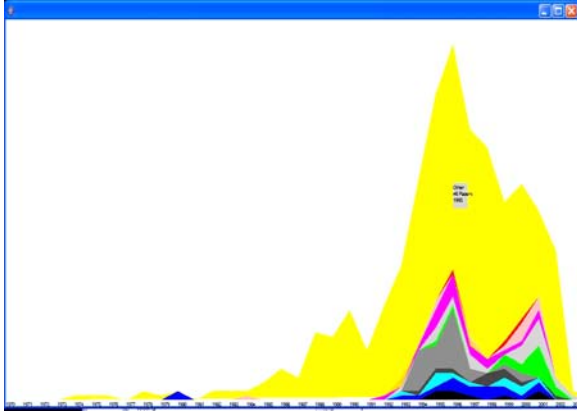

Figure 4: "Other" Papers

Clearly, had these papers had keywords, and therefore subjects associated with them, the ThemeRiver would have been even more effective, instead of showing the bulk of the papers in the last decade instead of spread across the thirty year period as we had hoped they would.

CONCLUSIONS

In summary, this project sought to visualize the field of Information Visualization by using a variety of techniques. The final system, while not fully implemented would feature the ThemeRiver, the ability to drag topics from the river to the puddle canvas, layout of documents and authors by spring tension, and finally the ability to examine intersections of topics by merging puddles.

Visualizing text and documents is an interesting sub-topic of information visualization, and in this project we attempted to create a system that goes well beyond a standard search and locate document-viewing system. We did this by focusing on tasks that fell outside this area, such as getting a general overview, distinguishing relationships between papers and authors and finding papers by topic intersection. The techniques used to implement these tasks are rather common in the field, but we feel we have combined them in a fashion that creates a unique and powerful tool for learning about this field.

REFERENCES

1. Kirkpatrick, D. (December 16, 2003). Going Deeper than Google. *Revamped search software called Grokker could be the* future for finding *information*. Retrieved April 20, 2004 from http://www.groxis.com/archives/fortune_121603

2. Pacific Northwestern National Laboratory (PNL) Information Visualization Technologies (n.d.). Retrieved April 20, 2004 from http://www.pnl.gov/infoviz/technologies.html

3. Havre, S. Hetzler, E. Whitney, P. Nowell, L. *ThemeRiver: Visualizing Thematic Changes in Large Document Collections.* Proceedings of IEEE Transactions on Visualization and Computer Graphics, Jan/Mar 2002.

4. Spence, R. (2000). *Information Visualization.* ACM Press.

5. Sun Microsystems Applet Demo: Graph Layout. (n.d.). Retrieved April 11, 2004 from http://java.sun.com/applets/jdk/1.2/demo/applets/Graph Layout/example1.html

6. Havre, S., Hetzler B., and Nowell L. *ThemeRiver: Visualizing Theme Changes Over Time*. In IEEE Symposium on Information Visualization, Oct 9-10, 2000.

7. Fishkin, K. and Stone, M. (1995). *Enhanced dynamic queries via movable filters*. From Human Factors in Computing Systems Conference Proceedings. CHI '95, pp 415-420.

8. Li Q. and North C. *Empirical Comparison of Dynamic Query Sliders and Brushing Histograms*. Proceedings of IEEE 2003 Symposium on Information Visualization, Seattle, WA, Oct. 2003, pp. 147-154.

9. Bier, E., Stone, M., Pier, K., Buxton, W., and DeRose, T. (n.d.). *Toolglass and Magic Lenses: The See-Through Interface.* Retrieved April 20, 2004, from XEROX PARC Web site: http://www2.parc.com/istl/projects/MagicLenses/93Sig graph.html

10. Stone, M., Fishkin, K., and Bier, E. (n.d.). *The Movable Filter as a User Interface Tool.* Retrieved April 20, 2004, from XEROX PARC Web site: http://www2.parc.com/istl/projects/MagicLenses/94CHI Filters.html

11. Kirkpatrick, D. (December 16, 2003). Going Deeper than Google. *Revamped search software called Grokker could be the* future for finding *information*. Retrieved April 20, 2004 from http://www.groxis.com/archives/fortune_121603

12. D'Andries, J., Hong, J., Richman, M., and Westfall, M. (n.d.). Zoomology: An information visualization tool for comparing two large hierarchical datasets. Retrieved April 23, 2004 from http://www.jumpingweasel.com/zoomweb/zoom.htm

13. Ware, C. (2000). *Information Visualization: Perceptions for Design.* Academic Press.