Visualization of Web Search Results in 3D

Seminar Report
On
Visualization of Web Search Results in 3D

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Index

1. Abstract: ............................................................................................................................... 3
2. Introduction: ............................................................................................................................ 4
3. Working of typical existing search engine: ............................................................................. 4
4. Information Visualization: .................................................................................................... 5
5. Why text is tough: ................................................................................................................ 6
6. Why we need visualization in web search: ........................................................................... 7
7. Goals of Information Visualization: .................................................................................... 7
8. Where We Locate Visualization Tools: .............................................................................. 7
9. How Typical Visualization Tool Works?: .......................................................................... 8
10. Visualization Techniques for Web Search: ..................................................................... 8
11. Case Study: NIRVE ........................................................................................................... 8
   11.1 Introduction to NIRVE ................................................................................................. 8
   11.2 NIST’s PRISE search engine ....................................................................................... 8
   11.3 Overview & goals of NIRVE ....................................................................................... 9
   11.4 Features of NIRVE ...................................................................................................... 9
   11.5 Working with NIRVE ................................................................................................. 10
      11.5.1 NIRVE control .................................................................................................... 10
      11.5.2 Document Space .................................................................................................. 13
      11.5.3 Concept Control ................................................................................................. 15
   11.6 Implementation of NIRVE ......................................................................................... 15
   11.7 NIRVE installation ...................................................................................................... 16
12. Conclusion: .......................................................................................................................... 16
12. Acknowledgements .......................................................................................................... 17
13. References: ....................................................................................................................... 17
1. Abstract:

The popular technique for finding information on the WWW is to use one of the content-based search tools (Google, yahoo, Msn, Excite, Altavista, etc.). These search tools attempt to index the entire web via its content, where they define content to be the words in a page.

The exponential growth in Web sites is making it increasingly difficult to extract useful information on the Internet using existing search engines. Despite a wide range of sophisticated indexing and data retrieval features, search engines often deliver satisfactory results only when users know precisely what they are looking for. Traditional textual interfaces present results as a list of links to Web pages. Because most users are unwilling to explore an extensive list, search engines arbitrarily reduce the number of links returned, aiming also to provide quick response times. Moreover, their proprietary ranking algorithms often do not reflect individual user preferences. Those who need comprehensive general information about a topic or have vague initial requirements instead want a holistic presentation of data related to their queries. To address this need, a 3D search result visualization system, displays all the Web pages found in a synthetic and comprehensible format, is a one solution.

In this seminar I would like to specify, working of typical existing search system, uses of visualization tools over textual retrieval, explains what is information visualization, Need for visualization tools to analysis of web search results, types of visualization tools, and design goals of NIRVE (NIST Information Retrieval Visualization Engine) i.e., a 3D search result visualization system, components of NIRVE, working of NIRVE.
2. Introduction:

Although the World-Wide Web (WWW) is an enormous and enormously popular information resource, finding information located somewhere on the WWW is frequently a daunting and frustrating task. As a result, an increasing number of services are acting as "Yellow-pages" (e.g. Bigbook, Yahoo, the Internet Business Pages), trying to organize information sites on the WWW into neat, descriptive categories. All this organizational effort achieves, at best, is to reduce the size of the space that a user needs to consider. The space may still be dauntingly large. And it only achieves that benefit if the pre-determined categorization used in the Yellow-page service matches some category that the user recognizes as relevant.

When searching the Web, the user typically enters one or more keywords and in return is presented with a list of matching pages, rank ordered according to how well they match. Despite a wide range of sophisticated indexing and data retrieval features, search engines often deliver satisfactory results only when users know precisely what they are looking for. It may be difficult for the user to compare the results returned by different queries by matching successive or multiple combinations of keywords in search pages. Search engines proprietary ranking algorithms often do not reflect individual user preferences.

3. Working of Typical Existing Search Engine:

It is estimated that the World Wide Web contains over 350 million pages of data [Kowalski, 1997], and every 3 to 6 months size of web is doubling. However, there is no widely accepted cataloguing mechanism, which makes it extremely difficult to locate information resources. Search engines have been implemented, all of which have been developed on an essentially ad hoc basis with respect to both indexing and query support, with a consequent lack of interface consistency and behavior.

Search-engines compile their own indexes of Web pages. These indexes normally identify all the pages containing a given word. Users can then submit a word, or set of words, (i.e., a query) to the search engine, which will respond with a set of links to pages. Each individual link in the set is referred to as a ‘hit’. Google uses Page Rank based on the linkage structure of the Internet. Here page Rank reagents the probability of a random user in visiting a page. Direct Hit uses popularity data (number of visitors of a specific link) more and more search engines are providing rankings based on comprehensive analysis.
A review of the major current search engines has shown that all of them present the user with the same type of interface: a text entry box. In addition, all of the search engines reviewed presented the results of searches as a list of links. A common complaint on existing search engines is they return too many pages (the search engines didn’t rank the pages very well).

4. Information Visualization:

Information visualization is all about making data visible—or, more precisely, the patterns that are hidden in the data. This is a method of presenting data or information in non-traditional and interactive graphical forms. By using 2-D or 3-D color graphics, text and animation, these visualizations can show the structure of information, allow one to navigate through it, and modify it with graphical interactions.

The use of computer-supported, interactive, visual representations of abstract data to amplify cognition. (Card, Mackinlay, & Shneiderman, 1999). At first glance this appears to be an obvious and transparent definition. But there are some subtleties that are worth noting. The goal of information visualization is not pictures, but insight. And it’s not about looking at pictures; it’s about interacting with them to ‘amplify cognition.’

The goal of information visualization is the unveiling of the underlying structure of large or abstract data sets using visual representations that utilize the powerful processing capabilities of the human visual perceptual system. Information visualization is an exciting topic, and the last decade has witnessed the development of many interesting ideas about how to visualize abstract information. So it aims to create a computer “user-interface” that is better than today’s “desktop” metaphor—so that people can get their arms (or, rather, their eyes) around the ever-increasing amount of information stored in corporate computer systems, available on the internet, or kept on PCs.
Information visualization joins the human’s capacity of visual thinking and the computer’s capacity of analytical computing, thereby building a bi-directional visual and interactive interface between human user and the information resources.

Very few information visualization applications do away with text altogether. The goal is to find the representation appropriate for a particular task. In many situations text remains the best form of representation. But we all know from experience that many complex ideas are best represented visually. Just as movies did not eliminate the novel, information visualization will not eliminate the need for text.

Information visualization will only succeed if it solves the scalability problem. This view assumes that the really big problems are the only interesting ones, and the only hard ones. It also assumes that if the dataset has billions of elements, it is important to display all of those elements at once. In many situations the real challenge is to narrow the billions down to a more reasonable and manageable subset. This is where data mining begins to play an important role. Size and scalability are important issues, but it is a mistake to think that information visualization only applies to extreme problems.

Information visualization is about speed. It is sometimes said that information visualization aims to help us move from slow reading to faster visual perception, and that it can help us deal with information overload by allowing us to process more information faster. This is only true up to a point.

Information visualization is about insight, not pictures. Insight means understanding and creating knowledge and learning. Those processes often require reflection, combination, and rearrangement. The speed element of information visualization aims to reduce the cognitive load of certain tasks so that larger, more complex tasks become possible. Particular tasks may be made more efficient, but information visualization can also open up a range of new tasks that were previously impossible or simply not feasible because they were too burdensome.

5. why text is tough:

Language only hints at meaning. Most meaning of text lies within our minds and common understanding. Text is not pre-attentive. Text consists of abstract concepts, which are difficult to visualize. Combinations of abstract concepts are even more difficult to visualize, for example, time, shades of meaning, social and psychological concepts, causal relationships. Text represents similar concepts in many different ways, for example, spaceship, flying saucer, UFO, and figment of imagination represents similar concepts. Text has very high dimensionality, Tens or hundreds of thousands of features.

When information presented with data, humans will naturally try to use their inherent capacity for visualization. Such mental imagery can be supported by the system only if the user interface is specifically designed to do so. User interfaces, as images are good for better understanding compared to textual.
6. why we need visualization in web search:

- Exploring *information collections* becomes increasingly difficult, as the volume grows high.

  For example, suppose a person wants to search for Maruti car price, the result will show hundreds of pages which are related to Maruti. It can contain its price or comparison with other cars or annual report on Maruti etc. So we need visualization tools for narrowing our search on documents, which are given by a search engine.

- With minimal effort, the *human visual system* can process a large amount of information in a parallel manner.

  It’s easy to get the information from appropriate things instead of only textual. Suppose its better also gives some of the information about the environment symbols or environment terminology to which that information is related to. Like using glyphs, it’s easy to interpret the expressions. When it is used with some other text or picture it specifies the sense in which it is spoken.

- The occurrence of advanced graphical software and hardware enables the large-scale visualization and the direct manipulation of interfaces.

7. Goals of Information Visualization:

Relieve the cognitive overload is one of the goals of information visualization. Visualization tools can reduce user’s mental load by giving things visually. The large size of information (e.g., no of search pages) can be seen at a time.

User interaction, visualization tools should support user interaction during showing web search results.

Speed, visualization tools enhancing understanding of concepts and processes. So users can easily and quickly get things.

Insight not pictures, visualizations not concern to graphics they give things near to user visualizations. By using this users easily understand information and creating knowledge. Because visualization tools present information from various viewpoints and several levels of detail. These are making invisible meanings to visible. These are increasing scientific productivity.

8. Where We Locate Visualization Tools:

At the Web Search engine, if visual tools located at search engine, then users do not have extra load. But in this approach, search is confined to only for results given by one search engine.

If visual tools are independent of search engines, then we can visualize all information, coming from several search engines. But in this special Visualization Tool to browse the search engine and give the results back in the visual mode, visual tools must understand results returned by several engines. E.g. NIRVE, TEOMA, Periscope etc...
9. How Typical Visualization Tool Works?

1. Visualization tool takes set of key words from user and gives to search engine
2. Search engine gives results to visualization tool as query per document
3. In each Query, frequent words, no of occurrences of each frequent word, URL is there
4. Creates concepts by taking some combinations of frequent words
5. Do text clustering by using concepts
6. Displays whole documents by using some visualization technique

10. Visualization Techniques for Web Search:

There are 3 types of Visualization Techniques for Web Search.

1. Textual
   In this textual mode visualization tools, Represent clusters linearly and No graphical Interfaces required. Now several visualization tools are present.
   Eg: TEOMA, Vivisimo, etc.
2. 2D approaches
   It represents all clusters with relationships between them by 2D graphical interfaces
   Structures used in 2D approach are Hierarchical trees, histograms, etc.
3. 3D approaches
   Represents all clusters with relationships between them by 3D graphical interfaces.
   The data Structures used in 3D approach are Cone trees, etc.
   Eg: NIRVE, PeriScope, AltaViz

11. Case Study: NIRVE

11.1 Introduction to NIRVE

   NIRVE means NIST Information Retrieval Visualization Engine. It is a 3d visualization tool/prototype for ZPRISE search engine. NIRVE is a 3-dimensional interface designed to enhance the information retrieval process by providing an overview of a set of text documents as well as access to the details of the individual documents through seamless user navigation and manipulation. Users can redefine the display space by consolidating related keywords from the input query into concepts, and by indicating the relative importance of those concepts. Document clustering is based on these user inputs. It is our hypothesis that this combination of 3D graphics and fine control by the user provides a more effective interface than is found in many comparable systems.

11.2 NIST's PRISE search engine

   NIRVE was based on the information that PRISE accepted and returned. PRISE accepts a set of terms, or keywords, as a query; it does not take Boolean combinations. It returns a set of entries, one per document.
   Each entry contains:
   • Unique document identifier
Visualization of Web Search Results in 3D

- Document title
- Relevance score (indicating the search engine's estimate of the "goodness" of the match between the document and the query),
- Document rank (according to its score)
- Document length
- The number of occurrences of each keyword.
- The number of documents returned is controlled by the query. Typically, we dealt with result sets of size 100-500.

11.3 Overview & goals of NIRVE

A user's query to a search engine can often result in hundreds of potentially relevant documents. The interactive 3D visualization techniques, used correctly, can be a powerful medium in which large amounts of information can be comprehensibly presented. In each Concept Space, NIRVE presents the documents by document Clustering. The goal is to give users 1) a seamless view of text document result sets, at both a general and detailed level and 2) a powerful set of operations through which the user can organize, filter, and inspect groups of documents.

NIRVE allows the user to consolidate related keywords into more meaningful concepts; the document set is then organized into clusters, based on these concepts. Users can control granularity of clustering, examine the title and full text of documents, assign a relevance status to documents and clusters and then view subsets based on this evaluation. Finally, the user can generate HTML summaries of an individual cluster, or of the entire subset of documents on display.

11.4 Features of NIRVE

NIRVE features are

1. Graphical summary of result set of search, with details on demand.
2. Map keywords into user-specified concepts.
3. Concept can be computed as union (OR) or intersection (AND) of its constituent keywords
4. Automatic clustering of documents, based on their concept profile
5. Cluster icons arranged on sphere or 2D surface; better clusters near the "North Pole"
6. Relationship among clusters illustrated by color-coded arcs representing set-difference
7. User can open a cluster to view constituent document titles, arranged according to title similarity and score assigned by search engine
8. User can mark documents and clusters as good / bad / unsure and apply display filter to result set
9. User can see document text with color-coded keywords, via HTML
10. User can see textual summary of all current clusters via HTML
11.5 working with NIRVE

The purpose of NIRVE is to allow you to visualize and manipulate a set of documents resulting from a query to a search engine. The query is characterized by a set of keywords. NIRVE will let you consolidate these keywords into a smaller set of concepts and then will organize the documents into groups, called clusters, based on the documents' concept profiles. You can inspect individual documents and clusters. You can also suppress viewing of selected documents and clusters so as to concentrate on items of greater interest.

NIRVE displays two windows to the user. The main body of this document explains the appearance of, and operations within, each of these windows. Here are two screen dumps illustrating the general appearance of these two windows, one with a more global view, and the other with a detailed view.

Users can use various features of NIRVE by using 3 windows

1. NIRVE control
2. Document Space
3. Concept Control

11.5.1 NIRVE control

NIRVE Control is a "menu" window used for overall control and mode-setting. Operations include database query, concept control, opening and closing clusters, filtering results, viewing, and finally summarization, and quit.

*Fig: Control panel of NIRVE*
Visualization of Web Search Results in 3D

a. Explain controls

There are three buttons, one for each set of NIRVE operations. When you click on a button, a message window will pop up to explain the general purpose of the corresponding window. To delete the message window click on the Close button at its bottom.

b. Database Queries

These buttons are used to retrieve a new set of documents from the text database.

The New Query button allows you to retrieve a new set of documents from the text database. A query window pops up, which you use to specify the new set of keywords to be matched and the number of documents to be returned. The window is initialized with the keywords of the immediately preceding query.

The Query History menu displays all queries submitted so far during the current session. You can select any of these earlier queries, edit it, and then submit the resulting altered query.

c. Concept operations

The New Concept button allows you to create a new concept: a word you define, with which you associate a color and a set of keywords. The documents are organized according to the subset of concepts they contain. A concept can be specified as disjunctive (constituent keywords are ORed) or conjunctive (constituent keywords are ANDed). Typically disjunctive concepts would be used for synonymous keywords (e.g. TORNADO = tornado or twister) and conjunctive concepts for proper names (e.g. RR = Ronald and Reagan).

The Delete Empty Concepts button deletes all current concepts, which do not contain any keywords.

d. Cluster operations

The Open Clusters button opens all clusters in the global display. This causes the titles of the documents in each cluster to be displayed on a 2D screen projecting out from the cluster icon.

The Close Clusters button closes all open clusters in the global display, which reverts to the global view of cluster icons only (no cluster contents).

e. Filtering

Every document has a user-controllable value, which signifies the user's judgment of that document: good, bad, or, unsure. The initial value is unsure. You can display any subset of these categories, as indicated by the check-buttons. Note that when you change the value of a document, the display is not immediately affected. If you wish to keep the same categories displayed (e.g. display good and unsure, suppress bad), simply press the Re-apply button, after marking documents with the desired values.

f. View mode

You can use the buttons to select the current view mode for the Document Space window. A brief description of these modes follows. Please see Operations in Document Space for more detail. Additionally, the Reset view button resets the view to its original setting, in which the entire array is visible.
Visualization of Web Search Results in 3D

I. Spin Mode
   The mouse is inactive; the entire icon display rotates at a constant speed around its natural axis.

ii. Move Mode
   You can use the mouse to move the display into any desired position. When the spaceball is used, view mode is automatically set to Move.

iii. Pick Mode
   You can use the mouse to see the titles, or the complete text of documents. Also, you can mark documents and clusters with a value reflecting your judgment of their usefulness. Finally, you can have an icon of interest swing around to the front for closer viewing.

g. Spin
   These buttons are used to control the speed and direction of spin of the document space display in the obvious way. The Stop button sets the view mode to pick. Any of the other buttons sets the view mode to spin.

h. Spaceball sensitivity
   This is an optional entry that appears only when NIRVE is enabled for spaceball capability. The buttons allow the user to control independently the sensitivity of rotations and translations performed via the spaceball. Clicking on the + button indicates higher sensitivity, the - button, lower sensitivity.

i. NIRVE State
   You can save and load (restore) the current state of NIRVE, namely the current set of documents, keywords, concepts, and keyword to concept mapping. You must supply the prefix of a file name which is used to hold the information. The standard filename suffixes '.doc' and '.kcm' are automatically appended to the name. When saving, you simply supply a prefix and the state is written to that filename. When retrieving, you will be given a choice of existing files in the current directory whose names end in '.kcm'.

j. Major operations
   The Weblist button creates an HTML summary of the set of documents organized into the clusters as currently displayed on-screen. This summary is displayed using Netscape.

   The User Guide button requests Netscape to display this User Guide.

   The Quit button does just that.

Categories of operation are represented by color as follows:
   Yellow is used for "help" buttons,
   Blue for normal operations,
   Green for querying the document database,
   And light red for warnings and drastic operations.
11.5.2 Document Space

Document Space contains the main display of icons representing the selected documents, and clusters thereof. You can see this display from any desired viewpoint, and request titles and/or full text of any document. Also, you can assign a value to documents and clusters representing your judgment about their usefulness to you.

The documents are arranged in groups called clusters, based on similarity of their concept profiles. Each cluster has an icon that displays the average concept profile for the documents therein and a user-assigned value. The concept profile is displayed via a histogram whose bars are color-coded to match the colors of the concept labels along the bottom of the screen.

Cluster icons are arranged on the surface of a globe. The number of concepts within the cluster determines their latitude: more concepts cause an icon to be located nearer to the 'North Pole' of the globe. Longitude has no intrinsic meaning; icons are arranged so as to try to place clusters with similar concept profiles near each other. Clusters which differ by a single concept are connected by an arc whose color represents the conceptual difference between them. E.g. if cluster A has the concepts 'boat', 'sink', and 'ocean', and cluster B has 'boat', 'sink', 'ocean', and 'storm', then they will be connected by an arc color-coded for 'storm'. The thickness of the cluster icon box is proportional to the number of documents contained therein.

- Clusters from concepts

A document's concept profile is simply the set of its strengths for each of the active concepts. Individual concept strength for a document is calculated based on the frequency of occurrence of the keywords that have been mapped into the concept, and on the document length. More occurrences imply greater strength, as does shorter length (since that implies a higher frequency rate). Document concept profiles are not displayed directly, but are used to sort documents into clusters.

By definition, two documents are in the same cluster if they have non-zero values for the same set of concepts. Thus, if there are five active concepts, there are at most 32 clusters. The basic information displayed for each cluster icon is a graphical representation of its concept profile (representing the average value for the documents contained therein). This is displayed as a colored histogram, one bar per concept. The correspondence between color and concept is shown in the concept legend at the bottom of the window.

- Operations in Document Space

The window is always in one of three view modes: spin, move or pick. Different operations are available in each of these modes. The following table presents an overview of the three modes.
You may use the NIRVE Control menu to switch among view modes. The current view mode is represented by the state of the radio buttons in the view mode entry of the menu, as well as by the cursor in the document space window.

You may also use shortcut keys to accomplish the same effect. (A shortcut key is a single keystroke typed at the document space window.) If you are in pick mode, the space bar switches to move mode; if you are in any other mode, the space bar switches to pick mode. Generally the space bar is used as a toggle switch between move and pick mode. If you are not already in spin mode, the 's' key switches to spin mode. When the spaceball is enabled, its use switches NIRVE into move mode.

**Spin Mode:**

Spin mode is denoted by a circular cursor in the document space window. The mouse is inactive. The document space display is rotated at a constant rate about its natural axis. You can adjust the speed and direction of spin via the appropriate entry in the NIRVE control window or you may use shortcut keys as follows:

- f : faster
- s : slower
- r : reverse direction

Note that within spin mode, the 's' key means "spin more slowly", but otherwise it means, "Switch to spin mode".

One recommended use for spin mode is to scan through the cluster icons to get a general idea of which concepts are represented (and which not) among the clusters.

**Move Mode:**

Move mode is denoted by a cross-arrow cursor in the document space window. The mouse is used to control the position of the array of document and cluster icons. Holding down mouse button 1 (MB1) allows the user to rotate the display, with horizontal motion controlling longitude and vertical motion controlling latitude. MB2 controls translation of the display horizontally or vertically. Finally, vertical movement with MB3 held down controls translation of the display towards or away from the viewer (i.e. along the "z" axis).

When the spaceball is enabled, it also may be used to position the document array. Rotation around the x-axis (latitude), the y-axis (longitude) and 3D translation may be performed simultaneously. Note that rotation around the z-axis (sideways tilting) is normally disabled for the spaceball as for the mouse.

**Pick Mode:**

Pick mode is denoted by a pointing-arrow cursor in the document space window. The mouse and/or shortcut keys are used to inspect and mark documents or clusters. The following table summarizes the pick mode operations.
Moving the cursor over an icon (with no buttons pressed) causes the icon to be highlighted. Cluster information is displayed at the top of the window. When an icon is highlighted, you can use the shortcut keys 'n' and 'p' to highlight the next or previous document or cluster and to position it for detailed viewing. This may be more convenient for systematically scanning through a sequence of entities than sliding the mouse.

11.5.3 Concept Control

Along the bottom of the Document Space window are arrayed the grouping of keywords into concepts that control document clustering. Concepts are color coded, and the cluster icons display a color histogram representing the frequency of each concept within the cluster.

The Concept Control features allow the user to consolidate the keywords used in the query into a smaller set of concepts. Typically, synonyms would be consolidated as disjunctive concepts, e.g. 'schooling' or 'education' and proper names as conjunctive concepts, e.g. 'internal' and 'revenue' and 'service'. The concepts are listed in their associated colors in one or more rows towards the bottom of the Document Space window, with their associated query-keywords listed underneath. The last concept, named UNUSED, serves as a collection of any keywords otherwise unassigned. You may alter the conceptualization within the Document Space window in the following ways (you must be in Pick mode):

- Using new concept button from the NIRVE control menu may create new concepts.
- By clicking mouse button 1 (MB1) on a concept name, you activate a menu that allows you to change the name, color and logic (AND vs. OR) of the concept, or to delete it.
- By clicking MB1 on a keyword and holding, you can drag/move the keyword from one concept to another. To discard the keyword from the concept, move it to UNUSED. Also, you can move unused keywords from UNUSED to the desired concept.
- By clicking MB2 on a keyword and holding, you can drag/copy the keyword from one concept to another. The keyword is then mapped to both concepts.

11.6 Implementation of NIRVE

- Control menu managed by Tcl/Tk software. Tcl/Tk is a Tool Command Language/Tool Kit. Combination of a scripting language (TCL) and a widget tool kit (TK) that allows the rapid creation of portable GUI programs.
- Graphical windows managed by OpenGL. OpenGL is a widely used 3-D graphics library.
- Graphical windows &control menu connected by Xlib. Xlib is a library of functions for displaying text and graphics and receiving input through (possibly remote) servers attached to displays and input devices.
11.7 NIRVE installation

NIRVE is composed of several windows, files and processes. In order to do new queries, NIRVE must be hooked up to the PRISE software in the appropriate way. Here are the basic steps you will need to go through to build NIRVE from source code on your system:

a) Software support
   You will need at least:
   - Access to a PRISE document server for full text of documents
   - C compiler
   - Xlib library
   - OpenGL library
   - GLX library (extensions to X Windows for OpenGL)
   - Tcl/Tk software
   - Netscape WWW browser

b) PRISE database
   You must have a PRISE database index of document titles, for retrieval based on keyword. Specifically, you will need the files conventionally named: postings, titles, titles_tables, docstats, and tcollstats. The program extract uses the first three to perform retrievals and make_lengths uses the last two to generate the doc_lengths file. Note that postings can be rather large, typically occupying tens or even hundreds of megabytes.

12. Conclusion:

Advantages of Visualization Tools:

- The utility of visualization techniques derives in large part from their ability to reduce mental workload.
- Search refinement of search is possible.
- The user can manipulate the retrieval set interactively while maintaining context.

Limitations of Visualization Tools:

- User experiences also influence performance.
- Assessing relations are based on statistical properties of term and/or document occurrence data.
- Visualization techniques are also not satisfactory, for very large amounts of documents (several thousands).

The technology is still in rudimentary phase and has scope for advance research to overcome these limitations.
12. Acknowledgements

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