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An Integrated Search Interface with 3D Visualization

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Abstract

There are some problems with the current popular search engines, namely filter bubble and the lack of visual representation. The result of a survey that we conducted shows that users were longing for a higher performing search engine with a holistic view of the search results. This work is aimed to elevate the effectiveness of web searching results by incorporating visual and social representation into the results. We have designed and developed a social and integrated search interface that utilizes three-dimensional image renderer to deal with the above issues. Social search results are incorporated with the basic search engine results, while giving users the capability of navigating and visualize through the search results using the three-dimensional image renderer. We tested the system by administering a survey to measure users' experience and satisfaction. It can be concluded from the result of the survey that in general the users were happy with how the search interface works, including the social media search results and the three-dimensional visualization. The system was able to enhance the users' experience when searching for some general topics by having a better visualization.

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Keywords: visualization, web search results, user interface, web graphics library

1. Introduction

These days, there are around a billion websites on the internet and that number increases every day. While each and every website has tried their best to cater for a wide area of functionalities, finding websites that suit your

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needs and interests is not an easy task. A strong desire of getting into the most relevant website in the most efficient and timely manner exists within a lot of internet users.

Search engines are a solution that have proven their worth by successfully tackling this task. By typing certain phrases or keywords, internet users are able to get results that are getting even better and more relevant than before. Nowadays, search engines have become the backbone of the internet. They have been afforded equal status with the address bar in most major browsers for quite some time. One of the most popular browsers even incorporates the search bar with the address bar into one omnibox[1]. All of these facts just show the importance and strong presence of search engines in daily internet usage.

Since their emergence in the early 1990s, many new search engines have given us innovative features and technologies. However, there are not many search engines that can face up to the competition. A lot of them are closing down, or being bought by the giant search engines simply because they were lacking funding, or unable to satisfy their customers' needs. The key positions are still being held by a small number of dominant search engines [2].

1.1. Filter Bubble

However, there are some problems with current search engines. Nowadays, some of the most popular search engines have been trying to customize and tailor their search results to match the users' interests and personality without clearly informing them[1]. While this intention might be good and useful at the first glance, it makes it easy for users to get into a 'filter bubble', where users keep getting results they want to see, not results that they actually need to see. Filter bubble, which was first coined by Eli Pariser, is an internet phenomenon where search engine results envelope its user within a bubble of limited information, due to the filter applied in the searching process and algorithm [3]. Search engines are doing this practice to promote their advertisement service to their prospective clients, in order to show that their products are able to reach the right people because they can pinpoint the advertisement to the right people, using the information that they collect from their search engine usage.

On the other hand, commercial and non-commercial websites have been trying very hard to get into the top search results of the search engine. The popularity of the website is often used as one of the criteria to rank the position of the website in the search result. A search engine counts the popularity of a website using an algorithm with some specific presumptions. Often website owners try many possible ways and do search engine optimization (SEO) to get into the top search results[4]. Therefore, a lot of websites have been found to be able to get into the top results without actually giving any important or relevant contents.

1.2. Search Results Presentation

Furthermore, the way search engines provide search results is not satisfying and informative enough. Many search engines provide the search result using linear, textual based representation. It is not an easy task for humans to perceive and process information in a linear pattern [5].

Search engine interaction between users and the search engine itself resembles a form of communication[6]. Firstly, users try to convey their intention using writings, by typing keywords to the search box. This action was performed by users who have an intention in getting the appropriate responses from the search engine related to the keywords. In some modern devices and browsers, users are able to convey their messages using speech, by saying their intended keyword to their device. After that, the search engine will response appropriately after it receives the inputted keywords, by processing the search term and sending back the related search results to the users. Most search engines present these search results in an unordered list of textual representation with no pattern between each result in the users' web browser.

If a search engine interaction between the user and itself is considered as a form of communication, the next question will be what constitutes as an effective communication in search engine interaction and whether the current textual representation based system is effective, or perhaps there are more effective ways of communicating between search engines and users. Research that was conducted by Nielsen Norman Group shows that the fewer words a webpage has, the more words users read and vice versa[7]. Web pages with fewer than 100 pages reach 80% efficiency while web pages with more than 600 words only reach 25% efficiency.

Another interesting finding is a paper by Aula, Khan and Guan that discovered that users would start formulating more diverse queries and spending longer time on the search result page as compared to the successful tasks when having difficulties in finding the information presented using text[8]. They also discovered that users' queries tend to get longer when they have spent a long time trying to find a solution, showing that there might be some problem with the way search engines present their results when the task is more complicated than usual. Jakob Nielsen, in his recent article supports this argument further with his own findings in his research[9]. He discovered the fact that by increasing the number of queries and keywords for the search term, the search success rate increased only for 10% and harder questions hit 28% success on the first mark. Nielsen strongly suggests in his article for program developers and designers to redirect users' effort into a better, more interactive and supportive interface, rather than presenting them with heaps of text.

These findings and phenomena indicate that the way search engines handle and respond to users' intention has not been effective enough, especially when the task is proven to be complicated. Search engines also need some improvements and innovations on how they present their search results to their users in order for users to find and formulate a better search immediately when they face a problem instead of wasting too much time on trial and error.

1.3. Aim of the Paper

The purpose of this paper is to design and develop a web interface that functions as a search engine. This work is focused on the user experience and presentational aspect of search engines, and examining methods of presenting the search results to users. The search interface combines many aspects and functionalities to present the search results to the users. Social aspects will be appended to the main search result page in forms of status updates and user shared content taken from relevant social media and user generated content websites. The main result page is represented in a form of three-dimensional graphs using the WebGL renderer.

The search interface assumes that all keywords are typed in English without having any grammatical and spelling mistakes in any form. Some of the functionalities of the search interface prototype are entering search keywords, retrieving search results from various sources and media, displaying the search results using graphical representation, clicking links that are related to the keywords, and bringing the users to the web pages that they want. Throughout the research, two user-oriented surveys are conducted. The first survey is aimed at understanding and analyzing the current trend of user search engine behavior, while the second survey is aimed at getting feedback and measuring the user satisfaction regarding the search interface prototype.

The rest of this paper is divided into the following sections: Section 2 describes the related work, Section 3 describes the detail of the proposed system, Section 4 shows the experiments and results of the survey, and Section 5 concludes the paper.

2. Related Work

Work on the web information retrieval or web search engine result visualization has been done by many different researchers since the early days of search engines. According to Zamir and Etzioni there are two categories of the search result visualization techniques[10]. The first category is the visualization techniques that display additional information about each retrieved document. The instance in this category includes visualizing the attributes of the retrieved web pages such as date, source, popularity, etc. The second category is the visualization techniques on the inter-document similarities. The similarities among the search results may help the users to find related web pages faster. Along the types of visualization we can also categorize the work into text-based visualizations, 2D graphic visualizations, and 3D graphic visualizations[11].

One of the earliest works in web search engine result visualization is work by Andrews[12]. He developed a 2D and 3D visualizing system for the Hyper-G Internet information system through the Harmony browser client. His visualization system can not only visualize the relationship among document collections but can also provide visual navigational facilities to avoid user disorientation.

Grouper[10] is an interface that clusters the search results based on the phrases extracted from the 'snippets' or a ranked list of search query results displayed by the search engine. In this case, Grouper can be considered as a text based visualization system that generates the clusters of the search engine results.

The work[11] by Sebrechts et al. evaluates the search results visualization from the NIVRE, which is a tool for visualizing the information retrieval results in both 2D and 3D. They found that the 3D visualization interface initially was more difficult to use, but that difficulty decreased substantially with experience. Thus, user experience influenced the user's search performance. The 3D condition visualization showed the greatest decrease in response time during the experiment.

The work[13] by Wojciech, Walczak, and Cellary propose Periscope, a system that uses a novel approach for adaptive and customizable visualization of complex web search results. It mainly focuses on 3D visualization that can adaptively choose the relevant presentation method based on certain properties of the search results.

More recently the work[14] by Gomez-Nieto et al. propose a visualization technique to display the results of web queries in clusters of snippets or a ranked list of search query results. Their method is a 2D cluster visualization of the snippets based on the cosine similarity measure.

The work in this paper differs from the previous work above. Our work does not only show 3D visualization to show the relationships among the search results but also integrate the social aspects of the search by appending the user shared content taken from relevant social media sites to the main search result page.

3. Proposed Search Interface

3.1. Survey on the Users' Search Behavior

We conducted a brief survey on search engine behavior prior to designing the search interface. This survey is intended to better understand the search engine usage behaviors present among the users, as well as providing information about features and capabilities that are needed and missed by search engine users. There were 59 survey participants, 68.75% of them are male, while the rest (31.25%) are female.

Search Engines often offer related search terms in their search result page. For instance, if you search about Apple, they will suggest searching about iPhone, iPad, and App Store. These related search terms are presented in text form, and it is usually located in a relatively small part of the web page. Related to this issue, we asked the opinion of the respondents regarding the visual representation of related search terms. As shown in Figure 1a, for this question, 23.7% of the respondents admitted that they use this feature and think it is satisfying enough. Another 23.7% use this feature yet they think it has not been satisfying enough. The rest (52.6%) said that they do not use this feature and 33% from these respondents think that it is because it needs some kind of improvement.

Most search engines provide their search results in textual form. Related to this issue, we asked if it is easier for the respondents to find the information that they need and to better understand the topics that are related with the information that they need, if the relation between search results and related search terms are presented using graphical representation, such as charts, maps and graphs. As shown in Figure 1b, for this question, 15.3% of the respondents felt that they strongly agreed with the stated sentences, and the other 59.3% agree with the statement. Only 18.6% of the respondents cannot decide what they feel about the statement while the rest disagree with the statement.

Search engines usually provide 10 relevant results on their first page. Related to this issue, we asked how many links the respondents clicked to satisfy their search in general. As shown in Figure 2a, for this question, there were 37.3% of the respondents that feel comfortable clicking one to three links, while the other 39% of the respondents are happy with clicking four to six links. Seven to nine links are required for 6.8% of the respondents, while the other 5.1% click all ten links and the rest often go beyond the first page.

We also asked the respondents whether they like to read comments from other readers when reading certain news or article on the internet. This helped them understand the public opinion about the news or article. As shown in Figure 2b, for this question, there were 28.8% of the respondents that strongly agreed with the statement, and another 54.2% agreed with the statement. Only 6.8% of the respondents felt undecided and 8.5% respondents disagreed, leaving only 1.7% or one person to feel that they strongly disagreed.

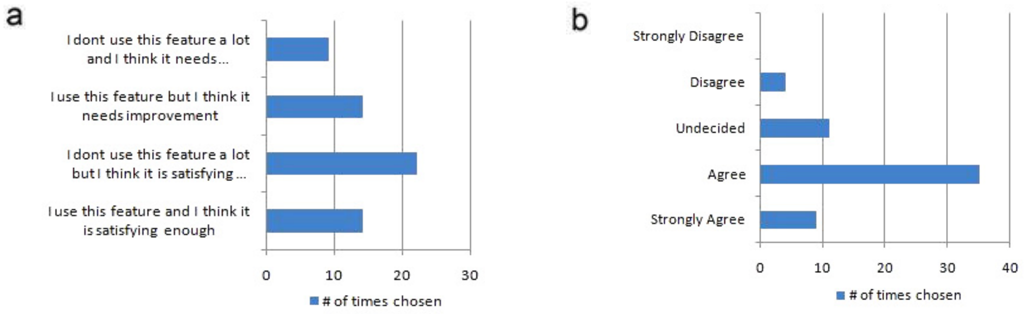

Fig. 1. (a) Survey result on related search; (b) Survey result on graphical presentation of the search.

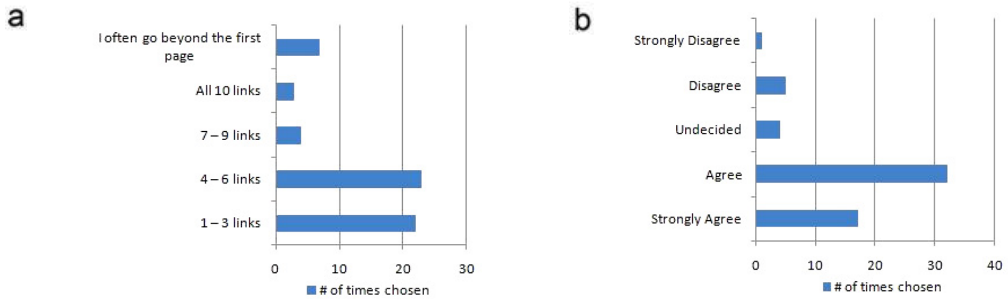

Fig. 2. (a) Survey result on the number of links required; (b) Survey result on the social aspect of the search.

3.2. Search Interface Design

To minimize the filter bubble, we propose incorporating social search results into the solution. It is expected that by including social search results as a part of the whole search results, the search engine users will be able to get a more thorough and holistic view of the issue that they are searching for. As has been described in the previous subsection according to the survey conducted regarding this matter, most of the respondents said that they often looked into the commenting section of an article and news to get further insight about what people think and perceive about the article or news. Thus the search interface will include some forms of social search results from some popular social web sites, such as Facebook, YouTube, and Twitter.

It has also been observed in the previous subsection that there is a need to consolidate the interaction between search engine users and the interface of the search engine itself. It was found that textual representation provides little help in aiding users to find the information that they want, and the harder the search gets the more unlikely it is that those users will get more relevant information. Thus we propose that search engines be built around user navigation and interfaces, and provide a good amount of interactivity for the users. The proposed search interface will also include an interface for users that enables them to interact and navigate dynamically using a three-dimensional representation.

Figure 3 shows the system architecture for the proposed search interface. The system was developed with a two-tiered architecture in mind, where the logical business part and presentation part is blended into one layer. The system consists of two web pages, which are the index web page and the search web page. Index.php serves as the home page for the whole system, where the search.php is the page that is responsible in fetching, processing and displaying data for the users. Other aspects outside the system which are crucial in keeping the system up and running are BING database server, Three.js and WebGL JavaScript-based libraries. Both of these JavaScript libraries were put in the same server that hosts index.php and search.php for the sake of efficiency and reliability purposes.

Rather than developing our own search engine, we used the BING database server because the focus of this paper is on the presentation aspects of the search results.

As shown at annotation number 1 in Figure 3, keywords are inputted by the users from index.php, where it is then sent to search.php. Figure 3 annotation number 2 shows how the searching process works. Search.php sends the keyword that it gets from users, and the BING server would response to the system by sending a JSON string containing the main search results. A similar process was done in order to get the related search terms and related search results from the BING server.

Annotation number 3 in Figure 3 shows the three dimensional interface rendering process. Search.php renders a three-dimensional interface with the help of a Three.js library. Three.js is a higher-level interface to the WebGL library. Therefore there is always constant communication between the Three.js library and WebGL library. Search.php also utilizes dozens of technologies in order to make it fully functional, such as PHP (PHP Hypertext Processor) as the server side scripting for getting search results from BING server, built-in JSON parser in PHP and JavaScript to interpret the JSON string from BING, and HTML and CSS as the web page layout.

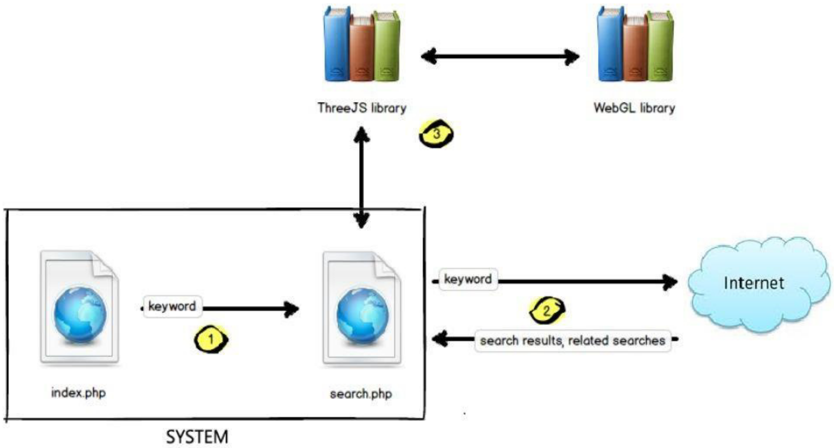

Fig. 3. The system architecture for the proposed search interface.

The system starts by displaying the home page to the user, showing a search box. The system then would read the users' keyword, and then fetch the main search results from the BING server. The system would also fetch related search terms and results from the BING server, using the same keyword that was read before. The system then would do two simultaneous tasks. The first task is to render a three-dimensional model as an interactive interface for the user, while also connecting the pre-fetched data into corresponding nodes in the three-dimensional model. The second task is to fetch social search results from Facebook, Twitter and YouTube servers respectively. After the social search results are fetched and the three-dimensional interface is rendered successfully, the system would display the resulting web page, showing all search results and interactive interface that it has processed. It also includes a search box for users to search again. If the users are satisfied with the search results, the system would end and the whole searching process comes to a conclusion.

3.3. Visualization Algorithm

The detail of how the search interface works can be described as follows. First of all, the system would fetch all search results from the BING server. These search results that are encapsulated in a JSON string format includes related search terms as well as the related search results. Since these results are initially fetched in server-side scripting, the next step would be assigning the value of these variables into client-side scripting. This step is quite important as from this point on each and every part of the script will be performed on the users' browsers, not the server.

After all variables are casted into client-side scripting, the system would start to render the three-dimensional visualization interface to the browser. It starts by rendering the scene, renderer, lighting and camera to make the scene visible with the right adjustments. Nodes and lines are drawn after the scene is ready, and the whole scene now is ready to be rendered using Three.js library. Search results are shown after the whole three-dimensional interface is rendered. It is shown under the three-dimensional interface using HTML and JavaScript. Users then would read the search results, if they are satisfied then the whole searching process would come to an end but they also have the option to tweak and interact with other related search results if they are not satisfied.

Should a user click and drag the three-dimensional interface, the three-dimensional visualization would rotate according to the user's mouse movement. It is also possible for the user to click on a single object and the system would check if the mouse click actually hits any object. The system then would highlight users' selection either by dragging or clicking, and then render the model and show the correlating results accordingly. These processes can be repeated indefinitely until the user is satisfied with the whole searching process and conclude the searching processes themselves. Table 1 shows the pseudo code for building the three-dimensional visualization interface.

Table 1. Pseudocode for building the 3D search result visualization interface

1. Initialize scene
2. Set camera and light to position
3. Set renderer properties
4. Set main sphere material and size
5. Add 1 main sphere to the scene
6. Set main lines material
7. Add 3 main lines to the scene intersecting with each other in the middle
8. Set child sphere material and size
9. Attach 6 child sphere material to main lines' end
10. Add 6 smaller lines to the scene each intersecting with existing main lines
11. Set grandchild sphere material and size
12. Attach 18 grandchild sphere material to smaller lines' end
13. Add event listener for mouse input
14. If mouse clicked down
    - Add event listener for mouse move
15. If mouse clicked up
    - Remove event listener for mouse move
16. If mouse is out of bound
    - Remove event listener for mouse move
17. If mouse is moved and there is an event listener
    - Check current position
18. If the new position is on the left of the old position
    - Rotate left
19. Else
    - Rotate right
20. DO checkRegion
21. Set camera to look at center of scene
22. Recheck mouse position
23. DO render
24. End

25. Function checkRegion
    - Check region of scene
    - Change visibility of the sphere
    - Sets search results

4. Experiments and Results

4.1. User Interface

Figure 4 shows the look and feel of the home page. The home page is aimed to have a simplistic view, so there are not many elements. Annotation number 1 in Figure 4 is for the logo of the web site, while annotation number 2 in Figure 4 shows the search box.

Fig. 4. Screenshot of the Home Page.

Figure 5 shows the first part of the screenshot of the result page. Since the result page is quite long, the screenshot is divided and explained into two parts. The logo of the website is located on the top leftmost part of the webpage, as noted with annotation number 1. Right below the logo lies the search results, noted with annotation number 2. Annotation number 3 shows the location of related searches. Users are able to click on the related search terms using the hyperlinks. The three-dimensional visualization interface is located on the center of the search result, as noted with annotation number 4. In the visualization interface, red circles represent the search results while yellow circles connected with straight lines represent the related search results. When the visualization moves, the search results change and vice versa. Users are also able to navigate by pressing the corresponding number on the keyboard. On the right side of the three-dimensional interface there is a Facebook search results box, as noted with annotation number 5. Finally, there is another search box should the user want to search again. It is located on the top right of the webpage, as noted with annotation number 6.

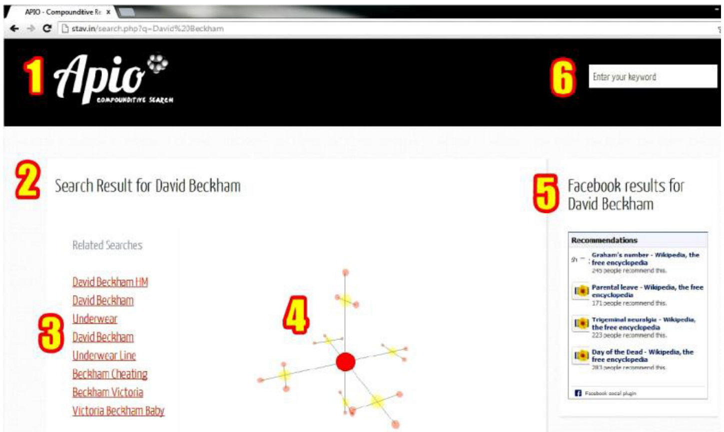

Fig. 5. Screenshot of the Search Result Page (Part I).

Figure 6 shows the second part of the result page. The screenshots are actually divided horizontally, so it can be imagined that the second part of the screenshot is actually located under the first part, being scrollable on the browser. Search results that are fetched from BING are located on the left part of Figure 6, as shown with annotation number 7. Twitter and YouTube search results are located below the Facebook search results from Figure 5, lined up vertically as shown with annotation number 8 and 9.

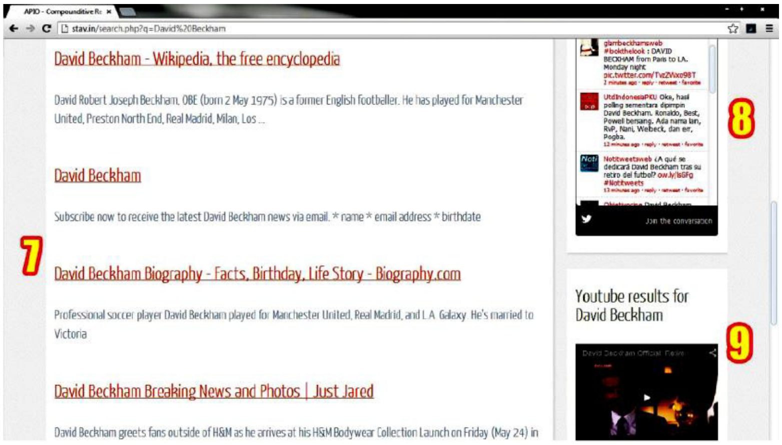

Fig. 6. Screenshot of the Search Result Page (Part II).

4.2. User Testing Results

The user testing was done using a survey that posed questions related to users' experience and satisfaction. The survey was conducted online and consisted of 16 statements divided into four segments. The respondents of the survey rated the statement after they had finished using the search interface. The survey used a Likert-like scale, in which respondents give 5 points to statements that they strongly agree with and 1 point if they strongly disagree. The four sections of the survey are related to the search results, related searches, three-dimensional visualization and social media search results.

Section I – Search results. In this section of the survey, the respondents' opinions for the search results were generally positive; no votes with one or two points. It can be concluded from the survey that the main search results were very relevant for the users, gaining 92.3% of the votes. We also found that the six links that were provided for the main search results was sufficient for the participants of the survey, yielding more than 75% of the votes. However, the number of links for related searches drew mixed responses, with only slightly over half or 53.9% of the respondents think that three links for each related search is enough.

Section II – Related search. In this section of the survey, most respondents agreed that the related searches were relevant to what they were searching for, reaching almost 93% of the votes. 76% of the respondents also agreed that by using the related search results, they were able to find information that was unable to be found on the main search results. Slightly more than half of the respondents or 61.5% think that the related search results brought new information that they had never known before. Finally, more than 78% of the respondents think that the related search existence was helpful for them.

Section III – Three-dimensional visualization. In this section of the survey, the impressions from users on the three-dimensional visualization were relatively more diverse and distributed than results from the previous two sections. Regarding the navigability of the three-dimensional interface, 53.8% of the respondents thought that it was very navigable, while the rests were neutral (38.5%) to slightly negative (7.7%) about this three-dimensional navigation. This result is generally in line with the findings of the work[11] by Sebrechts, et al. that the 3D visualization interface initially was more difficult to use, but difficulty decreased substantially with experience. 61.5% of the respondents had a positive impression about the three-dimensional visualization in helping them search. Additionally, 46.2% of the participants were satisfied with the color and shape combination of the three-dimensional visualization. Overall, 84.6% of the respondents were happy with the performance and presentation of the three-dimensional visualization interface.

Section IV – Social media search results. In this section of the survey, the importance of the integrated social media search results was examined. 92.4% of the respondents agreed that the social media search results helped them to understand various points of view about the topic they were searching for. Finally, 92.4% of the respondents were satisfied with the social media search results.

5. Conclusion

A search engine is a popular web service that helps users to find what they want in the jumbled data of the World Wide Web. Several issues exist in current popular search engines, namely the 'filter bubble' and the lack of visual representation. The results of a survey that was conducted showed that users were longing for a higher performing search engine with a more holistic view of the search results.

The purpose of this paper is to find the answer to this question which is of benefit to various internet users that use search engines every day. The scope of this work is to develop a social and integrated search interface that utilizes a three-dimensional image renderer. Social search results are incorporated with the basic search engine results, while giving users the capability of navigating and visualizing through the search results using the three-dimensional image renderer. It is also worth mentioning that the keyword is limited only to well-structured English keywords. We have designed a system to deal with the above issues. A survey was administered to measure users' experience and satisfaction. It can be concluded from the result of the survey that in general the users were happy with how the search interface works, including the social media search results and the three-dimensional visualization.

Some of the limitations of the current system are as follows. Firstly, it limits the search results into popular terms and English-based keywords only. Secondly, the optimal resolution of the display for the system to work properly was 1366x768 due to the CSS layouts. Some improvements can be done in the future work by implementing the user interface with a responsive web design approach to provide good viewing experience from a variety of computing platforms. The potential for improving search engines is still huge especially those that are related with visual representation.

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