Browsing Internet Content in Multiple Dimensions

Vision of a Web Browsing Tool for Immersive Virtual Reality Environments

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ABSTRACT

An immersive virtual reality environment (IVRE) offers a design space radically different from traditional desktop environments. Within this new design space, it is possible to reimagine a content search experience which breaks away from the linearity of current web browsers and the underlying single relevance metric of the search engine.

To the best of our knowledge, there is no current commercial nor research implementation that allows users to interact with results from a web search ordered in more than one dimension[11]. On the research front, a lot of work has been done in ordering query results based on semantic relations and different types of user interaction have been explored such as head rotation amplification. Current commercial browser applications in virtual reality (VR) port the current behaviour from PCs and mobile devices with the same linear search and scroll behaviour for retrieving content.

We propose a novel browser application in an IVRE which allows a user to execute a query which can be entered via either voice or a virtual keyboard. The resulting data arrangement of information benefits from multiple and interactable relevance-related metrics. This application combines the engaging environment of IVREs and the common search behaviour patterns as the next stage in the evolution of web browsing software.

1 INTRODUCTION

Immersive virtual reality environments are a technology that has been evolving since 1962, however, the core concept has remained the same, involving the user viewing a 3-dimensional rendered environment through a headset which they can interact with using controllers. At the time of writing, there are compact and affordable headsets such as the Oculus Quest devices from Facebook, that can handle virtual reality (VR) applications without the requirement of being plugged into a powerful PC. These headsets usually come with controllers which the user holds in their hands and can use similar to a mouse for a PC or as a pair of virtual hands.

The key motivation of this application is that existing web browsers for IVREs do not exploit the additional degrees of freedom available to the user to provide an immersive browsing experience. Currently, web browsers port over what is currently available on desktop PCs, with separate windows capable of displaying at most 3 search results each, forcing the user to scroll excessively. The goal of using multiple dimensions, i.e. having results surround the user rather than be presented in front of them on a panel, is to allow them to find desired results faster, making use of their spatial and short term memory, since the core objective when searching the web is to find and learn information. When referring to multiple dimensions in this context, we mean allowing the user to scroll and grab results in 3D, and organising information across more than one axis, compared to the vertical navigation of desktop browsers.

Our vision aims to implement a web browser application that uses an existing search API to perform a search engine's work. User's search tactics in information retrieval systems (i.e., browsers) have been categorized by previous literature into two distinct categories: goal-directed searching behaviour and exploratory search behaviour[2]. We note that there is not a clear line that can be drawn between the two. Users that exhibit Goal-directed searching behaviour, whom we will refer to as "Searchers", know what they are looking for and wish to find it quickly and easily (e.g. What is the current temperature in London?). "Explorers", on the other hand, are willing to browse results and may not have a clear idea of what they are looking for (e.g. What is the meaning of life?). Any information retrieval system should cater to both strategies.

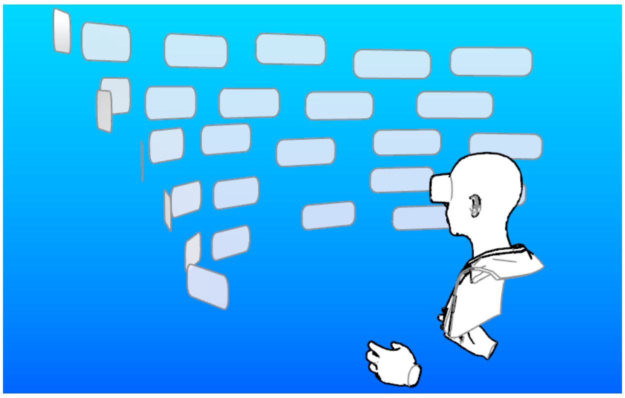


Figure 1: Third-person mock-up of Multi-Dimensional Immersive Browsing experience

The following section describes the state-of-the-art implementations in IVRE's which are either designed specifically for querying and browsing data or propose features that would make it more usable in an IVRE. We then discuss the motivation for the software, followed by the design options in the context and finally the concrete details of the idea.

2 CURRENT STATE-OF-THE-ART

2.1 Research Prototypes

VR provides a rich canvas for data exploration and some research papers have delved into these abilities further. None seem to have done so for general web content.

2.1.1 Data browsing tools. Two applications within data browsing tools are relevant for our work with the first focusing on representing semantic connections in 3D and the second aiming to query images in VR.

The goal of Subject Explorer 3D [7] is to propose a prototype for information exploration and retrieval with a core focus on semantic concepts. The prototype aims to “allow users to iteratively switch effortlessly between both types of search tactics” as mentioned before: "Searchers" and "Explorers".

This study presents a prototype developed for non immersive desktop VR. The prototype visualizes semantically related entities connected in branches forming a tree which the user can explore by pointing and clicking on nodes to "fly through" them. This was demonstrated using data from the Library of Congress Subject Headings, and was assumed that the model could be transferred to other data workloads. The article discusses the future work possibilities of usability testing and comparison with text-only information retrieval systems.

Virtual Reality Lifelog Explorer [6] presents an IVRE solution to the querying and browsing of a series of images of a persons' viewpoint collected over time. Most of the queries are over a range, searching for images containing an item or set of items or over a specified period. The user interaction methods discussed both involve point and click navigation and touching buttons on a panel, to select filters (categorical and temporal) to apply. The resulting images are ranked by the number of matching conceptual filters and then temporally (if the same number of filters match for multiple images). Images are presented in a list diagonally on a horizontal plane, moving further away to the user's right, with higher ranked items closer to them.

2.1.2 Prospective IVRE browser Features. Research has discussed the usefulness of applying "Egocentric Distance-Based Item Sizing" (EDIS) variations in combination with an amphitheatre layout of data icons [4]. This means altering the effect of perspective such that closer items do not seem as large as they normally would. It also discusses the effects of adding 3D landmarks into the virtual space, intending to allow users to alter the landmarks themselves, to act as memory aides for where certain elements are. The experiment, which was a version of the card-flipping game known as concentration, could be translated to a search context, in terms of a user remembering the layout of search results in an amphitheatre of text or icons. Recalling the spatial location of an object of interest (i.e., query result) enables users to access content they previously glanced at much easier.

The user study shows that EDIS had minor effects for the user's ability to recall elements spatially and that the 3D landmarks were a better approach, particularly when allowing users to set them themselves. In a commercial browsing application, this seems to be the same as bookmarks or previously visited resources, but visualised in a 3D setting.

2.2 Commercial Applications

Many current implementations of web browsers for VR systems still involve a window in which the user must scroll vertically through results in a single dimension. Some attempt to mask this by immersing the user in a virtual world when browsing or allowing multiple windows to span the dimensions.

2.2.1 Oculus Browser. Facebook's implementation of an IVRE browser[1] uses the standard model of result ordering, with point and click navigation, which is somewhat akin to desktop usage with the Google Search Engine. Switching between different types of content involves clicking on a different vertical tab (i.e., "All", "Images", "Maps" etc.). Navigation is limited by the ray-casting [9] interaction and there is no feature to manipulate the visual display size or distance, with the viewing range limited to just under 180 degrees.

An interesting feature is the ability to have multiple windows which make use of the surrounding virtual space, allowing users to switch their gaze between multiple result pages. Although, Figure 2 shows only 2 web results visible in an entire window.

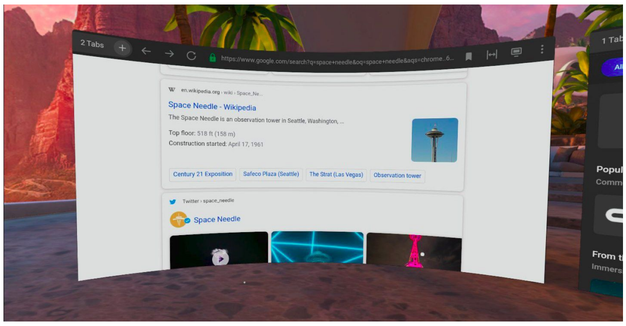


Figure 2: Oculus browser window showing results

2.2.2 Firefox Reality. The initial experience in the VR browser developed by Mozilla[2] is suggestion driven, with the home page showing popular content. One feature allows the user to set a virtual world as a background behind the browsing windows, similar to the native "virtual room" provided in the Oculus space. This reminds the user that they are in virtual reality and adds to the immersive experience.

The linear nature of results ordering is still apparent here, however, this browser allows for an additional query input mechanism – voice search. Although, the search results are not specific to the VR environment, being the same ones obtained from an identical query on a PC.

One other feature of note that Firefox Reality implements is to allow the user to configure the size of the window, adjusting it to their preference. This allows for greater depth and immersion in the virtual reality environment as well.

2.2.3 SoftSpace. Softspace labels itself as a productivity application rather than a browser[3]. Yet, its browsing features still act as a wrapper for a standard search page, allowing the user to create multiple windows (i.e., tabs), placing and resizing them as they wish.

Movement is implemented as pulling oneself through the environment, which is more interactive than both point and click teleportation and using the joystick to navigate. The resizing of windows by pulling both edges is very intuitive in IVREs. It is also worth noting that the keyboard is a virtual one that the user must be close to type on.

Regarding data layout, that is left up to the user, although, they are still limited to browsing in a window and the linear search experience discussed previously.

3 VISION

3.1 Motivation and Overview

Our vision aims to move away from the one-dimensional, linear experience of modern search engines, by developing a browsing application that presents results that are easy for users to scan and able to make use of the additional degrees of freedom available. The software implementing our vision should be able to make the users feel more immersed in their virtual browsing environment, by making them closer and more in control of the data items. This will result in the user becoming more productive overall, in terms of memory and data organisation.

[1] https://developer.oculus.com/documentation/oculus-browser/

[2] https://mixedreality.mozilla.org/firefox-reality

[3] https://www.soft.space/

The application implementing our vision should allow for a user to move past the query inputting phase quickly and efficiently, to then be greeted by many internet results around them. They should be able to rotate to view different result formats or pull a different type of result format in front of them through a specific controller or gesture interaction. The user must be able to grab and resize individual results that they wish to focus on, and equally save or discard the results to their desire.

3.2 Design Space

The following parts describe the different feature options available in various scenarios for the browsing experience.

3.2.1 Environment Interaction. The standard method of navigation in most IVRE's today is to have a virtual beam protruding from the controller which the user may control as a cursor, we refer to this as raycasting [9]. This puts distance between the user and the content they are interacting with and is unfavourable in creating an immersive experience. It can be difficult to use in some situations such as typing as it requires preciseness.

Alternatively, we could allow the user to grab and scroll to either move themselves or the data. Allowing locomotion could risk inducing motion-sickness and may make it more difficult for users to focus on results. Manipulating the data gives the idea that the user is in control of the data and where it is placed.

3.2.2 Query Input. At a high level, there were two options here, voice input and keyboard input.

Research implementations of voice input have gained positive feedback and have been shown to allow for an input rate of 23.6 words per minute [8].

Keyboard input can be separated into two further options: a touchscreen-like keyboard projected in front of the user, which they may type on using raycasting, or a desktop-style keyboard which the user can virtually type on. Studies have found that in IVRE's the latter appears to transfer more of the muscle memory since 45% of the typing speed from a touchscreen is retained, whereas a virtual desktop keyboard maintains 60% of the typing speed [5].

3.2.3 Data Arrangement. We considered the following structures to arrange the data:

- Amphitheatre layout - Depicted in Figure 1, similar to the one mentioned in section 2.1.2. The key advantage is that it allows the user to observe a clear ordering of results in multiple dimensions, in a way that is easy to scan.
- Virtual wall - This would appear from a third-person point of view as a cylinder surrounding the user, although, this may make the user feel claustrophobic considering that we want to make them feel close to the content they are interested in.
- Hierarchical tree - The layout would involve creating semantic arcs between results and allowing the user to navigate results by pulling themself through many small tree-like structures. A viable alternative to this would be to connect web pages with the same domain (e.g., spaceneedle.com/about and spaceneedle.com/plan-your-visit).

3.2.4 Results Ordering. In an IVRE we have three physical dimensions, each with an axis that could be used to order the results on. To ensure easier understanding, we simplify the design to use two axes in the 3D space.

The primary axis encompasses two dimensions, directed upwards and away from the users horizontal plane of sight. Naturally, we would order more applicable results (i.e. higher relevance) to appear closer to the user. The secondary axis would then be across the user, from left to right, and we could either order results in this manner, or outwards from the centre.

The search APIs use numerous metrics to determine relevance, for example, number of users clicking on a source and number of searches that match tags on a resource. The use of these metrics for result ordering is out of scope, as we are not intending to design a new search engine, but a browsing experience.

3.3 Design Choices and Implementation

Following careful consideration of the options discussed in the previous section, we now discuss the features that we will include in the application.

3.3.1 Environment Interaction. We aim to allow the user to interact with the data using virtual hands or controllers, enabling them to pull virtual delimiters for rows and columns to scroll and pick up individual data items they are interested in. The delimiters will be interactable with an open hand / trigger button and the data items can be selected with a grabbing gesture / button.

As well as being able to pull results closer and scroll with their virtual hands, we want the user to be able to intuitively pick up results, resize them to view the content, dock important content and discard undesired material virtually. Literature has shown this type of interaction to be beneficial as it requires less preliminary learning and dexterity when navigating the environment[1].

3.3.2 Query Input. The primary method of query inputting the tool exposes is voice search. The user will be able to speak into a virtual microphone and execute their query, this will be done via a speech-to-text engine which will send the resulting text to a search API. Since we aim to make this part of the application as fast and efficient as possible for the user, this is the most suitable option[8].

Voice search is not always 100% reliable due to multiple factors such as different accents and microphone quality. Thus, as a contingency, the secondary method of query input will be a virtual desktop keyboard.

3.3.3 Data Arrangement. Out of the potential methods for presenting results, the most appealing one that suits our vision is that of an amphitheatre, for reasons discussed in Section 3.2.3. This has been shown to work well for users in the spatial memory setting[4], allowing them to recall the location of results faster.

This layout also solves the problem of filtering different types of content (such as images and shopping content) as we can present content barriers in the 360° space, for example, the user may be able to look 90° to the right and see image results whereas directly ahead of them are web results. We intend to introduce UI indicating which type of result is in which direction.

Existing extended reality (XR) applications have attempted similar styles of data organisation, such as personal cockpit[3], which aims to target head-worn augmented reality (AR) displays, presenting mobile-like applications in a hemisphere in front of the user. Since this has worked effectively at organising information in front of the user in this setting we believe it can be clearly transferred to VR in a web search context.

3.3.4 Results Ordering. Since most search engines and API's have optimised search results for a single metric, relevance, this is how we will aim to order results on the primary axis.

We now propose the metrics we may use for ordering results along the secondary axes. For web results, a user usually wishes to learn the sought after information as quickly as possible, hence we will order results based on the average time to read the main content of a webpage or by the most recently updated sources. Images will be ordered by either size or date appeared. There are many potential modifiers for sorting shopping results with the most obvious being price.

3.4 Potential Additional Features

The Oculus Quest headsets also allow for explicit tracking of the user's physical hands to use as controllers. We will use this to add to the level of immersion.

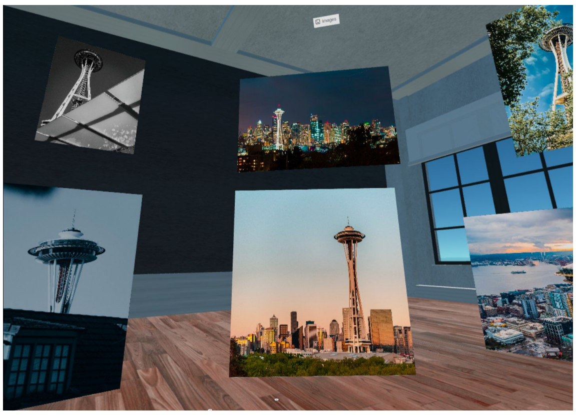
Some existing headsets provide eye-tracking capabilities and this could be used to create landmarks where the user's vision has dwelled, or instead, to collect data that adds to the relevance metric.

Lastly, taking inspiration from a recent study[10], this application would enable a mode for users sitting down, which amplifies rotation and would allow users to experience the entire 360° space when their field of movement is restricted.

3.5 Prototyping and Implementation

An initial prototype scene to demonstrate the interaction and data layout was made on an Oculus Quest 2 device using the BYLDR software. Figure 3 depicts the 0° and 100° points of view of a user when executing the search string "space needle".

(a) Web results, microphone and keyboard in front of user



(b) Image results to the right of the user

Figure 3: Point-of-view images from prototype scene

Following this, a high-fidelity prototype shall be made using Microsoft's prototyping software for VR devices, Maquette[4] . This will then be used as a reference to develop the application in Unity, using Microsoft's speech-to-text and search APIs for transcribing search queries and retrieving web results respectively.

[4]https://www.maquette.ms/

3.6 Evaluation Plan

It is important to note here that we are not comparing this application across different mediums, against a desktop search for example. Instead, we aim to ask users to find a described piece of information and must search for it using our software and also using Oculus Browser and Firefox Reality. Several warm-up tasks will be given to all users to ensure that they are at a similar level of skill when navigating the environment.

We will evaluate the user experience using a framework developed for use in immersive virtual environments[12], which presents a detailed questionnaire containing 10 measurement scales, including usability, immersion and cybersickness. We may also choose to observe our own additional metrics that are specific to the search scenario, such as the time for a user to successfully find the target information.

4 CONCLUSION

We have demonstrated an idea for an IVRE browser application that is radically different from the common one-dimensional experience seen in desktop PCs and other browsers in VR. The application is designed around the user's capabilities with a head-mounted VR device and makes use of as much of the additional space available through this medium. We have also seen how other research ideas have contributed to the feature development of this application and explored current commercially available browser applications for IVREs to date.

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