VisualExpresso : Generating a Virtual Reality Internet

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Abstract. Finding knowledge from vast quantities of data is a difficult task, made simpler by visually representing this information. The Internet can be considered a vast (global) database, but whose unstructured format frequently leads to a feeling of being "lost in hyperspace". Visualising this structure can make browsing a more productive endeavour. In this paper we introduce a means of "lossy" translation from HTML to VRML (Virtual Reality Modeling Language). This allows for the generation of a virtual world containing the structure with some content information about the site. This implements a new metaphor for intranet and internet browsing.

1   Introduction

When presented with an overwhelming quantity of information, it is difficult to know where to start, especially when trying to gain an understanding of the overall content of the information. This problem is complicated even further when the information is distributed and inter-linked by dynamic references. The WWW (World Wide Web) is an example of such a system, where a collection of electronic documents are connected by hyperlinks across numerous machines around the world. The current means for navigating and retrieving information from the WWW is by using conventional web browsing technology as offered by Microsoft and Netscape. These operate by manipulating graphical interfaces with the aid of search engines. However this method of interacting with the Internet using a page view is frustrating and forces the user into a DFS (Depth First Search) of the electronic documents which often leads to a fruitless search for information. This could be overcome by viewing the web site in its entirety.

One possible solution is to understand its structure, and allowing meaningful random access to it. A structure map for a subset (web site) of the WWW can be accomplished by firstly constructing an abstract representation of the site, presenting its meaning to the user in a graphical form. Many web sites try to accomplish this by providing static site maps in the form of two-dimensional picture. VisualExpresso is a powerful visualisation tool written entirely in Java, that allows site structure maps to

browsed in three dimensions, and unlike most other site map tools can be used in a number of different ways:

- A Network Management tool allowing Webmasters overview sites.
- A Site Design tool, enabling the visualisation of web site structures in a breadth first manner from any starting position. This is of great importance when designing an effective and navigable site.
- A navigation tool, the virtual environment allow the user to select any page at any level in the site structure, immediately jumping to the page by simply clicking the mouse.
- Being able to visualise the neighbouring HTML pages from your current position allows greater freedom when searching a site for a particular piece of information. It also avoids revisiting pages when re-searching a site.

Another major problem when dealing with information is the format in which it is presented to the user. One possible solution is to present the information in graphical from. Various techniques exist for visually understanding large information spaces [1]. The most realistic way of understanding abstract representations is to map them to the physical world, by manipulating three-dimensional graphics that allow interaction with constituent graphical objects.
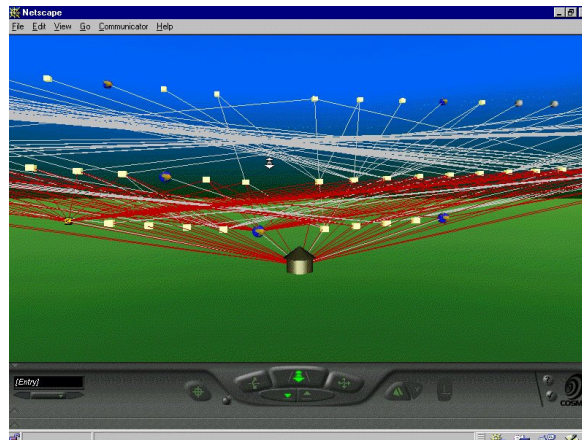

Fig. 1. Screen Shot taken of a virtual world representing a web site created by VisualExpresso.

VisualExpresso generates virtual worlds representing the structure and contents of intranet sites. This requires extensive computing power to firstly retrieve the entire contents of a web site, second to parse the entire contents of this site, third create intermediate structure and finally generate the final virtual world. The almost unlimited expense of such operations limits our tool to generating Intranet worlds, where "off site" internet locations are detected via their URLs and are depicted by spheres that are texture-mapped with globes - as in Figure 1. Visualisations of large sites also imposes heavy requirements on the browser's platform. For a true virtual

internet world, each site requires an equivalent virtual world representation. Thus, constructing a virtual reality internet would require extensive computation, distributed across many (or all) internet servers. The solution we propose to this seeming impasse is to have each site generate its own intranet world, which is lined to other sites via the existing URL locations. This distribution of computation makes possible the creation of a Virtual Reality interface to the internet. Without this distributed computation, the overwhelming complexity and cost of generating an almost unbounded Internet world is intractable. Furthermore, by a standard representation of nodes between visual worlds, we facilitate navigation between intranet worlds/sites. Thus is born the three dimensional internet.

2   The Need for New Browsing Techniques

Currently, most users of the Internet use conventional browsers like Netscape or Internet Explorer to extract information from the WWW, with heavy reliance on search engines. Although these methods are easy to use and have their place, using them to find exact pieces of information is nearly futile unless you know the exact location of or description of the data. One of the main failings of the conventional browser is its interface, which encourages depth first searching. Every time you descend a level the previous levels links disappear and the user is faced immediately with the choice of the next level. By continuing in this fashion down the information tree, the user is forced into a depth first search. This searching technique often leads to a *dead link* (one of no interest to the user), forcing backtracking [2] and resultant confusion.

One possible solution to these problems is to obviate the structural information, acting as a "road map" outlining the location of web pages contained within the web site and how to get to them. This information can act as an invaluable navigation tool to the user. Site maps let the user see the current position in relation to other web pages, supporting the identification of other pages from the current position. This information is crucial to any *productive* general purpose internet browsing.

3   Three Dimensional Web Browsing using VRML

VRML (Virtual Reality Modeling Language) is a standardised means of creating three-dimensional virtual environments over the Internet. It is an interpreted language, and is viewed through a VRML browser. The VRML worlds can also be viewed through a conventional web browser with the aid of a *plugin*. These VRML browsers have various navigational tools to let the user interact with the virtual environment. The most exciting features of VRML is that it allows the creation of dynamic worlds and sensory-rich virtual environments. The following features are very desirable when developing a new metaphor for browsing the Internet
- Animate objects in your worlds
- Play sounds and movies within worlds

- Allows users to interact with worlds
- Control and enhance worlds with scripts - small programs that are created to act on VRML worlds.

3.1 The Structure of VRML

VRML is hierarchical in structure and is built up of *nodes* describing shapes and their properties. Nodes are the building blocks for virtual worlds, and individual nodes are used to describe the shape, colour and appearance of the objects within the world. They also deal with the positioning, orientation and interaction of objects. A VRML file can contain any number of the following components:

1. The VRML header (compulsory at the beginning of the file)
2. Prototypes, a means of defining nodes.
3. Shapes, interpolators, sensors, and scripts that enhance the Haptic / Kinaesthetic system [3].
4. Routes (wired instructions) to make your world dynamic.

VRML has a pre-defined set of primitive shapes (box, cone, cylinder, line and sphere), and these are combined to create more complex shapes. The language also provides the means for defining custom shapes. VRML also supports the concept of *inline files* which allows the worlds to be defined in numerous files and connected together using *anchors.* Anchors are attached to shapes within the world and specify the location of the inline file redefining that section of the world. The location of the inline file is specified by a URL contained within the anchor node.

3.2 Why use VRML?

"Virtual reality, or virtual environment techniques, will change the way in which man interacts with computer systems" [3]. By displaying the hyper-documents structure in a virtual three-dimensional environment, we gain a better understanding of its content. Any interacting with the three-dimensional worlds we must address the following:

- **Navigation.** The world is viewed through a browser and provides a set of navigation tools to interact with the environment. These navigation tools allow total freedom within the VRML world, and is accomplished by the combined use of both mouse and keyboard. Although this interaction does not provide a great deal of haptic responses to the user, it offers enough feed back to give the impression of navigating through a virtual world.
- **Users perspective.** The visualisation site is comprised of distinct stages:
1. The set up stage specifies the particular web site to be viewed and the depth to which the site is to be analysed, combined with the required protocols to be displayed in the virtual world.
2. Once the set up stage is complete the user is free to interact with the world through a VRML browser. Unlike other web site visualisation tools, the user can create any

number of views of the site by interacting with the virtual environment and manipulating the objects contained within it.
3. Content view. Under certain VRML viewers, we can see a pages URL or title (etc.). This allows the user to view a page, without the usual exhaustive DFS steps.

4   VisualExpresso (for 3D web browsing)

Software visualisation is a human computer interfacing technology devised to improve human understanding of complex computer software using graphical design, typography, animation and cinematography techniques [4]. The application that was developed did not try to analyse all aspects of a web site, but concentrate on certain aspects of it. Incorrect or malformed *href* are ignored. For efficiency reasons, only pages that are contained in the same domain are parsed. A subset of the protocols supported by URLs [5]; HTTP, FTP, GOPHER, and MAILTO are represented. The structure of the web site is static reflected in the structure of the site at a given moment in time.

4.1   The Problems VisualExpresso addresses

When working with hypertext and other large information repositories, we encounter a variety of related problems. Among these problems are:
- How to conceptually understand the context and the expansiveness of the virtual environment?
- How to display large quantities of information in a confined space?
- How to provide a clear and consistent navigational cue throughout the virtual environment?
The World Wide Web is a vast collection of electronic documents, however it suffers from numerous problems when one tries to visualise it:

1. Organisation. The web is built upon a network of hypertext documents which has no discernible structure. This randomness provides a flexible way of presenting information, however it makes developing a context for a site almost impossible.
2. No physical context. As the user of a web site can only inspect one page at a time, developing an overall perspective of the site context can not be accomplished without extensive navigation through the site - and even so a complete picture is difficult to imagine.
3. Navigation and Orientation. Due to the nature of web sites and the limited navigation tools offered by conventional browsers, one can easily get the feeling of being "lost in hyperspace".

The above outlined problems are mostly dealt with in an *ad hoc* manner by the use of static site maps, frames or block diagrams created by hand. These methods are not data driven and are difficult and costly to maintain. Furthermore, they only capture a small section of the overall structure of the web site.

4.2   Abstract Graphical Objects Requirements

Abstract graphical objects provide the foundation for our visualisation. They are the mappings from the internet domain to the three-dimensional world. They are required to satisfy the following criteria [6]:

1. **Completeness.** Represent the entire target domain.
2. **Extensibility.** As the system will grow, it must be able to accommodate the unforeseen introduction of new graphical objects.
3. **Hierarchy.** Each visualisation must be broken down into reusable components. This helps in the logical mapping from abstract objects to graphical objects.
4. **Parameterization.** All properties of the graphical object should be parameterized to support declarative mappings, and ease of adaptation and expansion.
5. **Abstraction.** The graphical mapping should be represented independently in case they need to be changed.

VMRL provides a hierarchical language that allows construction of graphical objects in a manner that satisfies these criteria. In the next section we will examine how these abstract requirements can be mapped onto a VRML representation of site structure.

4.3   Three Dimensional Representation Of a web Site

The representation of the web site takes the graphical form of an inverted BFS (Breath First Search) tree, with each level in the tree an equivalent level of indirection from the base page. Before we are able to represent the structure of a web site, we must first establish the following:

1. **Node Representation.** The type of nodes in a web site are identified by their protocol as specified in the URL. Each supported protocol was assigned a VRML primitive shape, with a texture mapping applied to the shape, made key nodes easier to identify. A special node identifies the base page. Nodes located outside the DNS (Domain Name Server) of the base page are represented by a sphere. It should be noted that the above elements are defined in inline VRML files and are independent of the world generation application.
2. **Representation of hyperlinks.** The representation of hyperlinks between nodes was divided into two categories depending on their position within the web site:
- Links from a node to a deeper node, further down the parse tree
- A link coming from a node lower down the site tree back to the current node.
- Recursive links are not graphically represented.
3. **Dead Nodes**. These are elements contained within the web site that could not be connected too. These are depicted by black spheres.
4. **Scalability within world.** Each element within the world with the exception of the base node has the same VRML dimensions. The reason for making the base node larger was to make its identification easier in large web visualisations.

5 Overview of VisualExpresso's Architecture

VisualExpresso is a JAVA application that creates a VRML world to represent any web site on the internet. The application structure is designed on a component object oriented framework, that facilitates expansion.

5.1 Framework for creating three dimensional Worlds

The VisualExpresso tool can be thought of as a collection of abstraction objects viewed in a graphical manner [6]. This integrates three major functional units.
1. Generate abstraction objects.
2. Store the extracted objects in a coherent manner.
3. Manipulate the extracted objects to produce a visual environment.
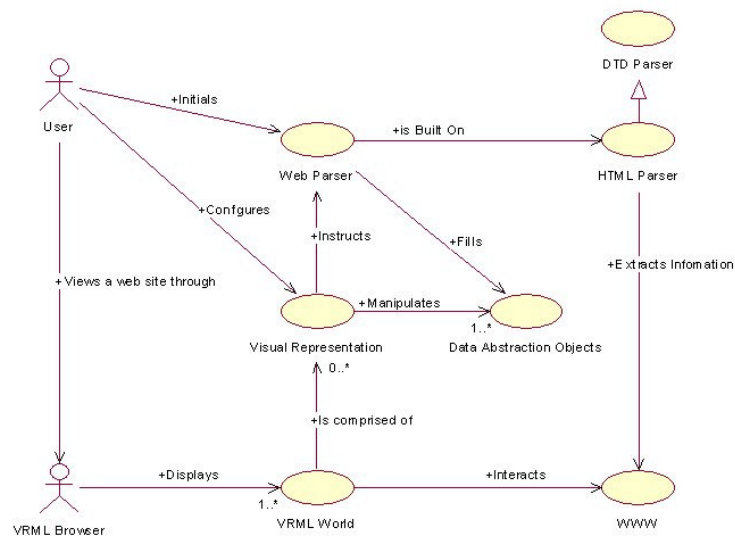The VisualExpresso Use Case Diagram is depicted in Figure 2.

Fig. 2. Use Case Diagram of the interaction of the user with VisualExpresso.

5.2 Information Extraction Process

It is clear form our initial analysis that the extraction of the information is going to be of major concern. This process will have to provide a flexible interface for the raw extraction of structural data. It will also have to be abstracted to a level that allows easy extension, supporting different types of information from the data domain.

The World Wide Web structure extraction process, can be thought of as a hierarchical problem. Each subset of the WWW to be analysed is a collection of smaller entities referenced by URLs [7]. So the extraction of data will adhere to two main constraints.

1. Parsing a given subset of the WWW in a breath first manner to an arbitrary dept, from an initial start point.
2. Extracting information from the individual entities within the subset of the WWW, this was be limited to HTML pages

HTML pages are parsed to extract structural information contained within them. The parsing was limited to URLs contained within *href* tags. This extraction process was accomplished by building an HTML parser. The HTML parser used was constructed by creating a package containing four objects and integrating these objects with a DTD parser developed by Sun Microsystems.

5.3 Storage of the Abstraction Objects

This collection of objects will store and manage the information extracted by the parser. It also stores details relevant for the creation of a graphical visualisation system depicting the structure of the web site. The main issues arising from the implementation of this aspect concerned the type of data structure to be employed. After careful thought to both the extraction process and the creation of a VRML world, a complex object model was constructed. The implementation of this object model relies heavily on holding and manipulating objects, built upon a complex object oriented data structure.

5.3 "Loosy" Translation to VRML

The VRML worlds generated by this application are composed of two major sections:

1. Pre-generated code, which is defined in Inline VRML files. This is used to draw the constituent elements of the world, like HTTP, FTP nodes etc.
2. Code automatically generated by the application, this in turn has to two parts:
− Nodes in the world to represent the elements contained within the web site.
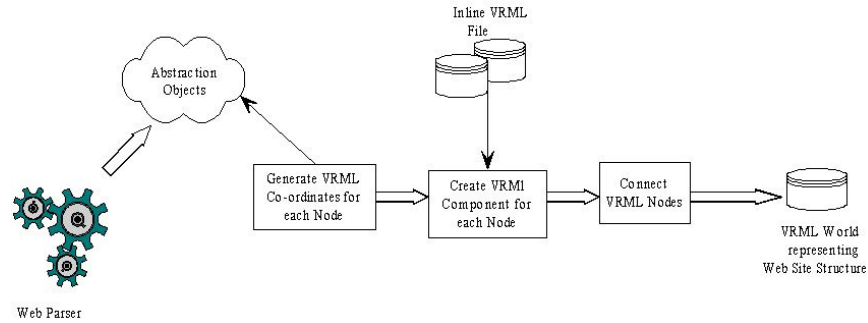− Links connecting the nodes within the world, depicting site structure.

Fig. 3. Overview of the process of creating a VRML world to represent a web site.

Organising a cohesive world structure is achieved as follows. Each abstract object is allocated a particular shape depending on its type. Each VRML node then, is integrated and allocated a VRML co-ordinate to position it in the world. The final process involves a two-pass technique to connect the nodes representing the site structure. This connection process involves distinguishing the connection of nodes to a greater parse depth and via versa. These events are summarised in Fig 3

5.4   Virtual World Layout, Orientation and Sense of Direction

We position nodes within the world corresponds to the breadth first manner in which the web pages were parsed. This arrangement conveys a similar perspective to that of a user visiting a site using a conventional web browser. However, the user is not forced into searching the site in a depth first manner as with normal browsers. The position equations were experimentally determined by examining web sites of various sizes and depths.

$$X = \frac{N + 100}{20} \tag{1}$$

$$Y = level \; \frac{N + 100}{20} \tag{2}$$

$$Z = - level \frac{N + 100}{20} \tag{3}$$

Where *N* is the number of nodes at a given level, and *Level* is the parse depth relative to the starting position (or base address).
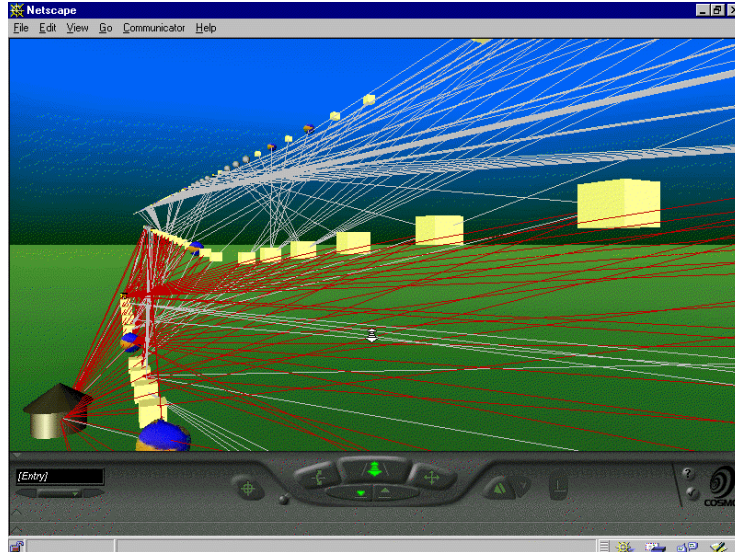
Fig. 4. An alternative screen shot of a world created by VisualExpresso, which shows how navigating the world is assisted by the uses of colour and directional aids.

VisualExpresso denotes direction by representing connections from a node to one at a greater parse depth by a grey line and the reverse by a red line Fig.4. An alternative approach of using multiple colours for the connections between levels was also tried, but this was rejected in favour of the previous representation, as it was deemed to be cleaner and less messy. The application also provided the option of enhancing the world by adding texture mapping to the nodes within the world to make it easier to identify the different node types.

6   Conclusion

To conclude we have proved that VRML can be used successfully as a three-dimensional visualisation analyse tool allowing virtual interaction with a three-dimensional representation of a complex networks of information. We have also thrown light into the dark abyss of Internet browsing suggesting one possible solution with the advent of high performance computing for the simplification and navigation of large volumes of distributed data found on the WWW.

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