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Searching for the Semantic Internet

D. O'Donoghue,
National University of Ireland,
Maynooth, Ireland.
diarmuid.odonoghue@may.ie

D. Cleary
Applied Research Laboratory, Ericsson,
Athlone, Ireland.
david.cleary@eei.ericsson.se

ABSTRACT

Search engines, directories and web browsers all deal with the Internet at the level of individual web-pages. We argue that this is too low a level of resolution for many, including the non-casual surfer, who has detailed knowledge of his/her topic of interest. We present the *shopping-mall metaphor* that is based on identifying tightly integrated communities of web pages, where pages procure information from each other via hyperlinks. A search operation identifies these web-page communities, rather that individual web-pages, and the communities are visualised as a Virtual Reality shopping mall - for presentation on a VRML enabled web browser. Each information outlet (shop) can contain multiple information "products" (pages) gathered around a common theme. The metaphor serves to integrate both search and visualisation phases, presenting a coherent information collection to the user - regardless of the search domain.

KEYWORDS

Internet Visualisation, Browsing, Searching, Virtual Reality.

INTRODUCTION

Current Internet search engines are aimed at the casual surfer who requires a single page containing some desired information - as exemplified by the "I feel lucky" button of the wonderful google [1, 2] search engine. This forms part of the "search and browse" mode for typical Internet usage. This mode deals with the Internet at the finest grain of resolution - individual web pages.

However, we identify a target audience of web authors who have an intimate regard for their search topic, and who want to survey *all* significant web-pages on that topic. Such a survey is difficult to accomplish using current tools. The problem we wish to address is, how do we both find and display a semantic web in a way that is meaningful to the user?

McDonald and Stevenson [3] have shown that user performance while interacting with hypertext is greatly improved by the presence of a map. This alleviates the problems of disorientation suffered by both expert and novice users of the underlying text. Significantly, a localised spatial map was found to be more beneficial than a topic list to all user groups. This finding calls into question, the "topic list" results returned by all Internet search engines and directories. The findings of McDonald and Stevenson were a key motivational factor behind the VR-Net project to integrate a search engine with a map like interface. However, seamless integration can be very difficult to achieve, which could leave users more disoriented than ever.

Smilowitz [4] has shown that suitable metaphoric comparisons greatly improve user performance when interacting with the Internet (*i.e. "The Internet is like a Library"*). For instance, novice users were found to perform certain tasks three times faster than those who had not been given the library metaphor. Interestingly, a metaphors advantage is carried primarily through the metaphors terminology, while graphic icons contribute by re-enforcing rather than driving the understanding. Smilowitz's findings showed that multiple metaphors have a confusing effect the user, though performance was still found to be better than the no-metaphor condition. Hence, we decided to use a single metaphor to structure the entire project, encompassing both the search and visualisation phases [5].

Smilowitz's work was a major incentive to investigate the use of a metaphor to integrate the search and browse components of Internet interaction. Furthermore, significant work has been carried out in modelling the metaphoric process [6,7]. This has led to a fuller understanding of the metaphoric process [8], which we availed of in developing the novel web interface.

We present the shopping-mall metaphor that treats Internet searching like shopping for information. The shopping-mall metaphor was chosen as it integrates the retrieval and visualisation activities, because users find this domain familiar and easy to operate within, and because it is applicable to *every* user's query. In essence, VR-Net [9] identifies shops *(sites)* containing products *(web-pages)* that are distinguished by popularity amongst a peer group of other Internet authors *(back-links)*. The peer group is very interesting as it performs a dual role: it contains useful products and it also serves to distinguish the most significant stores. This metaphor not only identifies web-sources, but also brings structure to the resulting assemblage of web-pages. VR-net depicts this shopping-mall by generating a desktop virtual reality

world in VRML 2.0. VR-net is composed of the following stages:

1. **Find candidate products:**
2. **Identify shops:**
3. **Collect peer shoppers (that double as shops):**
4. **Gather relevant products:**

Our shopping-mall metaphor is similar in effect to the citation referencing technique used to great effect by *google* [1] and others [10,11]. Without the *shopping-mall* metaphor, users might easily become disoriented by conflicting search and visualisation strategies. However, our metaphoric technique has the distinct advantage that it unites search with the visualisation process. The intimate union of search and display keeps users focused on their own information requirements, and not on the tools they use.

Identifying information clusters is particularly important given that most Internet searches consist of three or fewer terms [12], although different responses may be required by different users with the same query. Our approach maximises the information returned to users, and thereby minimises the number of distinct searches the user need initiate. Furthermore, many search engines automatically filter out multiple pages from the one site, instead offering a "More results from *URL*" link containing co-located references. This may force users into a manual depth-first search to survey all pages.

Initial results indicate that the VR-net algorithm produces results broadly similar to those of google. This we attribute to both tools reliance on hyperlinks, to identify significant resources. Visualising the relevant contextual information gives users a greater understanding of the semantic Internet, depicting all relevant information sources coupled with significant structural detail.

CURRENT PROBLEMS

Search and Browse has become the dominant mode of Internet usage, but is still fraught with problems and limitations. Search related problems range from lexical ambiguity to information overload. The browsers inherent limitations include disorientation [3], ambiguity over the destination of the "back" button, and lack of context information. Visiting multiple pages offered by a search engine and trying to find the most suitable, can be a tortuous affair.

While google's PageRank algorithm identifies wonderfully reliable information sources, its generation of topic lists binds users to the corresponding browser problems [3]. Furthermore, turning off google's automatic filter, which limits the display to two pages per site can occasionally overwhelm the user - but hides relevant information sources while the filter is active. Visualisation might help to alleviate these problems, but its exact form seems unclear.

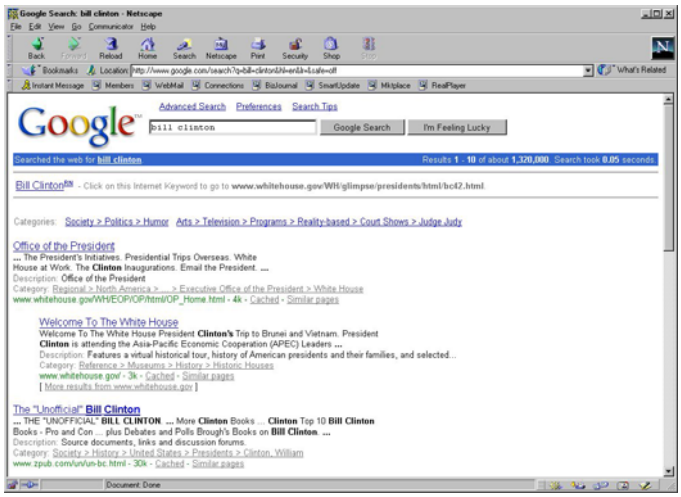

Figure 1 Page list generated by a "Bill Clinton" search.

User queries are generally very under specified, containing an average of just three terms [12]. Different users with the same query terms have different information requirements. We illustrate this point by example, highlighting the pragmatic ambiguity inherent in queries. Most significantly, we show how individual shops can address different pragmatic requirements of users - within a single view of the semantic Internet.

For some tasks it is better to deal with the Internet at a lower resolution than the individual web-page. Consider a VR-Net search on "Bill Clinton"[2] and the shops it identifies. The WhiteHouse.gov shop contains official information (plus contact details), and other products that reference this official information. The usatoday.com and now.org shops contain information from the perspective of the press.

Another shop identified by VR-Net is ImpeachClinton.org, which contains information with a very different focus. Other products in this shop advocate the jailing of Bill Clinton etc. Having examined one product in a shop allows the user to make inferences about the suitability of other products in that shop.

Figure 2 Aerial view of "Bill Clinton" *Shopping-mall*

VISUALISATION METAPHORS

Metaphors have previous been used to structure Internet tools. The CyberNet tool [13] also uses multiple 3D metaphors like a *City* and *Solar System* to aid visualisation of web resources. One metaphor even presents a virtual office, from where web resources can be reached according to their geographical location. However, this does not have the general applicability we desire of VR-Net. Other visualisations supported include analysis of network traffic and mappings between web resources and disk space.

CyberNet is a flexible visualisation framework, capable of presenting different metaphoric interpretations. Despite their use of metaphors, there are great differences between CyberNet and VR-Net. CyberNet focuses on visualising large amounts of dynamic information, whereas VR-Net presents static visualisations. CyberNet also does not encompass a web search activity. The focus of this paper is on the underlying metaphor, how it integrates search with visualisation, rather than on the visualisation component itself.

Terveen at al [14] tackle the joint problems of search and browse, but do so in two disjoint phases. We feel that integrating both phases produces a more cohesive and ultimately more useful tool. The Cospace [15] tool focuses on visualising multi-user networks and supporting interaction between them via avatars. Like VR-Net, Cospace "sits on top of the web" providing a novel interface. However, Cospace is not aimed at the same user group as VR-Net.

FINDING A SEMANTIC INTERNET

In our search for a semantic Internet we manipulate a series of ranking algorithms that extract relationship on a given search query and builds up a semantic map of web pages. Following the extraction and processing of the raw information from the web, we apply our *shopping-mall* metaphor to the information and finally present this to the user via the virtual reality desktop paradigm utilising VRML 2.0 [18]. The System Architecture can be graphically illustrated in the following block diagram.

Figure 3 VR-Net System Architecture

INTERNAL MODEL FORMATION

Our definition of searching for a semantic Internet is centred on the definition of an internal conceptual model that is in turn displayed via a three-dimensional visual medium. The goal behind creating an internal meta-model of the search results is to better understand the relationship inherent within the data, thus providing the descriptive padding around the raw data to realise our *shopping-mall* metaphor.

At the heart of VR-net is a complex information model that stores the shops, products and their inter-relationship. As this is central to both the search and visualisation processes, we will examine it first. The web information repository is built by creating a series of associated object hierarchies. The aggregation of these hierarchies provides a full view of the Internet domain in question needed to create the *shopping-mall* metaphor. The construction of these object families is based on the notion of a site reference rather than an HTML page reference, which is necessary to support our concept of shop sites. Also, within the shop hierarchy, additional structural and content information is stored to provide extra information for the final visual representation of the section of the web been investigated. This information is designed to facilitate the creation of VRML worlds. As the underlying structure of the web is based on a complex maze of electronically linked documents, the interrelationships of the nodes contained within the repository are modelled within their own object model.

Within the complex relationship model, one of our chief design goals when designing the information repository was to achieve a distributed and scalable data structure. To realise this we implemented the information repository in a location independent manner. The ability to serialise the information repository to a platform independent format supports the ability to transport this information across the Internet itself. Therefore, information retrieval may be performed separately from visualisation, accomplished by building the complex set of object oriented containers.

VR-Net does not focus on all aspects of a web site to formulate its semantic view of the Internet, it primarily concentrates on the URLs that are extracted from each page in the web information repository. Shops and Peer shoppers are similar to Clevers' *authorities* and *hubs* [10,17]. However unlike Clever we do not constrain our shops to be fixed to a given web page, but to a collection of related or grouped pages.

To aid in the understanding of URLs and to allow a useful structure to be determined, we apply a series of analysis stages to each raw URL, including:.

- Region grouping via examining the DNS (Domain Name Server) to which the URLs belongs.
- Absolute URL addressing
- The protocol embedded within the URLs is used to classify each web resources.

RANKING STAGES

To extract a semantically focused set of Internet information needed to realise our *shopping-mall* metaphor a number of ranking and retrieval algorithms are applied to a set of raw data retrieved from conventional web indexes. These ranking algorithms initially find a set of peer shops focused on the users product search. Following this, a sequence of relevant product gathering is performed to achieve a site centric view of a given product. Our perspective on the importance of web sites is based on, the weight of reference within a given page to another of a similar topic. This categorisation of data within the web allows for a semantic view the Internet.
During the following sequential process stages the key elements needed to realise the *shopping-mall* metaphor are established. These can be summarised as follows:

1 Find products: Our meta-search strategy is used to identify a large superset of products/pages that are semantically relevant to a users query - these are the initial set of candidate products. This first stage is realised by retrieving a seed set of URLs from a number of web indexes, for some given search topic. We then apply a ranking algorithm to this base set, followed by a threshold function. All further operations are restricted to dealing with a subset of these products.

2 Identify shops: From these candidate products, we identify products with the same location (web-site). Within this stage of the algorithm our key information groupings are identified using ranking functions based on the concepts that the URLs themselves contain valuable information in relation to the web site, i.e that they are pointing to and thereby identifying shops offering the most products (information).

3 Collect peer shoppers (that double as shops): Identify sellers who have also purchased a product from one of these shops. Every such purchase confers popularity upon that "shop" and also on its other products, from a peer-group of other Internet users.

4 Gather relevant products: Finally, collect all products due to the site-centric behaviour of Internet authors, we retrieve all other semantically relevant pages that are co-located with an identified shop. This often identifies collections of material that collectively forms a relevant resource.

Figure 4 Main entrance view of the Bill Clinton *Shopping-Mall*

DESKTOP VIRTUAL REALITY PRESENTATION LAYER

Virtual reality is the nearest tool available in mimicking real life by being able to display the abstract notations of a shopping-mall structure in a virtual three-dimensional environment. To bring this experience to the every day Internet user VR-Net uses VRML as its visualisation medium, rendering the scene in a traditional browser utilising a VRML plug-in. This desktop virtual reality paradigm allows the user interact with the scene, allowing 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. The virtual scenes created by VR-Net offer the full realisation of the shopping-mall metaphor. The user is initially placed at the start of a shopping corridor. From this starting point the user is faced with a prioritised set of shops. Each shop has a textural mapped thumbnail preview image to reinforce recognition of pages within the world. All relevant sources of information are displayed in the world, and their relations are clear by their spatial locations. Products are the golden multi-sided figures next to the shop, while the spheres stretched across the top of the shop represent the other shoppers who are also information suppliers.

NAVIGATION FRAMEWORK

To establish our navigation framework to aid the shopping-mall metaphor and realise the freedom needed to fully bind the user interaction with the desktop virtual reality, we leverage the internal metamodel as a cognitive map. Tversky [16] points out that "as mental constructs available to mental inspection, cognitive maps are presumed to be like real maps available to real inspection". It is through this approach we provide a set of focused view points of the shopping-mall to reflect a similar cognitive process that is under taken when a person is searching a map trying to find a given location. As with a user interaction with a geographical map the cognitive behaviour is similar. To assist the user with a similar set of tools available in the real world our framework provides a set of directional, view points to mimic the natural navigation tendencies.

VR-net supports both a *summary* and a *detailed* view of every shop. Initially, the user is presented with a summary view of all shops. This view uses simple groups of VRML primitives and prototypes, limited textures, and some text to allow speedy rendering of a large number of shops. This allows the user to see the entire world and to understand the relationship between the various shops' sites. On activation of a virtual world proximity sensor, in conjunction to the LOD node, extra information to that part of the scene is added. Details of shop members are now clearly visible, revealing each one with summary information of its contents.

Figure 4 Detailed view White House Information shop

A content view of each entity within the VRML scene can also be achieved by double-clicking on that entity. This renders the HTML in another browser window, thus allowing the user, if needed to return the detailed information contained within the native HTML format.

CONCLUSION

The current search and browse mode of Internet usage is riddled with acknowledged problems. We present the *shopping mall metaphor* that supports a cognitively aware solution to this problem, being founded on a simple metaphor. The metaphor seamlessly integrates search and visualisation processes, generating a shopping mall of information outlets. Regardless of the search topic, the metaphor identifies acknowledged information clusters, encompassing multiple web pages.

We describe the VR-Net tool that instantiates this metaphor, and uses it as a basis for developing a combined search and visualisation tool. It's meat-search engine identifies information shops, ordering them in terms of the number of popular products on offer. The resulting Virtual Reality mall is generated and passed to a VRML enabled browser. This integration of content and structural information within an environment supports a new mode of Internet interaction. VR-Net facilitates activities like, surveys of multiple pages, analyses of co-referencing between web-authors, and other context sensitive user tasks. Initial results from VR-Net are promising but further testing must be performed.

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