The Travails of Visually Impaired Web Travellers

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ABSTRACT
This paper proposes the inclusion of travel and mobility in the usability metrics of web design. Hypertext design and usability has traditionally concentrated upon navigation and/or orientation. The notion of travel extends navigation and orientation to include environment, mobility and the purpose of the travel task. The presence of travel aids are important for all users, but particularly so for those with a visual impairment. This paper presents the ground work for including travel into web design and usability metrics by presenting a framework for identifying travel objects and registering them as either cues to aid travel or obstacles that hinder travel for visually impaired users. The aim is to maximise cues and minimise obstacles to give high mobility as measured by the mobility index. This framework is based upon a model of real world travel by both sighted and visually impaired people, where travel objects are used for orientation, navigation, route planning and survey knowledge. Knowledge of the differences in travel between visually impaired and sighted people will enable the model to be used in assisting the design of better user agents and web content for visually impaired and other users.

KEYWORDS: visual impairment, navigation, usability, web, mobility, travel, hypertext

INTRODUCTION
Navigation of complex hypermedia environments, of which the web is the most obvious example, has long been considered a major issue in the hypermedia design and usability literature [McKnight91]. The potentially complex and difficult navigation task is further complicated if the user happens to be visually impaired, because the richness of visual navigational cues presented to a sighted user are not appropriate or accessible to a visually impaired user [Petrie97]. While there are a number of specialist browsers that support the *reading* task for visually impaired (VI) people [ZaicekPowell98, Chieko98], efforts have focused on supporting the 'sensory translation' of visual textual content to either audio or touch (through braille) rather than enhancing web *navigation* [Jones96].

To give some idea of the problem, consider the Internet Movie Database (IMDB) [IMDB] as an example of a classical, popular and well-organised commercial web site. An example of the site entry page is given in Figure 1. Sighted readers orientate themselves within the first five seconds[1] of the page being displayed.

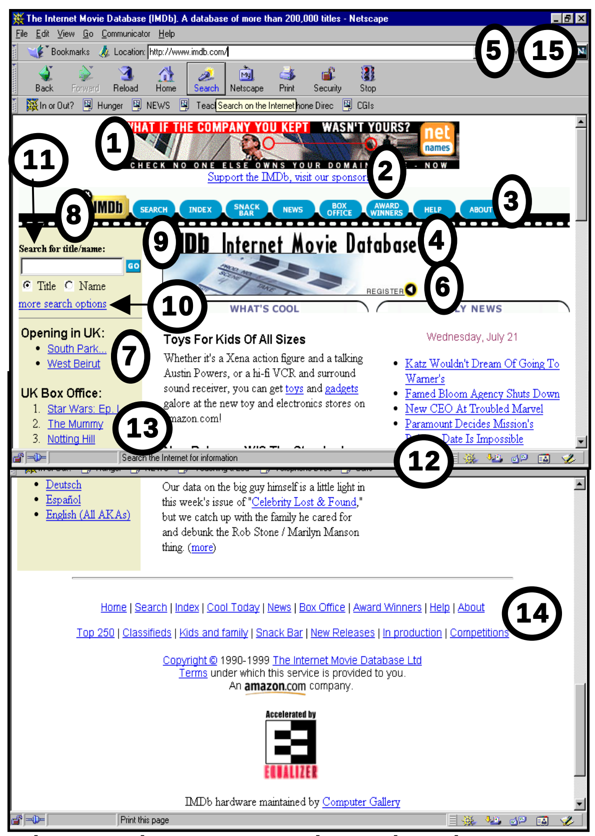

Figure 1: The Internet Movie Database home page.

support the imdb comma visit our sponsors period
[repeatedly until reader broke out of frame]
graphic 5; graphic 5; graphic 5; graphic 361; search

Figure 2: Figure 1 as rendered to a VI reader.

[1] From a requirements exercise conducted as part of this research

Imagine now that all you hear in those few seconds are the words in Figure 2. This is what an experienced VI person hears using Netscape and the Jaws screen reader. Pages are typically read from the top left to the bottom right, one word at a time. Only a small portion of the screen is viewable at any point. No overall picture is formed or maintained. All layout, style and font information is lost, and contextual information is easy to lose. No familiarity with layout and style is applicable, so every page is as if it has never been seen before.

The W3C Web Accessibility Initiative recognises these difficulties, tackling the issue from two directions: improving the overall design of web pages; and the recognition, appropriate interpretation and presentation of suitably marked-up pages by *user agents* [W3C99b]. User agents are defined as browsers and assistive technologies such as screen readers and braille displays that together interoperate to render the information to the user.

The web content accessibility guidelines [W3C99a] are presented in two themes of graceful transformation (of content, structure and presentation) and making content understandable and navigable. The first is mainly concerned with the supply of text alternatives and the correct use of markup, and is really oriented to the better support of sensory translation. Of the 14 guidelines, 11 are in this theme. The remaining three make some reference to more profound navigation and orientation issues, but an overall systematic analysis of how the users travel around pages is missing, and only two specific checkpoints attract a top priority. The guidelines for user agent accessibility emphasise system interoperability [W3C99b]. The navigation and orientation mechanisms are limited, although the overall vision of these mechanisms is good. The guidelines and priority balance suggest that there is more work to do on understanding how VI users really move around and between web pages.

A journey through the web can be likened to travel in the physical world; both involve moving from one place to another regardless of whether the destination is known at the start of travel, or if the journey is initially aimless [Cunliffe97]. In this context, a successful journey is one in which the desired location is easily reached and the purpose of the journey accomplished. However, travel is more than just navigation. Travelling also involves orientation, environment, purpose and mobility, the latter defined as the ability to move freely, easily and confidently when travelling. The web accessibility initiative alludes to mobility but it is not systematically addressed, burying it in a series of checklists and design features.

We think the notion of travel will increase the usability of the web for VI users and attempt to make mobility analysis systematic and replicable. In a requirements gathering exercise, we asked six visually impaired users and six sighted users, all of whom were experienced web users, to perform a series of travel tasks using the IMDB. Included within the task set was to read about the movie “Heart Beat”, which in turn requires finding it. Mobility is the ease with which a reader can: realise there is a search box and that this is the only means of navigating to this movie; navigate to a search dialog box; recognise the action to trigger a search; recognise that the new page has loaded (or not); orient oneself to a list of possible results; navigate to the correct page; orient oneself to it etc. The results showed a marked difference between the travel speed, and the efficiency and effectiveness of sighted users and VI users. It took a median time of 120 seconds (compared with 10 seconds for a sighted reader) for a VI user to realise a page had been loaded (by noticing that the hard disk drive or modem had stopped making noises, or manually probing of the application until a successful result is returned). Sixty percent of the VI users failed to label each area of the layout correctly or indeed at all. The requirements survey was not intended to be a rigorous scientific exercise, but rather to provide guidance. However, it does strongly suggest that movement within a page, from page-to-page and site-to-site, is difficult for VI users; a consequence of unsympathetic page and site design and user agents that do not support web mobility.

Navigation in hypermedia has previously been likened to movement through a physical space [Dillon93, Darken96]. There has been extensive work undertaken in the mobility of the visually impaired in the physical world, which we believe can be transferred and adapted to the web-based world. Our hypothesis is that travelling and mobility on the web mirrors travelling and mobility in the physical environment. We suggest that the hypermedia usability community has typically concentrated on navigation and/or orientation rather than the whole travel experience, and that this neglect is crucial when dealing with browsing by VI users.

In this paper we propose a model of physical travel, that is extended to a framework for assessing the mobility support given to visually impaired users of the web. This has been derived from physical world mobility frameworks, and by analysis of how VI people undertake travel on the web given current user agent technology. The components are:

- A *model* of travel based on a travel flow and the detection and identification of cues and obstacles. The model links travel *objects*, mobility *actions* on the objects and mobility *instruments* used to invoke the actions;
- *Inventories* of travel objects on web pages and mobility instruments offered by user agents;
- A classification of travel objects as either cues or obstacles;
- A *travel usability index* for simple comparisons between web pages, browsers and eventually web sites.

User centred design stresses the identification of the users and their needs, the usage of this information to develop a system that meets their needs, and the usability evaluation of the system [Catarci99]. By using this framework we will be able to: encode the needs of VI users for web travel; offer design guidelines for site and page developers, and the W3C; and drive requirements for new browsers for VI users. Our first application of the framework is to analyse the usability of current browsers, pages and sites for VI mobility.

The paper is organised as follows: section 2 describes travelling in the physical world, specifically from the point of view of VI people and thus provides a context for the framework. Section 3 describes the state of the art for travelling the web if you cannot see. Section 4 presents the web-mobility framework and applies it to a case study, the Internet Movie Database. We conclude with a discussion.

TRAVELLING IN THE PHYSICAL WORLD

Conventionally, physical mobility is separated into orientation and navigation [Brambring84], using three types of mental representation: landmarks, routes and surveys [Dillon93]. *Landmarks* are any features of the environment that are relatively stable and conspicuous. *Route knowledge* is the ability to navigate from A to B using landmark knowledge. *Survey knowledge* is the gestalt sense of a physical environment that allows an individual to visualise the environment in terms of an external map, enabling the traveller to give directions or plan journeys along routes they have not travelled or give relative locations of landmarks within an environment.

We extend this definition to define travel as confident navigation and orientation with purpose, ease and accuracy within an environment. ***Purpose*** could be specific, to seek a piece of information, or vague, to "wander about". ***Orientation*** is knowledge of the basic spatial relationships between objects within the environment, and the objects and the traveller [Bentzen95]. The term suggests a comprehension of objects that relate to travel within the environment. A person's orientation and intention requires information about position, direction, desired location, route, route planning etc. ***Navigation***, in contrast, suggests an ability to move within the local environment from point A to point B, either by the use of pre-planning using maps or fore knowledge, or by navigating 'on-the-fly'. ***Mobility*** is defined as the confident ease of movement within the environment and the *accuracy* of navigation. Mobility necessitates a knowledge of immediate objects and obstacles, of the formation of the ground (holes, stairs, flooring), and of dangers both moving and stationary for a successful travel experience. ***Environment*** is the context that the traveller travels through and includes the way the landscape is rendered and perceived.

Knowledge of how visually impaired people actually travel gives a context for their travel on the web. Visually impaired people travel a journey in a different way, using a number of different cues, to sighted people. Key points are highlighted as follows:

Information flow Physical travel aids perform a probing task such that a limited amount of preview and feedback is given [Brabyn82]. Sighted people navigate in physical space by ignoring details; people navigate a cluttered room by abstracting the clutter not by inspecting each obstruction. Too much feedback or complex information is not easily assimilated by non-visual means [Blenkhorn97]. Consequently, VI travellers use simpler information more frequently than complex information [Bentzen95].

Granularity VI travellers have limited preview of coming objects or obstacles (steps, kerbs, hedges, walls) and therefore the use of some type of preview device is important. Lack of a preview leads to body contacts with the environment. The stride length, walking speed and continuity of progress is diminished, and travel is taxing [Heyes83]. VI travellers orient themselves to a landmark about every 40 metres as opposed to 100 metres for sighted people [Brambring84]. The route is broken into a greater and more complex number of stages than when sighted people describe it, confirming the importance of a large number of fixed landmarks. Route descriptions are more complex and in finer detail, and obstacle information is more specific.

Egocentricity Many VI people have a tendency to think of the real world in a 'egocentric' manner, such that descriptions of distance and journey, route and survey knowledge, become associated with the traveller and not the environment [Dodds82]. For example, body rotation is used to describe parts of a journey, they use more temporal and egocentric terminology and less spatial and environmental terminology in defining points, and they make explicit statements on distance more often [Brambring84]. The specification of distance and direction is far more exacting. A sighted person may say "walk to pedestrian crossing and then continue on to the bank". A visually impaired person may say "walk 20 metres ahead [of me], then from the tactile surface walk 10 metres to the North West of that [my] position and you are at the Bank".

External memory and mental maps VI people have an increased use of cognitive or mental maps of route and survey knowledge. The use of hearing is increased and movement is focused on getting to a point rather than moving along an edge such as a kerb [Jansson84]. The mental maps created by visually impaired travellers have a tendency to be egocentric, exact, divided into smaller more manageable steps and with many more landmark points. VI travellers rely on a limited amount of external information to reach their destination [Dodds82].

Regularity and familiarity of environment VI people normally only travel independently in man-made urban environments with regular features, and would normally only travel unassisted in areas that were familiar to them [Jansson84, Brambring84]. As with preview, this is an issue of predictability.

Spatial awareness Visual impairment varies between individuals. Many congenitally VI people find it difficult to track their position against spatial information although there is no significant loss of mobility. The adventitiously VI, who had previous visual experience, are better at decoding spatial information. This has obvious implications on the usefulness of pre-planning devices, such as tactile maps [Dodds82].

MOBILITY AND THE WEB

Drawing parallels with the physical world can successfully yield insights into interface usability of a virtual world [Dillon97, Darken96]. Although the ultimate purpose of interacting with a hypertext document is not to get to the right paragraph but to read the paragraph, the user is required to *reach* the information before it can be comprehended. Here we are concerned with the pragmatics of easily travelling around the environment and to the information in order that it can be assimilated. There has been extensive work on the usability of hypermedia (e.g. [Garzotto97]), sometimes using the physical world as a model [Dillon97, Darken96]. Unsurprisingly, the focus is on sighted users. Web usability studies have found that organisation of content and navigation paths are the most important factors [Nielson99, Spool97], followed by link effectiveness, link differentiation and destination prediction. This usability research tantalisingly touches on mobility but conflates it with navigation, in the same way that utility is conflated with usability [Dillon97]: just because it is possible to navigate does not mean that it is easy or obvious to do so. Well-organised content is only of benefit if the reader is able to move around it with accuracy and agility, and be able to discover and absorb its organisation quickly.

The systematic hypermedia evaluation methodology, SUE [Garzotto97], includes *accessibility* (how easy it is for users to locate information) and *orientation* (a user's understanding of their current location and their own movements, and a user's grasp of their current navigation context) amongst its efficiency measures. However, accessibility concentrates on navigational richness and link completeness rather than mobility, assuming that the user can easily travel within the web site or page. SUE ignores presentation, and orientation presumes a speed of information assimulation unavailable to unsighted users. Although targeted at novice users, SUE's learnability measures apply directly to non-novice VI users. Criteria include consistency (both structural and dynamic) and predictability, where predictability is focused on the user being able to identify the meaning of a structure or foresee the results of an interaction. This is unsurprising as the VI reader is required to relearn afresh the page as it is presented, as if they have never seen it before.

Part of our work is encoding and encapsulating the set of assumptions, information or preconceptions a visually impaired user has, or the "user's knowledge conformance" [Garzotto97].

The Web Environment for the VI User

The environment is a strong influence on how mobile a traveller can be. The web landscape is defined in terms of the page and the user agent. The user agent is the combination of the browser and the device used to present information in an appropriate sensory form. Two different user agents will render two different environments for the same page. The user agents take two approaches:

- *Screen scraping* with conventional browsers such as Netscape or Internet Explorer. The text on the screen is read out word by word, line by line, starting at the top left and ending at the bottom right of a page. The potential functional utility of Netscape or IE is there but interaction with the HTML is lost.
- Using *specialist browsers* such as BrookesTalk [ZaicekPowell98] or The IBM Home Page Reader [Chieko98]. These make more use of the HTML, for example using headings to form an index to the page, or stripping out frames. However, many lack many features found in IE or Netscape simply because there is less programmer support for these tools.

Screen scraping is a sensory translation activity. It does nothing to support travel or mobility. Surprisingly, specialist browsers also tend to concentrate on sensory translation. While some systems do try and address other aspects of web interaction, few pay much attention to topics that are not directly related to making content audible. Mobility attracts only superficial attention and only for inter-page and site navigation. Little attention is paid to mobility within a page.

Travelling in the Virtual World

Below we parallel the observations made in the physical world:

Information flow is slower as listening to text is slower than scanning it visually. The "viewport" through a synthesised speaking device renders a small "point of regard" (the content currently available in the viewport) [W3C99b]. Sighted users do not read web pages, they scan them [Neilsen99] whereas, by default, VI users may have to listen to the whole text or undertake time consuming cursor based exploration of a window. The sensory translation of content gives all the words, making it difficult to abstract from the detail to visualise the overall picture. The presentation of the entire page as the result of a probing a link may be too much information, especially as the reader must wait for the whole page to be built before it can be rejected. The presentation of just the hyperlink may be too little.

Granularity. Environmental cue availability is the strongest influence on user behaviour [Darken96]. VI users make heavier, constant and more explicit use of environmental cues such as landmarks, paths, borders and boundaries, and need to be explicitly warned of obstacles. They continually probe to reassure themselves that they are where they think they are. The web world also has a strong dynamic element, as the landscapes change through alerts and active elements: for example the rotating browser icons cues that the browser is loading; the status messages dynamically indicate whether contact is being made with a server; and progress bars are cues that something is happening (or not). These "what is going on" environmental cues monitoring change are in contrast to the more static "where am I" and "where can I go next" environmental landmarks.

External memory is under-used. The slowness of accessing external memory sources such as history lists or site maps, means that less reliance is made on them than by sighted users. VI travellers use ***mental maps*** built through exploration, but models built by breadth-first algorithms require agile interactions with the page/site. VI users' exploration efficiency and effectiveness is seriously impaired, probing is difficult and slow, and reactions are slower because feedback is slower. Navigation and orientation takes longer and have to be explicitly explored. Passive cues such as link colour changes, to tell what parts of the site they have already visited, are usually invisible. Sighted users mostly prefer to explore the site until they find what they want or give up in the attempt, rather than build mental models [Nielsen99].

Spatial information is difficult to rely on, and even if a VI user can assimulate and comprehend it, it is difficult to convey it technically.

Regularity, *and* ***familiarity***, of structures, behaviour and user control, are important parts of predictability [Garzotto97]; the lack of mobility, speedy interactivity and rapid assimilation afforded to VI users mean that they cannot waste their time probing visual spaces for exceptions and differences. Sighted users are familiar with canonical navigation elements such as home-page site logos in the upper left corner [Neilsen99]. Few of these support devices are readily accessible to the VI, as they commonly use graphics. They often echo standard layouts derived from magazines, found in the sighted world's information grammar but not the world of VI people. There is less notion of layout in braille. Our VI users expressed surprise that sighted users had no trouble with interpreting terms such as 'banner' on the IMDB. Spawned windows or scripts that completely alter the users' focus and unexpectedly change the traveller's environment are particularly unwelcome.

Egocentricity Intuitively, the egocentric viewpoint of a VI traveller suggests that an unmodified direct translation of a sighted way of orienting and navigating may be inappropriate. For example, distance measures for how far the reader is from a point or how far they have travelled may have to be re-couched.

In summary, the reduced speed, diminished accuracy and limited control of information flow hampers the efficiency of the VI reader.

A MODEL OF TRAVEL

The application of a physical travelling metaphor to moving around the web requires a model of travel. To reassure themselves that they are safe to proceed and going the right way, the traveller uses landmarks and memory objects (summarised in table 1). The classifications are dynamic and can overlap. A landmark may be classified as a waypoint at a distance and additionally as an information point on closer inspection. An information point is both a memory object and a landmark. The traveller navigates and orientates by consulting memory objects, and detecting and identifying landmarks (summarised in table 2). Consultation, detection and identification are accomplished through the mobility instruments of in-journey guidance, previews, probes and feedback (summarised in table 3).

An obstacle is an object that either directly or indirectly obstructs the progress of a traveller to a specific destination. A cue is defined as an object, or series of objects in combination, that orientates and encourages onward navigation. An object that neither obstructs, nor encourages, progress is neutral. The travel objects potentially play the role of cue or obstacle. All detectable landmarks and memory objects are potential orientation cues; non-detectable ones are neutral. Those landmarks that encourage onward navigation are cues but those that hinder are obstacles. Memory objects that are easily accessible and assimilated are cues and those that are not are obstacles.

Figure 3 assembles these components into a model of travel. Explicitly defining travel in either the physical or virtual world is a difficult task. The difficulty is one of multiple granularities and dynamic perspective. A purpose may range from "acquire this knowledge" through "survey this page" to "read this word". A journey can be made up of a number of deeply nested sub-journeys of diminishing granularity. As in [Brambring84], our travel task is a series of interrelated tasks, but we emphasise the flow of the tasks. A journey is nested. At its finest granularity it is the simple navigation between two landmarks; we could term this a track. Travellers must keep on track until the next landmark point is achieved. The track may be bending or have a number of turns; if the next point is missed, the traveller goes astray.

Whether a travel object is a cue or an obstacle depends on the combination of all of the following five things:

1. The current travel *purpose*; for example information seeking, surveying, orientation, and navigation. For a VI user, a graphic is an obstacle in the context of information searching but a cue in the context of orientation.

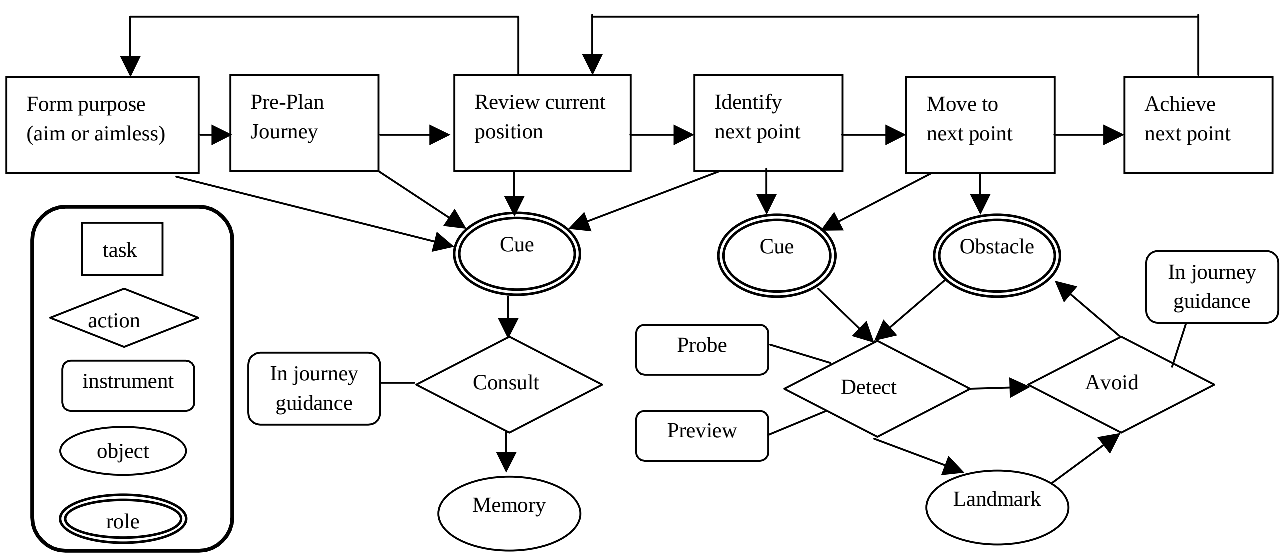

Figure 3: A flow-based travel model

2. The *user*. A lamp post may be a cue to a sighted person but an obstacle to a visually impaired person; the same obstacle may become a cue for a visually impaired person after the route has been traversed a number of times.

3. The *presentation form*. Graphics without ALT or description tags are unprobeable regardless of the browser. The confusing use of non-standard link colours on the web transforms the cue to an obstacle [Nielsen99];

4. The *timeliness* of access and feedback. A lamp post is detected if a VI traveller walks into it. Obstacles in particular should be detected before they become a nuisance, and cues should be presented as quickly as possible, otherwise frustration leads to inappropriate and inaccurate travelling;

5. The *user agent*. If the rendering environment only screen scrapes, graphics are invisible to the reader.

Mobility depends on the speed, accuracy and control of mobility instruments in order to successfully spot and use landmarks, and to find and easily interact with memory objects -- getting appropriate travel objects when you need them and when you want them. The rendering treatment of certain presentation types means that some explicit navigation landmarks are rendered invisible. Sometimes this means that they are simply no longer cues, but do not hinder progress. Sometimes, however, this is much more harmful. For example, a graphics-based site map that is the only form of travelling around the site means travel is impossible. A browser that cannot deal with frames limits travel around a frame-heavy page.

A Mobility Evaluation Framework

The design intention is to have no objects that are obstacles and a larger number of objects that are cues, by recognising and transforming obstacles to become cues. The cues and obstacles should be provided in an appropriate manner, giving explicit orientation information such that navigational information can be detected in a timely manner. In the physical world this is accomplished explicitly using tactile surfaces or by the use of traditional mobility aids and the placement of specific electronic devices known as 'waypoint' markers [Blenkhorn97]. The provision of some form of explicit, appropriate, orientation method such as waypoint devices is desirable. This would mean that a user can make a choice as to whether they want to be at the current location and if not how to best attempt to get to their perceived destination [Petrie97]. The two key questions to address in order to evaluate web mobility are:

1. Does the rendering environment give the instruments to find and use travel objects accurately and quickly?

2. Does the web page have the travel objects if the instruments existed to find and use them?

<table>
<tr><th></th><th>Object</th><th>Description</th><th>Physical</th><th>Web</th><th></th></tr>
<tr><td></td><td>Memory (M)</td><td>An external memory aid to supplement internal memory.</td><td>Route plan.</td><td>History list.</td><td rowspan="4">Memory</td></tr>
<tr><td rowspan="5">Landmark</td><td>Alert (A)</td><td>Alerts the traveller to a change in the environment or control of the journey</td><td>Traffic light</td><td>Download progress</td></tr>
<tr><td>Information point (IP)</td><td>A mechanism that allows access to memory information within a journey.</td><td>Street map.</td><td>Web site map hyperlink to a history list.</td></tr>
<tr><td>Identification point (ID)</td><td>Bears identification information</td><td>Sign</td><td>Frame title</td></tr>
<tr><td>Way point (WP)</td><td>A landmark within a journey at which a choice may be made that directly facilitates onward movement.</td><td>Road junction.</td><td>Menu item.</td><td></td></tr>
<tr><td>Way edge (WE)</td><td>A landmark similar to a waypoint but a continuous or large-scale object followed until it ends or some other factor or object is met.</td><td>A wall or pavement.</td><td>A guided tour or text border.</td><td></td></tr>
</table>

Table 1. Travel Objects

Action	Description
Consulting and reviewing	Consult internal and external memory objects, in-journey guidance systems, surveys, paths and trails blazed. Requires knowledge of an end goal [Blenkhorn94].
Landmark detection, recognition and avoidance	Accurate cue/obstacle recognition, obstacle avoidance planning and circumnavigation based on orientation knowledge and knowledge of an end goal [Gollege91].

Table 2. Mobility Actions

Instrument	Description	Web example
In-journey guidance	Ask for directions; refer to a memory object	Summaries, paths
Previewing	Identify objects; classify as obstacles or cues; predict destinations	Front loading
Probing	Choose objects to investigate; identify objects; classify as obstacles or cues	Jump between headings
Feedback	Return limited levels of detail rapidly and appropriately	Read alternative text

Table 3: Mobility instruments

The *combined* results of these two questions tell us first whether appropriate travel objects exist and second, whether each landmark and memory object is a cue or obstacle. A framework for systematically asking and logging these questions is required.

Probing the Presentations

User agent accessibility of a travel object depends on the presentation form of that object and instruments available to interact with the presentation form:

Presentation form. Typically, web-based presentation forms are visual: icons, layouts, cursor shapes, feints, maps, status bars, frames, banners, coloured hotlinks, search dialogue boxes and radio buttons. Most of these are difficult to find and interact with, or just plain invisible to VI users. A typical example is the use of graphics as menu options as in the tabs in Figure 1, interpreted by user agents as a series of graphics not as a logical menu, as in Figure 2. An inventory of some of the common presentation forms, the objects they are typically used to render and their potential as cue or obstacle for VI users is given in Table 4. Those forms indicated as obstacles should be supplied with an alternative interpretable by appropriate user agents.

Instruments. Some inaccessible presentation forms of table 4, for example graphic items with 'ALT' tags or form elements linked to a 'LABEL' tag, could be interpreted by an appropriate user agent depending on the instruments provided by the user agent to support mobility actions. Table 5 gives some instruments available to the IBM Home Page Reader. This specialist browser is the best of breed regarding the support of navigation, others, for example BrookesTalk, concentrate on summarising pages. This is essential for previewing a page, of course, but a page is only successfully summarised if landmarks such as waypoints and information points can be identified.

The travel objects

Travel objects are supplied by the page design and the browser. A hyperlink menu is a landmark that acts as both a way point and a memory object designed into the web page. A back button is a way point provided by the browser. They are both objects in the environment. In this paper we only present an inventory of the travel objects on a page, specifically the home page of the IMDB. At an extreme view potentially every single thing on the screen is a landmark to a VI reader, right down to letter serif or word. We consider only those objects we perceive as intended to be travel objects by the page or site designer. For each object we ask these questions:

- What presentation form does it take?
- Is it in the immediate port of rendering (field of view) or does it require some travelling to find?
- What is the intended function of the object?
- Does the user agent have the instruments to identify and present it?
- If it is a landmark, can it be probed or previewed?
- If it is a memory object, can it be identified and consulted at any point during travel?

Table 6 shows an analysis of the IMDB page of Figure 1. The navigation bar (3) is a site map with many roles. As an information point, can I probe for the options? As a way point can I probe and preview each map item? As a memory object can I be reminded of the site at any point in my journey around the page? A site map is a good travel object, however, if it is rendered graphically (e.g. 3) then its contents cannot be deciphered by a visually impaired person or it is only seen at the end of a three page scroll (e.g. 14) it is invisible.

The two browsers used are Netscape and the IBM Home Reader. The IBM browser has the instruments to cope with graphic items with built-in a 'ALT' tag and form elements linked to a 'LABEL' tag. If the feedback was text, this was read to the user. Otherwise the feedback was silent or announced the presentation type of the object.

The IMDB is a particularly bad design as no alternatives to the graphics are given, no description tags are included and none of the headings, menus, searches are labelled as such. The text site index is positioned at the bottom of the page, which requires a considerable scroll, especially as the page is much larger than the screen. The results of the two browsers were the same except that the IBM browser made explicit use of the title tag.

Table 7 accumulates the evidence, giving each travel object a decision as to its cue or obstacle status for VI users and sighted users. If the object is rendered in a form that, given the available instruments, it is able to fulfill its intended role, it is a cue. If not, it is an obstacle. For the IMDB, practically every page travel object intended to be a cue is an obstacle or serves no role.

A mobility index

The mobility index (MI) is intended to enable comparisons between browser and page combinations. Such measures give a rough guide as to how closely the features of a Web page match generally accepted usability [Keevil98]. The web object inventory exercise is performed on objects on the page and those provided by the browser. The cues, obstacles and neutrals are summed up and form a triple. The two triples are merged to enable a point to be plotted such that the relationships between sighted and visually impaired browsers can be easily shown. The Best Travel Target is defined as having no travel diminishing objects, and instruments for all travel objects such that they become explicit cues. Consequently, a best travel target should be formulated to enable a comparison between the MI for a combination of browser and page and the best travel target that can be expected for that specific combination.

DISCUSSION

This paper has introduced the notion of travel into web design and usability metrics. We have related travel in the virtual, web world to that in the real, physical world. The paper describes initial work on using travel to evaluate web pages and user agents. Work needs to be done to extend the framework to encompass more systematically purpose, and account for current focus of activity. We also need to more closely relate the work to hypertext usability frameworks, such as SUE, extending their notion of context observability for example.

Presentation	Used for	Role	Remarks
Menu	IP, ID	Cue	Using the menu tags this can be a cue to other navigation possibilities.
Titles (page, frame)	ID	Cue	Gives orientation information.
Title banners	ID	Ob	Image.
Headings	ID, WP	Cue	Heading tags can be used for generating preview lists, summarising and heading-based navigation.
Text Heading	ID, WP	Ob	There is no definition of this being a heading. Just bold text surrounded by other text.
Hyperlink	WP, IP	Cue	Navigation point to another page or part of page; also a means to access a memory object such as a history list.
Hyperlink menu	WP, M	Ob	List of hyperlinks meant to represent a menu. No other information about its properties etc. Recognised as a menu because it visibly looks like one.
Hyperlink feints	WP, M	Ob	Potential way points that are temporarily inaccessible. Pre-supposes knowledge of the surrounding document structure that may or may not be available. Otherwise it's just a bit of differently coloured text.
Hyperlink colours	IP, WP, M	Ob	Colour used to convey hot links or visited links; semantics difficult to surmise from colour alone and invisible.
Image Maps	IP, WP, M	Ob	A graphic. The active elements of the map are way points.
Text Maps	IP, WP, M	Cue	A textual overview is accessible to all if it is explicitly indicated.
Ordered lists	WP, IP, WE, M	Cue	Perceive the same ordered list of maybe navigational items repeatedly and it becomes a cue. Other lists include bookmarks, history lists.
Image Buttons	WP	Ob	A graphic.
Radio Buttons	IP	Ob	A graphic that indicates criteria that influence a navigation.
Layout tables	M, layout	Ob	No real navigational information for tables is present. A problem for columns and actual tables. Worse with columns and when used for screen layout as no headings or captions or descriptions are used.
Adjacent frames	M, layout	Ob	Similar to tables. Even if a browser loads the frames in order their spatial position conveys a great deal of information, e.g., menus on the left, content in the middle.
Colour boundaries	M, WE	Ob	Colours used to partition a layout are invisible.
Line boundaries	M, WE	Ob	Images used to partition a layout are invisible.
Prop'nal scrollbars	WE	Ob	A distance measure indicating how much has been read and how much further to go.
Pop-ups & spawns	Alert	Ob	Environmental change and focus shifts.
Script execution	Alert	Ob	Environmental change and focus shifts.
Animations	Alert	Ob	Moving images are invisible. Cursor shape changes, progress indicators.

Table 4: Presentation Inventory

Instrument type	Instance
In-journey guidance	Self-voicing installation; Bookmark titles; Browser History list;
Previewing	Page summary; Heading lists table of content;
Probing	Numeric Pad navigation; 'Where Am I' commands; Sequential navigation (i.e. previous, current, next); Table navigation keys; Jump between headings to navigate hierarchically
Feedback	Clear and fast page reading; Alternative text reading;

Table 5: Partial instruments inventory for IBM Home Page Reader

	Object	Presentation	View	M	ID	IP	A	WP	WE	Preview	Probe	Guidance	Feedb'k
1	Ad banner	Image/animation				✓	✓			✗	✗		graphic
2	Sponsor link	Hyperlink				✓		✓		✓	✓		text
3	Navigation bar	Image menu		✓		✓		✓		✗	✗	✗	graphic
4	Title banner	Image			✓	✓				✗	✗		graphic
5	Title tag	Text			✓	✓				✗ ✓	✗		text
6	Registration	Image button						✓		✗	✗		graphic
7	Contents list	Hyperlink menu				✓		✓		✗	✗	✗	text
8	Search box	Form						✓			✗	✗	edit box
9	Go	Image button						✓		✗	✗		graphic
10	Search choices	Radio button		✓				✓		✗	✗		none
11	Expand search	Hyperlink				✓				✓	✓		text
12	Layout	Table	✗	✓					✓	✗	✗		none
13	Contents Sublist	Hyperlink menu				✓		✓		✗	✗		text
14	Site Index	Hyperlink menu	✗	✓		✓		✓		✗	✗	✗	text
15	Tour	Image button	✗							✗	✗	✓	none

Table 6: Travel Object Inventory for Figure 1

	Object	Presentation	View	Sighted Cue	Sighted Ob	Sighted Neut	VI (Netscape) Cue	VI (Netscape) Ob	VI (Netscape) Neut	VI (IBM Reader) Cue	VI (IBM Reader) Ob	VI (IBM Reader) Neut
1	Ad banner	Image & animation		✔				✔			✔	
2	Sponsor link	Hyperlink		✔			✔			✔		
3	Navigation bar	Image menu		✔				✔			✔	
4	Title banner	Image		✔				✔			✔	
5	Title tag	Text		✔					✔	✔		
6	Registration	Image button		✔				✔			✔	
7	Contents list	Hyperlink menu		✔				✔			✔	
8	Search box	Form		✔				✔			✔	
9	Go	Image button		✔				✔			✔	
10	Search choices	Image radio button		✔			✔			✔		
11	Expand search	Hyperlink		✔				✔			✔	
12	Layout	Table	✗	✔				✔			✔	
13	Contents Sublist	Hyperlink menu		✔				✔			✔	
14	Site Index	Hyperlink menu	✗		✔			✔			✔	
15	Tour	Image button	✗		✔			✔			✔	
	Totals			13	2	0	2	12	1	3	12	0

Table 7: A cue and obstacle inventory for Figure 1

[Spool97] classify web usability into site level and page level, failing to include browser capability. So far, we have only used travel to assess the mobility of VI users around web pages with different user agents, although we believe that it is straightforward to extend its application to sites. We have initially concentrated on sites that can be interpreted as views on databases [Atzeni97] that are examples of dynamic content delivery using templates. We do not anticipate any major difficulties in applying the framework to web sites that take a more document based perspective. In order to test the repeatability of the framework, and its applicability to a range of site types, we are currently conducting an experiment where twenty-one different web users examine seven sites. The sites are classified on two dimensions: whether their content is generated dynamically or statically, and whether they are a database view or are document based.

Nevertheless, despite these shortcomings, we believe the work is timely and useful. The framework should aid the identification of obstacles that diminish mobility, and cues that support it, with the purpose of transforming obstacles to cues. It also gives some indication as to the quality of sites for unsighted mobility.

We next plan to use the same model to aid the design of travel objects in web content, providing design guidelines for site and page developers. However, our chief goal is the design of appropriate travel instruments within user agents, so travel objects can perform their roles. Such instruments would assist in the transformation of obstacles to cues, and actively support travel, rather than only navigation or content rendering. The instruments and their combination and interaction should support:

Granularity - are there enough cues, are they close enough together and can I find them?

Memory - can I access memory appropriately and effortlessly at any point in a journey?

Spatial – can spatial metaphors be reformulated into a non-spatial representation?

Regularity – are travel objects deployed in a regular manner and can this be recognised and exploited?

Information flow - is feedback fast, appropriate and not too detailed but detailed enough?

Egocentricity – is feedback and guidance in terms of where I am and my current focus?

The WAI propose a long and difficult validation process for inclusive web page and site design. Whilst validation by experienced human users will not be made redundant, the use of a mobility framework should reduce both the time and the craft content of validating designs for their travel aids. The WAI particularly promote the appropriate and extensive use of mark-up. We envisage the use of XML and XSL to include travel in web content and user agents. XML should encode the travel objects in a DTD, so objects within web content know their travel role. XSL would tell a user agent how to present travel objects. But this is no panacea, it merely enables the user agents to identify and classify objects more easily and less speculatively. The IMDB had many travel objects few of which were cues because mark-up was misused. In such a situation, user agents would be obliged to deduce the presence and identification of objects, infer their role, and choose an instrument to access and use them, through examination of the pages, site and travel process. This is difficult, and so it is better to explicitly incorporate travel into design and hypertext design methodologies.

The main aim is to improve the mobility of VI users around the web. However, the work is applicable to all users who are visually impaired by circumstances at some point during their use of web material, for example, by reduced display area [Jones96]. The model of real world travel can accommodate that of both sighted and visually impaired people and an opportunity exists to design for all, whilst using the same design framework.

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