A Foundation for Tool Based Mobility Support for Visually Impaired Web Users

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ABSTRACT

Users make journeys through the Web. Web travel encompasses the tasks of orientation and navigation, the environment and the purpose of the journey. The ease of travel, its mobility, varies from page to page and site to site. For visually impaired users, in particular, mobility is reduced; the objects that support travel are inaccessible or missing altogether. Web development tools need to include support to increase mobility. We present a framework for finding and classifying travel objects within Web pages. The evaluation carried out has shown that this framework supports a systematic and consistent method for assessing travel upon the Web. We propose that such a framework can provide the foundation for a semi-automated tool for the support of travel upon the Web.

Categories and Subject Descriptors

H.1.2 [**Models and Principles**]: User/ Machine Systems—*human factors, human information processing*; H.5.4 [**Information Interfaces and Presentation**]: Hypertext/ Hypermedia—*user issues, navigation*; K.4.2 [**Computers and Society**]: Social Issues—*assistive technologies for persons with disabilities*

General Terms

Human Factors, Experimentation

Keywords

Travel, mobility, visual impairment, travel objects, mobility support tool.

1. INTRODUCTION

This paper presents a description and evaluation of a framework that enables the analysis of travel support offered by Web pages. This travel analysis framework will provide the basis of a tool that encapsulates a technique for the support of travel upon the Web.

Harper [11] introduced the notion of travel and mobility on the Web to improve the accessibility of Web pages for visually impaired and other travellers by drawing an analogy between virtual travel and travel in the physical world. **Travel** is defined as the confident **navigation** and **orientation** with **purpose**, ease and accuracy within an **environment**, that is to say, the notion of travel extends navigation and orientation to include environment, mobility and purpose of the journey. **Navigation** suggests an opportunity of movement within the local environment. **Orientation** is the knowledge of the basic spatial relationships between objects within the environment, and the objects and the traveller. **Mobility** is the ease and confidence at which travel can be accomplished. **Environment** is the context in which the traveller journeys through and includes the way the landscape is rendered and perceived [9]. **Travel objects** are environmental elements that are used during a journey; in the Web, they are supplied by the page design and the browser.

Visually impaired people have difficulties accessing the Web, either because of the inappropriately designed Web pages or the insufficiency of the currently available technologies. This lack of accessibility leads to poor travel support for visually impaired users. Visually impaired people usually access the Web, by using screen readers [13] or specialist browsers [2]. For these access technologies to work properly, Web pages must be appropriately designed and must be encoded in valid HTML that conforms to its DTD (Document Type Definition) and various accessibility guidelines. The W3C Web Accessibility Initiative and others, recognise these difficulties and provide guidelines to promote accessibility on the Web [5, 10]. Unfortunately, not many pages are so designed. Additionally, these access technologies have focused on supporting the sensory translation of visual content to either audio or touch (through braille) rather than deeply affecting travel on the Web [12].

Our main goal is to provide tool support for enhancing travel on the Web – moving the travel component from a craft towards an engineering paradigm. The aim of this tool is to analyse the travel support offered within a Web page and semi-automate the process of:

1. Extracting travel objects;
2. Discovering their roles;
3. Annotating the extracted objects;
4. Transforming the page.

Before we can devise such a tool that encapsulates the components above, we need to capture the travel analysis process in a framework. Although Harper [11] has proposed a mobility analysis framework, the focus is on providing a mobility rating which shows the mobility support of the page being analysed. In practice, this framework proved to be inappropriate and insufficiently detailed to be the basis of our tool. Although it is a useful start, the framework needed to be modified and extended as it is intended to be used by

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designers. Consequently, it is 'craft based' and requires to be systematised so that it could be encoded into a semi-automated tool. In this paper, we will explain the extended and modified framework. The travel analysis framework consists of the following two stages:

1. Inspecting a Web page in order to create a travel object inventory;

2. Classifying each travel object in the inventory according to the role it plays in the travel process.

These stages capture the first two components of our tool. Figure 1 illustrates the proposed architecture. The travel analysis framework will be the core for the development of other two components. They will be built upon the implementation of the framework. The proposed tool is described as 'semi-automated', because it is intended that the analysis framework, when captured within the tool, can extract and classify travel objects with no human intervention. This will, in all likelihood, be sub-optimal. The automatic extraction will often form the basis for human intervention to optimise selection of travel objects and their classification. Therefore, the framework developed must be usable both by humans and machines.

Automatic implementation will be based on heuristics, derived from the framework, that will enable identifying and classifying travel objects. The intervention will be the manual implementation of the framework by an analyst. This could be needed because:

1. Travel analysis is a subjective process, therefore cannot be fully automated to give as high-quality results as human analysis.

2. An automatic tool cannot wholly identify the layout of the information, the navigation structure, the value of information and various aesthetic aspects.

3. An analyst can deal with visual effects and add further description to original content.

This paper also presents the evaluations of the framework. They were conducted to test the systematic notion of the framework. We tried to demonstrate that the travel analysis process in the framework can be applied automatically as well as manually.

This paper is structured as follows: Section 2 describes the extended and modified model of real world travel and the travel analysis framework. Section 3 explains the evaluation of the framework. Finally, Section 4 offers some conclusions and suggests some future steps to be taken.

2. TRAVEL OBJECTS

Travellers use or may need to use environmental features or elements in order to make a successful journey. We call these features and elements *travel objects*. Travellers use landmarks and memory objects to reassure themselves that they are safe to proceed and going the right way. Landmarks and memory are two main classes of travel objects, and these classes also include sub-classes which are as follows [9]:

- *Landmarks*: Alert, information point, identification point, way point and way edge.

- *Memory*: Memory, alert, information point and identification point.

These classifications are dynamic and can overlap. An identification point is both a landmark and a memory object. A landmark may be classified as an information point and a way point on closer inspection. This classification depends on the context of the travel. The traveller navigates and orientates by consulting memory objects, and detecting and identifying landmarks. Consultation, detection and identification are accomplished through the mobility instruments of in-journey guidance, previews, probes and feedbacks. These components form the model of real world travel [9].

Our mobility support tool will encapsulate this model of travel. Fundamentally, the encapsulated process will be based on extracting travel objects from the environment in which travel takes place – a Web page. Therefore, before we can extract them, we must identify such objects and specify their characteristics. These have to be in detail and must reflect the key environmental features used by travellers. This means modifying and extending [9]. The extensions and modifications lead to have three broad categories of travel objects: (1) way points, (2) orientation and (3) travel assistants. These broad categories also include sub-classes and in the following sections, we will explain them in detail. The inventory of travel objects and characteristics can be used as the basis for the heuristics that will enable the classification of travel objects. These heuristics will be encoded in the tool.

Research on the mobility of visually impaired people in the physical world, wayfinding, spatial orientation, urban and architectural design suggest that visually impaired or sighted travellers use a variety of sources of information during a journey [17, 19]. We will here highlight the key travel objects and their characteristics. Table 1 shows these objects and examples from the real and Web world.

2.1 Way Points

These are the points within a journey at which a decision may be made that directly facilitates onward movement. Below, we explain the sub-classes of way points (see Table 1), however other classifications may also be considered as way points depending on the journey undertaken:

Decision Points are the choice points where alternative paths of travel are possible. Travellers recall the direction they must travel to reach their destination and they change their direction of travel if necessary [16]. At decision points people have to choose from different paths.

Way Edges are the environmental elements that are linear or continuous and act as boundaries between two areas [17]. Visually impaired travellers, during a journey, usually make exclusive references to these elements in the environment [8].

Navigation Points provide a possible route and the traveller exercises some control by choosing to follow or not to follow it. They can be considered as decision points in wayfinding, but the traveller is not choosing from a set of options; the traveller needs to decide to follow or not to follow it. They relate directly to the *paths* that are defined as channels along which people potentially move [17].

Reference Points or Landmarks are some aspects of the environment that are unique and memorable [17]. They are defined as the most salient cues in any environment [6] and are conceptually and perceptually distinct locations [15].

Increased usage of landmarks or reference points is one of the strategies used by visually impaired people to travel efficiently in their homes and communities [16]. Landmarks have to communicate some specific, identifiable features [20]. They may be primarily physical objects, but they can be sounds, odours, temperature or tactual stimuli [4, 16, 20].

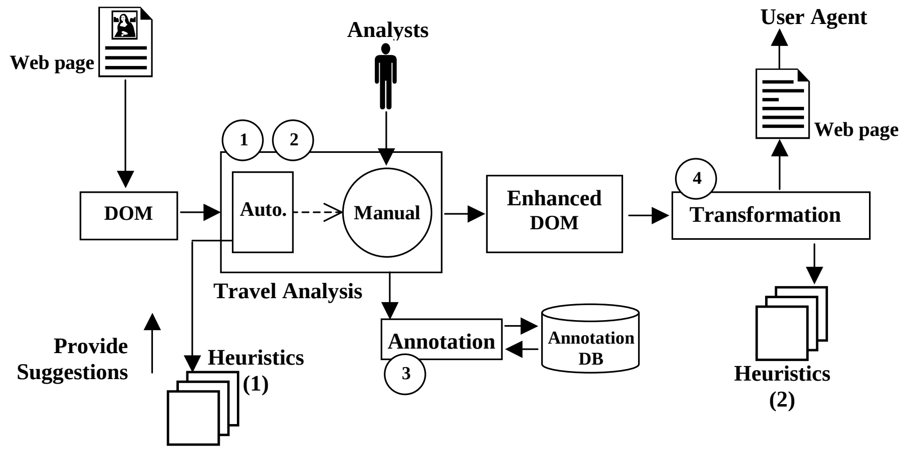

Figure 1: The proposed architecture of the mobility support tool.

	Role	Real World	Web	
Way Points	**Decision Points (DP)**	Junction, corridor intersections.	Menu, check boxes, and combo box.	
	Way Edge (WE)	Wall, shorelines, hedges, fences, cliffs, railroad tracks [17], edge of lawns.	Colour boundaries, frame borders.	
	Navigation Points (NP)	Streets, walkways, canals, railroad [17], corridors and some examples specific to buildings: stairs, escalators, elevators [19].	Hyperlinks, mail to, search box.	
	Identification Points (ID)	Building name, house number, street name, campus entrance identification, floor number.	Heading, title, URL, frame title.	
	Alert (AL)	Traffic lights, signs that identify hazards, bridges, stops, and curves.	Progress bar, a search field icon can change the color and appearance to indicate that the search is in progress, displaying or animating an hour glass.	
	Attention (AT)	Advertisements.	Animation, advertisement, banner.	
	Reference Points (RP)	Big Ben, Precinct centre bridge on Oxford road [19], sculptures, structural or decorative elements, information booths, and etc.	Logo, title banner, some aspect of the style.	Orientation
	Location & Position (LP)	”You are here” signs, signs that show the current position, reassurance signs on the motorway.	Hyperlink menus highlight the active page, some sites show the active page (e.g., home>products).	
	Direction (DR)	Signs that show the direction to cities, towns, signs with arrows.	Scrollbar direction, Back and Forward button.	
	Distance (DS)	Signs that show the distance to cities or towns.	Scrollbar (distance from top & bottom of the page).	
Travel Assist.	**Information Points (IP)**	Information or help desk, police, friends.	Search Box.	
	Travel Aid (TA)	Map, tactile map, road list, floor plan.	Site index, table of contents, site map, outline.	
	Travel Memory (TM)	Route plan, journey plan.	Previously visited links change colour, history list, bookmark.	
	Travel Support (TS)	Guided tour, visually impaired individuals may learn new routes by guiding them.	Guided tour.	

Table 1: Travel objects and examples from the physical and Web world.

Reference Point Components are directly related to the information points and are defined as two or more stimuli that, when linked, allow a traveller to determine his or her exact location [16]. A single reference point component might not be enough to identify the exact position of the traveller him or herself. Whereas, when two or more reference point components are linked, a traveller can determine his or her exact position. They are common features which do not provide precise position. However, they might help in determining one’s general position.

Identification Points are identification signs that are elementary state description of a location and usually perceived when the destination is reached [19]. These points identify an object, a place or a person in the space.

Identity is what makes one part of an environment distinguishable from another; it is a characteristic that allows the traveller to differentiate parts of the environment [1]. Travellers can use identification points to validate their arrival at the destination (“this is it”).

Attention These are the objects that attract traveller’s attention and may change the traveller's focus. They may be used for observations that may lead to interesting discoveries but yield most initiation control to the environment [18].

Alert These objects alert the traveller to a change in the environment or control of the journey [9]. Like the attention objects, they also attract the traveller's attention, but they usually notify approaching action or danger.

2.2 Orientation

Orientation is defined as the knowledge of one's direction and distance relative to things observed or remembered in the surroundings and keeping track of these spatial relationships as they change during locomotion [3, 4]. The concepts[1] of position or location, directionality and laterality are important cognitive components for orientation during mobility [16]. Moreover, as one moves towards a desired goal, establishing orientation and maintaining orientation are critical components of successful travel.

The knowledge about orientation suggests that a person needs information about location, distance and direction in order to be oriented in a journey. Landmarks are used to give sense of location [14] and are defined as spatial anchors since they provide precise information about one's location [16]. Landmarks are also important for the orientation of visually impaired travellers [3].

Direction Directional information is essential to the navigator's ability to remain oriented within the environment [7, 17]. A sense of direction that is an ability to maintain direction while moving, is usually equated with a sense of orientation [19]. Directional information can be provided through the directional signs that designate direction towards a place, an object or an event in form of a name, symbol or pictograph and an arrow. They may also show which direction the traveller is moving along.

Distance The ability to make accurate distance estimations facilitates establishment and maintenance of orientation [16]. Objects that provide distance information may indicate distance from the traveller's starting position or from the traveller's destination. They may also show where one is with respect to nearby objects and the target location.

Location or Position Landmarks provide implicit location or position information, because the different travellers may have varying amounts and type of information about landmarks. However, there may be some objects in the environment which provide location or position information explicitly. Location or position objects are directly related to reassurance signs and are defined as checkpoints which are used by travellers to reassure themselves that they are on the right track [19].

2.3 Travel Assistants

Sighted or visually impaired travellers may all experience problems in orienting themselves from time to time in an unfamiliar or familiar environment. They use different strategies for solving this problem including consulting a map; exploring the space systematically, either alone or with a guide; or following verbal or written directions [16].

Information Points are medium from which a traveller can directly request information. The traveller controls the type and amount of information requested and supplied, so they are active information supply [16].

Travellers can update their spatial information by interacting with other people while travelling. This is one of the strategies used by travellers for re-orienting themselves [16]. A supportive environment can be thought of in terms of information points at frequent and regular intervals. Particularly, information points may be important for visually impaired travellers, since they compensate for not having access to distant cues that are so useful to the sighted travellers [21].

Travel Aids provide an overview of the environment. They usually place the entire environment within the traveller's view. We refer to them as passive information supply, because, unlike information points, the traveller does not control the type and amount of information. They can also be considered as secondary sources, which can be used for spatial knowledge acquisition. They may help travellers to determine their position in the environment, their direction of travel, and the relative position of other objects or places in the environment [6].

Travel Memory holds information about where the traveller has been and provides means to get back there. It can be considered as an external memory aid to supplement internal memory [9].

Travel Support A traveller may make a journey without controlling all the details of the journey, that is to say, the traveller may not actively control the journey undertaken. Travellers may make a journey by actually being guided throughout. This could be a strategy for travellers to learn the spatial relationships in an unfamiliar environment [6].

2.4 Identification of Travel Objects

If we look at the Web landscape from the real world travel perspective, the travel objects explained above also exist in the Web landscape (see Table 1). The Web landscape is defined as the combination of the page and the agent (e.g., browser) [9]. The travel objects play an important role in the mobility of the Web users. Particularly, since the Web landscape of visually impaired users do not present travel objects appropriately, their mobility is reduced. Travel objects should be presented in a way that they can fulfill their intended roles and ease travel on the Web.

In the first part of the framework, Web pages are analysed to find out the provided travel objects and create a travel object inventory. The aim of identification is to filter the page and find the objects that are useful in promoting the onward journey. These objects are the regions or portions of the page. These can be the result, in the rendering, of HTML elements, collections of HTML elements or parts of elements. These objects can be placed in a structure, that describes the travel about a page. A journey should be made by noting which parts of the page (rendering or underlying code) are useful in promoting the onward journey. These then become the travel objects.

We have developed a set of guidelines for identifying the travel objects within a Web page. These guidelines are established by investigating a large number of Web pages. They are designed to be used during the manual travel analysis process that will be encoded in our tool. Moreover, the aim is to make the identification process systematic and consistent. If the process is proved to be so, the guidelines may form the basis of heuristics for travel object identification within the automated part of the tool. These heuristics may also evolve throughout the application. The guidelines are principally grouped into four. We will summarise these groups and

[1] Concepts are defined as mental representations, images or ideas [16].

present some examples for each:

- **Extracting travel objects from a page** These are the fundamental strategies for extracting travel objects, and the important aspects about the environment and travel objects. E.g.,
  - *A bird's-eye view* of a page may help to spot the visual groupings and draw a sketch of the page. Then the sketch can be extended by zooming in and out from the groupings and considering their relationships.
  - *Granularity* A travel object may be atomic or composite. It may be composed of other travel objects.
- **HTML source code** Some details are hidden in the source code and some are in the rendering, so it is important to inspect both. E.g.,
  - *An image map* When the rendering of a page is analysed, it may be difficult to realize the image maps, whereby analysing source code may help to elucidate the details of the image maps.
  - *Layout tables* The details of invisible layout tables can be obtained from the source code. Sometimes groups of objects are located in a cell of the layout table, so it may help to check whether or not they can be considered as a single travel object.
- **Using elements of a document** The general knowledge about the structure of a standard document can be used in finding out the travel objects (the role of a part of a document can be considered). For example, sections, paragraphs, titles, headings, bulleted or numbered lists are all different travel objects. Similarly, the HTML elements can also be considered, for instance, links. E.g.,
  - *Sections and headings* The heading and the content part (section) should be considered separately because it is likely that they have different roles during a journey. The headings can be obtained by checking whether the source code contains H1 through H6 tag set. However, this may not be enough because not all the headings are explicitly specified by using this tag set. Different typefaces may be used to indicate the headings; thus it is important to inspect both the rendering and the underlying source code.
  - *Line boundaries* are used to visually divide information or sections, for example by using an HR tag. Besides helping in recognizing the context division in a page, they may also be considered as travel objects.
  - *Links* All the links on a page are candidates for being a travel object despite the fact that they could be grouped together with other objects depending on the context.
- **Neighbourhood objects** Objects that are grouped together to provide a common function can be considered as a single travel object. E.g.,
  - *Functional dependency* If the functionality of an object depends on an other object then they can be considered as a single travel object. For instance, the search capability in a page is usually provided by a search box, a 'go' button and a label. These three objects can be considered as a single travel object because the functionality of the 'go' button depends on the search box and cannot be used on its own.
  - *Interaction* If the traveller needs to interact differently with consecutive objects then they may be considered as different objects.

2.5 Classification

The second part of the framework aims to classify the extracted travel objects. The main use of this classification is to discover the roles of each travel object in the inventory. Every travel object has at least one role during a journey and depending on the journey, it may have more than one role or it may have different roles in different journeys. Since we cannot consider all the different possible journeys, we only consider the possible roles of travel objects in a general context.

The classification process consists of a series of questions that have to be answered for every object in the created inventory. The expected answers to the questionnaire are *yes* or *no*. This is to simplify the process and make it systematic. The results are then evaluated to infer the possible roles of the travel objects. The aim of asking every question to every object is trying to decrease the subjectivity and provide a systematic approach to classification. In the automated part of our tool, the heuristics will be developed from the proposed classifications of travel objects (see Table 1) and also from the questionnaire.

3. EVALUATION OF THE FRAMEWORK

The purpose of the evaluation presented here was to test whether the proposed travel analysis framework can be used to analyse the travel support offered within a Web page.

Two evaluations were conducted: First analysing the *Google Directory* page and second the home page of the *Royal National Institute of the Blind (RNIB)* by using the framework. The same process was followed in both evaluations and can be summarised as follows:

Hypothesis If the users of the framework would be able to create a travel object inventory, classify travel objects and the results would be consistent between users , then we would be able to design a tool to support this framework.

Participants Twelve participants were used in the first evaluation (referred to as P1–P12). All the participants were experienced Web and HTML users. They had created at least one Web site before. In the second evaluation, six of the twelve participants of the first evaluation were reused.

Materials In the first evaluation, twelve participants analysed the *Google Directory* page. This page was used because the design is simple, navigation based and provides many travel objects. We did not want to use a complex page and confuse the participants, because they were not familiar with the notion of travel and did not have experience in identifying the travel objects. Moreover, it is obvious that it was not designed with accessibility in mind.

In the second evaluation, six participants analysed the *RNIB* home page. Compare to *Google Directory* page, this page has a linear structure, it is more text-driven. While the design of this page is not as simple as *Google Directory*, the main design focus of this page was providing accessibility.

Evaluation procedure The same procedure was followed in both evaluations. We first explained the problem domain, the goal of the framework and discussed some accessibility issues with each participants. We also explained the notion of travel on the Web and mobility. Then we asked them to apply the framework as follows:

- Inspect the Web page to identify the travel objects by using the provided guidelines;
- Answer the questionnaire to classify the identified travel objects.

After the participants completed applying the framework, we asked them a set of questions concerning the overall usability and efficiency of the framework. They are rated on a 5 point rating scale, 1=very difficult (not useful at all) and 5=very easy (very useful).

3.1 The Results

Both evaluations were successful in demonstrating the applicability of the framework. The participants were able to create inventories of the travel objects on both Web pages and classify the travel objects in their inventories. The created travel object inventories were highly consistent and were able to demonstrate that the encapsulated process in the framework is systematic.

Table 2 shows the analysis results of the *Google Directory* page of Figure 2. Similarly, Table 3 shows the analysis results of the *RNIB* home page of Figure 3. On average, each travel object on the *Google Directory* page (Figure 2) was extracted by 84.8% of the participants and this average increased slightly in the analysis of *RNIB* home page (Figure 3) to 88.8% (see Table 3). While most of the extracted travel objects were common in the inventories of all the participants, there were also some objects that were considered at different granularity[2]. For example, although ten participants considered logo (1) on the *Google Directory* page as a single travel object, two participants considered parts of it ("Google" (1A) - "Directory" (1B)) in their inventories rather than considering them as a single travel object. Similarly, some objects were considered as composite objects: the participants included both the entire object and parts of it in their inventories. For example, hotspots list (6) on the *RNIB* page was identified by all the participants and two participants also considered a part of it (6A) as well as the entire object in their inventories.

As can be seen from Tables 2 and 3, classifications of extracted travel objects from both of the pages (Figure 2) were also consistent. For example, line separator (7) on the *Google Directory* page was identified and classified as a way edge by all the participants. Participants were also able to classify objects in more than one group, for instance, hotspots list (6) on the *RNIB* page was extracted by all the participants. This object was then classified as a decision and navigation point by all the participants and as travel memory by three participants. In both analyses, participants failed to classify travel objects as travel memory. This could be because they had to visit the links and then answer the questionnaire, but they usually answered the questionnaire without following the links.

Generally, the classifications of the travel objects on the *RNIB* page (Figure 3) were more consistent than the *Google Directory* page (Figure 2). This could be because participants became familiar with the questionnaire and the classifications, or it could be because the role of travel objects were more precisely specified on this page because the design focus was providing accessibility. The results of the two analyses also suggested that some questions in the questionnaire need to be improved. For example, several objects were classified as a direction or travel aid object even though they should not be so classified .

In both evaluations, some aspects were also investigated concerning the suitability of the framework for automated and manual implementation that will be encoded in our tool. The following issues are related to the automated implementation:

- **Applicability of the guidelines** In order to validate potential heuristics that might be developed based on the guidelines, participants were asked if they have used guidelines and how useful they found the guidelines. In the evaluation, all the participants followed the guidelines and on average they were rated as very useful.

- **Answering questionnaire** In the second part of the framework, the participants successfully answered the questionnaire for every object in their inventories. The expected answers were *yes* or *no*, rather than on a scale of 1 to 5. This is aimed to ease the automation. Participants indicated that they found this part of the analysis easy.

Similarly, the following issues from the evaluations concern the parts of the tool that will be handled manually:

- **Application time** Although the exact time to apply the framework was not recorded, each participant was asked to provide the approximate time that was spent to complete the framework. Table 4 shows the approximate times to complete the first and the second evaluation. As it can be seen from Table 4, the participants spent significantly less time analysing the *RNIB* home page than analysing the *Google Directory* page. The time difference between two analyses suggests that, after an analyst analyses three or more pages, it will take him(her) quite a short time to apply the framework. Additionally, some participants, for instance participant P2, indicated that the first analysis required a lot more concentration than the second analysis because of being unfamiliar with the framework and also with the concept of travel.

- **Understanding travel** We asked participants to rate their understanding of travel on the Web before and after the evaluations. This is important as the better understanding can lead analysts to do more accurate and efficient analysis. After the first evaluation, ten participants stated that the framework improved their understanding of travel on the Web. Participants P9 and P11 stated that the framework did not change their understanding, however it has changed their point of view to the travel on the Web.

- **Usability of the framework** We asked participants questions concerning the difficulty of the overall framework and the two stages of the framework individually. After the first analysis, on average, the overall framework and the first stage,

Participant	Time (Google)	Time (RNIB)
P1	2:30h	1:00h
P2	2:15h	1:15h
P3	2:10h	1:05h
P4	2:00h	1:15h
P5	1:30h	
P6	1:10h	
P7	2:15h	1:00h
P8	1:40h	
P9	3:00h	
P10	2:30h	2:00h
P11	2:45h	
P12	3:00h	
Average	2:13h	1:15h

Table 4: Time taken for analysing the first page (*Google Directory***) and the second page (the** *RNIB* **home page).**

[2]These objects are indicated as A and B in Tables 2 and 3.

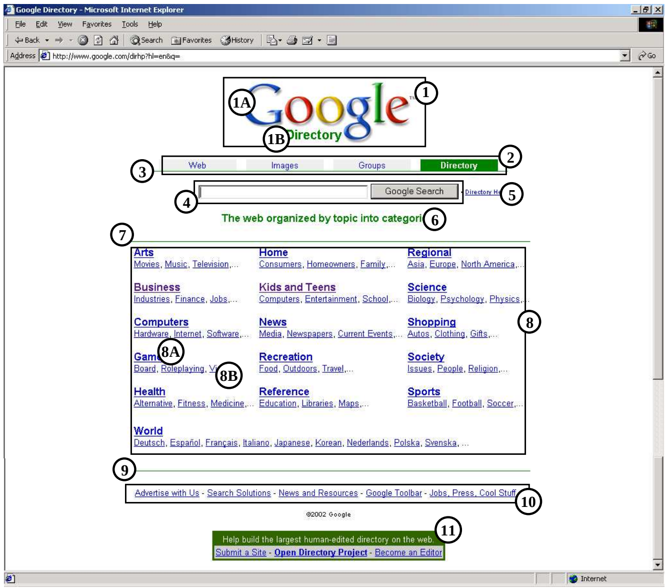

Figure 2: The *Google Directory* page (12-Mar-2002).

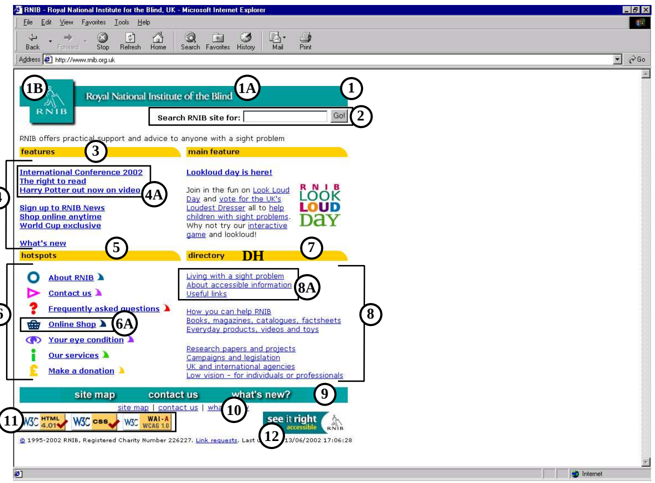

Figure 3: The *Royal National Institute of the Blind (RNIB)* home page (12-Jun-2002).

	Object	Total	DP†	WE†	NP†	RP†	RPC†	LP†	DR†	DS†	ID†	AL†	AT†	IP†	TA†	TM†	TS†
1	Logo	10				10∗	2	3			5∗						
1A	”Google”	2		1		1	2						1				
1B	”Directory”	2					2				2						
2	Main menu	12	12∗		10∗			3∗	5				3		3		
3	Line separator	5		5∗													
4	Search box & go	11			8∗	3							4	10∗			
5	Help link	10		1	9∗						2				4	1∗	
6	Description	8					3	1			4∗				5		
7	Line separator	12		12∗													
8	Categories table	12	11∗		11∗	4	1		3		2			1	3	3∗	
8A	Category title	4	1		4						2				2	2	
8B	Category list	3	2		3				2							2	
9	Line separator	11		11∗													
10	Footnote menu	12	10∗		11∗				1		3		1		2	3∗	
11	Footnote	9	3∗	6∗	3∗						2		6				∗
	Average (except 1A-B, 8A-B)	**10.18 84.8%**	† See Table 1. ∗ Potential roles of the travel objects.														

Table 2: Travel object inventory and classifications from the first evaluation (*Google Directory* page (Figure 2)).

	Object	Total	DP†	WE†	NP†	RP†	RPC†	LP†	DR†	DS†	ID†	AL†	AT†	IP†	TA†	TM†	TS†
1	Logo & banner	5		∗		5∗	2	1			1∗						
1A	Banner	1				1					1						
1B	Logo	1				1											
2	Search box & go	6			3∗	2					2			5∗			
3	Features heading	6		4∗			1		1	1	6∗						
4	Feature list	6	5∗	2	6∗				1						2	3∗	
4A	Features sub-list	1	1	1	1											1	
5	Hotspots heading	6		4∗			1		1	1	6∗						
6	Hotspots list	6	6∗	2	6∗				1				∗		3	3∗	
6A	Hotspots item	2			2											2	
7	Directory heading	6		4∗			1		1	1	6∗						
8	Directory list	6	5∗	1	6∗				1						2	4∗	
8A	Directory sub-list	1	1	1	1											1	
9	Site menu	3	3∗	3∗	3∗				1		2				2		
10	Site menu (text)	3	3∗		3∗				1						1	1∗	
11	W3C approvals	5	3∗		5∗								4∗		1		
12	RNIB logo (small)	6			6∗		∗				2		2				
	Average (except 1A-B, 4-6-8A)	**5.3 88.8%**	† See Table 1. ∗ Potential roles of the travel objects.														

Table 3: Travel object inventory and classifications from the second evaluation (*RNIB* home page (Figure 3)).

were rated as easy, and the second stage was rated as moderate. After the second analysis, on average, only the rating for the second stage was changed from moderate to easy. This could be because of the familiarity with questionnaire in the second stage. These results suggest that, after several analysis, it will be very easy for the users to apply the framework.

In both evaluations, although the participants did not have difficulties classifying the travel objects concerning the proposed classifications (see Table 1), the following suggestions and feedbacks were provided:

- Participant P11 mentioned that location and position should not be considered in the same class. He(she) indicated that they suggest different granularity. For example; location (I am in Manchester), position (I am at the phone box, outside the Precinct centre in Oxford road in Manchester). He(she) indicated that, in this context, some objects were providing the location information but not the position, so it was difficult to answer some of the questions concerning this class.

- In the definition of direction, we only considered the movement direction in the page (up, down, left, right), but some participants stated that it should include the journey direction as well.

- Similar to direction, in the definition of distance, we only considered the distance in a page, for instance, how far is the traveller from the bottom of the page. Some participants indicated that the journey distance should also be considered (e.g., the number of links that a traveller should follow to reach the destination).

Consequently, we modified and extended the travel object classifications by concerning these suggestions and feedbacks.

Finally, the following issues were also revealed from the evaluations:

- **Importance of the framework** The site menu (9) and site menu (text) (10) objects on the *RNIB* page (Figure 3) were important for the evaluation. Although the site menu (9) object looks like a repetition of the site menu (text) object (10), actually it is not; they have different roles in the page and the framework can draw the distinction between them. The site menu (9) object is a way edge but the site menu (text) (10) is not. Similarly, site menu (text) (10) object is a travel memory but the site menu (9) is not. One Participant commented that these objects are good examples that illustrate the importance of the framework. Furthermore, these objects also demonstrate what is missing in the text-only browsers and the way screen readers render a Web page.

- **Environment** Although the participants were informed that the environment is composed of the underlying browser and the page itself, most of the participants did not identify the travel objects provided by the browser. This could be because participants usually use the same browser and after a while they use the browser instinctively, without considering the facilities provided by the browser. When they access the Web, the only changing thing in their environment is the retrieved page. Additionally, participant P11 stated that he (she) did not consider the browser because it is the third party and difficult to change, modify or improve, but we could try to change or improve the design of the Web pages.

As a conclusion, the hypothesis was confirmed. All the issues discussed above demonstrate that the framework could be used as the basis of our mobility support tool. We will be able to semi-automate the travel analysis process which is encapsulated in the framework. The process in the framework is consistent and systematic. It is rigorous enough to be used as the foundation of our mobility support tool.

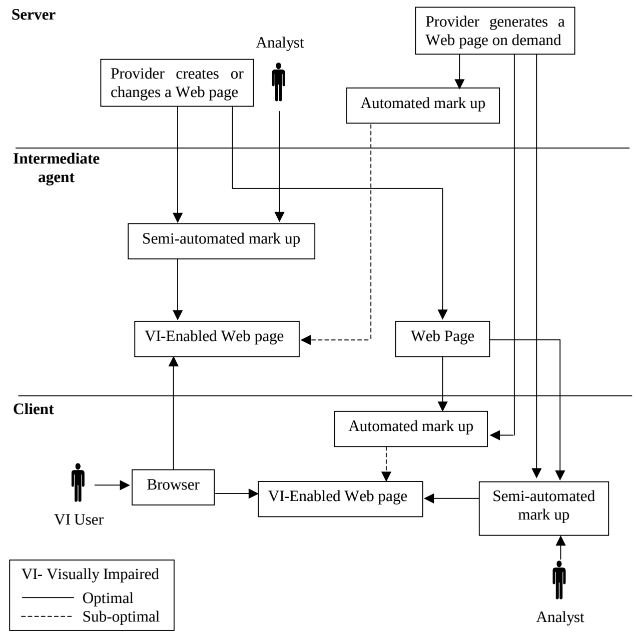

Figure 4: A flow diagram of the tool in use.

4. DISCUSSION

This paper has presented a travel analysis framework and discussed the evaluation of the framework. This framework is based upon a model of real world travel which has been presented and extended in this paper. This framework is used for identifying travel objects on Web pages and classifying them by concerning the roles of travel objects in the model of real world travel.

Our main goal is to improve the mobility of visually impaired users by providing tool support for the provision of mobility. The travel analysis framework will be the foundation of such a tool. The evaluation of this framework demonstrated that the travel analysis encapsulated in the framework is consistent and systematic. Furthermore, the evaluation showed that the framework is rigorous enough for being used as the basis of a mobility support tool. The tool will semi-automatically:

1. Identify travel objects– a Web page will be inspected for extracting potential travel objects;

2. Classify– the role (roles) of the extracted travel objects will be identified;

3. Annotate– the extracted travel objects will be annotated;

4. Transform– the analysed page will be transformed into another form by considering annotations so that the identified travel objects can fulfill their intended roles.

The travel analysis framework is dealing with the first two points, that is to say, it provides the platform that a tool can be build upon. The aim of the transformation is to improve the provided mobility support. In this paper, we have left the issue of annotation and transformation open on purpose, since it is the current focus of our research.

As a first step towards designing our tool, we set the context for the implementation and the usage of the tool. Figure 4 provides the overall context. The tool could be implemented and used on both the server side and the client side. It is more likely that it will be implemented on the client side. A Web page could be automatically and semi-automatically analysed and annotated. Both approaches have pros and cons. The automatic annotation might not deal with the subjective issues such as the navigation structure, however, may be efficient in time and effort because it does not require manual intervention. On the other hand, semi-automatic annotation might lead to accurate and optimal annotation and transformation. However, it may not be efficient in time and effort since requires manual intervention. Similarly, on the server side, the designer or the owner of the page can use the tool to semi-automatically analyse and annotate the page before publishing it. The automatic analysis can also occur on the server side, when a page is created on the fly.

As a conclusion, the next challenge is to encode the classifications and guidelines into heuristics. Establishing heuristics will lead us to the design and implementation stage of our mobility support tool.

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