

A Travel Flow and Mobility Framework for Visually Impaired Travellers

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Abstract

The aim of this paper is to propose a framework for travel by visually impaired people in order to provide a basis on which to develop future mobility and orientation systems to support such travellers. The 'travel task' is reviewed, and then analysed in the context of visual impairment, leading to the development of a simple framework to describe how travel is accomplished. Once this framework has been developed it can be used as a means of examining travel and travel aids for visually impaired people so that inadequacies in the provision of these travel aids can be addressed.

1 Introduction

A degree of mobility is essential for many species, as most animals survive through movement to some degree or another, and this is no different for humans and much human activity is accomplished through the ability to travel from one point to another. Travel then is essential not because of the human capacity for mobility, but because of the enabling aspects implicit in this mobility. Most information provided to aid the independent traveller is in the form of visual cues. These cues typically include graphical signs, coloured lights, road markings, printed public transport information etc. These variations in mobility markings for sighted users suggest that travel should not be thought of as a single activity but a sequence of different activities because there has evolved a preferred means of conveying the useful information associated with each of the different travel activities to a user. Alternative forms of information display, catering for different sensory preferences, are however very rare, and hence travellers with visual impairments are at a significant disadvantage with respect to their sighted counterparts. Clearly technological travel aids for visually impaired people could help overcome this disadvantage and so a number of different technologies (both simple and complex) should be implemented to support effective travelling for visually impaired people. However, we believe that it is only possible to make meaningful proposals for such aids if the travel task itself is properly understood in the context of the visually impaired individual. The objective of this paper is then to analyse and suggest a framework for how individuals travel, review travel specifically in the context of people with a visual impairment and make suggestions about travel in the context of the proposed "travel framework".

2 Mobility Primer and Terminology Reference

Travel can be thought of as the whole experience of 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. Conventionally, travel or mobility can be separated into two aspects, those of Orientation and Navigation [7].

- Orientation - can be thought of as knowledge of the basic spatial relationships between objects within the environment [1]. It is used as a term to suggest a comprehension of a travel environment or objects that relate to travel within the environment. How a person is oriented for travel is crucial to successful travelling. Information about position, direction, desired location, route, route planning etc. are all bound up with the concept of orientation.
- Navigation – in contrast, suggests an ability to move within the local environment [10]. This navigation can be either by the use of pre-planning using maps or fore-knowledge, or by navigating 'on-the-fly' and as such a knowledge of immediate objects and obstacles, of the formation of the ground (holes, stairs, flooring etc.), and of dangers both moving and stationary are all required.

3 Egocentricity

Because navigation entails some form of mapping and knowledge storage, an understanding of how information is stored and processed in the brain can be useful in mobility research. Cognitive or mental mapping is an abstraction of the real world, covering the mental abilities that allow us to collect, organise, store, recall, and manipulate information about the spatial environment and real world surroundings [9]. In the context of travel, this means everyday spatial environments. Thus information is stored to make sure navigation is possible, ('how to get there'). In addition, other cognitive knowledge is used to discover 'where to go' [8]. Many visually impaired people have a tendency to think of the real world in a 'egocentric' manner, such that descriptions of distance and journey become associated with the traveller and not the environment [9]. A sighted person may say "walk to pedestrian crossing and then continue on to the bank" where as a visually impaired person may say "walk 20 metres ahead, then from the tactile surface walk 10 metres to 45 degrees to the right of that position and you are at the Bank". It can be seen that the specification of distance and direction is far more exacting and the traveller relies on a limited amount of external information in order to reach the destination. Visually impaired travellers also break their journey into shorter stages and orientate themselves within the journey a greater number of times, therefore the mental maps of a visually impaired person have a tendency to be egocentric, exact, and divided into smaller more manageable steps. Tailoring feedback to enhance these traits would therefore enhance the mapping process for visually impaired travellers [9].

4 Travel and Visual Impairment

Visually impaired people travel a journey in a different way from sighted people using a number of different cues to sighted people. Because the travel task is second nature to most sighted people, and is learnt implicitly from an early age, the actual mechanics of it are often not explicitly considered. When studying travel in the context of a visually impaired person however, knowledge of how visually impaired people actually travel (i.e. without instruction) is important to the creation of a mobility framework. Visually impaired people have no preview of coming objects or obstacles and therefore the use of some type of preview device is important. Major concerns when travelling unassisted are down steps, kerbs, and stairs etc. Hedges, walls and other obstructions are not normally thought of but in the context of visually impaired travel the issue of ‘inside track’ obstacles are important and need to be recognised. Consequently the stride length and therefore walking speed of a visually impaired person is less than that of a sighted person, as is the continuity of progress [13]. Body rotation is also used to describe parts of a journey and route descriptions are more complex when given by a blind person. Obstacle information is also more specific and present in greater detail when a visually impaired person describes a route. Moreover, visually impaired people also use simple information more frequently than complex information [1]. The lack of vision, even with a primary assistive mobility device, does limit the travel experience. In studies, many visually impaired people relate that they would normally only travel independently in man-made urban environments (with regular features) and not in countryside environments. In addition to this preference for urban environments, many also stated that they would normally only travel unassisted in areas that were familiar [7]. Any framework for describing the travel and movement of visually impaired people must address these issues (see Table 1).

Table 1: Travel and Mobility Summary

Obstacle Detection and Avoidance

Visually impaired people have limited preview of upcoming objects or obstacles and therefore the use of some type of preview device is important.

Mental Maps

Although visually impaired people do not exhibit extraordinarily well developed non-visual senses, studies do show that an increased use of mental maps is present.

Egocentricity

Visually impaired persons use more temporal and egocentric terminology and less spatial and environmental terminology in defining points than do their sighted counterparts.

Regularity of Environment

The lack of vision, even with a primary assistive mobility device, does limit the travel experience. In studies, many visually impaired people relate that they would normally only travel independently in man-made urban environments (with regular features) and not in countryside environments.

Providing Spatial Information

Many congenitally visually impaired people find it difficult to track their position against spatial information although there is no significant loss of mobility.

5 A Journey Case Study

Most people are able to describe a frequently travelled simple route, however this is not normally done because a sighted individual typically performs the journey without thinking explicitly about the actual route. However if a simple journey is examined then a number of similar parts can be distinguished. These parts are not specific to the journey but to the process of performing the journey and these are of interest. To clarify this concept of a ‘flow of travel’, a short journey will now be described (from the authors office to the train station and into a train. This decomposition is illustrated in Figure 1.) The sequence can be broken down into a series of sub-tasks that represent this ‘flow of travel’. The journey description can now be highlighted within certain relevant contexts to see how the journey breaks down.

<p><u>Key to Description Breakdown (Contexts)</u> <i>(print style denotes travel activity)</i></p> <ul style="list-style-type: none">• <i>Object detection and avoidance</i>• <i>Waypoint/Orientation point (attempting to provide a regular environment)</i>• Complex Information Given or processed (adding to the users mental map)• <u>Direction Information (egocentric spatial information)</u>• Distance Information (egocentric spatial information)
<p>The starting point and destination are defined implicitly, and any pre-planning is implicit as it is a journey made many times.</p> <p><i>“While all the time making sure I don’t walk into anything or into anybody. Walk from my <u>desk</u> to the <u>door</u> of my office, open the door and <u>continue</u> a short distance past the <u>lifts</u> until <u>turning right</u> and <u>proceeding down</u> a long <u>corridor</u>. At the point where I reach a set of <u>double doors</u> I <u>continue</u> through them and <u>down</u> a flight of <u>stairs</u>, turn <u>180 degrees</u> and <u>down</u> another flight and then turn <u>180 degrees</u> and then <u>down</u> another flight. I am now at <u>ground level</u> and exit the building by walking <u>straight out</u> of the <u>single door</u>. On the <u>outside</u> I turn <u>right</u> and make for the <u>pedestrian crossing</u> turn <u>left</u> to cross it, and turn <u>right</u> again to <u>continue</u> about 500m to the <u>train station</u>. I enter through the <u>double doors</u> and move <u>directly</u> to the electronic departure time display, find the time and platform of the train I wish to board, and follow the signs to that location. Here I wait until the train has arrived, and then, when the doors have opened and are clear of disembarking passengers, board it.”</i></p>

Figure 1: Breaking Down the Travel Task

6 The Travel Task Framework (A Flow of Travel)

Currently the travel task is thought of as being grouped into two areas, these being navigation and orientation. It is the contention of this paper that the travel task is far more complex than this, and like Brambring [7] it is considered that a series of interrelated tasks are performed. However, the view proposed here differs somewhat from that of Brambring, who considers travel as being split into a tree of differing tasks (see Figure 2 [7]), in that it is thought that the travel task can be best likened to a looping ‘flow of travel’. This flow of travel can also be analogised to the flow and looping characteristics of control programs running on computer systems. In addition it is suggested

that devices to support travel by visually impaired people should be grouped according to which part of this flow of travel they aid. This will help to show which areas are currently neglected in the provision of primary and secondary electronic travel aids. The framework (see Figure 3) represents a user task analysis model of real-world journeying. The tasks are listed to the left and connected by a thick black line so that the different stages of a journey can be distinguished in the order that they are performed and providing a graphical commentary to the right of each task extends the framework. This commentary groups navigation and orientation objects into memories, obstacles and cues each with a set of associated actions to be performed. These actions are then linked to a method, this means the manner in which this action on this object is supported, and these methods have a number of properties associated with them so that the information returned to the traveller can be examined. For example: it can be seen that a 'Journey' task must detect and avoid an obstacle object, this is accomplished by preview and probing methods where both specific and detailed information about the object is returned thereby enabling it to be avoided. As previously stated, travel can be thought of as the whole experience of 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. In this context a successful journey is one in which the desired location or goal is easily reached. Two important areas that assist a traveller in completing a successful journey are preview and external memory (see following section).

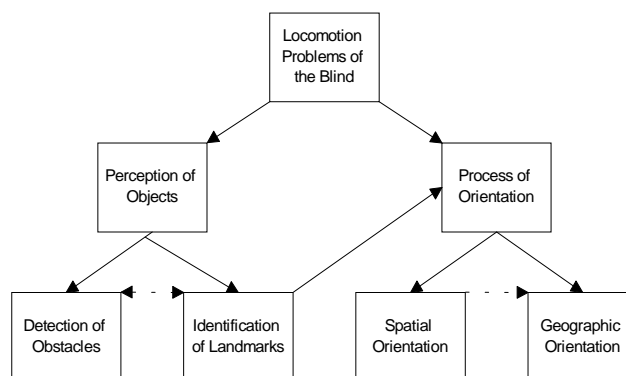


Figure 2: Brambring's General locomotion problems of blind persons.

In the framework we distinguish between, *waypoints*, *orientation points* and *information points*. These are all intended to represent some form of information giving object. A *waypoint* for instance may be just an arbitrary point (say, where two roads/tracks meet) or it may be a specific point intended to be a *waypoint* (a beeping sound marker, say). It is however intended that the *information point* will represent some form of device that gives complex information (for example a timetable, or street map 'information point').

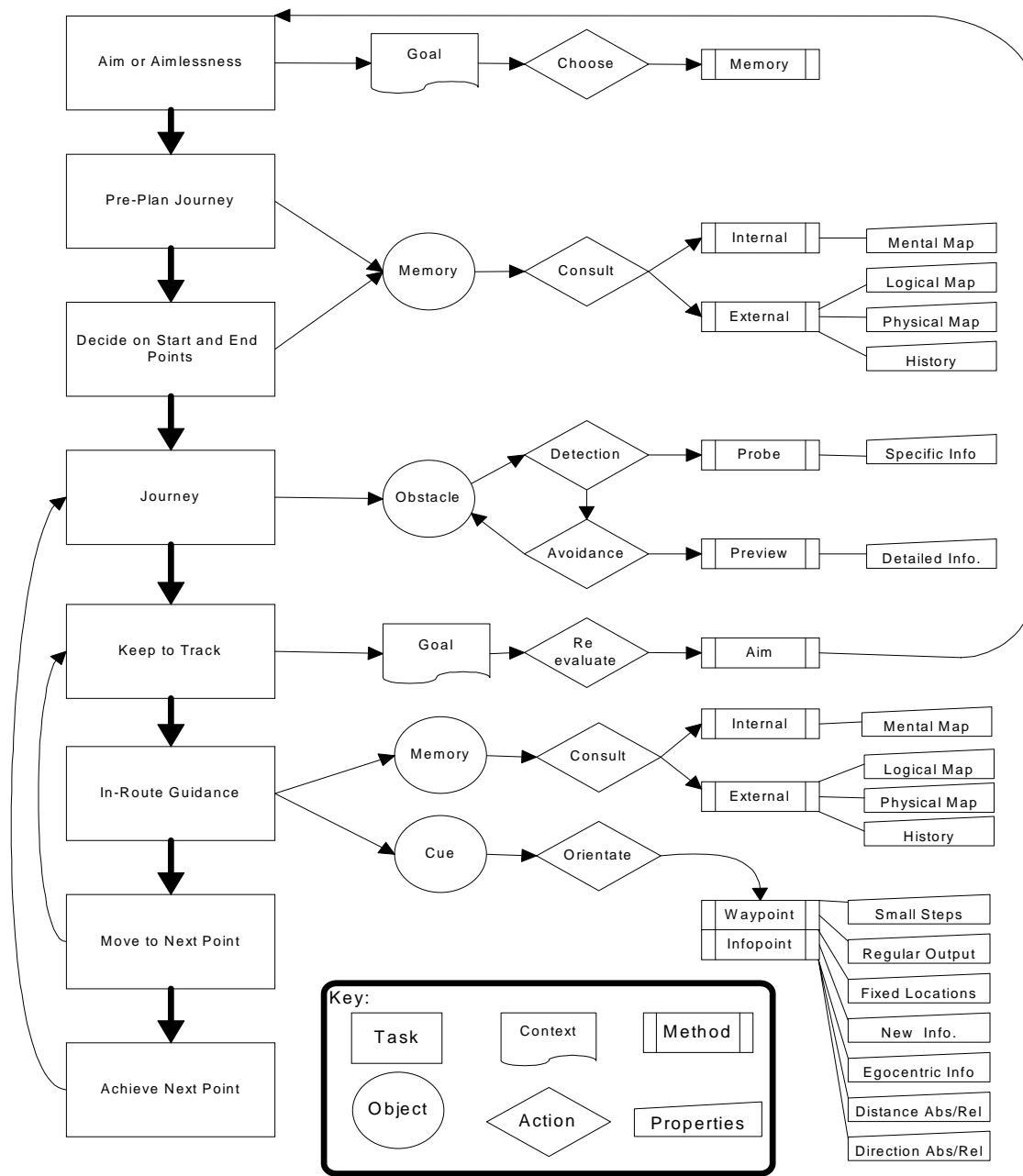


Figure 3: A Travel / Mobility Framework

7 The Travel Framework in Relation to Travel Aids

7.1 Preview and Probing

In real world blind mobility, a lack of preview of upcoming information is one of the major issues to be addressed. Consequently, this preview is supported by both electronic and non-electronic means and travel aids range from the conventional cane and long cane through to laser obstacle

detectors. However, in all cases the travel aid performs a 'probing' task such that a limited amount of preview is given [5, 6].

7.2 External Memory

Blind mobility solutions exist to accomplish obstacle avoidance and are based on both enhancing preview (as described above), planning to avoid obstacles through knowledge of the environment (orientation), and on navigating oneself around obstacles based on a knowledge of ones orientation within that environment [11]. Planning to avoid obstacles suggests a certain knowledge of an end goal to be achieved, while this is true in many cases it is not always known at the outset, and related travel information may be used in transit as the goal becomes more evident [3, 4].

7.3 Cueing

Orientation or 'where-ness' (detecting behaviour, like going round in circles, direction and distance) is important in blind mobility as it enables travellers to navigate with some degree of accuracy. However, problems exist for visually impaired travellers, because they do not have the luxury of visual cues to base these judgements on. Therefore, the environment must be updated such that cues are provided in an appropriate manner, giving explicit orientation information such that navigational information can be detected.

7.4 Feedback

Supporting the general mobility task by providing appropriate explicit feedback, returned implicitly from many objects, is also undertaken by many real world travel aids. Feedback is mainly included as an addition to a travel aid fulfilling a different task, for instance, an obstacle detection device. The premise of these additions is that much feedback is implicit and can be assimilated at speed if the recipient is sighted. This is not the case however, if the recipient has a visual impairment, as the cues, and the complexity of the cues, often depend on the recipient having vision and being able to assimilate this complex visual information quickly [14].

8 Conclusion

Applying knowledge about travel and journeys to inform the creation of a mobility framework can enhance the travel experience for visually impaired users by identifying anomalies in the provision of travel aids. The use of egocentric description, accurate journey information, and more frequent orientation points are directly related to the lack of preview found when travelling as a visually impaired user and so these points can then be addressed when creating travel aids. Tools and devices that supplement and enhance the travel information provided by travel aids can then be

created and new devices can be tailored to fill the spaces in the mobility framework left by the current array of travel aids. As can be seen, a journey involves very many complex real-time challenges. However, a dissection of the journey presented in the paper has enabled the formulation of a number of different elements to be identified based on the concepts of mobility and orientation. Although some of the detail will naturally be lost in any attempt to derive a general purpose framework, it is asserted that the ‘Travel Task Framework’ (as described above) represents a concise, understandable and structured basis for any future discussion on individual unassisted travel.

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