Creating a Framework for Situated Way-Finding Research

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Creating a Framework for Situated Way-Finding Research[1]

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Abstract. Preliminary themes to scaffold an investigative framework supporting human navigation from a egocentric (viewer-centered) perspective are described. These emerge from prototyping a mobile information appliance that supports, and is ecologically compatible with, human vision-based navigation and acquirement of spatial knowledge during movement through the physical world. The device assists a person finding his/her way from an origin to a destination by providing route information between images of landmarks, presented as they would be seen when walking rather than from an abstract map-type view. The use of the device in a foreign, built environment of the scale of a small university campus is illustrated and related to its use as a community authored resource. Emerging themes, such as the proximity, alignment and spatial separation of "ready-to-hand" landmarks, are discussed. Suggestions for further exploration are proposed and related to intersubjective and cross-cultural differences in communicating and using information for piloting navigation.

1 Introduction

A person in a foreign environment can often successfully navigate to a place by using information, communicated by a person more familiar with that environment, to pilot. Piloting refers to performing a goal-directed path using distinctive environmental features, or landmarks, in conjunction with an itinerary deduced from the spatial relations between current and destination locations [1]. Here, we discuss themes arising from our first endeavours in developing a mobile information appliance that supports, and is ecologically compatible with, human vision-based piloting and acquirement of spatial knowledge while walking through the physical world. The appliance assists a person finding his/her way from an origin to a destination by providing directions which refer to a viewer-centered, rather than an abstract, aerial, map-type, view of the surrounding environment. Supporting the user's natural predisposition for recognizing places and following paths between places helps circumvent some of the complexity issues associated with developing devices based on detailed three-dimensional spatial models of the environment, for example traditional virtual/mixed realities. Further, it affords the potential for a community authored resource in which

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the details of paths between places, provided by members, refer to a repository of images of landmarks.

We present, for formative purposes, a scenario illustrating the motivations for our research and outline aspects of the ecology of human navigation situated in the real physical world. Next, we relate these to the design and testing of a prototype appliance which supports wayfinding from a viewer-centered perspective. We then discuss themes emerging from our preliminary field experiments and their implications for establishing an investigative framework for supporting human navigation by piloting. We conclude by indicating the future direction of our research.

2 A Usage Scenario

a b

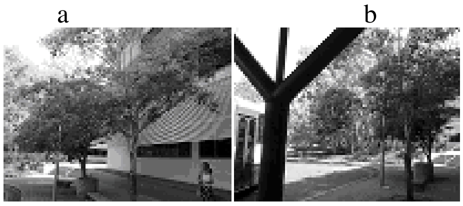

Fig. 1. Images presented by the way-finder with the instruction (a) When you get off the bus facing the big white building look LEFT; (b) Go up the steps between the two white buildings

a b

Fig. 2. Images presented by the way-finder with the instructions (a) Go UNDER the link bridge towards the sun canopies; (b) Do NOT pass under the sun canopies, look RIGHT when you get to them

Peter Schroulig, a visiting professor, arrives at the only university in Australia's Northern Territory on the first day of his sabbatical. Equipped with a personal digital assistant (PDA) loaded with a digital way-finder, he hops off the bus at the university stop (Figure 1a). The way-finder contains a file, downloaded from the web site of his host Belinda Willco, comprising images of distinctive features of the university campus and its environs and route instructions for paths between them. Belinda created the file by customizing resources selected from a way-finding library authored by members of the university community. Peter selects "university bus stop" when prompted to enter his current location, consults Belinda’s last email and enters “Belinda’s office” as his destination. The way-finder instructs Peter to look to his left and presents an image of two large white buildings where the corner of one obscures the other and there are a few steps leading to a path in between. Peter looks across to his left to see the buildings which match those in the image (Figure 1b) and clicks "OK". The way-finder returns the instruction for Peter to ascend the steps and follow the path between these buildings. At the same time it presents an image containing, in the upper half, a mirrored overhead building link bridge in the foreground and, in the lower half, a white sun canopy further away. As Peter rounds to the left of the nearer white building he notices the link bridge, and behind it a sun canopy, so he walks towards the link bridge and clicks "OK" when under it (Figure 2a). The way-finder zooms into the sun canopy to indicate that he should proceed directly to it and instructs Peter to look right on reaching the sun canopy (Figure 2b).

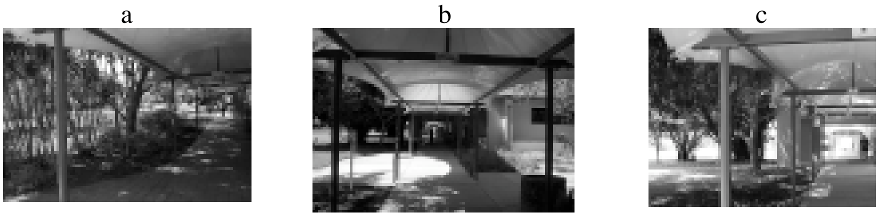

Fig. 3. Images presented by the way-finder with the instructions (a) Walk along the path UNDER the sun canopy; (b) Go PAST the blue wall to your right; (c) Go PAST the red pillars of building 22 and turn LEFT at the junction in the footpath

Peter proceeds, following and interacting with the wayfinder's series of instructions and images, he walks along the footpath beneath the canopy (Figure 3) until he reaches a junction. At the junction the wayfinder instructs him to turn left and presents an image of a building supporting a satellite dish in the background (Figure 4a) which enters Peter's view of the real world shortly after he has turned left. He passes the water feature corresponding to the next image (Figure 4b), sees an imposing link bridge ahead of him (Figure 4c) and walks towards its left hand side (Figure 4d).

Fig. 4. Images presented by the way-finder with the instructions (a) CONTINUE on the footpath with the satellite dishes to your right; (b) PASS the water feature to your right; (c) Go TOWARDS the large link bridge following the footpath you are on; (d) Go UNDER the right hand linked building

Once past the link bridge the campus becomes less dense with buildings and, with the wayfinder guiding his path, Peter clicks "OK" as he passes, to his far right, the sun canopy and some distinctive red buildings (Figures 5 a & b). The wayfinder indicates that when he sees the unusual "cyclone-proof" architecture of sciences he should be outside Belinda's office (Figure 5c). Peter notices the sign to his left denotes that the less imposing building close-by is "41", clicks "destination reached", enters the building and follows signs to Belinda's office in time for coffee.

a b c

Fig. 5. Images presented by the way-finder with the instructions: (a) Stay on the footpath PAST the sun canopy to your right; (b) Stay on the footpath PAST the red box-like buildings to your right; (c) The Science building is ahead to your right, you are now OUTSIDE Belinda's building

3 Research Background

People first acquire the spatial knowledge to navigate successfully from their direct experience of an environment rather than symbolically [2]. This knowledge allows humans to navigate transparently, without reference to symbols, canonical directions, or alignment with the Euclidean properties of the world (e.g. distance walked). Humans walking in the world draw upon allocentric (object-centered) and egocentric (viewer-centred) frames of reference from perspectives that are independent or relative to their vantage point, respectively. Unlike the extrinsic referents of maps these do not require orientation knowledge.

Mobile navigation at the scale of interest may be supported using landmark information alone or, together with route knowledge, for piloting. In navigation by landmarks salient distinctive visual cues at intermittent points along a route are used to determine both the path to the destination and current location relative to the path [3]. The importance of humans' conception of space as a collection of familiar landmarks has been shown phenomenologically [4], behaviorally, for example for newcomers to a city [5] and cognitively [6, 7]. Route knowledge requires spatio-temporally relating a specific sequence of landmarks (e.g. the steps taken to move between landmarks) into a chronotopic structure. People learn the order of landmarks in a route rapidly and earlier than the landmark's actual location.

Narratives of spatial layout suggest how frames of reference vary with the scale of a person's experience in the environment. People tend to describe groups of rooms and buildings in towns allocentrically by mental route and features of a room egocentrically by "gaze tours" with deictic references, such as "in front of" or "to the left of" [8]. In contrast, people tend to describe larger features of towns by "survey" using canonical direction terms (e.g. North, South). It takes significant time for people to configure a cognitive map [9] of their survey knowledge, not least because space on a larger scale requires longer exploration. This internal representation entails constructing a mental model of the interrelationships among places with extrinsic frame of reference. The mental model, which may be map-like [10] or conceptually more abstract [11] is imprecise and qualitative and requires association with landmarks to act as an index [1].

The majority of mobile navigation systems seem to focus on an extrinsic perspective and appear better suited to larger scale navigation or assisting a person with some familiarity with the location. For example, systems implemented as headmounted displays, such as WalkMap [12] or handheld devices, such as Cyberguide [13], pictorially represent the user's position on a map. Limited representations of an intrinsic perspective of the environment have been implemented in the mobile tour GUIDE [14] and Tourist Guide [15]. In these, digital images of key tourist attractions were used to relate a user's perspective to the extrinsic perspective map.

We propose a way-finder application which presents route information between images of landmarks, presented as they would be seen when walking. Relative and intrinsic, rather than extrinsic, perspectives of the environment appear better suited to the 50% of people preferring to memorise and use route information rather than maps [16] and more "ready-to-hand when situated in the context of walking. Relative or intrinsic representational perspectives would reduce the cognitive steps of transposing a person's mental model of their environment, based on their current perspective of the real world, to a map. They may also assist in circumventing current limitations of global positioning systems (GPS) [17]. Further, relative or intrinsic perspectives might allow use of the appliance in areas that are not yet covered by sufficiently detailed maps (e.g. Arnhem Land) or where extrinsic maps are limited by geographical constraints (e.g. vertical planes of canyons or in underground caves).

Combining images and route information may extend possibilities for sharing navigation information. Individuals in a community, such as university staff or students, could contribute navigation information by uploading to the web route information to their choice of destinations that relates to a local library of landmark images. Relative and intrinsic perspectives of the environment appear to be less prone to the intersubjective and cultural constraints of a map's symbolic traditions. Further, customization of the resource offers adaptability to cultural and language biases for egocentric or allocentric referents [18]. To our knowledge, understandings of landmarks to learn, apply and communicate navigation information have focused on the memorability of real [4] or computer-mediated environments [19] environments.

3.1 Design of an Exploratory Prototype

To develop an investigative framework for design we explored a prototype application *in situ*. The prototype, developed by the first author used MS Windows Explorer slide show viewer running on a HP Tablet PC TC1000 to present a series of images of landmarks each preceded by a textual route instruction. It was tested by the second author to navigate naturalistically Charles Darwin University's Casuarina campus.

The first author decided on a simple route, described here in the useage scenario, along footpaths to a building known to be a likely destination for the test author. Fifteen digital photographs of various features along the route were taken with a Kodak CX330 3.1 megapixels with 3x optical zoom using landscape adjustment. The features were chosen for seeming to be distinctive or at turning points in the route. Eight photographs were of proximal features, taken at distances of 5-15M, and of 2-4M in height, approximating to one storey of a building. Six of the photographs were of distal features, taken at distances 30-60M, of heights greater than 4M, such as whole large buildings. The remaining photograph was of a feature of 2-4M in height taken at a distance of 25M. The images were sequenced according to encountering their constituent landmarks along the route. A handwritten instruction of 8–16 words, captured using MS Windows Scribble Notes and created from memory of the route, preceded each landmark image (Figure 6).

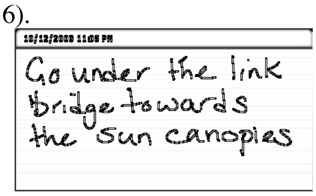

Fig. 6. Sample of route instructions preceding each image in the prototype

Both authors walked the test route together. The tester, who recently arrived at the University and had visited limited parts of the campus, used the prototype while the first author observed and avoided consciously hinting unless required. The discussions in this paper sprung from the observer's notes of tester's explanations of what he was looking at, thinking, doing and feeling while he navigated using the device using the think-aloud-protocol [20] and post-activity analysis and interpretation.

3.2 Themes & Design Implications from Experiences with the Tool

The prototype enabled the tester to navigate to the destination autonomously with the exception of two instances when the observer provided some guidance. Several important themes emerged which bear upon a research framework for situated navigation by piloting and prototype design and development.

Approximately half of the landmarks and their associated textual instructions adequately accounted for the dynamic nature of the tester's frames of reference afforded by the real world as he walked. These tended to be those landmarks which were in close proximity and/or ahead of him as he walked. Many distal landmarks (e.g. large buildings), particularly if aligned parallel to the route, confused despite instructions designed to compensate for this (e.g. Figure 5b). Even highly distinctive buildings at distance appeared "part of the background" (e.g. Figure 5c) and, like proximal landmarks positioned outside of the central region of the image, did not tend to draw attention and afford strong reference frames (e.g. Figure 3b)

The ready-to-hand characteristics of distal and proximal landmarks may relate to intersubjective differences, information paucity in images and the qualitative nature of landmarks in context. Gender differences, for example, may contribute since women (first author and developer of the prototype) take a wider view than men (tester) [21]. The absence, in still images, of cues humans use in the world may have differential affects on the ready-to-hand nature of distal and proximal landmarks. These cues may be visual, such as optical flow field, motion parallax and binocular disparity, or multimodal, such as aural cues associated with different distances and substrates. Functionally more significant, in addition to physically larger, environmental features are prioritized for learning landmarks [8] and our experiences suggest this relates to what a person notices. While distal large distinctive buildings are indeed physically larger they appeared to have less functional significance for walking between landmarks. We expect this to differ between people, cultures and useage since characteristics of an environment are influenced by a person's schema of spatial context.

Designing with the assumption that the user does not re-orient his/her head from a forward looking focus has several implications. The user may still look at any 25° of the horizontal subtent of the environment's image which represents only 50% of the panorama captured by a normal, 50mm focal length, lens. Where possible the landmark should be central in the image. Encountering a person during our test yielded insights related to specifying regions in a visual field, for example spontaneous communication of a region using hand and body gestures to index specific landmark referents. A prompt, such as an arrow on the image, should direct the user's focus towards landmarks which are relatively small, at a peripheral position or at a height that differs from majority and are not transparently conveyed by the textual description. The system may be additionally advantaged by indicating the correlation between the navigator's own body orientation, for example from input from an integrated flux compass, with information on the camera's canonical orientation captured with the image.

Various observations suggest that the system should synchronously present route instructions, and other topographically relevant textual information, and its associated image. Frequently the tester read the instruction, responded by walking immediately and consequently nearly passed the position for the optimal correspondence between his real world frame of reference and the relevant image. Indeed, on occasion, he became confused and retraced his steps because he referred to the image only after his walking caused it to be obscured by some trees.

Predictability and consistency are salient design principles to support navigating real spaces. Our observations suggest that route instructions should include a metric between landmarks, such as how far apart they are. The landmarks used for our prototype were at irregular distances and were referred to non-relatively by rather parsimonious route instructions. This does not satisfy a user's apparent need to anticipate encountering the next landmark and may compromise trust in the device. For example, the tester interpreted a temporary lack of correspondence between his real world frame of reference and an image to be an error in the prototype rather than requiring him to take a few more steps forward. Various observations indicate that every turn should be associated with an image of a landmark, for example two particular turns were more complex when using the prototype *in situ* than anticipated.

Presenting topographically relevant textual information synchronously with its associated image is a design challenge when screen real estate is limited. The screen size of a Tablet PC, used for our prototype, has sufficient space for adjacently aligning or overlaying instructions on the image, however a PDA's 3.5" screen does not. Embedding hyperlinks in the image could be used to guide attention to the landmark feature and link to the appropriate information.

Our prototype illustrated the potential of several physical constraints in capturing and displaying digital images and sensory constraints in viewing digital images. Our observations support, in agreement with those in virtual environments [7], that landmarks need to be realistic if they are to be transferable to navigation in real places. Photographic images record light intensity and wavelength non-veridically and compress contrast. The majority of images rendered on the Tablet PC afforded a good match to the environment. However, in one image the white wall of a landmark was rendered blue, due to relative glare, and the tester hesitated when using the prototype. The standard 10.4" (resolution 1024 x 768) screen of the Tablet for our prototype was fairly difficult to see in the bright tropical sun and prevented the tester from using sunglasses. We are exploring the extent to which the limited resolution and field of view of a PDA further compromises correspondence between the image and real world.

There are several potential physical and functional contextual adaptation challenges in further developing our prototype. The image capturing and prototype testing shared many similar physical contexts. For example, they both had a similar time of day, weather conditions, seasonal features and numbers of people walking around. We noticed a number of landmarks that may not be visible at night and flora and fauna features that might significantly alter the real world image. The tester obediently followed the prescribed footpath and we did not explore the affect of detours, for example when encountering obstacles or seeking shelter against weather conditions. During the test we unexpectedly engaged, en route, with the person we intended to visit as a goal for the navigation activity. This yielded insights into the vulnerability of a user's ability to re-situate their navigation after a distraction.

Two diverse observations invite us to explore the complementarity between knowledge supporting navigation that is in situ and in the mobile appliance. Characteristics of route information communicated to a user should be compatible with permanent or temporary environmental information en route. On several occasions the tester observed opportunities for locational or semantic information, associated with a landmark, which would enrich the user's sense of orientation. For example, information on sign-posts readable from only one approach direction in the real world could be embedded in the application. This may be particularly useful in less autonomous or unified environments such as towns which contain mixtures of standard and idiosyncratic naming and signposting conventions. It is of interest to examine qualitative differences in landmarks in different environments. Characteristics of landmarks in a university campus, which has a relatively cohesive and homogeneous architecture engineered to support pedestrians, may differ from those in towns which serve diverse purposes and have evolved by gradual synthesis. Landmarks in a built environment, such as a university campus, which presents an image with a distinctive structure featuring places connected by paths and dominated by right angles may be qualitatively different from landmarks in natural environments.

4 Current & Future Work

We seek to elaborate an investigative framework to explore constraints in landmark based navigation which draws on ethnographically and semiotically informed approaches. Our work proceeds in parallel directions which focus on the nature of images of landmarks as communication tools and cross-cultural themes relating to support for piloting navigation. It seems to us that as a consequence these may also yield insights for cyberspace navigation.

To initiate our research in identifying dimensions in human-human communication of landmarks. we are using a race of "pilots and orienteers" as a situated protocol. The object is for the orienteers to follow a pilot's intended route, by using a sequence of photographs taken by pilots across a specified distance anywhere in the university campus. Orienteers will answer a standard set of brief questions, printed on the reverse of each image and record any additional observations. At the end of the way-finding race pilots and orienteers will discuss their experiences and observations.

The influence of intersubjective and cross-cultural differences on the nature and use of landmarks and route information is significant since spatial representations inherently combine both environmental and world order views. One investigative dimension relates to cultural biases in noticing, describing the environment and routes. Different nationalities vary in the richness of descriptions of sites along a route and route directions [22]. The preferential bias of different reference frames by various language communities [8] will influence route descriptions. For example, Australian Aboriginal, Mayan and Japanese languages have exclusively absolute, relative and intrinsic frames of reference, respectively. These investigative dimensions, coupled with the privilege of our own location, might provide opportunities for informing design. We are exploring mutually beneficial opportunities for harnessing alternative navigational strategies by our country's indigenous people. Aboriginal people's narratives of journeys, embedded in the land, seem to both enable navigating a vast continent and nurture specific superiority in locating position schematically and diagrammatically [23].

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