Usability issues of navigating in Virtual Environments

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ABSTRACT

Navigation is defined as an act of 'way finding' with a certain environmental aid. Navigation adds realism to a 3D virtual environment, whether the environment comprises of a small room or a huge sprawling University campus. Unfamiliar environments, whether real or virtual, are always difficult to navigate. Users, especially novices equipped with a 'mouse' or a 'touch screen' find it uneasy to navigate in a widespread 3D, virtual environment whose motion is relative and may wish to abandon it after a frustrating experience. There is a need for providing a better method of navigational assistance for such environments to make the experience more pleasant, efficient and close to reality. A qualitative user study was conducted to investigate our hypothesis that a 2D reference of a 3D environment, using which a user can gauge his/her present location and orientation accurately, is required to give effective navigational assistance. Inference from the user study is that for a 3D virtual environment navigational assistance should satisfy needs of a novice as wells as an advanced user. It is recommended that for a virtual environment, both 2D reference map as well as an 'environment embodied' navigational assistance should be provided to suit the needs of all kinds of users. The embodied navigational assistant here can be referred to as a signboard system, vocal agents [14] or natural language processing dialogues.

KEYWORDS

Navigational assistance, navigation mode, architectural walkthrough, virtual environment, virtual reality modeling, user centered, usability.

INTRODUCTION

The development of 3D graphics standard and 3D graphics acceleration hardware has revolutionized desktop based interactive 3D graphics. Conventional Virtual Reality often refers to applications which are immersive and requires bulky setup like CAVE [15], Data Gloves [18] and Head Mounted Displays [8] for viewing. However, its definition has become broader with the advent of technologies like Augmented Reality [3], Virtual Reality Modeling Language (VRML) [21] and Ubiquitous Computing [3]. It is now possible to create a Virtual environment on a desktop machine. Standardization of 3D formats like VRML 2.0 contributes to the global acceptance of VR on WWW regardless of computing strength. Various free and commercial plug-ins for the viewing of VRML file format (.WRL file extension) have been developed [5] [2] [4]. These plug-ins are compatible with popular web browsers like Netscape [13], Internet Explorer [9] and Mozilla [12] etc. and are easily installed on a PC with certain performance requirements depending upon the type of plug-in.

A typical VRML browser plug-in supports various navigation modes like WALK, EXAMINE, FLY, ROTATE, GO TO etc (refer Fig.1). Most of them support the collision detection node as specified in the VRML standard specification [21]. Nearly all plug-ins support WALK type navigation as it is the most natural form of navigation for exploring a 3D environment, for example an architectural walkthrough of a virtual building. Users can further modify other controls like, CPU load, type of rendering and many other attributes, using inbuilt controls menu of plug-ins [4].

Thus a typical plug-in provides mostly all the necessary features to navigate in an environment except navigational assistance, while viewing the 3D environment which the creator or developer is supposed to provide. Unfamiliar environments, whether real or virtual, are always difficult to navigate [19]. Users (regardless of their experience) often find it difficult to navigate through hypermedia without adequate reference or assistance. They often feel frustrated with this kind of maneuvers especially when the frame rate on an average PC is not high enough for smooth interactive navigation.

It is posited here that the main reason behind this is the lack of effective online navigational assistance and low frame rates for complex environments. The frame rate can be optimized by suitably up-grading the system but the problem for an able and effective navigational assistance persists in 3D virtual environments. There have been interesting philosophical debates on designing intelligent and user friendly interfaces.

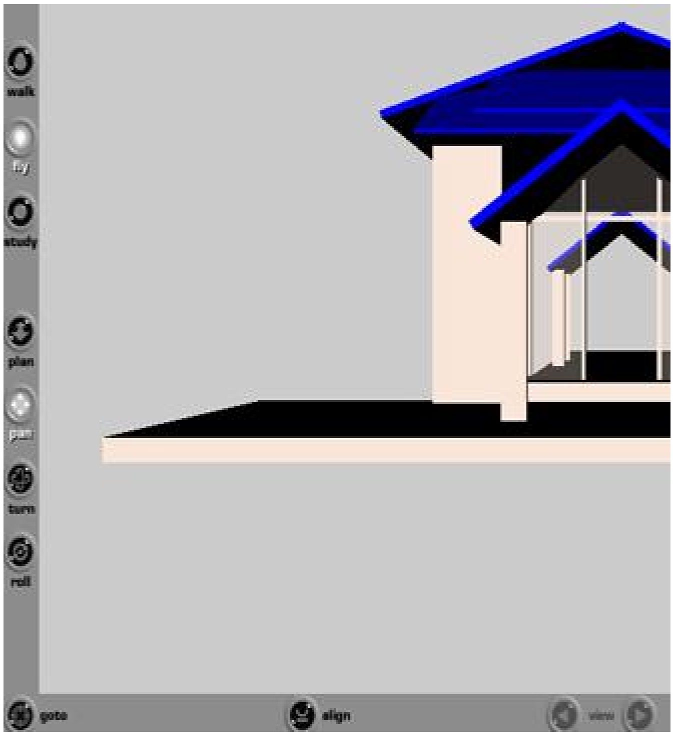

Fig.1. Basic navigational modes (walk, fly, examine, go to, align etc.) shown on the control bar of a VR Interface.

Direct manipulation is considered to be an effective metaphor for interface design as the system behavior is more predictable than with the interfaces based on agent technologies [16]. A user study was required to investigate this finding and to verify our hypothesis. It is posited that a WEB3D standard like VRML and the most recent development - X3D [22] is in the grasp of most common network users. Web3D sites on network offer virtual tours like virtual museums, 3D chat rooms, virtual site seeing etc. Growing use of palm top devices like a PDA has created further demand for a VRML plug-ins for such devices. Special plug-in for PDAs are available on network for download [4]. All this has resulted in ever increasing demand for a better navigational assistance for virtual environments. VR is not only limited to CAVE systems or a desktop, it has many real time applications and in future it is projected that a common urban resident will be interacting with these environments in public places, therefore, this study is a commencement towards solving more complex problems of user interactivity and usability. Many other serious issues will be projected towards Web3D community in the near future.

NAVIGATION

Navigation was originally defined as process of moving in the course of an environment. With the standardization of World Wide Web norms, this definition has changed to suit navigator's/visitor's goals during his\her visit to web pages and other informational contents on web. Darken and Sibert [7] have defined as follows "Navigation is a process by which people control their movement using environment cues and artificial aids such as maps so that they can achieve their goal without getting lost." Others have extended this definition by applying further characteristics such as domain, knowledge of the navigator, goals of a navigator, possibility of providing clues and aids etc. [10][17][19][20]. The World Wide Web consortium (WWW) allows the presentation through web pages of explicitly predefined information in the form of text, tables, pictures, audio, video and animation. While the navigation activities on conventional 2D web pages mainly comprise searching for information, with the development of virtual environments, the attention for 'exploration' has increased. Darken and Sibert [6] have classified navigation as a way finding task in which they have distinguished exploration from search activities. Search activities are further subdivided in naïve search (navigator has no prior knowledge of target's location) and primed search (where navigator knows location of the target). Benyon and Hook [1] have categorized navigational activity as either goal-oriented (how to find a way to reach a destination), or explorative (just to have a look around and explore environment's subparts), or aiming at object identification (finding types and clusters of objects, exploring individual characteristics of different objects of an environment). Categorization by Darken and Sibert [6] suits a user who has a prior familiarity with the environment whereas later categorization suits a novice user. Though mutually exclusive these categories may intersect during real time navigation: exploration may invoke goal-oriented activities or vice-versa. [6].

NAVIGATIONAL ASSISTANCE

Researchers have proposed basic design principles [6] which should be taken care of while designing a navigational assistance for an environment. It is advised to divide large scale worlds into distinct parts that are easily organized. A definite structure should be provided that enables a user to mentally organize whole environment. Environment embodied signage systems, visual or auditory cues etc. can be provided to ease recognition by the user of these parts and subparts of the environment. Another possible navigational assistance mode is a 2D reference map providing exact location and orientation of a navigator. These maps are intended to provide spatial information directly in such a way that a navigator can produce flexible, orientation independent representation of the environment. The basic reference map design principles incorporate showing landmarks, paths, subparts, organization and navigator's position. Further it is advised to orient the whole map towards user such that the map is presented in the same orientation as environment itself so that a navigator feels that the map is in front of his/her chest [7].

The modes of navigation described here are undeniably derived from real world support. However especially in virtual environments, more real world navigation principles and aids can be included. The embodied navigation here can be referred to as a signboard system, vocal agents[14] or natural language processing dialogues [14]. Virtual agents can be added to a 3D environment. Agents can interact with a visitor, assisting the visitor with what he/she wants. Moreover, a 3D environment can be a multi-user world where visitors can chat, show gestures, play games or interact through embodied objects. In these environments, other users can provide assistance; their behavior can be observed and imitated [1]. This type of environment can be further studied under socio-cognitive behavior of users. For the sake of simplicity, the environment built for the experimentation described in this paper was that of a single user world.

Considering the categorization of navigation, navigational assistance modes can be classified as

(a) Environment embodied assistance: elements of navigation are inbuilt in the virtual environment itself and navigator interacts with them while navigating,

(b) 2D reference map: a scaled, 2D representation of the 3D environment provided with navigator's exact position and orientation at any instance and user has to continuously refer to it while navigating through that environment.

Users have different psychological and mental profiles, and to suit their respective needs, they perhaps require different kinds of gestures, symbols, cues and references as far as navigation is considered.

HYPOTHESIS

It is posited here that a 2 Dimensional reference map of a 3D virtual environment through which a navigator can gauge his/her location and orientation accurately, is sufficient to provide an able and effective navigational assistance, provided he/she uses a 'touch screen' or a 'computer mouse' regardless of his/her desktop computing experience.

EXPERIMENTATION

A set of randomly chosen 11 subjects (9 male 1 female) with age ranging from 19 to 23 were tested. Each one of them was briefed before testing to allow them to get familiar with the environment. They were appropriately instructed regarding the objective of the experiment. Subjects were randomly divided in two categories. Subjects of both the categories were asked to navigate in a 3D virtual environment with two separate modes of navigational assistance (5 subjects for each mode). The differences were noted.

EXPERIMENTAL SETUP

The virtual environment embodied significant buildings of IIT Guwahati (New academic complex, administrative block, guest house, transit complex etc.). A random navigational path (road) was designed interconnecting these buildings. Two different modes of navigation, namely '2D Reference Map' and 'Environment Embodied Reference System' were incorporated with the same environment but independently. The embodied reference was built in the form of internal signage boards in the virtual model. The nature of the chosen modes of navigation and navigational assistance were purposefully kept very fundamental so as to test user's primary intuition (regardless of computing experience) and to qualitatively optimize the output. The virtual testing environment was created on an interactive touch screen in the UE-HCI laboratory, DOD IITG, (Fig.2). Though, a touchscreen adds relatively high degree of reality and an immersive impression of an environment, users addicted to a desktop find it quite difficult to navigate on touchscreens [11]. Moreover, touchscreens are still the most suitable option for installation of information kiosks, corporate learning environments etc. [11].

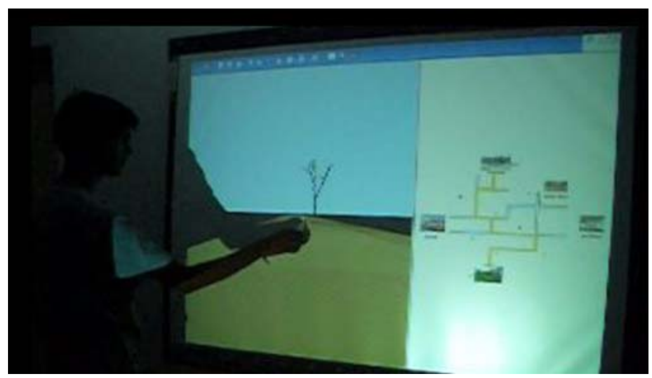

Fig.2.Touch screen used for testing.

The navigation mode chosen for each group of subject was goal-oriented (subjects knew their target and they had to follow the way leading to it using the provided navigational assistance). Each subject was given a short demonstration and approximately three minutes to become familiar with the set up prior to testing. To start, subjects of the first group were allowed to navigate through the environment with the navigational assistance mode as a 2D reference map, depicting every significant element of the 3D environment. Path and direction of navigation were highlighted on the map, projected on the interactive touch-screen, to further ease navigation (Fig. 3). The subjects were asked to do the following tasks:

- Recognition of entry point and destination location before starting navigation.
- Following 2D map as a reference while navigating.

- Recognizing his/her location and orientation at any instance during navigation.
- Reaching destination comfortably (without rushing).

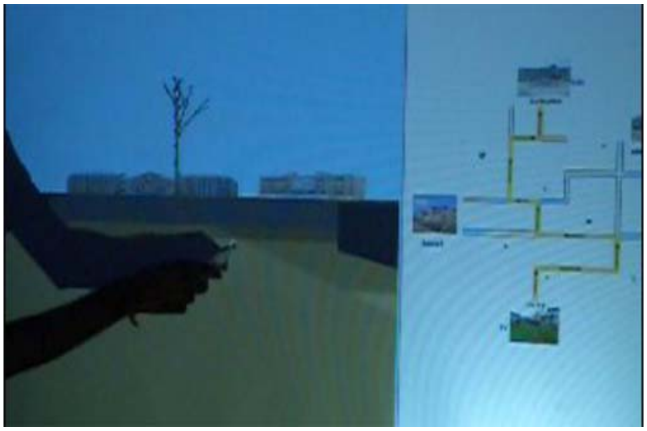

Fig.3. User navigating with 2D reference map aid.

The second group of subjects was given the similar task with a different mode of navigational assistance. Their aim was to navigate in the environment with the aid of an 'environment embodied signboard system'. Appropriate textual signboards were provided at every node of the path with directional arrows (<= / =>) (refer Fig.4).

Their task included:

- Recognition of entry point and destination location before starting navigation.
- Following signboards as a reference while navigating.
- Recognizing his/her location and orientation at any instance during navigation.
- Reaching destination comfortably (without rush).

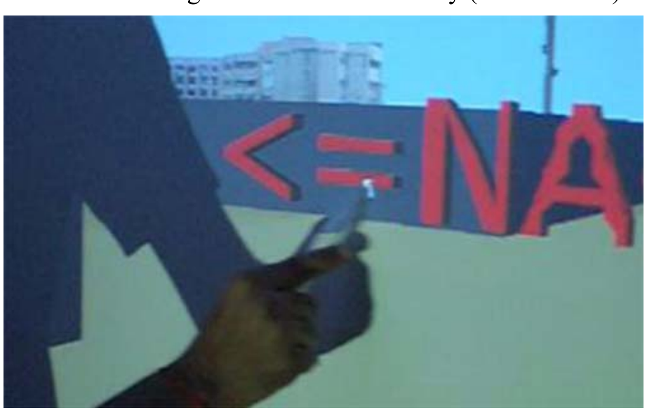

Fig.4. User navigating with the aid of embodied directional signboards.

Time taken (in seconds), for each subject's action was recorded in both the cases. A questionnaire was given to them in order to analyze their experience qualitatively and to draw logical inferences.

The Questionnaire Consisted:

1. Question regarding extent of prior acquaintance with desktop computing environment.
2. Question regarding familiarity with 3D virtual environments if any.
3. Questions verifying whether subject was briefed adequately regarding environment before testing.
4. Regarding subject's information about his current position and orientation.
5. Was the navigational reference provided to the subject sufficient?
6. Was the subject lost while navigating at any instance?
7. Possible reasons of misdirection.
8. Does the subject have Vertigo (a disorder in which a person feels uneasiness under certain conditions, for e.g. nausea during journey, or relative motion in a merry-go-round).
9. Subject was asked to rate his experience on a 10 point scale (0 for extremely frustrating and 10 for very pleasant).
10. Finally, they were asked to pick up their choice of navigational assistance mode.

Almost all questions had two to four choices as answers from which a subject had to pick his/her response.

EXPERIMENTATION RESULTS

The experimental results can be deduced with the help of qualitative data organized in table 1 (for 2D map as reference) and table 2 (for embodied signboard reference). An index is provided after table 1 for reference.

Table.1 (2D Map as Reference)

	U1	U2	U3	U4	U5
Time taken to reach destination (seconds)	362	332	305	315	323
Prior desktop computing experience (years)	1to3	1to3	>5	>5	>5
Ability to locate position with respect to starting point.	WD	Y	Y	WD	N
Adequacy of reference provided to reach destination	Y	N	N	N	N

(yes/no)					
Misdirection	Once	5	Once	N	N
Reason for misdirection	a	a, b	*	a	----
Vertigo	N	N	N	N	N
Rating(0-10)	8	2	5	6	3
Choice of assistance mode	B	C	C	B	C

Index:

U1, U2 etc. are users, WD= with difficulty, Y=yes, N=no
a =unable to locate his/her exact position and orientation.
b =unable to refer 2D map and environment simultaneously.
* = shadow hampered vision (projector's light falling on user's body).
A =Embodied signboard system for the virtual environment.
B =2D reference map with instantaneous position and orientation data provided.
C =A and B integrated

Table.2 (Environment Embodied Signboard System)

	U6	U7	U8	U9	U10
Time taken to reach destination (seconds)	171	184	303	233	179
Prior desktop computing experience (years)	>5	1to3	>5	1to3	>5
Ability to locate position with respect to starting point.	WD	WD	Y	N	N
Adequacy of reference provided to reach destination (yes/no)	Y	Y	Y	Y	Y
Misdirection	N	N	N	N	N
Reason for misdirection	----	----	----	----	----
Vertigo	N	N	N	N	N
Rating(0-10)	6	7	7	6	6
Choice of assistance mode	C	C	A	C	A

Discussions

Most of the subjects chosen have prior familiarity of more than 5 years with the desktop environment. As the average time taken to accomplish the task is much less in the case of 'embodied' situation (214 sec.) as compared to the 2D map situation (327.4 sec.), a direct inference is that for a goal-oriented navigation, environment embodied navigational reference could be a better choice than a 2D reference map. In the embodied situation, subjects are clearly finding it relatively difficult to locate their current position and orientation as they have no reference map, thus there is a need to refer a map along with the provided navigational assistance. Moreover, if a navigator gets lost in between due to any reason, he/she has nothing to refer his exact position and orientation.

The average rating of experience in first case (2D map) is 4.8 whereas in second case (embodied signage) it is 6.4. It shows that a navigator probably wants simplicity and direct manipulation in the environment. The ease of navigation or the comfort in reaching the destination is certainly more weighted along with the immersive experience. Another crucial inference that can be drawn is that, it is rather difficult to navigate using a 2D map as a source of reference on a touchscreen since user has to refer his position continuously through the map. It effects user's concentration and perhaps subdues the excitement of immersion. Once again, due to goal-oriented nature of the navigation, users find references provided in the embodied signage situation more effective than earlier case. Similar reasoning could be applied for the amount of misdirection in '2D map' case. In the embodied signage situation, each subject was able to reach his/her destination without getting lost. None of the users have vertigo disorder; therefore, they were physically suitable / comfortable for the testing.

A significant result of the experiment is that 6 out of 10 of the subjects have chosen a navigational mode with an integrated '2D reference map' and 'environment embodied signboard system', even though none of them was familiar with the other mode of assistance. The mode of use – exploratory or goal-oriented that a user is likely to adopt cannot be predicted. Moreover, an 'environment embodied' type of navigational mode attracts goal-oriented navigation, whereas, a '2D reference map' type of navigation appeals to an explorative navigation, therefore, an integrated system could prove more beneficial if applied than any of the other two types of assistance modes. The results stated above are qualitative in nature and demands a further study at certain micro levels with a larger number of subjects.

CONCLUSION

The posited hypothesis gets an uncertain answer from the inferences drawn from the experimental results. However the evidence did not result in rejecting the hypothesis either. An uncertainty remains in proving the hypothesis. However certain inferences can be drawn from the experimental results.

An important conclusion inference is that for the purpose of suiting all genres of users (regardless of their computing experience), an integrated navigational assistance mode in which both 2D reference map and environment embodied references are provided, could be the most suitable option as a navigational assistance mode for 3D virtual environments. This type of mode could fulfill the needs of novice as well as expert users. It has been observed during the experimentation that a user, after getting familiar with the environment is able to navigate with much ease. Therefore, after getting comfortable with the 3D environment, it is evitable that the issue of type of navigational assistance mode may subdue.

Due to constraints such as low computing power, and involvement of less number of subjects, it is not possible to come to a conclusion.

FUTURE WORK

A trail approach of usability testing was applied here for the experiment; further, refinement is required since it was a pilot study. For this purpose, more number of subjects can be involved in the experiment and a more organized pattern of testing to study micro details can be adopted. Several problems have scope for further experimentation in this particular area of Virtual environments. The 'environment embodied' type of assistance mode tested here was an 'embodied signboard system', whereas many other similar modes of navigational assistance such as an inbuilt vocal agent or natural language processing dialogues etc. remain to be tested. Different permutations of the '2D reference map' to aid navigation can also be tested. Some other issues of navigation in virtual environment like viewpoint sticking [23] at certain places after colliding with objects can be dealt with in a more user friendly manner so as to retain the excitement and realism of navigating through a virtual world. Apart from usability issues, VRML supports external authoring interfaces using languages like java and java script which are very useful in adding interactivity to the environment. New modes of navigational assistance can be designed using them. 'Comparative study of navigational assistance modes based on navigation mode', 'ergonomic issues of using a touchscreen immersive environment', 'comparison of degree of realism in virtual agent mode of navigational assistance' etc. are some of the suggested topics for future research.

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