Landmark-based Audio Visual Interfaces for Way-finding for less educated users

Anirudha N.Joshi
Industrial Design Centre
IIT Bombay
anirudha@iitb.ac.in

Prasad G.Rashinkar
Industrial Design Centre
IIT Bombay
prasad.rashinkar@gmail.com

Nagraj R.Emmadi
Industrial Design Centre
IIT Bombay
nagrajmumba@gmail.com

Jagdish Rath
Industrial Design Centre
IIT Bombay
jrath95@gmail.com

Saurabh Srivastava
IBM
saurabhsrivastava@in.ibm.com

Nitendra Rajput
IBM
rnitendra@in.ibm.com

ABSTRACT
GPS-based way-finding solutions have not yet gained popularity in India. One reason for this perhaps could be that these solutions have not been designed for the Indian cultural contexts, and particularly the local way-finding habits. Could it be possible to design better navigation systems for such contexts using landmark-based navigation rather than map-based navigation? We started with contextual inquiries with 25 participants in Mumbai and Lonavala to understand how people navigate to their destination in real life. We found that people tend to navigate and give directions primarily based on landmarks. We hypothesize that a way-finding solution based on landmarks is likely to be less time consuming and less error-prone. To test this hypothesis, we designed two prototypical way-finding solutions. The design approach in one solution is similar to the typical GPS systems available in the market, while the other solution is primarily landmark-based navigation. We conducted a comparative evaluation with 10 users. Results show that the design using landmark-based navigation not only did better in terms of time and errors, but was also preferred by the users. While our study focuses on one specific context, it shows how cultural complexities may be turned to an advantage

General Terms
Performance, Design, Experimentation, Human Factors.

Keywords
Landmarks, way-finding, audio-visual interface.

1. INTRODUCTION
India has seen significant economic growth in the last two decades. One outcome of this growth is that people tend to travel to new areas often, either because of migration, or on account of work, or simply for tourism. In a new area, way-finding can become a major problem, particularly if navigation aids such as detailed signage or maps are absent and also if there is no culture of using such aids.

Several Global Positioning System (GPS) based navigation solutions are available, either as an application running on a mobile phone or as a dedicated GPS device. These solutions show a geographical map that highlights user's current location and desired route. Such a solution assumes that the user has the ability to read a map. However, people with low levels of education may not have sufficient ability to read maps. Although there are applications such as Google Street View, which gives a three dimensional representation of the real world, only 121 million Indians use the internet [1] as compared to 893.84 million people who use the mobile phone [2]. Usage of internet over mobile phone is much less.

Another problem typical in India is that maps simply do not have sufficient level of detail. Maps often lack information such as the curves or bends in a street, signals, one-way rules, allowed turns etc. At times, whole streets are missing, or non-existent streets are shown in the map. Further, maps often get outdated as rules change or new roads are constructed. Google Mapmaker [3] and Wikimapia [4] intend to solve this problem by crowd-sourcing the activity of map-making. While the quality of these maps is much better, these still are not being used in GPS devices and even if they would be used, a majority of less educated users may not be able to use them.

Based on findings from contextual inquiries, we designed two interfaces with fundamentally different visual approaches to support way-finding. In one design we used traditional maps and in the second design we used photographs of the landmarks to guide users. We used voice instructions in both cases, but in the latter case, voice instructions also highlighted elements of the landmarks.

The next section describes related work. Section 3 describes our findings from the contextual inquiries. We describe the design of the two interfaces in section 4 and their evaluation in section 5. Section 6 presents the conclusions.

2. RELATED WORK
A lot of work has been done on mobile guides and way-finding. One such system is GUIDE system which presents users with a

India HCI Conference'12, Month 4, 2012, Pune, Maharashtra, India.

mixture of hand crafted and generated textual descriptions, pictures and maps of the city. The interfaces were used in conjunction with the audio commentary. It was found that, as the audio is being played the usage of the picture view increases significantly [5].Another study in Vienna on mobile tourist guide explains the technical feasibility in mobiles. Map presentation on smart phones with small displays is feasible. Even routing systems can be implemented on such devices [6]. Extensive work has been done in the area of route planning information and directions for way-finding [7] [8] [9]. C.Kray et. al. Compared different modalities of giving directions and way-finding instructions – text, speech, 2D route sketch, 2D maps, 3D maps in Norway. They found that users were able to use the 3D maps but they were comfortable with 2D route sketch, because users were used to navigate using 2D paper maps. Users used the 3D maps for confirmation of the location and used the 2D maps for knowing the route between source and destination. Users appreciated the idea of 3D maps but commented that it would be better if the 3D maps are much closer to the real world maps or images [10] [11] [12].

Use of landmarks has also been investigated in the past. Goodman et. al. designed a pedestrian navigation aid for a handheld computer, which guides the user along a route using photographs of landmarks, together with audio and text instructions that reference these landmarks. This aid was designed with older users in mind who often find their mobility hampered by declines in sensory, cognitive and motor abilities. There were in all 32 users (16 young and 16 aged) who tested the application in a part of the campus of Glasgow University. They concluded that such an aid can significantly outperform a paper-based map and that older people derive substantially more benefit from it than younger people. [13]. Other studies have shown that people use landmarks to learn routes between places [14] and apply and communicate this information by providing a sequence of decision points along a route [15]. They also show the human conception of space as sets of familiar landmarks in terms of cognition, behaviour and phenomenology [16] [17] [18]. Landmarks acts as reference points in the environment and hence contribute to organization of space cognitively [15]. Pierre et. al. reported, users while giving the direction not only specifies what to do but also refer to landmarks located along the routes. The landmark also helps movers to construct a mental representation of an unfamiliar environment in advance and to prepare them cognitively to get through difficult or uncertain parts of that environment. The term landmark is used as an object or structure that marks a locality and is used as a point of orientation in locating other structures [19]. JaeJeung et. al. Uses integration of fragmented description from blogosphere for way finding purposes and finds that the recognition of the location description shows a higher level of accuracy than the official addresses [20] [21]. Map based navigation when combined with Audio Modality reduces time as reported by Chewaret. al. [22]. They report that with audio modality, time taken to look at the screens reduces. Also work has been done in case of speech and non-audio modality to provide navigational assistance in case of normal sighted and visually challenged users [23] [9] [24]. In complex instructions audio faces similar challenges as in textual. In other studies, Nicola et. al. proposes a scheme for collaborative wayfinding through textual information in Short Message Service (SMS) [25]. Kray et. al. reports use of arrow sketches in maps help to reduce the cognitive effort, although the sketch form may reduce the visual clues provided in the basic map [10]. Another stream of research compares the arrow directions and their orientation . Hermann et. al. says that the egocentric view of maps is an important precondition for pedestrian navigation. With the help of the egocentric maps users could complete the task much faster [26]. A forward up map reduces the navigational errors as compared to north up maps [27] [28]. A study by Luca et al. compares Map based, combination of map and photographs and large arrow with photographs. The results of the evaluation show that when the map is combined with photographs that clearly indicate the direction to the user or when the map is replaced by a combination of directional arrows and photographs, users' performance is significantly better. Moreover, the combination of map and photographs was highly preferred by users [29].

The landmark-based navigation was better than traditional map-based navigation for most of the users. In this paper we study if landmark-based navigation will work in case of users with lower levels of education. However, no research has been reported on the effectiveness of landmark-based navigation for less educated users. We build on these earlier streams of research and evaluate how landmark-based navigation compares with traditional map-based navigation for less educated urban users in a developing country.

3. DIFFICULTIES IN WAY FINDING

We interviewed 25 users in context of way-finding to understand the problems they face in Mumbai and Lonavala. Users included postmen, courier delivery boys, teachers, other working professionals, students looking for a specific thing, people who are new to the city etc. We looked for users who were a mix of regular commuters, one-off travellers such as tourists and people who need to do way-finding regularly as a part of their profession (e.g. courier deliverers). In Mumbai, we were mainly looking for behaviour in a large city, where users may not be familiar with all parts of the city. Lonavala is a tourist place and a weekend getaway. Here we were looking for behaviours of tourists. We observed current problems but also probed the users about earlier experiences to identify problems and insights. These contextual inquiries were the part of user studies course work by junior interaction design students of IDC, IIT Bombay, Mumbai, India.

The most common method of way-finding is asking someone for directions. However, information out of context or contradicting is often misleading. While giving directions, the instructor uses local terms and names for places. The instructor is quite familiar to the geographical area while the way-seeker is not. For example, people often use terms like take a left from *main building*, go straight from *infinity corridor*, etc. The instructor often accompanies his verbal directions with gestures, either to signify the direction of travel or size of landmarks. However, this is not enough and the way-seeker faces difficulty in visualising the path.

Further, instructors give directions such as "take the 3rd right". However, way-seekers often get confused while counting the number of right turns. Some ignore narrow lanes or lanes with short dead ends, while others don't.

It is common for way-seekers to ask for directions repeatedly, particularly at the point of confusion. At times, this can confuse the way-finder even more if there are inconsistencies in the two instructions. This can happen particularly if there are multiple paths to reach the destination. Further, even for the same path, different instructors may choose different instructions. In case of such inconsistencies, the way-finder chooses to ask a third person as a tiebreaker.

Some users seemed to have particular preferences about whom to ask for information. People prefer to ask a "serious looking" person rather than someone who is not perceived to be so. E.g. once, while searching for computer science department a user skipped all college students who were nearer and asked for help from an elderly person. Another user asked a security person rather than college students. Professional way-finders such as courier delivery persons or postman prefer to first look for signage or landmarks instead of asking people. Even if they were to ask, they would ask a stationary person such as a shopkeeper.

Instructors often use landmarks to describe the route. Common landmarks used are buildings, trees, parking lots, restaurants, banks or shops with large signage. Instructors choose landmarks that are visually identifiable and well-known rather than written postal addresses or the actual importance of buildings. They give instructions to locate landmarks such as "keep looking on the right".

While navigating, landmarks on the route play an important role. When the way-finder is able to locate a landmark, it gives him a confirmation that he is on the right track and an assurance that he would reach destination by following this route.

However, several problems can still occur while using landmarks for way-finding. There could be some disconnect between the instructor and the way-finder. The way-finder may not be able to visualise a landmark beforehand. Further, the instructor may choose an inappropriate landmark and as a result the way-finder may miss it. When asking for directions on subsequent instances, way-finders may ask for directions to an intermediate landmark rather than their final destination, assuming that the intermediate landmark might be a better-known place. While this strategy works in many situations, sometimes it could fail if the way-finder is directed away from the destination and towards the landmark.

Way-finders often ask distances to a landmark to anticipate the effort, as a checkpoint and to decide when to ask for further directions. Some instructors provide this information in terms of distance (meters or kilometres), while others provide it in terms of time taken to walk or drive. Way-finders need time-to-time confirmation that they are on the right track.

4. DESIGN

Traditional GPS devices evolved mainly in developed countries where maps were already widely available. Since map-based way-finding was already common, these GPS devices could use existing conventions in maps effectively. However, in the context of developing countries, detailed maps are becoming widely available only in recent times and predominantly in an electronic form. These are often not used by a large segment of the population for way-finding purposes. Could it be possible to design better navigation systems for such contexts using landmark-based navigation rather than map-based navigation?

To compare these two approaches, we developed two prototype systems: 1. A traditional map-based navigation complemented by voice instructions (as in typical GPS devices) and 2. Voice instructions supported by photographs of landmarks.

4.1 Common Design Elements

To ensure that we only compare the desired variables, we chose to create comparable prototypes with as many common features as possible. Both prototypes were created in Flash and were played from a Nokia N95 mobile phone.

Voice instructions are critical as they help in eye free navigation, particularly while driving or walking on a busy street. Instructions are better comprehended if they are in users' natural language. Differences in language style, voice clarity or volume of the audio could make significant differences in understanding the instructions. To account for this, both prototypes had pre-recorded voice instructions in the same voice, recorded in a similar studio and in a similar language style. The language of instruction was Hindi, which is commonly understood in Mumbai. Similar headphones were used for listening to instructions so that the users can see the corresponding map without missing any details.

4.2 Traditional map-based navigation

The prototype representing the traditional map-based navigation, starts with displaying a map and depicting the user's location on the map indicated by a white dot (fig 1a). The interface gives the first instruction to help the user get oriented with his location and then asks the user to navigate till the next turn: *"You are currently standing opposite Mangii Restaurant. Walk straight for 300 meters and press 2 once you reach the signal. To listen to the instruction again, press 0."* The path to the next turn is shown in light blue and the next turn itself is indicated on the map as a blinking red dot. The path from the current position to the red dot is always displayed vertically. The audio instruction repeats after 15 seconds.

Once the user presses 2, it is assumed that the user has reached the point indicated by the red dot. The white dot moves to the new location, the map is reoriented such that the next turn is in a vertical direction again (fig. 1b) and the new instruction is given in audio. If the next turn is too far away and cannot be represented on the map without changing magnification, the instruction is given only for the next 200 meters rather than till the next turn.

Figure: 1a

Figure: 1b

4.3 Landmark-based navigation

In the prototype representing the Landmark-based navigation, the user is oriented with respect to the nearest landmark. To get oriented correctly, thumbnails of 3 photographs are displayed –

the landmark that is supposed to be in front of the user, the landmark that is supposed to be to his left and the landmark to his right (fig. 2a). During the voice instruction, the respective thumbnails zoom in to cover the whole screen. The voice instruction says: *"Stand in such a way that you are facing towards this pole (fig 2b), and to your right there is a building with a board IBS on it (fig 2c), and towards your left there is Hiranandani Hospital (fig 2d).If you can see all this, press 2."*

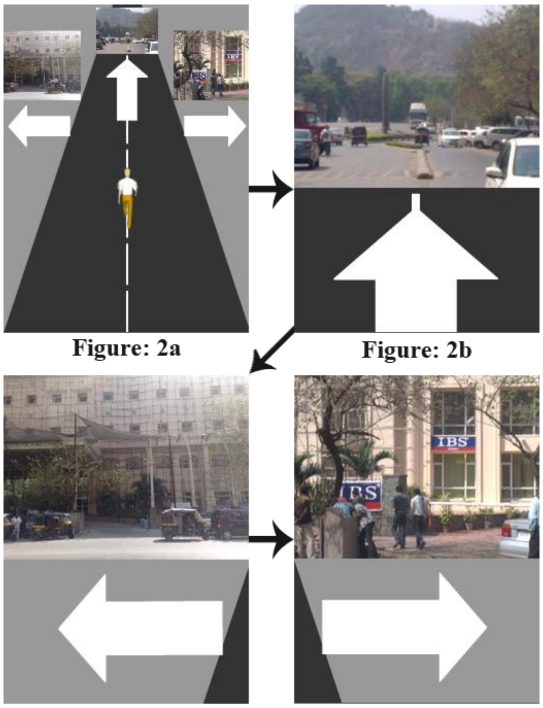

Figure: 2a Figure: 2b Figure 2c Figure: 2d

Once the user presses 2, it is assumed that the user has oriented himself correctly and the next instruction is provided: *"From here, walk straight. After about 80 steps you will reach an intersection (fig 3a). There, you will see the same pole in front of you (fig 3b), you will see this blue and yellow board on your left (fig 3c), and you will see a road going towards your right (fig 3d). When you reach this intersection, press 2."*

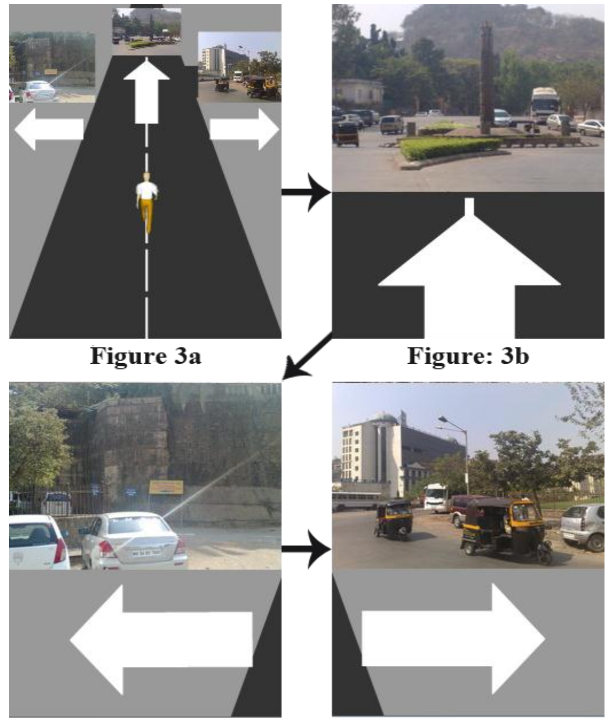

Figure 3a Figure: 3b Figure: 3c Figure: 3d

After the user reaches to the next landmark, he presses 2 and he is given the descriptions of the next landmark. This process of describing landmarks and giving directions from there continues till the user reaches the destination. The user can repeat the current instructions by pressing 0. The user can retrace his steps and go back to the earlier landmark by pressing 8. The user can see the larger image of the thumbnail on the left side by pressing 4 and the thumbnail on the right side by pressing 6.

5. USABILITY EVALUATION

Google map with GPS on mobile phones has been quite popular amongst tech-savvy, urban users. However very rarely for non tech-savvy low literate users application is seen useful. But there seem no such concrete evidences and proofs. Here we try to investigate whether Landmark-based navigation proves to be better for such user group. Simultaneously we also observe whether giving an audio feedback to Traditional-map based navigation would help users in navigating or not .For this purpose the routes chosen were almost of equal distances and also at most care was taken to negate the difference between the voice instructions in both the prototypes.

To understand the significance and the relevance of the designed prototypes ten usability tests were conducted in Mumbai. Prototypes were evaluated within the subjects.

5.1 Users

All the participants were selected based on following criteria:

Age	30 – 50 years
Education	Not more than 7th std.
Language	Hindi
Mobile Ability	To punch in numbers

Test Location	No familiarity
Geographical Maps	No familiarity

Table 2: User recruitment criteria

To understand the tech-savvyness of the participants, their mobile usage was noted. Out of 10 users, all the 10 users could make and receive a call while only 6 users can check missed calls and can save a number, 7 users can read SMS and only 4 users can write an SMS. Table 2 shows that this can be the lowest tech-savvyness possible. The younger people tend to have more hands on technology, they were not considered for the study and also elderly people (above 50 years), as they lack in motivation to learn and adopt newer technologies.

5.2 Method

Before the usability evaluation, it needs to be ensured that a participant is briefed about the context, in which the system is being used, what are the expectations from the participant, and Dos and Don'ts for him.

Consent about the participation of the user needs to be taken before the evaluation begins, which should include the points like:

- The participation is voluntary.
- One should be careful during the study.
- One should be able enough to walk, cross roads and negotiate the traffic without the help of anybody.
- Permission for Audio/Video recording (if any) of the actions/reaction and views.

Moderator accompanies the user throughout the route. Users are taken to the test location that is at the starting point of the journey, where the device is handed over to him after starting the application. To simulate the real life situation, user of his own has to orient himself by hearing the instructions given by the system. Help was provided upon user's request and accordingly he was given points. Once user feels satisfied with his position he makes input to the system by pressing a key and then the system gives the instructions of how to move ahead.

The entire journey is divided into small intermediate destinations as it was observed during the contextual inquiries that such approach would enhance user experience. Following are the quantitative measurable:

- Time taken to reach each landmark.
- Errors induced due to the device and the design.
- Number of times the participant seek for the help to locate the landmark.

Qualitatively moderator notes users reactions, what makes users to lose the way and users reactions in such situations to get back on track etc. users are not allowed to look for any external help. Success is calculated based on intermediate destinations that is if a user fails to reach to the destination, the score till he has reached successfully is considered valid.

There are two fundamentally different styles of prototypes and hence they shall be evaluated within the subject to get the comparison. Results of the participant considered valid only if they try out both the prototypes. During the pilots, it is observed that the users loose the concentration after shifting to another prototype. Hence a break of a day was given, while evaluating the second prototype with the same user. On the second day user will start on new route with the other prototype.

At the end of each round users were asked to rate the prototype they have used on the scale of five. This rating helped in assessing the user satisfaction and experience of using the prototype. As the learning from one prototype may affect the other, assignment of the prototypes were made random but controlled enough to have equal number of users using Traditional map-based navigation first and also Landmark-based navigation first. Care was take that the demographic details such as age, education, mobile phone ability and mobile usage should not be differ significantly on either side. Both the routes were considered equal in terms of difficulty level and the complexity of the instructions; hence they were assigned randomly to the user with respect to prototypes. This strategy eliminates any biases for route specific, prototype specific, and learning related factors.

All the participants were compensated for their time and effort, care was taken that the participant will not have to spend to reach the test location.

6. RESULTS

The usability tests were conducted with 10 users. While testing the two prototypes with the same users, it was decided to follow two separate route for each prototype. It helped to reduce or eliminate the learning from one prototype to apply on the other prototype and made sure that the designs tested are unbiased . Both the routes were equal in terms of complexity, distance, number of instructions etc. Hence, the route was not considered as a variable in the statistical analysis.

The results of the assessment are summarized in the following table.

	Traditional map-based Navigatoin	**Landmark-based Navigaton**
# Users	10	10
Avg. Success Score	20.8	29.8
Z Score	0.019	
Avg. Time Taken	18.51	19.68
Z Score	0.21	
Avg. Error	1.88	0.88
Z Score	0.19	
Users Reached	7	9

Table 4: Statistical Analysis

The success score is a cumulative addition of the points that a participant earns on each checkpoint while reaching to the destination. One can earn maximum of 33 points on route one and 36 on the route two. More the average success score close to 33 points better is the prototype performed. From table 4 it is evident that the users who used the Landmark-based navigation prototype on any of the routes, leads to higher chances of a participant reaching to the destination. Further an independent proportions test is used to compare the significance of dichotomous variables such as success score i.e. *Z score*. It is proved that the Landmark-based navigation is better in terms of way finding in comparison with Traditional map-based navigation. The difference between the scores is though not significant but more towards proving it significantly better.

User Satisfaction Ratings

	Prototype	
	Traditional Map	**People Map**
Users	10	10
SUS	78.75	81

Table 5: SUS scores

After the test every user was given a questionnaire called Software Usability Scale (SUS) to analyse the user's satisfaction about the system.

Users using any of the prototype are equally satisfied with system. However, it should be noted that none of the participant had ever used any technology to find way to the destination as a result those who have used Traditional map-based navigation first, appreciated it with higher ratings. While using the Landmark-based navigation thought they found it better, the rating for it could not go ahead as the scale has upper limit as 5 and lower as 1. This can be more evident if we consider a few typical scenarios like- while on route 2, one of the users took a wrong turn at one point, however within next 2 minutes he realized that he is on the wrong path. His words to the moderator were, "*it seems that we have gone wrong here, the building shown in the picture is not this one"*. At same location when another user missed the path while on map based prototype, he could not recover and the test had to be finished their itself giving 0 points for the checkpoints ahead on the route.

There were participants who did equally well on both the routes, all of them had reported that they were more confident and comfortable with the Landmark-based prototype. Some users said that they liked the Landmark-based prototype because they can match the image on the screen with the real world scene and hence they could confirm that they are on the right track, such thing helps in gaining confidence which is an essential thing to achieve as observed during the contextual inquiries. In case of Traditional map-based prototype, users had comments like "I am not sure whether the right turn being showed in the map is the same right turn that I have to take". More importantly it was observed that the user seeks a confirmation about his action after it has been taken e.g. after taking right turn user seeking the confirmation.

This response is analogous we also wanted to analyse the instructions on prototypes specifying the distance that the users have to cover to reach a particular checkpoint. The instructions in the Traditional map-based navigation says "walk for about 150 meters and then press 2", which failed badly because, users had no idea whether they had covered 150 meters or not and users were confused whether or not to press 2. So if you don't keep the landmarks, users are not able to make decisions on what to do next. Hence users felt more confident when they saw landmarks on the screen rather than a straight line directed towards destination.

7. DISCUSSIONS AND FUTURE WORK

It is important to notice that both the prototypes were supported by voice instructions. Voice instructions helped user in eye free navigation, it is critical for pedestrians as they have to negotiate the traffic too especially in the areas where there are no footpaths. During the usability tests it was observed that participants mainly listened to the voice instructions carefully and used the photographs of the landmarks only for the confirmation. One of the implications of the above data set could be that voice is the only critical medium and visual support is required to enhance user experience. As a part of future work we shall test the application to check and verify the importance of voice over visual and whether one of them can suffice for low literate users.

The pre-tested and proved fact that the usage and criticality of landmark is validated with the low literate and non tech savvy audience too. As stated above, photographs of the landmarks help user to avoid errors and build confidence. On the other hand users while using maps observed to hardly refer maps when they get confused. During such situation users listens to the instruction time and again. Repeating the instruction after a time interval and on user's wish was appreciated too.

The instructions, regarding the distance they have to cover in meters, failed, as none of the pedestrian could approximate the mentioned distance to the distance they have covered to a fair extent. One of the things that we did not test here is that whether the distance mentioned in time period will be helpful *e.g. walk for approximately 2 minutes i.e for 100 meters and then from… take a left turn.*

8. ACKNOWLEDGMENTS

This project was funded through a grant from IBM. We thank all the moderators and the users for participating in this project and sharing their insights. We also thank Abhinav, Anshumali, Anura, Chandni, Meera, Neha, Priya, Puneeth, Radhakrishna, Rohit, Rumin, Shruti and Vishal students of IDC, IIT Bombay, Mumbai for sharing their course work.

9. REFERENCES

[1] Internet World Statistics. (2011, December) Internet Users in the World. [Online]. http://www.internetworldstats.com/stats.htm

[2] TRAI. Telecom Subscription Data as on 31st December, 2011. [Online]. http://www.trai.gov.in/WriteReadData/trai/upload/PressReleases/869/PR-Dec-11.pdf

[3] google mapmaker. [Online]. http://www.google.co.in/mapmaker

[4] Wikimapia. [Online]. http://wikimapia.org/#lat=19.2&lon=72.9667&z=10&l=0&m=b

[5] K. Cheverst, N. Davies, A. Dix, A. Friday, and J. Seitz C. Borntraeger, "Experiments with multi-modal interfaces in a context aware city guide.," in *Mobile HCI 2003, Springer-Verlag*, 2003, pp. 116–130.

[6] M. Umlauft, and E. Michlmayr G. Pospischil, "Designing LOL@, a mobile tourist guide for UMTS," in *Mobile HCI*

2002, 2002.

[7] M. Goldstein, M. Nyberg, and M. Erikson D. Chincholle, "Lost or found? A usability evaluation of amobile navigation and location-based service," in *Mobile HCI 2002*, 2002, pp. 211–224.

[8] D. Cavada, and Q. Nguyen F. Ricci, "Integrating travel planning and on-tour support in a case-based recommnder system," in *Mobile HCI 2002 Workshop on Mobile Tourism Systems, 2002*, 2002.

[9] D. Morse, and H. Gedenryd S. Holland, "Audiogps: Spatial audio navigation in a minimal attention interface," in *Personal and Ubiquitous Computing*, 2002.

[10] K. Laakso, C. Elting, and V. Coors C. Kray, "Presenting route instructions on mobile devices.," in *IUI 2003*, 2003, pp. 117–124.

[11] E. Kulju and E. Kaasinen, "Route guidance using a 3D city model on a mobile device.," in *Mobile HCI 2002 Workshop on Mobile Tourism Support, 2002.* , 2002.

[12] O. Gjesdal, and J. Sulebak K. Laakso, "Tourist information and navigation support by using 3D maps displayed on mobile devices.," in *Mobile HCI 2003 Workshop on HCI in Mobile Guides, 2003*, 2003.

[13] Phil Gray, Kartik Khammampad,Stephen Brewster Joy Goodman, "Using Landmarks to Support Older People in Navigation," in *MobileHCI 2004*, Berlin Heidelberg, 2004, pp. 38–48.

[14] Golledge R, "Wayfinding Behaviour," 1999.

[15] H.A. & Tversky, B. Taylor, "Perspectives in Spatial descriptions," vol. 20, no. 5.

[16] A.W. & White, S.H Siegal, "The development of spatial representations of large-scale environments," vol. 10.

[17] K. Lynch, "The Image of the City.," 1960.

[18] P.W Thorndyke, "Performance models for spatial and locational cognition.," in *Rand, Washington DC, 1980.*, 1980.

[19] Michel Deni Pierre-Emmanuel Michon, "When and Why Are Visual Landmarks Used in Giving Directions?," in *COSIT 2001 Proceedings of the International Conference on Spatial Information Theory: Foundations of Geographic Information Sciences* , 2001.

[20] Merriam-Webster. (2000) Merriam-Webster's Online Dictionary.

[21] JaeHoon Cho, Yuseong-gu, Jung-hee Ryu JaeJeung Kim, "“An architecture for dynamic location description generation from the web for human way-finding”," in *Proceedings of the 7th International Conference on Advances in Mobile Computing and Multimedia.*, New York, USA, 2009.

[22] C. M. Chewar and D. S. McCrickard, "Dynamic route descriptions: tradeoffs by usage goals and user characteristics.," in *Smart Graphics 2002*, 2002, pp. 71–78.

[23] R. Michel, H. Petrie, A. Raab, and T. Strothotte S. Fritz, "MoBIC: user needs and preliminary design for a mobility aid for blind and elderly travellers.," in *European context for assistive technology*, 1995, pp. 348–351.

[24] J. Krosche, and S. Boll P. Klante, "AccesSights – A multimodal location-aware mobile tourist information system.," in *ICCHP2004*, 2004, pp. 287–294.

[25] Christopher Lueg and Jeff Axup Nicola J Bidwell, "The Territory is the Map: Designing Navigational Aids," in *CHINZ '05, July 6-8, 2005*, Auckland, NZ, 2005.

[26] G. Bieber, and A. Duesterhoeft F. Hermann, "Egocentric maps on mobile devices.," in *4th International Workshop on Mobile Computing, IMC 2003*, 2003, pp. 32–37.

[27] M. O'Grady, and G. O'Hare C. Sas, "Electronic navigation - some design issues.," in *Mobile HCI 2003*, 2003, pp. 471–475.

[28] B. Schmidt-Belz and F. Hermann, "User validation of a nomadic exhibition guide," in *Mobile HCI 2004*, 2004, pp. 86–97.

[29] Stefano Burigat Luca Chittaro, "Augmenting Audio Messages with Visual Directions in Mobile Guides: an Evaluation of Three Approaches," in *MobileHCI'05.*, 2005.