Different Reality Modalities for Museum Navigation

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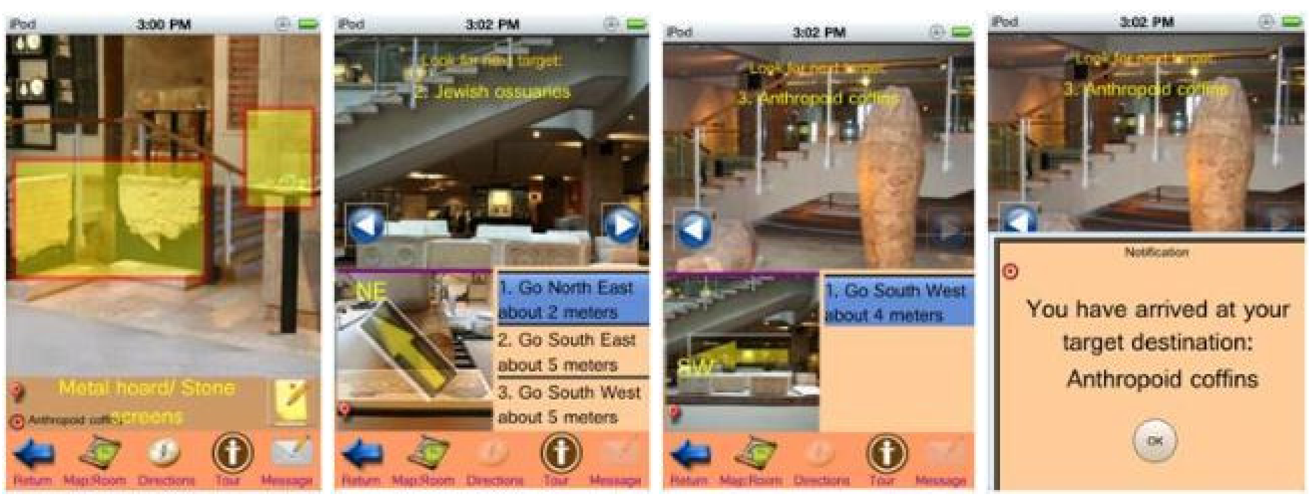
ABSTRACT
Certain museums can be complicated places to navigate within. They may not have a clear path through the museum and may offer many alternatives. In order to facilitate navigation, we experimented with a variety of techniques and display devices on a mobile museum guide. The types of techniques examined were photo landmark navigation and maps. The display devices we used were a pico projector and handheld devices (IPad, IPod). Each combination of device and technique leads to different reality modality, such as Mixed Reality, Augmented Reality, Dual Reality and Virtual Reality. We examined the benefits and disadvantages of the various combinations, and report qualitative trends from our experience with user experiments and visitor studies. We introduce the term Quality of Reality correspondence (QoRc) to describe the differences noted.

Author Keywords
Indoor navigation, PolySocial Reality

ACM Classification Keywords
H.5.1. Artificial, augmented, and virtual realities.

INTRODUCTION
Museums are known to be rich in interesting exhibits and information. Some museums are complicated places to navigate within. They may not have a clear path through the museum and may offer many alternatives. The problem is complicated even further given the fact that a visitor usually has limited time for a visit. Hence visitors usually need some kind of navigational aid in order to find their way within a museum. The classic navigation aid is the paper map of the museum, which is based on the museum floor plan and enables the visitor to orient themselves and find the way in the museum. However, such paper maps may be inconvenient and not easy to use, especially when a group of visitors is visiting the museum together. Current mobile technology opens new possibilities for supporting indoor navigation. The use of virtual reality and augmented reality techniques may ease the indoor navigation – enabling the visitors to visualize the way from the current position towards the destination, see the path, identify a landmark, see through walls or overlay navigation instruction over the current view – using the devices built in camera or steerable



(a) (b) (c) (d)

Figure 1. Landmark Directional Navigation step by step

projectors installed in the environment – all these provide a variety of technological solutions for supporting indoor navigation. The paper examines two approaches and devices for supporting indoor navigation – using landmark-based directional navigation and maps on both a mobile, personal device and a pico-projector that presents navigational information over surfaces in the environment.

RELATED WORK

Navigation within indoor museums demands visitors' attention and increases their mental load. Technological solutions for navigation require both indoor positioning and smart navigation information delivery. Positioning may be detected by sensors such as RFID, cameras, QR-codes, You-Are-Here maps and dead-reckoning [7]. As for information delivery, Mulloni et al. [5] present a handheld 3D indoor navigation tool, using augmented reality within a building, assisting personal navigation by using sparse-localization info-points. The localization is based on coded posters (similar to QR-codes) posted on the floor as info-points. The system is activity-based, taking into account the current state of a person, e.g., standing or walking, where people navigate through simple activity instructions such as "go ahead 20 steps" [3]. Indoor navigation systems based on augmented-reality have used several methods and devices to present relevant navigation data to users. Augmented reality HMI devices include smart phones, PDAs, tablets, handheld computers, and projection of data on the point of interest. Handheld smart devices or smart phones are used to present simple easy to understand photos, sketches, icons or text instructions on the screen [5, 6,9]. Smart devices are used not only to assist in navigation but also to recommend personalized routes of interest to people as in the case of a museum [8,10]. Handheld pico-projectors are used to present navigation information on the floor of a walking path preventing the need to split the attention between the screen of the device and the walking path [2].

INDOOR NAVIGATION ALTERNATIVES

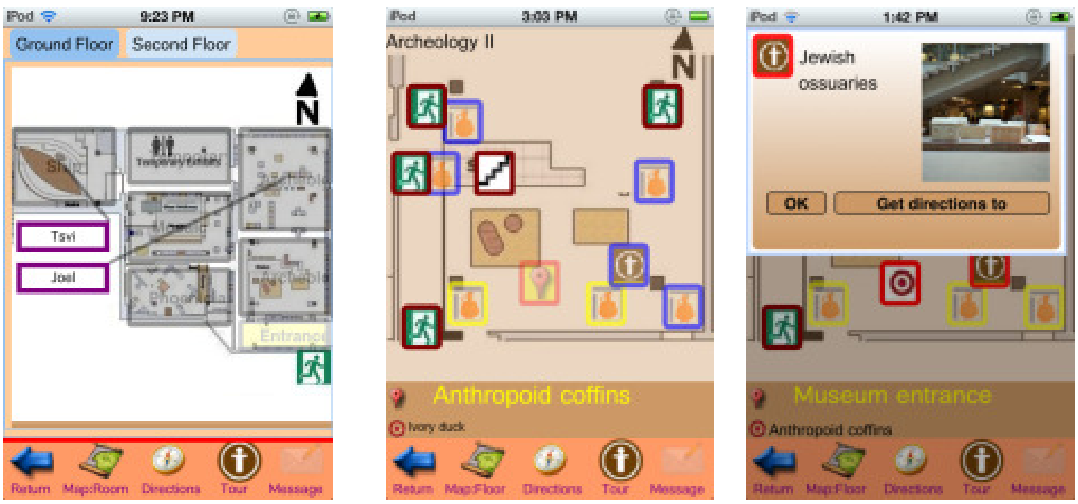
We experimented and compared two different navigation techniques: navigation directions (based on landmarks photos) and the use of maps using both iPods and Pico-projectors.

Directions

Fig. 1 shows a typical usage scenario in which a visitor wishes to go from the current position to a chosen destination. In the example, the user sees the current location (Metal hoard, Fig. 1a) and has already chosen the destination (Anthropoids coffins). The user prompts the navigation by pressing the “Directions” icon on the bottom of the screen. After pressing the direction icon, the user is then shown the path by a series of images of landmarks. He or she can look (scroll) through the list to see how many segments exist. On the current position segment (Fig. 1b, and 1c) the user sees the next landmark on the top, and the previous position image on the bottom left corner. There is an arrow overlaid on the previous position image showing the user which way to go. The arrow is adjusted according to the visitors’ compass orientation. Between landmarks, the user gets directional information to progress to the next landmark (bottom right corner of Fig. 1b and 1c). As the as users advance towards and arrive to a new landmark, the screens automatically changes to show the next landmark. When the users arrive at a landmark, a popup dialog informs the user that she/he has arrived at the destination target (Fig. 1d).

Maps

An alternative form of way finding in the system is maps. The system supports maps at the room level (Fig. 2b),



(a) Floor view **(b) Room View** **(c) Pressing Location on map**

Figure 2. Maps

showing the individual points of interest (POI), and at the floor level (Fig. 2a), showing rooms. At the room level, each POI is a button which when pressed shows an enlarged image of the POI and has a button requesting directions to the POI (Fig. 2c).

The current position is marked with a flashing YAH (You Are Here) icon. The next destination is marked with a target icon. POIs that currently have many people near them (as recognized by the system) are marked as congested. All symbols used within the maps are described in Table 1. At the floor level, the positions of the members of the group are marked with an icon containing their name.

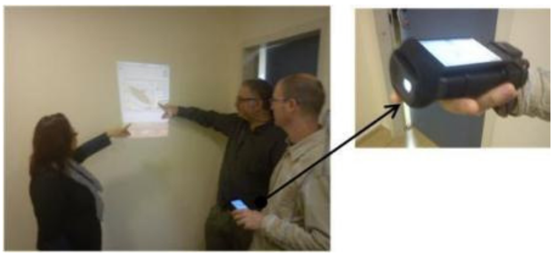


Figure 3 – Pico projector

DEVICES

There were two types of devices: 1) a personal pico projector, a 3M 160 MPro(TM) attached to an Apple(TM) iPod touch 4 (running TVOut2) having an output of 30 lumens (Fig. 3), and 2) a handheld mobile device, both an Apple(TM) iPod Touch Gen 4 & iPad 2.

PARTICPANTS

There were three groups of participants. The first group was composed of the normal visitors to the museum who agreed to use the guide on the iPods. The second group was students who used both devices in various studies. The third group consisted of museum visitors who were asked to use the projector. Those visitors were shadowed in a Talk Aloud study.

ENVIRONMENT

The combination of directions vs. maps and handheld devices gave us a variety of "realities" to examine. In Table 1 we enumerate the mapping of our conditions to the various realities.

	Device			
	Projector		IPod	
Maps	I	Mixed /Dual Reality	II	Dual Reality
Directions	III	Augmented Reality	IV	Dual Reality

Table 1. Devices, Navigation Mode, Reality Type

Quadrant I is considered a Mixed Reality, since on one hand we project a form of virtual reality (a map) onto to actual reality, it is also a Dual Reality since the person's real position is shown on the map. Quadrant II removes from the previous quadrant, the element of being projected and augmenting reality, thus it is considered a dual reality Thus the virtual reality (a map), is updated from the "real world" position. Quadrant III is considered and Augmented Reality since we project an arrow onto the space showing which direction the user should proceed. Quadrant IV can be considered a dual reality, since it shows a picture of targets and verbal directions (representing a virtual reality), yet also includes the arrow which is responsive to the user's movement in the real world, hence dual reality situation.

OBSERVATIONS

From the variety of configurations and realities, we indeed see that we are clearly within PolySocial Reality[1]. We examine each Quadrant for their benefit and disadvantages.

Quadrant I

The projector brings the virtual world of the map into the real world. This allowed groups to plan together where to go and help each other interpreting the map. The map icons and especially the YAH icon was found useful in positioning the group in the virtual world of maps via data from the real world. Groups of users would point to the map in a number of different ways (point on projection, point from a distance, use a finger as a stationary point and move the projector)[12] This sense of a shared space was deemed important to the users and gave place where users gathered around to plan navigation.

Quadrant II

Using the map by a group on the small screen of the iPod was difficult. In general it led to just one person doing the navigating and others following his lead. Again the YAH icon led to increased satisfaction.

Quadrant III

Directions via the arrow when projected were a useful group feature. Having the directions project allowed the entire group to participate in finding the target. The lack of a "true" connection (latency of 30 seconds) between the projected arrow and the person location caused many problems with the interface (the location technology only provided information concerning proximity to an exhibit and not coordinates). This dissonance was the major source of dissatisfaction with the system. In addition there was a phenomenon of people scouting ahead to find the next landmark, but returning to the projected area (much like honeybee scouts).

Quadrant IV

Directions on the smaller screen was deemed less useful as opposed to being projected, as some user found it difficult correlating between the arrow direction on the screen and which way the were supposed to walk (perhaps a 3D arrow would have helped here). Again the dissonance between the instruction and the actual position was a major source of dissatisfaction.

Projectors vs. iPad

While theoretically both the projector (by annotating the real world) and the iPad (by acting as a looking glass with annotations on the real world) provide a way to annotate reality. A reported deficiency of the "looking glass" method is that ergonomically users tire of holding the device at eyesight height as opposed to belt height that projectors need to be held. This however may only be a temporary problem of the "looking glass" method, as technologies such as Google glasses [11] come into place. "Glasses" however may still have the problem of not having a "shared" display (they may or may not be equivalent to synchronous views on iPods). On the other hand non-shared displays provide a degree of privacy.

Augmentation vs. Virtual Reality

As we have seen, the usage of most applications today can invoke instances of PolySocial Reality. Direction as an "augmenting" technology seemed the easiest for most users to navigate. This came at the cost of allowing less freedom in terms of navigation choices when compared with the "virtual" map setting. Dual reality applications that were primarily based on a virtual world (i.e. maps) were less sensitive to the connection with the real world (YAH in maps that did not update quickly, was not as critical as the compass arrow in directional instructions). We also did experiments with showing multi-media content; here visitors had less of a preference for augmenting technologies; though admittedly the technology's presentation of content did not take advantage of having a "Dual Reality" aspect to it (e.g. an arrow pointing to a part of the exhibit).). A useful way of thinking of this sensitivity is Quality of Reality correspondence (QoRc) which consists of *accuracy, stability, latency, and update frequency*. *Accuracy* describes how accurate the representation (e.g. position) of one reality is within another. *Stability* describes the reliability and timeliness of delivery of the representation information. *Latency* refers to the delay in delivering the representation information. *Update frequency* refers to how often the information is updated.

CONCLUSIONS

Novel technology opens new opportunities for indoor navigation. Visitors to the dense and sometimes challenging museum environment may benefit from these novel technologies, as demonstrated by our work. The use of individual mobile devices to support indoor navigation, as it supports outdoor navigation, is the most common approach. However, group navigation support may be achieved by the use of mobile projectors or by interaction with large displays. As technology will improve, more applications of augmented and virtual reality with differing QoRcs may be used for supporting visitors on the go, enabling them to blend the navigation instruction into the real environment and personalize them as needed.

ACKNOWLEDGMENTS

The work was supported by the Israeli Science Foundation (ISF) grant 226/2010 and by the collaboration project between the Caesarea-Rothschild Institute at the University of Haifa and FBK/irst and FIRB project RBIN045PXH.

REFERENCES

1. Applin, S.A.; Fischer, M.D.; , "Pervasive Computing in Time and Space: The Culture and Context of 'Place' Integration," Intelligent Environments (IE), 2011 7th International Conference on , vol., no., pp.285-293, 25-28 July 2011
2. Arning, K., M. Ziefle, M. Li, and L. Kobbel: Insights into user experiences and acceptance of mobile indoor navigation devices. Paper presented at Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia, (2012).
3. Brush, AJ, A. K. Karlson, J. Scott, R. Sarin, A. Jacobs, B. Bond, O. Murillo, G. Hunt, M. Sinclair, and K. Hammil: User experiences with activity-based navigation on mobile devices. Paper presented at Proceedings of the 12th international conference on Human computer interaction with mobile devices and services, (2010) .
4. Klemmer, R.S., Thomsen, M., Phelps-Goodman, E., Lee, R. and Landay, J.A. Where do web sites come from? Capturing and interacting with design history. In *Proc. CHI 2002*, ACM Press (2002), 1-8.
5. Mulloni, A., H. Seichter, and D. Schmalstieg.: Handheld augmented reality indoor navigation with activity-based instructions. Paper presented at Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services, (2011).
6. Serra, A., Carboni, D., and Marotto, D.: Indoor pedestrian navigation system using a modern smartphone. In Proc. MobileHCI '10, ACM, (2010), 397-398.
7. Torrok, A., and Helfenbein, T.: A Novel Framework for Personalized and Context- ware Indoor Navigation Systems. MOBILITY 2012 : The Second International Conference on Mobile Services, Resources, and Users, (2012), 60-63.
8. van Hage, W., N. Stash, Y. Wang, and L. Aroyo: The Semantic Web: Research and Applications, (2010), 46-59.
9. Vlahakis, V., N. Ioannidis, J. Karigiannis, M. Tsotros, M. Gounaris, D. Stricker, T. Gleue, P. Daehne, and L. Almeida: Archeoguide: An augmented reality guide for archaeological sites. IEEE Computer Graphics and Applications, (2002), 52-60.
10. Walker, K..: Interactive adventures. Digital Technologies and the Museum Experience: Handheld Guides and Other Media, AltaMira Press, (2008), 109-124.
11. http://www.technologyreview.com/view/509456/the-latest-on-google-glass
12. Wecker, Alan J., et al. "Pathlight: supporting navigation of small groups in the museum context." *Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services*. ACM, 2011.