Projected Fiducial Markers for Dynamic Content Display on Guided Tours

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Abstract
In this paper, we present a novel interaction technique – combining mobile projection and visible, fiducial marker based information display. We vision it to be suitable for small groups e.g. for narrative playful experiences and guided on places, where physical tags would be disturbing. This interaction technique, where one person (guide) is projecting a marker and other users can read it with their mobile devices, enables *in situ* information delivery while the guide can control the dynamics of the situation. We present an example use case of using the interaction technique on a guided tour, and a preliminary results from the user evaluation.

Author Keywords
Interaction techniques; mobile projection; fiducial marker; mobile devices; tour guides.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Mobile phones are omnipresent devices, nowadays the majority of which are smart phones. People are used to use their phones or tablets in various everyday life situation to obtain information ad hoc, for example by

browsing the Internet, or using a navigation app. Situations such as being on a guided tour, e.g. as a tourist, exhibition visitor or student, are no exception to this. Mobile phones are also increasingly commonly used with applications, which use visible, fiducial markers, e.g. QR codes, which are viewed via the mobile device to obtain extra information

In this paper, we present a solution that combines the benefits of visual markers and ability to visually broadcast coded information in situ. As a use case of this interaction approach, we propose a tour guide operated mobile projector that dynamically creates a visual marker, which is then read by the tour audience with their mobile phones.

Related Work

Using Markers for Mobile Information Delivery

The use of visual markers, such as QR codes, in mobile interaction has been frequently researched, and solutions are increasingly deployed in commercial and public settings. Makela et al. [6] has pointed out that visual markers may give a somewhat technical impression and are aesthetically not pleasing. However, in the positive sense, viewing a marker with a mobile phone camera viewfinder was reported as a familiar and thus easily conducted action. The versatility of the use of tags is described by Hardy et al. who report on an in-the-wild study on user customizable NFC tags [4].

Morrison et al. [8] examined how the AR based MapLens concept would work in guiding groups in-the-wild with a physical map. The study findings suggested that participants concentrated more on tasks, which involved e.g. problem solving and social interaction. The use of MapLens reportedly had the effect of integrating the participants in the study group, improving the co-operation in executing the study task.

There are few studies that combine the use of projection devices and fiducial markers to created located information presentation. One such system is presented in [1] where the authors describe a study that took place at the National Botanic Garden of Wales. The study explored the participants' reactions to a prototype that utilised a pico-projector attached to an iPod. The iPod was used to scan QR codes situated next to exhibits (e.g. plants). As well as displaying exhibit information on the iPod screen, the user could project exhibit related imagery onto the exhibit object itself.

Mobile Projection

There is a large amount of existing research on handheld projectors in a variety of application. Rukzio et al. have reported on the design space around personal projection, highlighting many potential areas of use [9]. The Sixth Sense [10] project illustrated several possible concepts e.g. for creating ad hoc user interfaces with a mobile projector. Molyneaux et al. [7] report on studies using handheld projection both for infrastructure-based and infrastructure-less cases. Mobile projection has been used to augment maps [5], by projecting additional information on top of them. Of particular relevance to our research is the Pathlight system [11] which utilizes a handheld pico-projector to provide navigation support for museum visitors.

Our work differs from the prior art by combining these two techniques, visual markers and mobile projection, to a single, multiuser interaction technique. Earlier, the use of projected markers has been rarely studied. Examples being their use with a fixed projector and

read by robots [5], and with invisible projected IR markers [13]. As far as we are aware our approach using handheld projection and visible markers is previously unstudied.

Projected Markers Interaction Concept

In our concept, we propose a new technique to use visible, fiducial markers, by projecting them ad hoc from a handheld projector, Figure 1. These projected markers are then read with a mobile device, i.e. a smart phone or tablet.

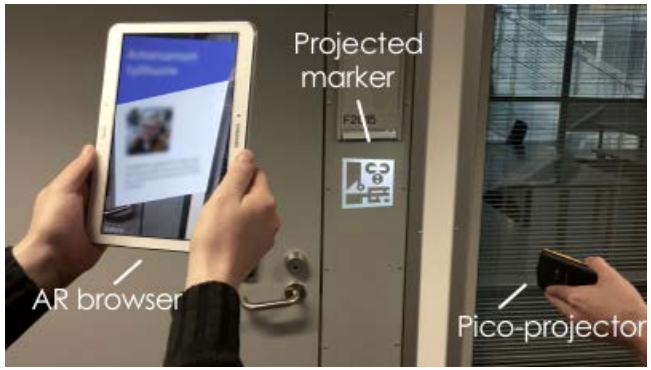

Figure 1: Projected markers interaction technique.

Use Scenario – Guided Tours

We selected a guided tour as a use scenario to trial the projected marker concept. Guided tours take place e.g. in museums, exhibitions and when presenting buildings or industrial sites to groups of visitors. Such tours already often take advantage of mobile technology, e.g. with autonomous context-aware guides [2], or utilizing QR codes [13]. However, also personally guided tours have maintained their popularity, benefiting from the contact between the tour participant and the guide. In our scenario, we seek to combine the advantages of available technology and a personally guided tour by using projected markers as part of the tours' media content.

In our concept scenario, a tour guide is giving a guided tour to a group of people who each have a smart phone. The tour guide stops to some point of interest (POI) to verbally explain the information related to the place. At a given point of the story, the guide uses a mobile phone integrated pico-projector to project a visual marker on to the wall. The visitors then use their smart phones, equipped with a viewer application, to scan the marker and view the multimedia content that is linked to it, see Figure 1.

The advantages in our projected marker based interaction technique are two-fold. Firstly, the information can be better viewed from a personal mobile device, e.g. the distance from the content is not a hindrance and people can read the content at their own pace. Secondly, the approach serves to maintain the relationship between the presenter and the audience. This is a consequence of the content presentation being mediated by a physically visible object that is dynamic in nature, and under control of the presenter. Additionally, the projected marker technique combines the functionality of a pointer, such that in addition to dynamically selecting what content to show, the presenter can also control its location.

Comparing Different Interaction Techniques on a Guided Tour

Interaction Techniques

To test the interaction concept, we set up a guided tour, which included media content at several POIs,

which was presented using different information delivery techniques (Figure 2). In this way, we sought to compare the proposed projection-based marker technique with other more traditional and well-known presentation techniques. The techniques used are described in Table 1. Thus our experiment design consisted of a balanced study based on two independent variables, projected vs. printed and viewed directly vs. viewed via a smart phone.

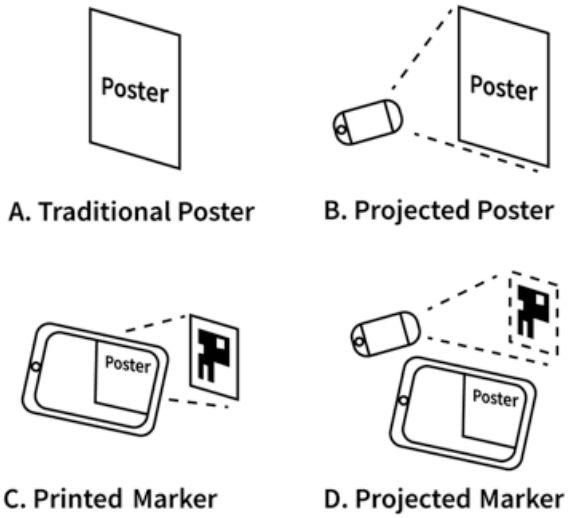

Figure 2. The four presentation techniques used in the study.

Using a printed poster (A) is the most traditional conventional way to provide information at a location. Similarly, the use of fixed projectors to project to create information displays is a widely used technique. The use of mobile projectors to share information in public (B) has been trialled in [3,12]. These techniques (A and B) are basic information sharing techniques that test participants would be familiar with.

Study Set-Up

To evaluate the interaction techniques, we organized a guided tour at the university premises at the beginning of the semester and recruited 27 students (14 male, 13 female) as test participants. The building in which the guided tour took place, was new to the students. The participants ages ranged from 18 to 37 years (M= 25, SD = 5.6). All participants owned a mobile phone and almost everyone (24/27) had prior experience of using QR-codes with a smart phone.

Technique	**Description**	**Tour-guide controlled**	**Read with mobile device**
A. Paper poster	A printed A3-paper poster placed at the POI.	No	No
B. Projected information	Image projected to the wall with a handheld projector phone.	Yes	No
C. Printed marker read with mobile device	Printed black and white A4 marker placed to the wall at POI	No	Yes
D. Projected marker read with mobile device	Markers projected with a projector phone on to a physical surface at the POI	Yes	Yes

Table 1: The information delivery techniques that were compared in the tour.

The guided tour consisted of eight points of interests (POIs), two for each interaction technique A, B, C and D (Figure 2 and Table 1). The tour lasted for approximately half an hour. Altogether six tours, each with 3-6 participants were given, with the cumulative number of participants being 27. Participants were given a smart phone or tablet to use, which was running a mobile application developed to present tour content based on recognition of a visible marker. At the end of the tour, participants completed an end questionnaire, which included Likert scale questions where participants could rate the different presentation techniques and give free-form comments. In addition, a researcher, acting as an observer, accompanied the tour and took notes during the tour.

Preliminary Results

This work-in-progress paper contains the preliminary results of the user study. From the Likert scale responses (Figure 3), the paper poster (A) was considered the easiest to interact with, whilst the smart phone based methods (C & D) received the highest ratings for interesting and fun. Participants noted that the printed poster (A) was less versatile than the other solutions. For their usefulness, all options A-D received similar ratings.

In qualitative results, benefits of projected marker technique were commented to be its adaptivity for different situations on a tour, and because it did not leave any disturbing physical marks into the environment. Thus, several participants suggested that it would suit to guided tours on museums or other historical sites. As negative side, poor luminance and hand tremor were noted.

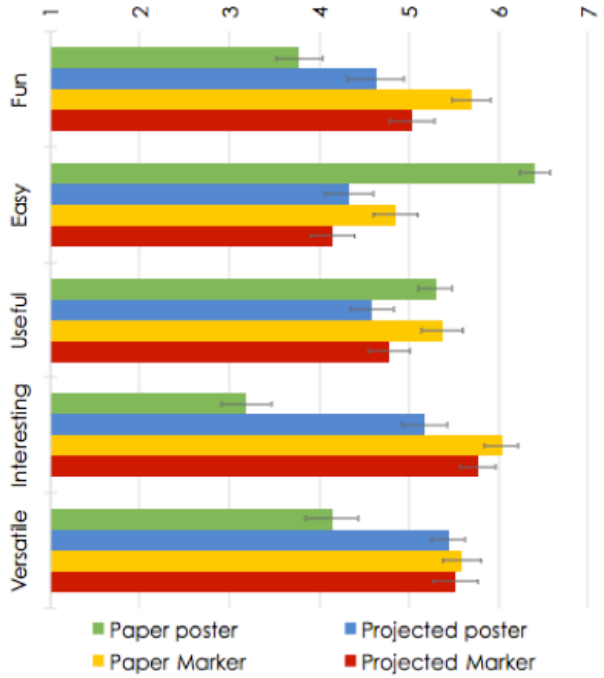

Figure 3: Mean rating for different aspects of each presentation technique rated on a scale of 1-7 (1= not at all, 7= very much). Error bars indicates standard error of mean.

Discussion and Conclusions

In this paper, as a contribution we have presented a novel mobile interaction technique utilizing projected markers, which are then read by other users with their mobile phones. A key facet of the approach is that the dynamically positioned visual marker both focuses attention to the location in which it is projected, and also serves to create a connection between the group members viewing the content.

We envision that this interaction approach could be applied in situations where one person wishes to provide additional information for a group of other users *in situ,* while still maintaining the attention of the group. This situation may appear e.g. in story telling, games, or guided tours.

Limitations of the technique relate to the luminance of the projected marker and the need for a suitable projection surface. Such limitations will reduce as pico-projectors with improved performance become available. The work is currently at an early stage, but we believe as it progresses we will identify a range of applications that can benefit from this interaction concept

We have evaluated the interaction technique in a real world setting for introducing campus area to new students, and presented preliminary findings. Next, we will dig deeper in the evaluation of our projected marker concept to provide more comprehensive results.

References

1. Liam Betsworth, Huw Bowen, Simon Robinson, and Matt Jones. 2014. Performative technologies for heritage site regeneration. Personal Ubiquitous Comput. 18, 7 (October 2014), 1631-1650. http://dx.doi.org/10.1007/s00779-014-0766-3
2. Keith Cheverst, Nigel Davies, Keith Mitchell, Adrian Friday, and Christos Efstratiou. 2000. Developing a context-aware electronic tourist guide: some issues and experiences. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems* (CHI '00). ACM, New York, NY, USA, 17-24. http://doi.acm.org/10.1145/332040.332047
3. Andrew Greaves, Panu M. Åkerman, Enrico Rukzio, Keith Cheverst, and Jonna Häkkilä. Exploring User Reaction to Personal Projection when used in Shared Public Places: A Formative Study. Presented in *CAM3SN workshop at MobileHCI'09*, 2009. http://comp.eprints.lancs.ac.uk/2264/1/cam3sn2009_greaves.pdf
4. Robert Hardy, Enrico Rukzio, Paul Holleis, and Matthias Wagner. 2011. Mystate: sharing social and contextual information through touch interactions with tagged objects. In Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services (MobileHCI '11). ACM, New York, NY, USA, 475-484. http://doi.acm.org/10.1145/2037373.2037444
5. Minoru Kojima, Maki Sugimoto, Akihiro Nakamura, Masahiro Tomita, Masahiko Inami, and N. I. I. Hideaki. "Augmented coliseum: An augmented game environment with small vehicles." In null, pp. 3-8. IEEE, 2006.
6. Markus Löchtefeld, Johannes Schöning, Michael Rohs, and Antonio Krüger. 2009. Marauders light: replacing the wand with a mobile camera projector unit. In Proceedings of the 8th International Conference on Mobile and Ubiquitous Multimedia (MUM '09). ACM, New York, NY, USA, , Article 19. http://doi.acm.org/10.1145/1658550.1658569
7. Kaj Mäkelä, Sara Belt, Dan Greenblatt, and Jonna Häkkilä. 2007. Mobile interaction with visual and RFID tags: a field study on user perceptions. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '07). ACM, New York, NY, USA, 991-994. http://doi.acm.org/10.1145/1240624.1240774
8. David Molyneaux, Shahram Izadi, David Kim, Otmar Hilliges, Steve Hodges, Xiang Cao, Alex Butler, and Hans Gellersen. 2012. Interactive environment-aware handheld projectors for pervasive computing spaces. In Proceedings of the 10th international conference on Pervasive Computing (Pervasive'12), Springer-Verlag, Berlin,

Heidelberg, 197-215. http://dx.doi.org/10.1007/978-3-642-31205-2_13

9. Ann Morrison, Antti Oulasvirta, Peter Peltonen, Saija Lemmela, Giulio Jacucci, Gerhard Reitmayr, Jaana Näsänen, and Antti Juustila. 2009. Like bees around the hive: a comparative study of a mobile augmented reality map. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '09). ACM, New York, NY, USA, 1889-1898. http://doi.acm.org/10.1145/1518701.1518991
10. Enrico Rukzio, Paul Holleis, and Hans Gellersen. 2011. Personal projectors for pervasive computing. *In Pervasive Computing*, *IEEE* 2, 30-37.
11. Sixth Sense http://www.pranavmistry.com/projects/sixthsense/ (Last accessed September 25th, 2015).
12. Alan J. Wecker, Joel Lanir, Tsvi Kuflik, and Oliviero Stock. 2011. Pathlight: supporting navigation of small groups in the museum context. In *Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services* (MobileHCI '11). ACM, New York, NY, USA, 569-574. http://doi.acm.org/10.1145/2037373.2037462
13. Karl DD Willis, Ivan Poupyrev, Scott E. Hudson, and Moshe Mahler. "SideBySide: ad-hoc multi-user interaction with handheld projectors." InProceedings of the 24th annual ACM symposium on User interface software and technology, pp. 431-440. ACM, 2011.
14. Max L. Wilson, Dan Craggs, Simon Robinson, Matt Jones, and Kristian Brimble. 2012. Pico-ing into the Future of Mobile Projection and Contexts. *Personal and Ubiquitous Computing* 16, 1: 39-52
15. Annika Wolff, Paul Mulholland, Mark Maguire, Danielle O'Donovan (2014). Mobile technology to support coherent story telling across freely explored outdoor artworks. In *Proc. ACE 2014*. ACM