Pico Projection for Performative Place Based Services

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Abstract
In this paper we explore using handheld projectors in place of traditional location-based information services. We built a prototype system to compare performative projection of animations and images against conventional on-screen information. We conducted a user study to test the informative and the new performative design, gathering user feedback and reactions to the approach. Our findings highlighted design issues and the potential benefits of performative projection for prompting interaction with exhibits as part of the experience at a visitor attraction.

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Introduction
The availability of mobile internet and realtime geolocation is increasingly allowing the information we seek to be linked in some way to the places we visit. Many of the mainstream location-based information services to date have focused on delivering images, multimedia or text in situ, direct from the internet to a mobile client.

Of these services, there are multiple AR lens applications that make use of a camera, overlaying digital content on a realtime physical world image (e.g. see layar.com). However, while these systems can augment camera images with digital content, the user still has to hold their device in front of the real object – a digital divider between them and the physical world. The technology element is visible and in the way – it detracts from the magic of the experience.

By using pico projection, we can take this type of AR lens application one step further. By projecting into the environment rather than displaying on a screen, both the problem of sharing (screen size) and the existence of a digital divide (technology visibility) are compensated for. Instead of manipulating an image recreated on a device screen, we can now project onto the real world itself. Full-size projectors have been used on many occasions to augment buildings as part of a multimedia performance,

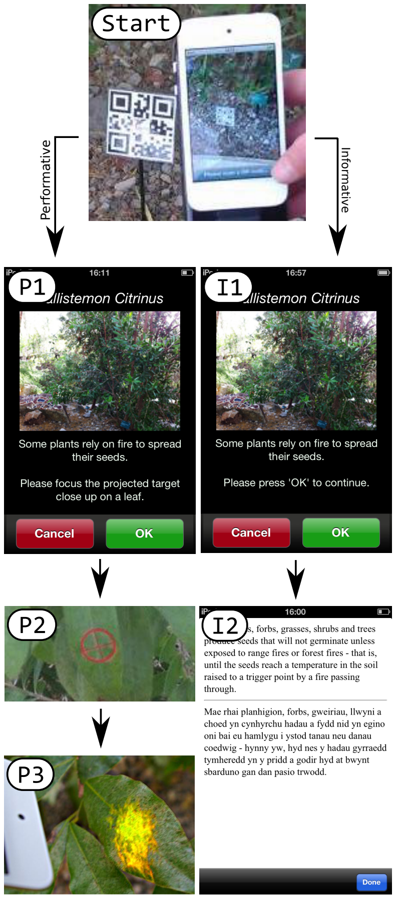

Figure 1: Using both prototype systems: scan QR code with iPod touch (Start) *Performative:* prepare (P1 & P2; confirm and point target) and project (P3) or, at right, *Informative:* confirm scan (I1) and display text (I2).

using 3D video mapping to make the buildings appear to come to life (e.g. see nuformer.com). With pico projectors we can create a similar display while mobile, but rather than simply informing the user of relevant digital information, we can allow them to become part of the performance itself.

In this paper we report on a prototype system to display pico projected images and animations. The novelty of this work lies with the use of pico projection to augment exhibits at a visitor attraction. In particular, there was a large emphasis on the user being able to control the placement of the projections in a free-form way, positioning projections using a red dot, preventing the need for a sophisticated tracking system. While some of the findings have been seen in prior works, the performative perspective of this research sheds new light on the possibilities.

Background

In recent years, there have been multiple attempts at developing mixed reality experiences for groups of people to share. The 'Augurscope' [5], for example, was an early outdoor mixed reality prototype for groups of people at an attraction. Small mobile screens are good at displaying private and personal information, but this also makes them very poor at displaying public information to groups of people. In recent years, researchers have experimented with various solutions of presenting public information on a public display using a personal mobile device [2].

Pico-projectors now enable mobile devices to show a much larger display than that of a laptop or other mobile device. Researchers have been quick to take advantage of these devices in mobile information scenarios, using projectors for collaborative learning [3] or gaming [7]. Our prototype is inspired by these previous designs, but we focus on the collaborative, shared viewing experiences possible when using public mobile projection (such as [2]).

Bongers was one of the first to realise the potential of taking the projector out of its intended context [1]. In considering potential research directions, he concluded that it would be "very interesting to create a location-based instrument that projects images and sounds depending on the spatial context of the performer". Wecker et al. developed 'Pathlight' [6], a handheld projector experience that helped visitors navigate a museum using projected arrows (on either the floor or wall) depending on the user's location and orientation. To our knowledge, our implementation is the first to focus on location-based curated content, providing a handheld interactive projection-augmented experience that can overlay exhibits at a visitor attraction.

Prototype

We developed a mobile prototype to demonstrate performative, place based projection. We worked with the curators of a popular tourist location—a national botanic garden—carefully crafting and tailoring the types of performative projection specifically to the context of their visitor attractions. Our system reuses QR codes and some curated content from a previous project at the gardens (similar to [4]). We use QR codes for location awareness.

For this research, our main aim in using a pico projector is not as extra screen space, but specifically to allow a visitor to augment the real plants and objects with digital content, acting out or performing actions with the elements they project. In the context of this paper, we define performance as manipulating the projections to achieve effects with the projected content. Where

Figure 2: Projecting images and animations in *performative* mode. From top to bottom, projections show: a sunbird flying to a plant; a witchetty grub on a tree trunk; and, raindrops falling on a leaf.

spectators are present, the moving and positioning of the projector and the effect can create an illusion of AR. Our system uses an iPod touch attached to a pico projector (see Fig. 1). The iPod is used to scan QR codes situated next to eight exhibits around the gardens' visitor centre. After scanning, an image and sentence of context about the exhibit are shown onscreen, along with a prompt to focus a projected target on the object. The user presses a button when ready, and imagery or animation is then projected. Figure 2 shows several such examples, where the projection appears next to or on top of the related artefact. Apart from the initial QR scan, the system does not implement any additional tracking. This allows users of the system to project freely onto objects in an attempt to promote performative and playful behaviour.

Informative, screen-based system
We also built a second, alternative mode into the system, allowing us to compare traditional screen-based location information with the projected content approach. After recognising the QR code and showing the same initial content on-screen as in the performative system (i.e. a sentence of context and an image), upon pressing a button it then displays a page of textual information about the object, instead of a projection (see Fig. 1).

Field trial

We conducted a study over six days at the botanic garden. The aim was to test both systems with real visitors in situ. We had two research questions: **RQ1:** How do perceived learning and enjoyment through performance with projections compare to perceived learning and enjoyment with text-based information?; **RQ2:** How does the performative aspect of the projector system affect involvement or interest from non-participant visitors when compared to the informative system?

Participants
Twenty groups of participants were recruited as they entered the building. Ten groups used the informative system and ten used the performative system. A total of 58 participants took part, with 34 people using the informative and 24 using the performative system. Participants' ages ranged from 3–80, with 29M, 29F overall, and similar gender distribution between systems. The average group size was 3 participants.

Measures
To gather users' opinions of the system a short survey was built into the prototype. After scanning a QR code and either projecting or reading the related content, the prototype prompted the group to give feedback. Groups were instructed to give feedback collectively. The survey questions asked: 1) how many non-participant visitors stopped to look; 2) participants' enjoyment; 3) perceived learning value; and, 4) how they felt their understanding was affected in each location.

Questions 2 and 3 allowed participants to select a rating from 1 (low) to 5 (high). Q4 allowed a selection from 'decreased,' 'unaffected,' and 'increased.' In addition to the survey, participants answered a short semi-structured interview at the start and end of each session. For one of the six days, two additional researchers observed groups' behaviours from a distance while they used the prototype, being careful to avoid intruding on the experience. In total four groups (13 visitors) were observed, with three using the performative and one using the informative system. In addition, during that day, many visitors who were not participating in the study were also observed.

Procedure
After groups agreed to participate, a short training session was conducted to demonstrate usage of the system to the

Figure 3: *Top:* the large glasshouse in which the study took place. *Bottom:* the garden map with exhibit locations 1–8 indicated.

group. The group was then given the prototype (in either performative or informative mode), and an information sheet in case they needed further guidance. This sheet also incorporated a map showing the approximate location of eight QR codes to scan (see Fig. 3). The group then left the researcher, finding and scanning each separate code and completing the five survey questions after viewing the content associated with each display. At the end of each session, the group were debriefed in a short post-study interview, thanked for participating and given a gift voucher.

Results

Considering first the data gathered by the mobile application after each exhibit. For Q1, the average numbers of non-participant visitors that were reported were 1.39 for the informative system (sd: 1.66) and 1.88 for the performative system (sd: 2.33). There is an overall significant difference in participants' rating of whether their understanding of an exhibit was affected (Q4), with the informative system seen to be more beneficial in that respect ($p < 0.002$; Mann-Whitney). Turning to the ratings of enjoyment (Q2) and perceived learning (Q3), there was no significant difference between systems.

In the post-study interview, all participants indicated that they had noticed interest from other non-participant visitors around them. A common sentiment was captured by one participant, who said: "if people were around they looked." In some instances, other visitors were curious enough to ask participants what they were doing. Three groups using the performative system reported that they demonstrated the system and engaged with non-participant visitors. One of these said that their performance involved 13 visitors who became interested in what was happening.

Participants often commented that the system they used added interest to their visit, with one participant claiming that the performative system gave "an extra dimension." Some of the groups with children (using either of the systems) noted the enjoyment in seeking out and scanning the QR codes themselves. One participant using the informative system explained this, but noted: "the children love to find the codes and scan them but they're not interested in reading any of them." Several participants commented that the brightness of the projector was sometimes an issue.

Observations

Considering first the group observed using the informative system (four adults; one child) – in general this group gathered closely around the system after scanning each QR code. No single individual in this group took control of the prototype; instead, participants took it in turns to scan each QR code. In some cases one participant read aloud to the rest of the group; for other exhibits individuals read to themselves instead, huddled tightly around the device. While other visitors were aware that the group were doing something unusual, they were not seen to experience the information the group was reading.

With the performative system, where three groups were observed, there was evidence that projection encouraged participation beyond the device itself. Participants were not gathered around the device, but were seen to be focused on the projections rather than the prototype. In one group (two adults; two children), an adult held the device and let the children direct his hand, pointing the projections at plants while visitors stood by and watched.

Discussion

The higher rating given to the informative system in terms of "understanding" is not surprising given that the system provided detailed textual content for each exhibit, in contrast to the performative system's images and animations. We might have expected a higher rating for perceived "learning" in the informative version for similar reasons; and, conversely, a higher rating for "enjoyment" for the performative. However, no significant effect was apparent. For this reason then, we may speculate that both types of system provide benefits in these respects – allowing for both informative and performative modes in future designs would seem a sensible approach.

Clearly image quality, particularly brightness, impacts on the efficacy of projection. Visibility seems to have played a part in participants' opinion of the performative prototype as a learning resource. No significant difference was found in the numbers of people reported as stopping to watch by participants using both systems. However, post-study interviews and group observations suggest that bystanders had a more active engagement with the performative prototype.

Conclusions and future work

A pico projection system, such as the one employed here, may encourage people to engage with their surroundings rather than focus on signage or, if using a conventional mobile device, the device itself. Furthermore, there is some evidence that projection might allow groups to enrich their shared experiences and to draw in bystanders.

The choice of locations and attractions for performative projections can clearly impact on the effectiveness of the approach. Forcing visitors to stand in "disruptive" locations to project content—for example, changing the flow of others along a pathway—may encourage spectators. Careful stage-craft is needed, though, to avoid annoying bystanders or embarrassing performers.

Pico-projection brightness will remain an issue for some time. To accommodate this, and to further use digital output to prompt physical engagement, we might consider providing more stage direction to users. For example, in the garden context, instead of simply asking people to target the beam on an exhibit, the group could be asked to stand round the plant (providing shade), with one of them cupping their hand around a leaf (further darkening the object) before animations begin.

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