Position Paper:

Projector Phones Afford Novel Interaction Modalities

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ABSTRACT
Projector phones are starting to be marketed for business presentations and media viewing, and we have begun to document how people use them "in the wild." We have observed that, in addition to the expected uses, projector phones afford novel interaction modalities. A key observation is that users can readily exploit projector phones' new facilities to author effects employing superimposition, juxtaposition, scaling, and animation.

Author Keywords
Projector phones, user study, interaction

ACM Classification Keywords
H5.2 [Information interfaces and presentation]: User Interfaces; B 4.2 Input Output devices

General Terms
Human Factors, Documentation

INTRODUCTION
Pico projectors are increasingly being embedded in commodity mobile phones. Projector phones are being primarily marketed to business consumers for presentations and ad hoc meetings, and proposed consumer applications have been limited to passive media viewing. Researchers are beginning to design new applications and projection-specific interaction techniques to explore a broader array of possible uses [1,2,5]. Observations of usage practices are crucial to informing the design of devices, interfaces, and applications, and our initial observations of commodity projector phone use "in the wild" have revealed that even the basic platform affords novel interaction modalities.

FIELD STUDY
We have begun to document how people use projector phones through a 4-week, 10-participant, exploratory field study [3]. We observed that, in addition to the expected uses, many unexpected practices emerged. A key observation is that users can readily exploit projector phones' new facilities to author effects employing superimposition, juxtaposition, scaling, and animation, and combinations of these representational techniques.

Because a projector phone can be easily oriented and can throw an image over a distance, decoupling the device from the display, projected information can be dynamically superimposed onto (Figure 1a) or juxtaposed next to (Figure 1b) things in the physical environment. These techniques can perceptually bridge the physical and digital

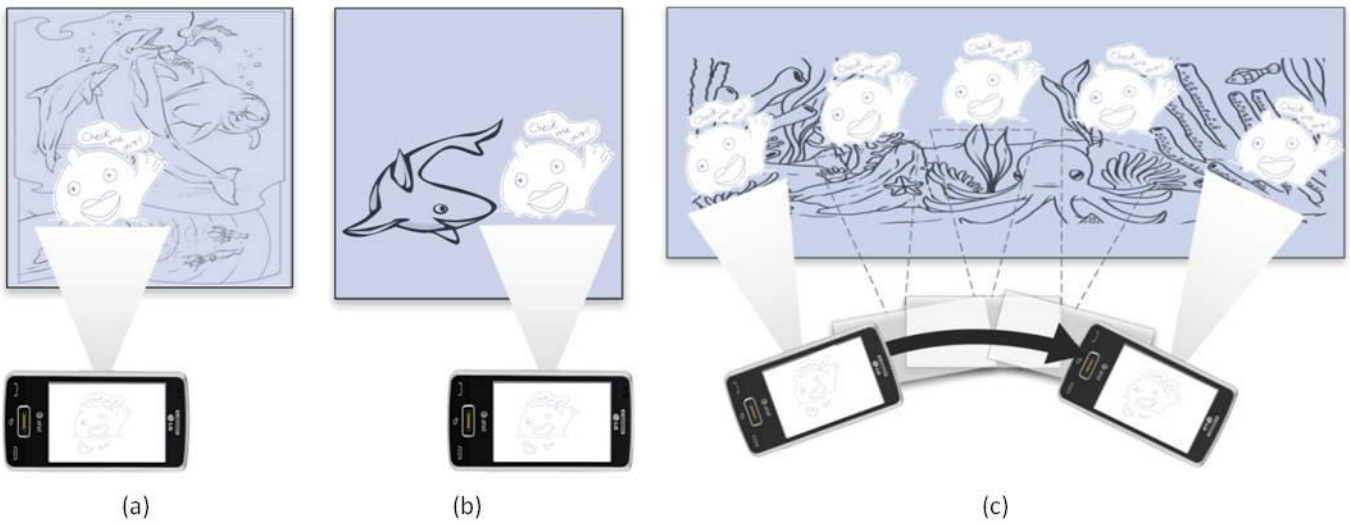

Figure 1: (a) Superimposition, (b) juxtaposition, and (c) animation

worlds. For example, one participant projected a drawing onto a wall that had "*some kind of feel to it*" to add texture, and another playfully immersed himself in a projected underwater scene to create an effect "*like swimming with sharks.*" The physical display surface and the projected content can contribute to blended meanings, such as when one participant projected fire onto a colleague's back to imply that she was burning. Superimposition and juxtaposition can also support comparison, making it easier to identify similarities and differences.

A user can directly move and orient the projector relative to the display surface to scale the projected image. With a projector phone, as one increases the throw distance the entire projected image is enlarged, whereas in contrast, on an ordinary display as one enlarges an image beyond the display's size it is clipped. One participant leveraged this facility, using the projector to enlarge a drawing that he wished to paint and transfer it onto canvas. The size of a projected image can represent its dimensions, quantity, or importance, and a change in size can indicate literal or figurative growth or reduction or a change in emphasis. Further, scaling can support comprehension and interaction at human scale. For example, a participant juxtaposed a sketch drawn on paper with a projected digitized version of that sketch, scaled to the same size, to check for differences— combining representational techniques.

Projector phones can also support animation. The distance between the projector and the display surface can amplify the effects of projector movement, enabling a small change in the projector's orientation to cause a large change in the position of the projected image. In contrast, a traditional projector remains fixed during use, and the motion of a non-projected display is not amplified by throw distance. The relative motion of the projected information can represent animation (Figure 1c). For example, one participant made a Snoopy cartoon appear to fly, rotating the projector in his hand to cause the projected image to move quickly around a room's walls, and another made a cartoon fish appear to "*dance on the ceiling*". In contrast, when another participant projected through the window of a moving car onto the side of a moving truck, tracking its position with the projected beam, the projected information did not appear to be moving because its position relative to the truck did not change.

DISCUSSION AND CONCLUSIONS

A projector phone's small size and the ease of orienting its projected display support what Luff and Heath term "micro-mobility" [4]. Users not only can carry projector phones from place to place, they can readily position and orient projected information during interactions. With a handheld projector, a user can orient the display by simply moving his / her hand and can hide information by averting or occluding the projector (e.g., with his / her free hand).

Our results suggest that projector phones are not merely mobile media displays; they go beyond combining existing projector and phone technologies to afford new, emergent practices. Projector phones' mobility and their ability to throw an image over a distance enable novel dimensions of authorship, supporting a unique concentration of representational facilities in a single artifact. Further, the ease, tangibility, and directness of showing, hiding, and orienting projected displays are novel features of mobile personal projection.

Researchers are beginning to design applications and interaction techniques that harness the motion of handheld projectors, exploring a number of metaphors. For example, in the spotlight (a.k.a. flashlight) metaphor the projector's beam illuminates a region of a virtual information space, which appears to remain static as the beam moves over it [1]. In contrast, in the MotionBeam metaphor a projected foreground object remains static relative to the projected background as the projector's beam moves over a physical background, and graphic art techniques are employed to convey impressions of animation [5]. And as we have observed, even the basic projector-phone platform affords novel interaction modalities, enabling users to author representational effects by orienting projected information relative to the physical background.

Each interaction mode has a unique set of affordances, and when switching between them we trade one set of affordances for another. Future work could explore enabling users to quickly and easily switch between these modes to tailor the interaction style to the current activity.

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