Public Issues on Projected User Interface

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Abstract

What will happen when pocket projectors become mainstream personal display channels? What will be affected when numerous projections intrude our living space without proper control? Today's technology in projection has promised a big screen viewing experience from mobile devices, pushing us toward a truly ubiquitous display environment. But, is our society prepared for the next projection-generation?

We argue that the Projected user interface (PUI) will introduce new problems both in environmental and social aspects which are seldom been explored. This paper explores our rights to project and be projected in public space. Can we project on human body without asking for permission? Can we refuse to be projected? Can projection pollute the environment and influence the people therein? This paper proposes several issues about people's rights on projection, and provide discussions on possible solutions.

Keywords

Handheld projector, Projected user interface, multi-user interaction, public display

ACM Classification Keywords

H5.2 [User Interfaces]:General. K.4.2 Social Issues. I.3.6 [Methodology and Techniques]: Interaction techniques.

General Terms

Design, Human Factors

Introduction

With the rapid development in projection technology, projector units are becoming much cheaper and smaller. In 2009, several companies have released pocket projector products, promising a big size screen viewing experience. Currently, these pocket projectors are used mainly as a secondary output channel for devices with small display screens like *iPhone*. In addition, some consumer products are equipped with built-in projectors. For example, Nikon has introduced a digital camera [1] with a built-in projector for instant sharing of photos with friends nearby.

P. Mistry from MIT Media Lab proposed SixthSense [2], a concept that builds on a wearable projector-camera device, enabling the user to utilize the physical world as kind of interface. SixthSense benefits in its large screen from projection, natural gesture interface from camera, and ease of share with people around. However, we should also consider the problems that will likely arise when projections are truly everywhere [3]. In the rest of the paper, we use "projected user interface" (PUI) as the representative for interfaces that use interaction techniques, such as SixthSense.

Traditional LCD-based personal devices are limited in its small screens, and only demand a small physical space in their usage. These devices are not really related to the environment and other people's personal spaces. However, when these personal devices are equipped with projection ability, the displays from projections can easily intrude one's personal space.

In this paper, we explore the rights of human to project and be projected in public space. In the next few sections, we try to raise possible issues and to further discuss possible solutions in angles of technical, sociological and legal aspects.
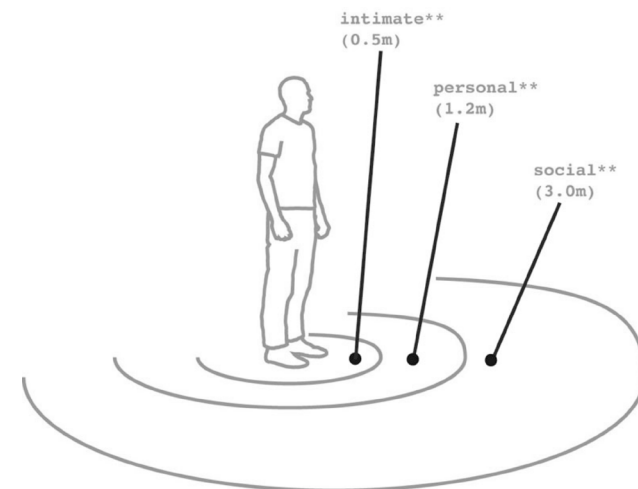

figure 1. Four zones of relation in *Proxemics*. The inner circle around the person indicates one's intimate space, which is about 0.5m; the circle in the middle indicates the personal space, which is the distance that one feels safe. [11]

Projection as Intruder

Hall [4] conducted a psychological study featuring the *Proxemics* (Figure 1) *which* has been widely discussed in HCI community. *Proxemics* explores how people

relate to each other according to their physical proximity. His paper reported four distances: the intimate distance, the personal distance, the social distance, and the public distance, ranging from centimeters to tens of meters away between two persons.

However, when projection becomes one of common personal displays, the definition of relationships in *Proxemics might no longer hold.*

Early studies of the use of cell phone in public space can be observed in Wei[5] and Humphreys[6], however, few studies have been done on the effect of using pocket projectors and PUI device in a public space.

Currently, pocket projectors are restricted by its low luminous level, narrow focus area, and small projection size. But their ability in projecting can still easily intrude one's personal space, and even touch his/her body. We are not arguing that *Proxemics* is unnecessary, just that more issues need to be further discussed.

Considering the projection

On projecting, projection occupies a 3D cone in space and a 2D quadrilateral on the surface. The 3D cone can be considered as a soft obstruction which cognitively stops passerbys from penetrating it. Therefore, not only the projection itself can land on the personal space of others, the paths it created in 3D restrict one's moving space. Moreover, the light scattered by the projection surface can also affect the people nearby.

Considering the content

Content in the projection could have a wider sphere of influence than the projection itself. For instance, Peter wants to browse and organize his photos while waiting for the bus. He needs a big display space to facilitate this process. In Figure 2, a media device built with PUI just meets his needs. However, to the others nearby, the projection could be a nightmare.
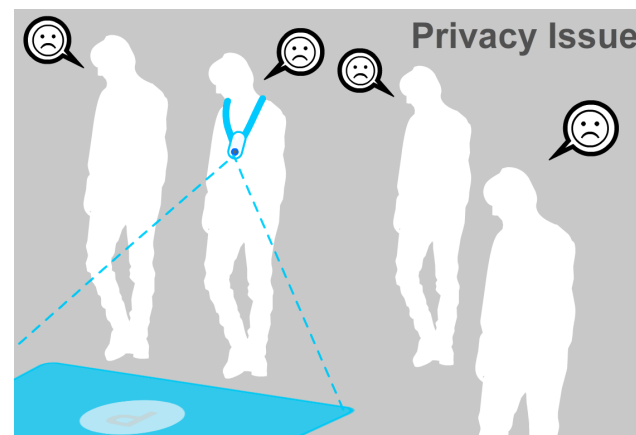

figure 2. Privacy issue of Projected UI. The projection owner might feel awkward because others are around the projected content.

Even if the projection does not intrude upon other people's personal space, the big display of the projection still forces us to notice the content it delivers. If we do not want to see the projection from others, do we have the right to refuse it?

In the previous scenario, Peter simply projects his personal photos in public space. What if Peter projects pornographic pictures or videos?

Privacy Issue

What can we project, and what can we not project?

Privacy is an obvious issue for projection. In Figure 2, the owner of the projection wants to enjoy a big projection screen, but does not want others to see the projected content.

Analogously, mobile phone have similar considerations in privacy issues when used in public. In order to avoid the issue, people could use their phones in the corner to avoid letting others looking directly at their phone screens. Moreover, a common solution to this problem is using a privacy screen sticker to further restrict the viewing angles.

The major difference in pocket projectors is their ability to directly intrude upon one's personal space, as well as the inability of the projection owners to protect their own projections.

Contention in Projection

Who can project, and who cannot?

Projection is made of light. There is no simple way to prevent others' projections from invading yours. When the day everyone equips with PUI, we might need to fight for spaces to project.

Figure 3 depicts a scenario of contention in projection. Peter is checking his Facebook page using his pocket projector while waiting in a line. Unfortunately, he finds that his projection is being overlaid on the projection next to him. Peter decides to move aside properly in order to have a clear space for his projection. Suddenly, another person walking up from behind and also starts projecting
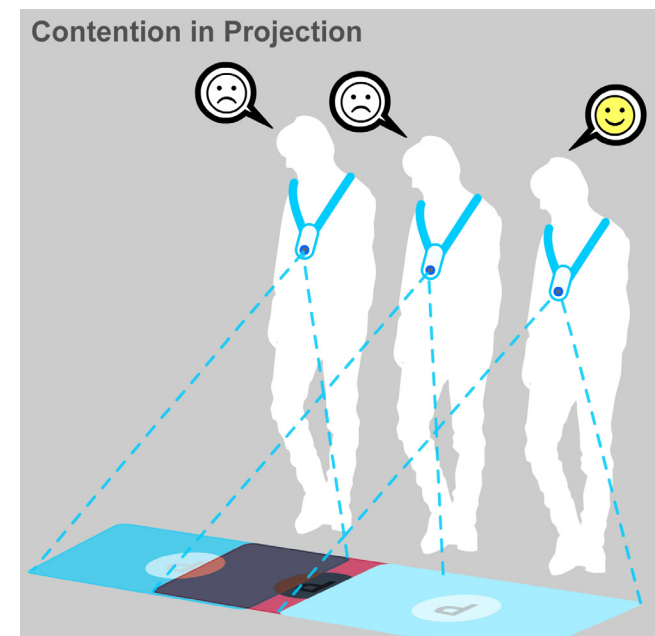

figure 3. Three projections from users A, B and C occlude each other on the ground. User C can still obtain a good viewing quality because he/she uses a ultra-high brightness projector.

While competing for projection, projection brightness can be an important factor in determining success. For example, in Figure 4, the user C is using a high-end pocket projector with ultra-high projection luminance, which is able to overwhelm all other projections in the proximity.

Cao et al.[7] have explored multi-user interaction techniques using multiple portable projectors. Although the motivation for Cao's work is to facilitate collaborative tasks, the techniques used in the research can be applied to solve the contention problem. For example, each projector can detect nearby projections by using computer vision techniques. Furthermore, they can communicate to each other through a preset protocol. Therefore, in a way, projectors are able to project more politely.

Moreover, the government might also be able to set up projection lots, where individual projectors can be encouraged, or even restricted to projecting only inside a lot.

Authorities to project

Where can we project, and where can we not?

Scheible proposed MobiSpray [8] which allows participants to draw virtual paints on physical buildings by using a laser projector. In this example, the projection is used to augment digital drawings in public spaces. However, is everyone allowed to do so? The answer might be different under different society cultures.
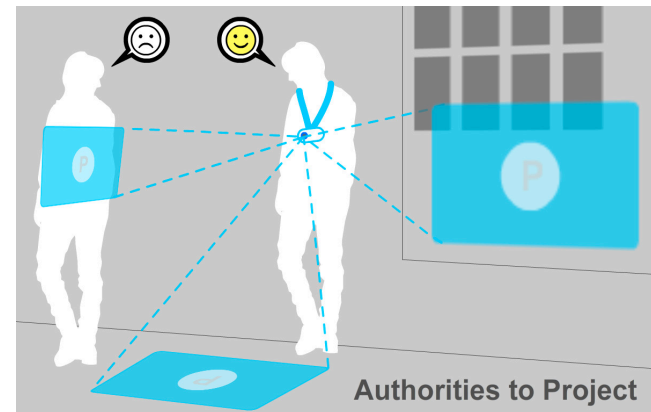

figure 4. User may intentionally or unintentionally project an image onto a place or a person, when he or she has no right to do so.

Can we project on human body?

As shown in Figure 4, if a person enters my personal space, do I have the right to project on his/her body? Can the person say no to my projection? The answer is simply yes, because according to the spirit of democracy, we and we ourselves alone retain the rights to our own bodies

Nontheless, there is another possible issue at hand. What if we do not even know that we are being projected on? What can we do?

The Image Fulgurator [9] physically augments an image on an object being photographed, by using a flash projection exactly at the moment when the photo is taken. The object being photographed would not notice the augmentation, as the entire process takes

only a few milliseconds. If the object being augmented is a public property, such as a building, then the action might be legal. However, if the target being photographed is a person, is the action still legal then? What if the projection delivers improper content that is harmful to one's personal image? The society needs to have more discussions on the aforementioned issue. Furthermore, the discussions should cover diverse perspectives in order to set up subsequently appropriate protective measures.

There are some possible ways to tackle the legal issues. Firstly, whoever is attempting the projection should request permissions from the person or object being projected on. For example, the pocket projector devices should have the ability to make constant queries into whether a place or a target projection plane is open to being projected. This can be achieved through the use of positioning techniques like GPS or other accurate 3D sensors. In addition, small sensors can be fitted onto those people or objects that are against the idea of being the target of projection. The sensor will be able to detect projector light, and send either a permission or a decline message to the projector device.

Light pollution

When can we project, and when can we not?

Light pollution is a broad term that refers to multiple problems, all of which are caused by inefficient, unappealing, or arguably unnecessary uses of artificial lighting. Specific categories of light pollution include light trespass, glare, light clutter and skyglow. The pollution from glare can be further classified into different types: Blinding glare describes effects such as

that caused by staring into the sun, Disability glare describes effects such as being blinded by oncoming car lights, and Discomfort glare does not typically cause a dangerous situation in itself, though it is annoying and irritating at best.

The pollution types caused by portable projectors may fall into more than one of these categories. . Among which, Glare could be the major category of pollution from portable projectors.
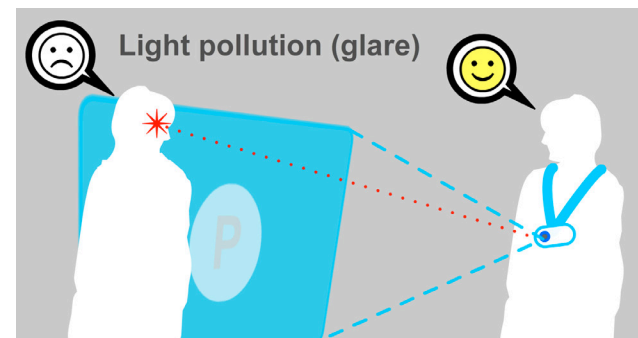

figure 5. Light pollution. People nearby a pocket projector might be blinded by the projection light.

Because users can effortlessly change the projecting direction of the pocket projector, the glaring problem can easily happen in a public space, as shown in Figure 5. The problem could even have a negative effect on visually-impaired people, as low level lighting could still damage their eyes.

There could be a technical way to help people in public spaces to escape from the pollution of Glare. With computer-vision technologies, it is possible to detect

human faces in the field of the projector, and further locate the eye positions. Then, we can darken regions of the projection, or appropriately resize the projection to avoid potential damages.

Discussion

How will it turn out, and what can be done?

We have highlighted issues in previous sections, which describe possible situations that might happen when using PUI in public. We give a summary in the following paragraphs.

Firstly, projecting in public space should be considered at both the appropriate time and place. Due to the high mobility of pocket projectors, it is easy to cause unwanted incidents. For instance, people can accidentally get unwanted glares from projections, and improper contents can unintentionally be projected in front of underage children. Secondly, we need to conduct methodologies and protocols for PUI devices, so that the projectors can negotiate and share the rights to project and to be projected. The protocols will keep us away from unwanted projections that impolitely intrude our personal space. Moreover, the protocols will protect us from unnecessary contentions when multiple users are using PUI in a limited space.

The purpose for pointing out these issues is not to discourage the development of PUI. Instead, we hope to induce more discussions and future studies to find out possible obstructers that block the spread of PUI.

In the following, we discuss some brief ideas worthy of further investigations.

- **Context-aware projection**
  Context-aware projector can provide adaptable projections that are capable of smoothly transitioning in the environment, while preserving stable projected contents to the users. To build up context-aware projectors, PUI devices should be able to detect the existence of similar devices nearby. Therefore, they can exchange information to perform adaptation on their projections.

  Cao et al. [7] have explored multi-user interaction techniques with the use of multiple portable projectors. They attached each projector with 3D position sensors, so that two projectors can collaboratively perform a task. Likewise, the techniques can be applied to solve the contention problem. For example, each projector can detect nearby projections and communicate to project politely.

  Moreover, pocket projectors with built-in cameras can detect nearby projections in order to avoid overlapping projections (see Fig. 6). Equipping PUI devices with steerable mirror can greatly extend their sensing and projection abilities. The camera can also detect human faces, and enable the projector to darken the face regions in the projection, so as to avoid accidentally shining passer-bys in the eyes.
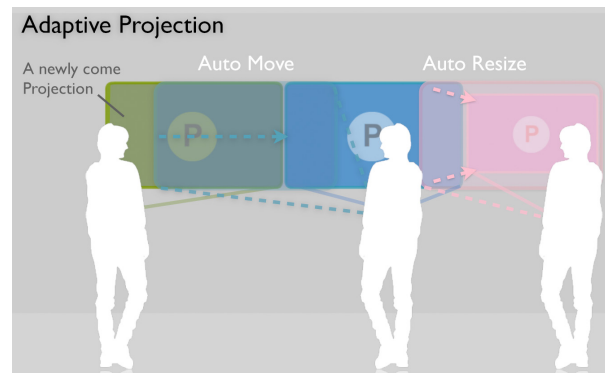
figure 6. Adaptable projection helps preserving individual projections in a limited projection area, without suffering from the problem of overlapping. A new projection comes from the left, and the other projections automatically move and scale their projections to achieve a better arrangement.

In addition, people should be able to register a location or an object as projectable or un-projectable properties. And the PUI devices should be able to check the information online to inform the user about the projecting rules in that particular place. Furthermore, an individual can register himself/herself to be un-projectable. As a result, nearby projectors will not be allowed to project on the personal space of the individual.

▪ **Visibility controllable projection**
Being able to control the projection only visible to a specific user or particular group of users would be helpful in solving the privacy issue. To control the visibility of a projection, Sakurai [10] attached a polarized layer on the surface of a projection-based

tabletop system to achieve visibility control. By using the technique, we can project contents on a handheld board equipped with the polarizer film. Moreover, we could attach the films on entire pavements that are specifically preserved for projection. The privacy film restricts the viewing angles so only the projection owners can see the projected content.

For another solution, it is possible to use infra-red (IR) projection, if we do not want our projection to disturb nearby people at all. IR projection can deliver contents totally invisible to normal human vision, while the projection owner can still see the IR projection via a head mount display that can capture and display IR illumination. However, it is important to note that the IR projection can only display gray scale information.

We have considered that the ultimate solution might rely on the public power, such as national government and international organizations, to set up laws of usage of PUI in public. Under such laws and regulations, all PUI devices can conform to communicate with each other, as well as users and non-users in a public space.

Conclusion
Pocket projector is attractive due to its ability to display information on a large screen, its instant sharing function, and the fact that it be used anytime, anywhere. It is expected that the projected user interface (PUI) devices will be applied in our daily life in the near future. Previous researches had proposed various kinds of PUIs with regards to different technical approaches. However, few of them had discussed issues of applying these PUI techniques in real life. In

order to encourage discussions on PUIs in all aspects, this paper proposed possible public issues of PUI, through exploring our rights to project and be projected in public space. Moreover, it also provided technical solutions worthy of further studies. We readily acknowledged that this paper is about the first step of exploring, and further exploration is clearly needed.

The findings of this study highlight the need for HCI community to investigate many of the aforementioned possible issues, and in particular, to apply new methods and solutions to improving the PUI usage in our daily life in the future.

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