Unphotogenic Light: High-Speed Projection Method to Prevent Secret Photography by Small Cameras

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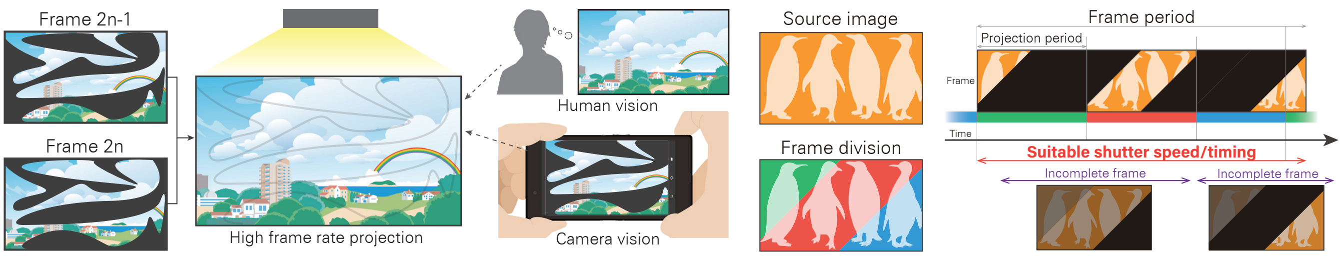

Figure 1: Left: overview of unphotogenic light. We project entire images by switching each divided image at high frame rate. Humans can observe an entire image whereas cameras cannot capture complete photo. Right: theory and effect of the proposed method. The image is divided into multiple parts and projected in turns. We must synchronize camera shutter speed with frame period to capture the entire image correctly.

CCS CONCEPTS

•**Human-centered computing** →**Displays and imagers;** •**Hardware** →*Displays and imagers;*

KEYWORDS

Protection, secret photography, security, privacy, copyright.

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1 INTRODUCTION

We present a new method to protect projected content from secret photography using high-speed projection. Protection techniques for digital copies have been discussed over many years from the viewpoint of data protection. However, content displayed by general display techniques is not only visible to the human eye but also can be captured by cameras. Therefore, projected content is, at times, secretly taken by malicious small cameras even when protection techniques for digital copies are adopted. In this study, we aim to realize a protectable projection method that allows people to observe content with their eyes but not record content with camera devices.

To achieve this goal, we exploit the difference between the human vision system and the camera vision system. Notably, humans cannot recognize the high-speed changes of light. We were inspired by previous work that used these properties to show on-screen invisible markers. There are several studies that aim to present imperceptible on-screen markers using high-speed projection between the afterimage effect of human eyes and shutter speeds of digital cameras [Luiz et al. 2015; Yamamoto et al. 2014]. From another point of view, these techniques show specific content only to the human eye while showing different content to a camera. Thus, we can project images that can be seen by human eyes whereas cameras only capture an incomplete frame as illustrated in Figure 1. Therefore, this means the projected light is unphotogenic.

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2 IMPLEMENTATION

2.1 Overview

We use a high-speed programmable projector (DLPa Light Crafter 4500, Texas Instruments Inc.) that projects divided images with high speeds. If we attempt to capture the entire image with the camera, we must match the projection period of the system and exposure period of the camera, as shown in Figure 1 (Right).

2.2 Evaluation from camera vision

We evaluate our system with the vision of a camera, as shown in Figure 3. First, we used a DSLR camera to evaluate the shutter speed threshold in which the proposed method is most effective. The results are shown in Figure 3 (c). When the shutter speed is faster than 1/60, the effect of our method is noticeable in the picture.

Next, a smartphone (iPhone 6, Apple Inc.) was used to consider the scene of practical secret photography. We used a camera application that can control the shutter and ISO speeds as shown in Figure 3 (d). Please note that the f-stop of the smartphone is not controllable. If the brightness of the screen is sufficiently high, the camera speeds up the shutter speed to avoid blowing out highlights.

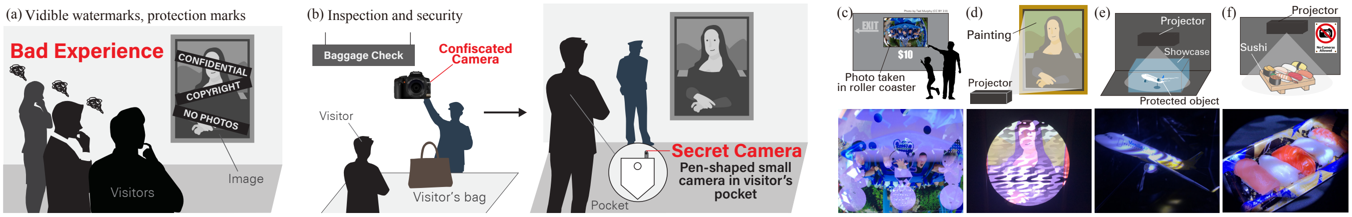

Figure 2: Practical stories of the proposed method. (a) Visible watermarks are simple and an effective method. However, it creates bad experiences for visitors. (b) Inspection and security are other solutions; however, secret photography by small cameras is still feasible. The proposed method aims to prevent secret photography in this situation. (c)fi(f) Application examples; top: schematic diagrams, bottom: applications taken by the smartphone.

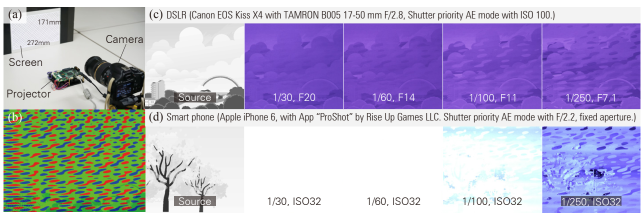

Figure 3: (a) Setup for evaluation from camera vision. (b) Images are divided into three parts. Projection period (see Figure 1) is 4166 microseconds (approximately 240 Hz). (c), (d) Images from camera vision. Please note that f-stop of smartphones is fixed (specification).

Because small cameras tend to have this limitation, the proposed system is effective to prevent secret photography by small cameras.

3 APPLICATIONS

3.1 Protection of screen content

The main purpose of this method is to discover protection techniques to prevent secret photography. For example, it can be applied to secret pages in a presentation. Speakers then do not need to caution the audience members about taking photos. While oral caution might be an effective method, it may be ignored. It also hinders a smooth presentation and the attention of audiences from presentations.

As another example, our system can be used in theme parks as shown in Figure 2 (c). There is a system that takes a picture of passengers in the middle of an attraction such as a roller coaster in theme parks. Pictures are previewed on a screen near the exit, and a passenger has the option to purchase the picture. However, a passenger can also take photos of the screen with a smartphone. By using the proposed method, these photos are prevented. In addition, if the shape is divided into the silhouette of a character, people will be able to enjoy theme parks even more.

3.2 Protective illumination

The proposed system can be used not only as an image projector but also as a lighting system. For example, the system can be installed in an art gallery as a spotlight, as shown in Figure 2 (d).

It is worth noting that photos with DSLR cameras may still be taken. Therefore, the next example is a situation in which a visitor cannot use a DSLR camera, as shown in Figure 2 (e). Because the showcase surface has reflections, it is difficult to shoot with a camera with a large lens such as that of a DSLR camera. In this case, a small camera such as a smartphone will be used; however, the proposed method prevents this when installed as a spotlight.

As another example, the proposed system can be used in restaurants. If a restaurant chef dislikes the photography of food by smartphones, the proposed system can be used as lighting. Because the customers cannot take photos with their smartphones as shown in Figure 2 (f), they can instead concentrate on eating the food.

4 DISCUSSION

4.1 Camera parameter

If the shutter speed of a camera becomes higher than the threshold defined by projection speeds, people cannot photograph a complete image. Conversely, the image can be captured by long-term exposure. Therefore, high-specification cameras, such as DSLR cameras, can evade our system. However, the situations shown in Figure 2 (a) and Figure 2 (b) are assumed. Small cameras tend to be exploited when taking secret photographs. They only have a non-adjustable f-stop. If the screen is sufficiently bright and has a fast shutter speed, the proposed system protects the image content.

Further, it is very difficult to take a photo or video if the projected content is a video. This is because the camera needs to synchronize with the frame timing and cover shutter period to capture the entire video. Furthermore, by changing the projection period randomly, we can also prevent measures taken by a camera application such as a detective function to remove the flicker from lighting.

4.2 Flickr

When the screen viewpoint of a person changes, the person tends to perceive a flicker on the screen using the proposed system. For example, this may happen when people shake their heads or because of saccades. There are trade-offs between the flicker resistance strength on the screen and the minimum acceptable shutter speed of the system. We need to explore suitable parameters and adjust them for various viewers.

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