Basic Study on Creation of Invisible Shadows
by Using Infrared Lights and Polarizers

Hikari Tono, Saki Sakaguchi and Mitsunori Matsushita*
Kansai University

Abstract

This paper proposes a method for hiding information inside of an actual object and viewing the hidden information as shadows selectively by rotating the object. Our proposed system creates shadows by using the properties of the polarizing plates and the 1/2 wavelength boards. The goal of our research is to realize a novel method of information hiding.

CR Categories: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities;

1 Introduction

There are a method that can add an invisible information to an object, and then visualize by performing a specific action(e.g.,sympathetic paper). The Layered Shadow system[Sakaguchi et al. 2013] hides information within an object, and different shadows are cast from the object when placed under light of different wavelengths. This system uses an object made of infrared(IR) pass filter. The user can create the shadow selectively by irradiating the object with light of specific wavelengths. The shape of the shadow depends on the IR light wavelength. This paper proposes a method for hiding information inside of an actual object and viewing the hidden information as shadows selectively by rotating the object. The goal of our research is to realize a novel method of information hiding.

2 System

Our proposed system creates shadows by using the properties of the polarizing plates and the 1/2 wavelength boards. The 1/2 wavelength boards are fixed between two polarizing plates that is same direction. The angle of the optic axis for the polarization direction is assumed to be $\theta°$. If θ is $45°$, the direction of the light will rotate at $90°$. The polarizing plate blocks the light by rotating the light direction by $90°$ through the 1/2 wavelength board. This system creates invisible shadows by the IR light. The shadow may not be created even if $\theta = 45°$, depending on the wavelength of the IR light. Therefore, a user can control the creation of shadows by changing the wavelength of the IR light. As shown in Figure 1, the in-side of the object consists of a plastic board and two pieces of 1/2 wavelength boards. Each 1/2 wavelength board has a different shape and optic axis (blue line shows optic axis of 1/2 wavelength), and hence, rotation of the irradiated object changes the shape of the shadow cast. SC-74 filters attached to both sides of the object prevent the user from viewing the internal structure of the object.
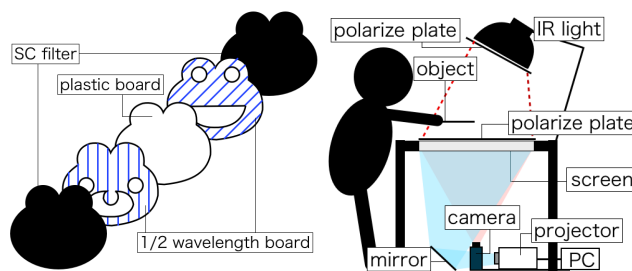
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*e-mail:mat@res.kutc.kansai-u.ac.jp
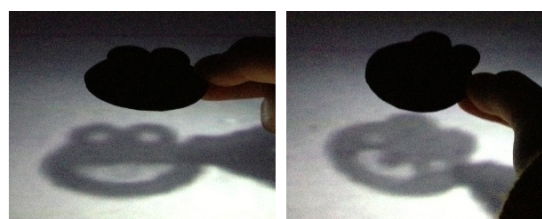
Figure 1: *object* **Figure 2:** *system*

Figure 3: *shadow*

Figure 2 shows an outline of the proposed system. The system consists of an IR light source, two polarizing plates, an IR camera, a projector, and a screen. When the objects are placed on a table illuminated by IR light, the system creates shadows that are invisible to the human eye. An SC-74 filter is attached to the CCD camera to transmit the IR light. The screen is suitable for back projection so that it enables projection of invisible shadows cast by the IR light and images produced by a projector. Placing the projector underneath the screen, inhibits interference of the image from the projector and the invisible shadow. The IR light source can be adjusted to produce one of two wavelengths: 770 and 940 nm. The polarizing plate for IR light is attached to the light source, and that for light is attached to the screen.

3 Applications

We created an application to cast shadows of different shapes from an original object. A user can see the shadow shapes by placing the object over a screen and change the shadow shapes by tilting the object. When the light wavelength is 770 nm, two different shadows appear depending on the object angle, and when the light wavelength is 940 nm, the shadows disappear. Figure 3 shows the two types of shadow created using the object shown on Figure 1. If the user tilts the object, the created shadow changes from a bear to a frog shape.

References

SAKAGUCHI, S., TANAKA, T., AND MATSUSHITA, M. 2013. Layered shadow: Multiplexing invisible shadow using infrared lights with different wavelengths. In *Proc. Virtual Reality International Conference: Laval Virtual*, VRIC '13.