Optical Camouflage Using Retro-reflective Projection Technology

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Abstract

This paper describes a kind of active camouflage system named Optical Camouflage. Optical Camouflage uses the Retro-reflective Projection Technology, a projection-based augmented–reality system composed of a projector with a small iris and a retroreflective screen.

The object that needs to be made transparent is painted or covered with retroreflective material. Then a projector projects the background image on it making the masking object virtually transparent.

1. Introduction

Various methods have been proposed to integrate the visual space. In the field of Mixed Reality, one of the most popular topics is about displaying a virtual object into real world [1].

However making objects virtually transparent, like in HG. Wells' "Invisible Man" can also be seen as dream of human being. In this paper, we describe what could be called a camouflage technique named Optical Camouflage.

2. Retro-reflective Projection Technology (RPT)

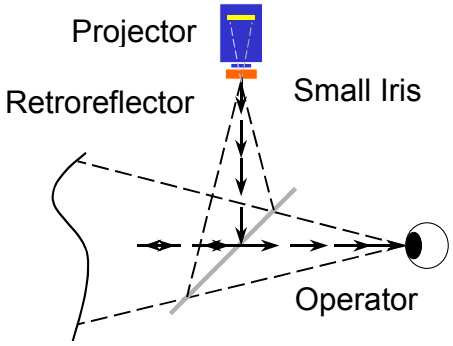
Optical Camouflage is a type of active camouflage that uses technology named "Retro-reflective Projection Technology (RPT) / X'tal Vision," [2], which uses optical projection. Before describing the Optical Camouflage, we will first illustrate RPT. When using a See-Through Head-mounted Display (STHMD) to merge virtual and real environments, the operator may see the image of a virtual object that is meant to be located behind a real object. This contradicts our intuition of depth, since the projected image of an object located behind another object in one's field of view will be obstructed at least partially. This depth cue is called occlusion, and is critical for the effectiveness of the presentation of virtual objects in three dimensions. To solve the occlusion contradiction problem, we developed RPT.

The three key techniques of RPT are the followings:

1. To use an object covered by retro-reflective material as a screen;
2. To place a projector into a position optically conjugated with the observer's eye by using a half-mirror;
3. To make the projector's iris as small as possible (by using a pinhole).

Each of these points provides the following advantages, respectively:

Fig. 1 shows the principles of RPT. The image of a virtual object is projected through a pinhole. The projected image is reflected by the half-mirror on a right angle and then retro-reflected by the retro-reflective screen.



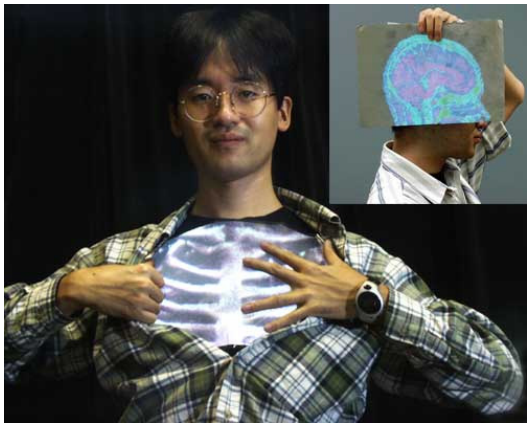


Fig. 1 X'tal Vision

3. Optical Camouflage

Optical Camouflage is developed with the simplicity of Columbus' egg. A projector projects the image of the background onto the masked object. (Fig. 2)

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A camera behind the masked object takes the image of the background. The object that needs to be transparent is painted or covered with retroreflective material. The projected image is composed by computer using an image-based rendering method to create the image that should be seen from the viewpoint of the user from the image from the viewpoint of the camera.

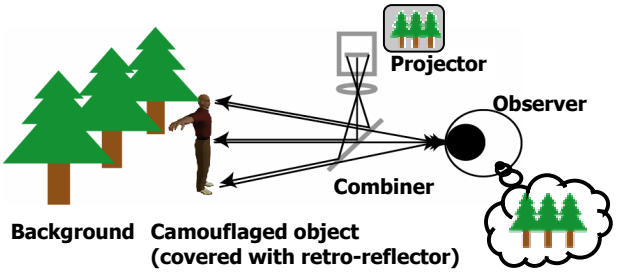

Fig. 2 Configuration of Optical Camouflage

4. Results

Fig.3 shows the haptic display (real object) hiding the virtual object, but Optical Camouflage techniques permit to make the haptic display to become transparent. However, the operator's hand is not made transparent, which implies that it is possible to use this technique selectively.

Fig.4 shows a demonstration of "Invisible Cloak". It looks as if a red truck can be seen through the body of a man who wear a retro-reflective coat. Actually, he does not become transparent perfectly. The shape of the coat is observed clearly. Nevertheless, it looks like a very low refractive index glasswork, which is enough to observe the background.

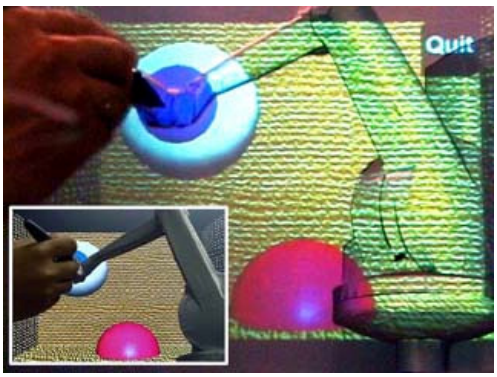

Fig. 3 Optical camouflaged haptic display

Fig. 4 "Invisible Cloak"

5. Conclusions

We have developed an Optical Camouflage system. Optical Camouflage can be used on surgical globes or equipments so they don't block surgeon's view during delicate operations. In aviation, cockpit floors could become 'invisible' to assist pilots during landing.

The weak point of this technique is that the observer needs to look through a half-mirror. The current system needs a half-mirror and projectors, which were fixed on the ground.

In the next step of our research, an observer would be able to observe the background image from various viewpoint with H.M.P. (Head-Mounted Projector)[3].

References

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