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A Review of Retro Reflective Technology for Optical Camouflage Applications

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Abstract

One of the long cherished fantasies of humans has been to master invisibility. A lot of research is being done in this area to make it practically pertinent. The application of Retro Reflective Technology for Optical Camouflage has been evolved and its relevance and appliance in various spheres of life is being tested world over. It might become very useful in surgeries, flying and aviation industry, driving and traffic control, video gaming, warfare, theatres and motion picture development, etc. This paper is a review on the creation of invisibility with the help of optical camouflage; image based rendering and retro reflective projection. The basic techniques involved have been discussed, some case-studies of its applicability reviewed and innovative ideas for future proposed.

Keywords: Optical Camouflage Technology, Retro-Reflective material, Head Mounted Projector (HMP), invisibility

1. Introduction

Optical camouflage is a hypothetical type of active camouflage currently only in very primitive stage of development. The idea is to create the illusion of invisibility by covering an object with something that projects the scene directly behind that object. It displays an image of the scene on the side opposite to the viewer on it, so that the viewer can "see through" the wearer, rendering the wearer invisible. [1]This idea is

very simple. If the background image is required to be projectedonto the masked object then the masked object can be observed just as if it were virtually transparent. In 2003, three professors at University of Tokyo–Susumu Tachi, Masahiko Inami and Naoki Kawakami-created a prototypical camouflage system in which a video camera takes a shot of the background and displays it on a cloth using an external projector.

2. Materials and Methods

Creating complete optical camouflage across the visible light spectrum would require a coating or suit covered in tiny cameras and projectors, programmed to gather visual data from a multitude of different angles and project the gathered images outwards in an equally large number of different directions to give the illusion of invisibility from all angles. To create invisibility or transparent illusion a video camera, computer, projector, a combiner and a retro-reflective material is needed.

2.1 Retro-reflective material

The cloak that enables optical camouflage to work is made from a special material known as retro-reflective material. A retro-reflective material is covered with myriads of small beads whenthe light strikes one of these beads, the light rays bounce back exactly in the same direction from which they came. A rough surface creates a diffused reflection because the incident (incoming) light rays get scattered in many different directions.A perfectly smooth surface, like that of a mirror, creates a reflection in which incident light rays and reflected light rays form the exact same angle with the mirror surface. In retro-reflection, the glass beads act like prisms, bending the light rays by a process known as refraction. This causes the reflected light rays to travel back along the same path as the incident light rays. The result: An observer situated at the light source receives more of the reflected light and therefore sees a brighter reflection. [2]

2.2 The Video Camera and Computer

2.2.1 Video Camera

The retro-reflective garment doesn't actually make a person invisible. It is actually perfectly opaque. The garment creates an illusion of invisibility by acting like a movie screen onto which an image from the background is projected. Capturing the background image requires a video camera, which is located behind the person wearing the cloak. The video from the camera must be in a digital format so it can be sent to a computer for processing.[5]

2.2.2 *Computer*

All augmented-reality systems rely on powerful computers to synthesize graphics and then superimpose them on a real-world image. For optical camouflage to work, the hardware/software combo must take the captured image from the video camera, calculate the appropriate perspective to simulate reality and transform the captured image into the image that will be projected onto the retro-reflective material. This technique of image processing is called image based rendering.[6]

2.3 The Projector and Combiner

2.3.1*The Projector*

The modified image produced by the computer is shone onto the garment. A projector does this by shining a light beam through an opening controlled by a device called aniris diaphragm. An iris diaphragm is made of thin, opaque plates, and turning a ring changes the diameter of the central opening. For optical camouflage to work properly, this opening must be the size of a pinhole to ensure a larger depth of field so that the screen i.e. cloak can be located any distance from the projector.[7]

2.3.2 *The Combiner*

The system requires a special mirror to reflect the projected image toward the cloak as well as to let light rays bouncing off the cloak return to the user's eye. This special mirror is called a beam splitter, or a combiner which is a halfsilvered mirror that both reflects light (the silvered half) and transmits light (the transparent half). If properly positioned in front of the user's eye, the combiner allows the user to perceive both the image enhanced by the computer and light from the surrounding world. This is critical because the computer-generated image and the realworldscene must be fully integrated for the illusion of invisibility to seem realistic. The user has to look through a peephole in this mirror to see the augmented reality.

2.3.3 *Head-Mounted Displays (HMP)*

Most systems apply Head-Mounted Displays (HMDs)[3]which assemble the combiner and optics in a wearable device. There are two types of HMDs: optical see-through displays and video see-through displays. Optical see through displays look like high-tech goggles, sort of like the goggles Cyclops wears in the X-Men comic books and movies. These goggles provide a display and optics for each eye, so the user sees the augmented reality in stereo.Video see-through displays use video mixing technology to combine the image from a head-worn camera with computer-generated graphics. In this arrangement, video of the real world is mixed with synthesized graphics and then presented on a liquid crystal display. [4]In video see-through displays virtual objects can fully obscure real-world objects and vice versa. A variation of a video see-through display that brings together all of the components necessary to make the invisibility cloak work with an apparatus calledHead-Mounted Projector(HMP) is being developed with two projectors, one for each eye to produce a stereoscopic effect.

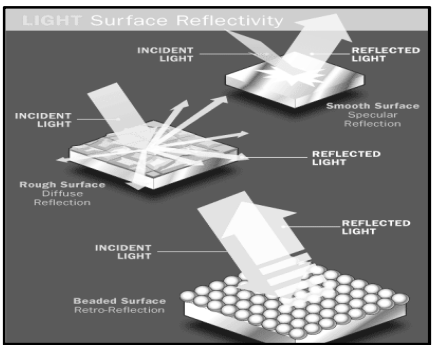

Figure 1: The Process of Optical Camouflage

3. Results

The entire components discussed abovecombine together to make the invisibility cloak appear to make a person transparent. Once a person puts on the cloak made with the retro-reflectivematerial, the following set of events creates the illusion of invisibility as shown in figure 1:

1. A digital video camera captures the scene behind the person wearing the cloak.
2. The computer processes the captured image and makes the calculations necessary to adjust the still image or video so it will look realistic when it is projected.
3. The projector receives the enhanced image from the computer and shines the image through a pinhole-sized opening onto the combiner.
4. The silvered half of the mirror, which is completely reflective, bounces the projected image toward the person wearing the cloak.
5. The cloak acts like a movie screen, reflecting light directly back to the source i.e. the mirror.
6. Light rays bouncing off of the cloak pass through the transparent part of the mirror and fall on the user's eyes. Remember that the light rays bouncing off of the cloak contain the image of the scene that exists behind the person wearing the cloak. The person wearing the cloak appears invisible because the background scene is being displayed onto the retro-reflective material. At the same time, light rays from the rest of the world are allowed reach the user's eye, making it seems as if an invisible person exists in an otherwise normal-looking world.

4. Recommendations

4.1 Surgeons could use optical camouflage to see through their hands and instruments to the underlying tissue for more precise surgeries.

4.2: The technique of making objects in visible from the invisible is called Mutual Telexistence: This perceives with the feeling that of being at several places at once**.**

4.3 Professional illusionists and magicians along with theatre show people can use this technology to create invisibility as an act.

4.4 In aesthetic and adventurous architecture providing a view of the outside in windowless rooms is one of the more fanciful applications of the technology.

4.5 A quick glance backward through a transparent rear hatch or tailgate would make it easy for automobile drivers to know when to stop their vehicle. This would particularly aid in commercial parking areas like malls, underground and multi-floored parking.

4.6 This technology can be applied in theme parks, science museums, and real maze games for creating illusionary disappearances.

4.7 Pilots landing a plane could use this technology to make cockpit floors transparent enabling them to see the runway and the landing gear by glancing down.

4.8 Pervasive gamingis another application where players with mobile displays move through the world while sensors capture information about their

environment, including their location. This information is used to deliver users a gaming experience that changes according to where they are and what they are doing.

5. Conclusion

The advancement in science is making what we may have thought of as impossible. We have seen that anyone can be almost invisible with this technology. Invisibility technology is currently being developed by major universities and scientists. More R & D should be promoted in Research Centers and Universities for evolving better and efficient technologies of optical camouflage.

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