Invisibility Cloak

(Application to <u>IMAGE PROCESSING</u>)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

SUBMITTED BY

KANTA ABHISHEK

IV/IV C.S.E

INTELL ENGINEERING COLLEGE

ANANTAPUR

EMAIL:besmile.2k9@gmail.com,abhi1431123@gmail.com

MOBILE: 9704448428

ABSTRACT:

The latest milestone in the quest for a Harry Potter-like invisibility cloak has been reached: a way of bending the geometry of space so that light from all directions travels around an object, rather than hitting it. Unable to interact with light, the hidden object is therefore invisible, a new study found. Cloaks of invisibility are relatively rare in folklore; although they do occur in some fairy tales, with optical-camouflage technology the invisibility cloak is already a reality. Design and aesthetic is a powerful tool in getting us to accept new things and ideas. Within art, this can be used in a critical or subversive way. Every period and every technology needs to develop its aesthetics in an organic relation to its own time. Instead of hiding technology we should use the power of design to visualize and express this real world.

Introduction:

This seems perfectly believable when you're reading about a fictional world filled with witches, wizards and centuries-old magic; but in the real world, such a garment would be impossible, right? Not so fast. With optical-camouflage technology the invisibility cloak is already a reality.

Optical camouflage delivers a similar experience to Harry Potter's invisibility cloak, but using it requires a slightly more complicated arrangement. First, the person who wants to be invisible (let's call her Person A) dons a garment that resembles a hooded raincoat. The garment is made of a special material that we'll examine more closely in a moment. Next, an observer (Person B) stands before Person A at a specific location. At that location, instead of seeing Person A wearing a hooded raincoat, Person B sees right through the cloak, making Person A appear to be invisible. The photograph on the right below shows you what Person B would see. If Person B were viewing from a slightly different location, he would simply see Person A wearing a silver garment (left photograph below).

Fig1: Invisibility cloak

Still, despite its limitations, this is a cool piece of technology. Not only that, but it's also a technology that's been around for a while.

Altered Reality:

Optical camouflage doesn't work by way of magic. It works by taking advantage of something called augmented-reality technology -- a type of technology that was first pioneered in the 1960s by Ivan Sutherland.

Augmented-reality systems add computer-generated information to a user's sensory perceptions. Imagine, for example, that you're walking down a city street. As you gaze at sites along the way, additional information appears to enhance and enrich your normal view.

Perhaps it's the day's specials at a restaurant or the show times at a theater or the bus schedule at the station. What's critical to understand here is that augmented reality is not the same as virtual reality. While virtual reality aims to replace the world, augmented reality merely tries to supplement it with additional, helpful content.

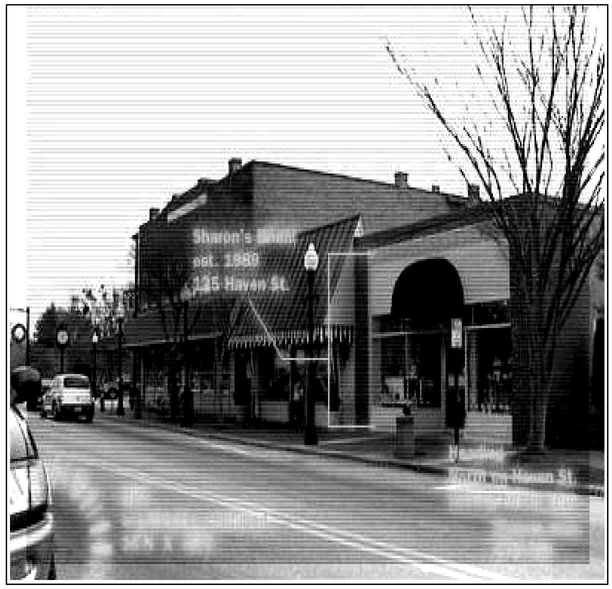

FIG: Augmented-reality displays overlay computer-generated graphics onto the real world.

Most augmented-reality systems require that users look through a special viewing apparatus to see a real-world scene enhanced with synthesized graphics. They also require a powerful computer. Optical camouflage requires these things, as well, but it also requires several other components. Here's everything needed to make a person appear invisible:

- A garment made from highly reflective material
- A video camera
- A computer
- A projector
- A special, half-silvered mirror called a combiner

Let's look at each of these components in greater detail.

<u>The Cloak</u>:

The cloak that enables optical camouflage to work is made from a special material known as **retro-reflective material**.

Fig: Optical camouflage

A retro-reflective material is covered with thousands and thousands of small beads. When light strikes one of these beads, the light rays bounce back exactly in the same direction from which they came. On April 30, 2009, two teams of scientists developed a cloak that rendered objects invisible to near-infrared light. Unlike its predecessors, this technology did not utilize metals, which improves cloaking since metals cause some light to be lost. Researchers mentioned that since the approach can be scaled down further in size, it was a major step towards a cloak that would work for visible light

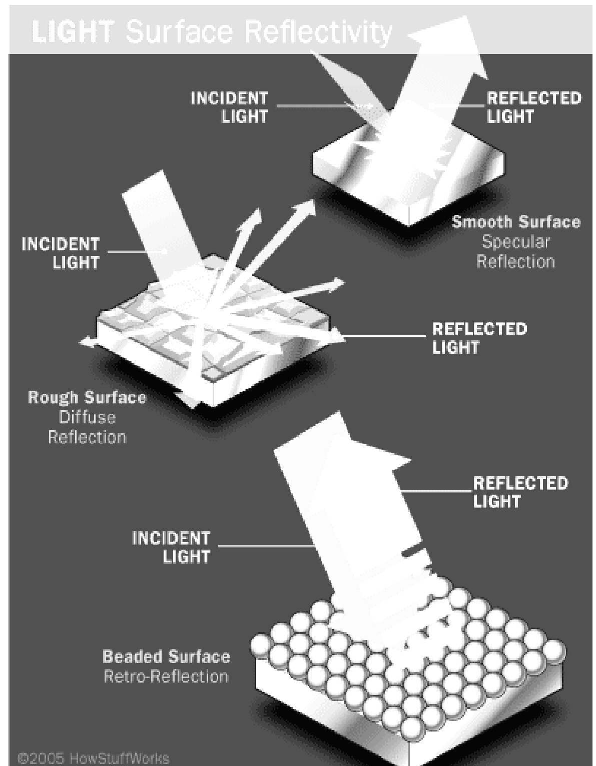

Fig: Light Surface Reflectivity

To understand why this is unique, look at how light reflects off of other types of surfaces. 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 what is known as a specular reflection -- 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.

Retro-reflective materials are actually quite common. Traffic signs, road markers and bicycle reflectors all take advantage of retro-reflection to be more visible to people driving at night. Movie screens used in most modern commercial theaters also take advantage of this material because it allows for high brilliance under dark conditions. In optical camouflage, the use of retro-reflective material is critical because it can be seen from far away and outside in bright sunlight -- two requirements for the illusion of invisibility.

Video Camera:

The retro-reflective garment doesn't actually make a person invisible -- in fact, it's perfectly opaque. What the garment does is create 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 sits 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.

Fig: The cloak in use

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.

The Projector:

The modified image produced by the computer must be shone onto the garment, which acts like a movie screen. A projector accomplishes this task by shining a light beam through an opening controlled by a device called an **iris 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. Why? This ensures a larger depth of field so that the screen (in this case the cloak) can be located any distance from the projector.

Fig: effect of iris diaphragm device

TheCombiner:

The system requires a special mirror to both reflect the projected image toward the cloak and 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 -- a half-silvered 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 real-world scene 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.

The Complete System:

Now let's put all of these components together to see how the invisibility cloak appears to make a person transparent. The diagram below shows the typical arrangement of all of the various devices and pieces of equipment.

Once a person puts on the cloak made with the retro-reflective material, here's the sequence of events:

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,

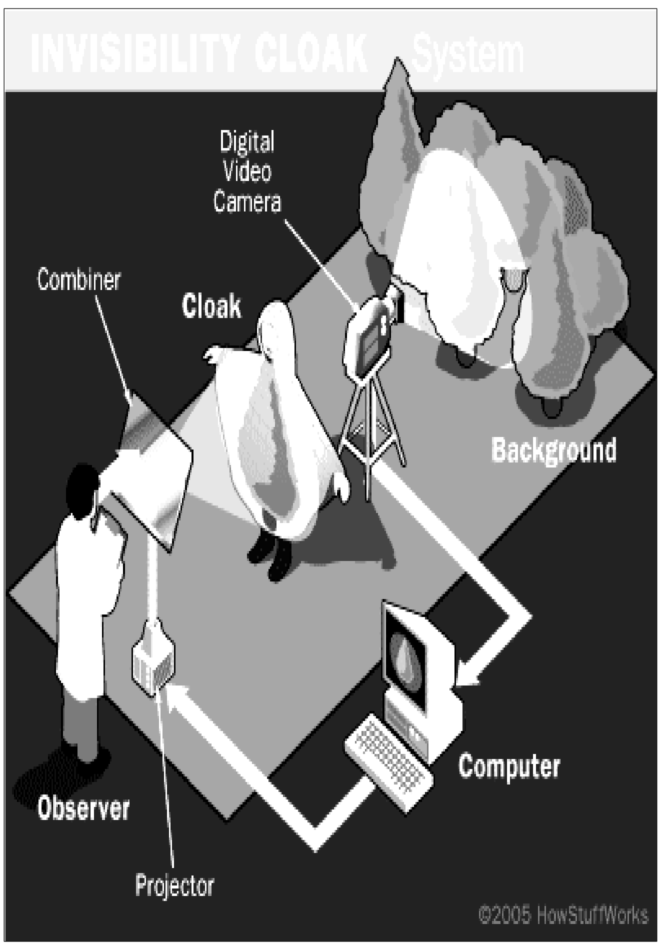

Fig: The complete system

reflecting light directly back to the source, which in this case is 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.

Head-mounted Displays:

Of course, making the observer stand behind a stationary combiner is not very pragmatic -- no augmented-reality system would be of much practical use if the user had to stand in a fixed location. That's why most systems require that the user carry the computer on his or her person, either in a backpack or clipped on the hip. It's also why most systems take advantage of head-mounted displays, or HMDs, 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**, on the other hand, 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. The great advantage of video see-through displays is that virtual objects can fully obscure real-world objects and vice versa.

The scientists who have developed optical-camouflage technology are currently perfecting a variation of a video see-through display that brings together all of the components necessary to make the invisibility cloak work.

FIG: Video see-through display

FIG: Prototype head-mounted projector

They call their apparatus a **head-mounted projector** (HMP) because the projection unit is an integral part of the helmet. Two projectors -- one for each eye -- are required to produce a stereoscopic effect

Real-World Applications:

While an invisibility cloak is an interesting application of optical camouflage, it's probably not the most useful one. Here are some practical ways the technology might be applied:

- Pilots landing a plane could use this technology to make cockpit floors transparent. This would enable them to see the runway and the landing gear simply by glancing down.
- Doctors performing surgery could use optical camouflage to see through their hands and instruments to the underlying tissue.
- Providing a view of the outside in windowless rooms is one of the more fanciful applications of the technology, but one that might improve the psychological well-being of people in such environments.
- Drivers backing up cars could benefit one day from optical camouflage. A quick glance backward through a transparent rear hatch or tailgate would make it easy to know when to stop.

One of the most promising applications of this technology, however, has less to do with making objects invisible and more about making them visible. The concept is called **mutual telexistence**: working and perceiving with the feeling that you are in several places at once.

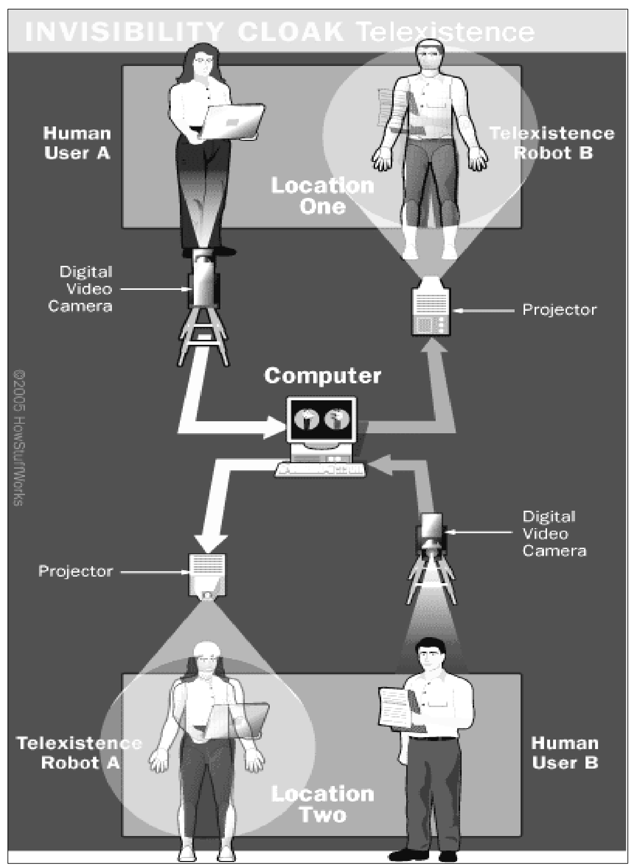

Fig: Telexistence of invisibility cloak

- Human user A is at one location while his telexistence robot A is at another location with human user B.
- Human user B is at one location while his telexistence robot B is at another location with human user A.
- Both telexistence robots are covered in retro-reflective material so that they act like screens.
- With video cameras and projectors at each location, the images of the two human users are projected onto their respective robots in the remote locations.
- This gives each human the perception that he is working with another human instead of a robot.

Conclusion:

That's because our brains insist on viewing light as having traveled in a straight line, when in fact the water has bent it. Glass does the same thing, which is why telescope lenses make objects appear closer. An invisibility cloak would simply replicate this process in a more sophisticated way.

References:

• M. Inami, N. Kawakami, D. Sekiguchi, Y. Yanagida, T. Maeda and S. Tachi. "Visuo-Haptic Display Using Head-Mounted Projector." http://projects.star.t.u-tokyo.ac.jp/projects/MEDIA/xv/oc.html

• M. Inami, N. Kawakami and S. Tachi. "Optical Camouflage Using Retro-reflective Projection Technology," Proceedings of the Second IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR 03). http://projects.star.t.u-tokyo.ac.jp/projects/MEDIA/xv/oc.html

• S. Feiner. "Augmented reality: A new way of seeing," Scientific American. April 2002, pp. 48-55.

• S. Tachi. "Telexistence and Retro-reflective Projection Technology (RPT)," Proceedings of the 5th Virtual Reality International Conference (VRIC2003), pp. 69/1-69/9. http://projects.star.t.u-tokyo.ac.jp/projects/MEDIA/xv/oc.html