OPTICAL CAMOUFLAGE

Image 1 : Chameleon

RAJA PAVAN KARTHIK
Computer Science - AI
AM.EN.U4AIE20060
Amrita Vishwa Vidyapeetham

Table of Contents

ABSTRACT

Mankind always sensed the milestones of science as wonders. Designing of things and applications that the humans may not even dream of has become the ultimate aim of scientists and researchers. Here, we present one of such creative and awesome technology that emerged as a landmark in the field of artificial intelligence.

In this unique paper, we aim to explain how to turn any living or non-living object invisible. This is not magic and is made possible by revolution in the field of optical physics. The application of aug-mented reality and nanotechnology are the pillars behind this concept. A new concept called retro reflection, made possible through nanotechnology is also demonstrated.

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.

The entire set up and the process behind this including the projector, digital computer and the clock made of weeds is elucidated very clearly by including some real life and commercial applications.

In a single statement, our innovative paper deals with the concept of optical camouflage, which holds the key in making a desired object or a person look invisible and can even object a person at different places at different places at the same time by using the fundamentals of optical physics. To be clearer, our concept delivers similar experiences to that of Harry potter's invisibility cloak.

INTRODUCTION

Most animals have enemies. In order to survive, they have to defend themselves. Some animals use speed and strength to survive. Others, like alligators, use their powerful jaws and sharp teeth. Some, like rattlesnakes and black widow spiders, use venom. Others, such as turtles, have hard body coverings. But other animals must rely on the color and pattern of their body covering for survival.

The use of coloring and patterns to disguise and conceal is called camouflage. Many kinds of animals use camouflage in order to survive. Predators animals that hunt use it to sneak up on their prey without being seen. Prey use it to hide from predators.

Camouflage comes in many forms. Some animals have permanent color patterns that help them to hide. Others have color patterns that change with the seasons. Still others have color patterns that change with the surface the animal is on. And still others use patterns that change during different stages of life. Let's take a look at different forms of camouflage.

Some animals have camouflage patterns when they are young, but lose these patterns when they grow big and strong enough to outrun their enemies. When young, their parents must leave them alone for periods of time to go find food. If the young are camouflaged, they are less likely to be eaten by a predator while their parents are away.

Camouflage patterns are well known in baby deer. Similar light-colored spotting also occurs in the young of Tapirs (a hoofed mammal) and wild boars. Topi antelopes of the African desert blend in with the sand while they are young. When they grow strong enough to flee their enemies, they develop black markings. Even some young predatory animals use camouflage to hide. Lion cubs have spots that help them blend in.

Some animals are even camouflaged before birth. Many animals are at risk of being eaten when they are in the egg stage. Birds that nest on the ground are at great risk for having their eggs stolen when they leave the nest. Oystercatcher eggs are the color of pebbles along the beaches where they live. The eggs of other ground-nesting birds have streaks and blotches to break up the egg-shaped outline to help them blend with their surroundings.

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

Optical camouflage doesn't work by way of magic. It works by taking advantage of something called augmented technology - a type of technology out of your television screen or computer display and integrating them into real-world environments. If you project the background image onto the masked object, you can observe the masked object just as if it were virtually transparent. This shows the principle of the camouflage.

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 special at a restaurant or the showtimes 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.

Most augmented-reality systems require that users look through a special viewing apparatus to see a real-world scene enhanced with synthesized graphics.

OPTICAL CAMOUFLAGE

Optical camouflage is a kind of active camouflage in which one wears a fabric which has an image of the scene directly behind the wearer projected onto it, so that the wearer appears invisible. The concept exists for now only in theory and in proof-of concept prototypes, although many experts consider it technically feasible. But however several What is Optical Camouflage? hands on experiments have been performed. There are proofs and photographs based on optical camouflage. This is the primary definition of optical camouflage but the process carried out and the devices used will in detail be explained in the article.

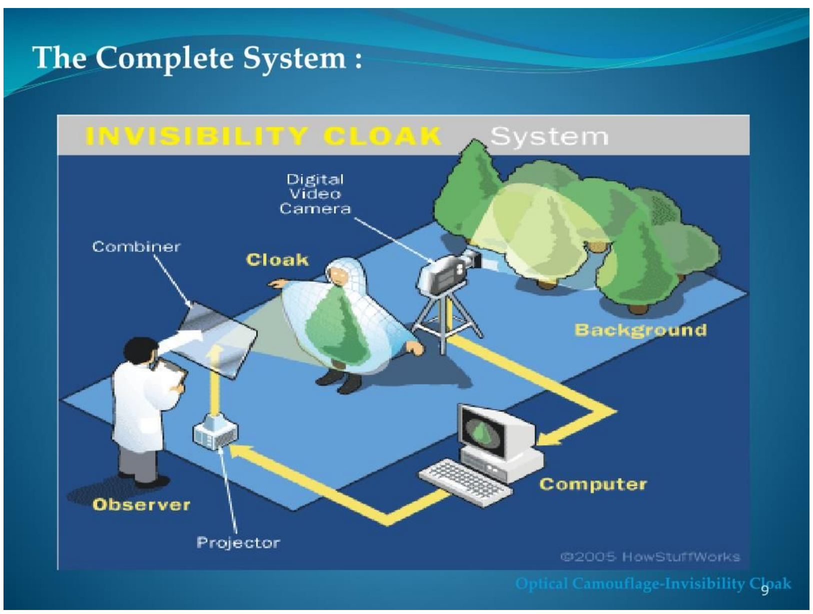


Image 2 : Configuration of Optical Camouflage

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

More About Optical Camouflage

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. For a surface subject to bend like a flexible suit, a massive amount of computing power and embedded sensors would be necessary to continuously project the correct Images in all directions.

This would almost certainly require sophisticated nanotechnology, as our computers, projectors, and cameras are not yet miniaturized enough to meet these conditions. Although the suit described above would provide a convincing illusion to the naked eye of a human observer, more sophisticated machinery would be necessary to create perfect illusions in other electromagnetic bands, such as the infrared band. Sophisticated target-tracking software could ensure that the majority of computing power is focused on projecting false images in those directions where observers are most likely to be present, creating the most realistic illusion possible.

Creating a truly realistic optical illusion would likely require Phase Array Optics, which would project light of a specific amplitude and phase and therefore provide even greater levels of invisibility. We may end up finding optical camouflage to be most useful in the environment of space, where any given background is generally less complex than earthly backdrops and therefore easier to record, process, and project.

ACTIVE CAMOUFLAGE

Before knowing the in-depth study of optical camouflage, here is given a brief explanation of the main branch active camouflage, of which the optical camouflage is a part of Active camouflage (or Adaptive camouflage) is a group of camouflage technologies which would allow an object (usually military in nature) to blend into its surroundings by use of panels or coatings capable of changing color or luminosity.
Active camouflage can be seen as having the potential to become the perfection of the art of camouflaging things from visual detection.
Theoretically, active camouflage should differ from more conventional means of concealment in two important ways. First but less importantly it should replace the appearance of what is being masked with an appearance that is not simply similar to the surroundings but with an exact representation of what is behind the masked object.

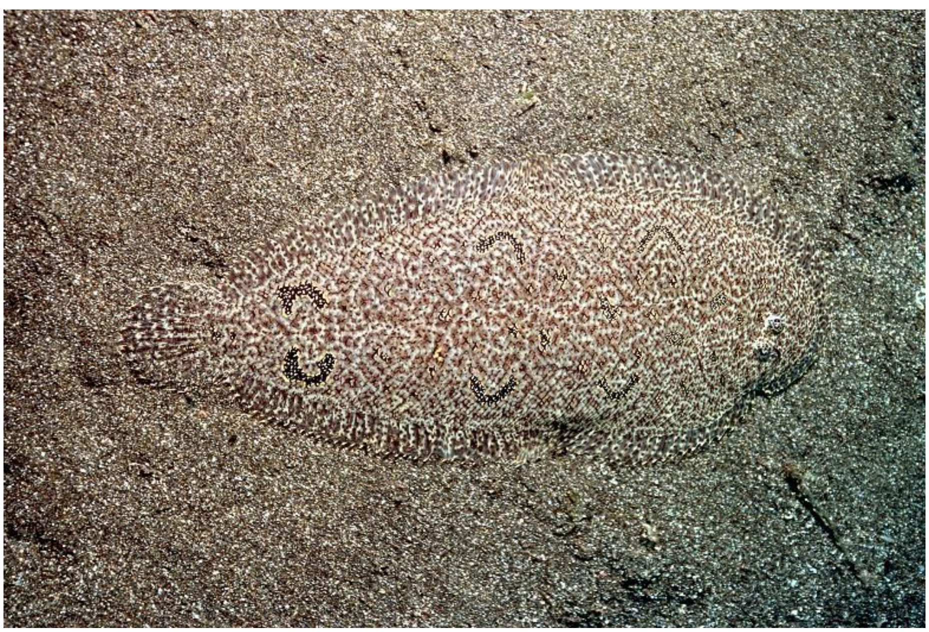


Image 3 : Peacock flounders can change their color and pattern in just eight seconds

Second and more importantly, active camouflage should also do so in real time. Ideally active camouflage would not only mimic nearby objects but also distant ones, potentially as far as the horizon, creating perfect visual concealment.

In principle, the effect should be similar to looking through a pane of glass making that which is hidden perfectly invisible. Illustrating the concept, i.e. active capture and redisplay, creates an "illusory transparency", also known as "computer mediated reality".

This technology is poised to develop at a rapid pace, with the development of organic light emitting diodes (OLEDs) and other technologies which allow for images to be projected from oddly shaped surfaces.

With the addition of a camera, while not allowing an object to be made completely invisible, theoretically the object might project enough of the background to fool the ability of the human eye or other optical sensors to detect a specific location. As motion would still be noticeable, an object would merely be more difficult to hit, and not undetectable under this circumstance. This has been demonstrated with videos of "wearable" displays where the camera could see "through" the wearer.

Wearable version of the illusory transparency, made from a tiling of wearable flat panel displays, wearable cameras, and computer vision system running on a wearable computer. This is a fully functioning prototype, but has limitations due to the number of sensors and transducers. Active camouflage is not a human invention. Many animals can change their color, among them the chameleon, but the ability is used primarily to communicate.

ANIMALS WITH THE CAMOUFLAGE MECHANISM


Image : A white weasel blends in with the snow


Image : A leopard blends in with a tree


Image : A cuttlefish blends with in sand in water


Image : A snowy owl blends in with the snow


Image : A White tailed deer blends with surroundings


Image : A Leaf Insect blends with dry leaves

1. Retro-reflective material

The cloak that enables optical camouflage to work is made from a special material known as retroreflective material. 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. 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.

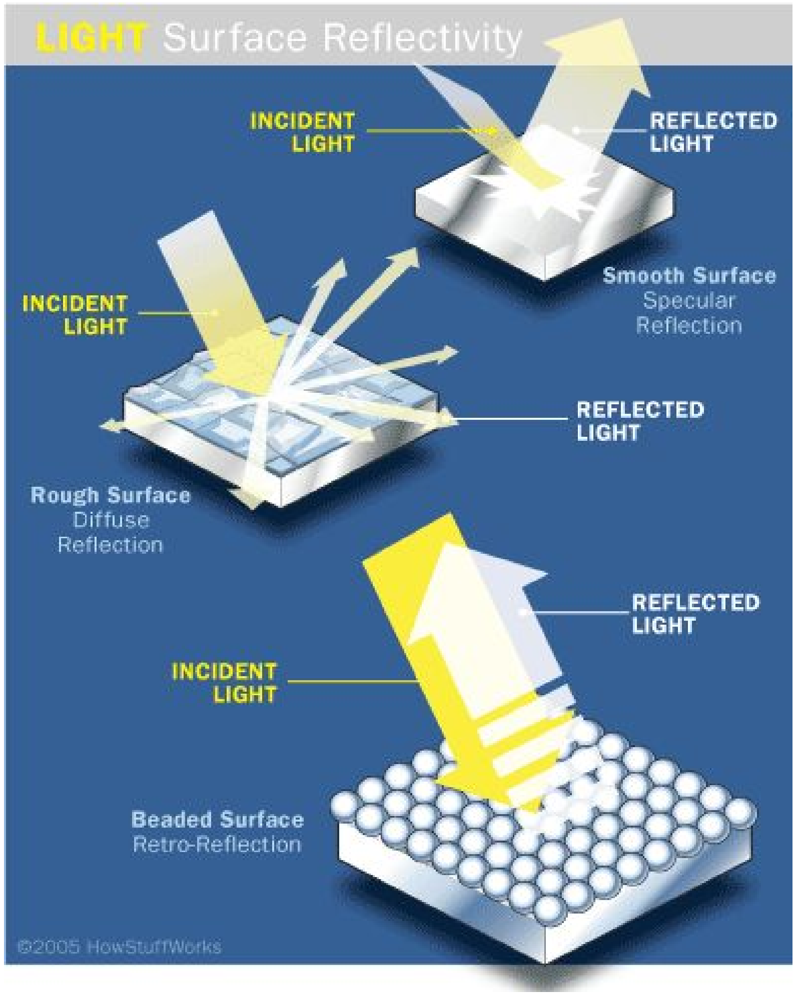


Image 4 : [How it Works]

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.

2. Video Camera and computer

i). 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.

ii). 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.

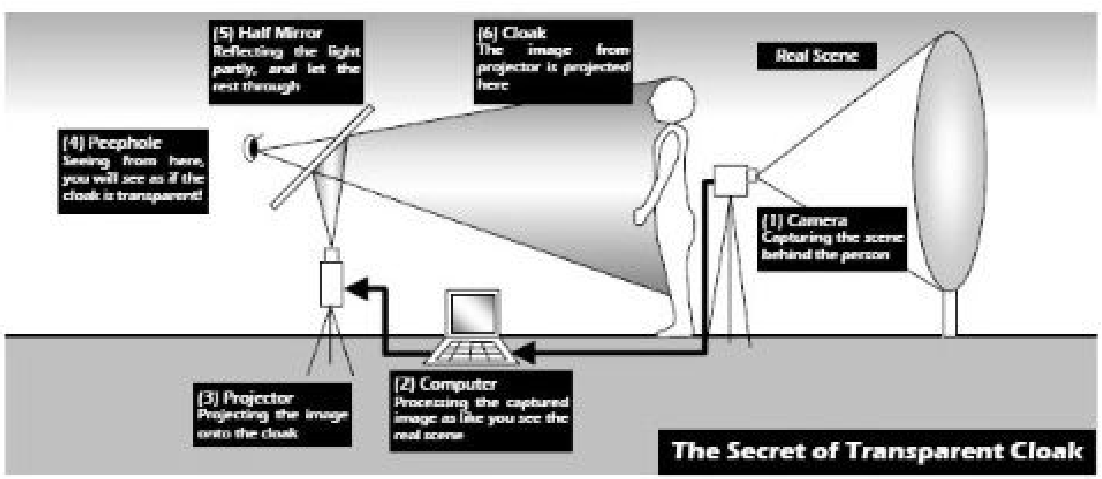


Image 5 : Entire Setup for Optical Camouflage

3. The Projector and Combiner

i). 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.

ii). The Combiner: 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.

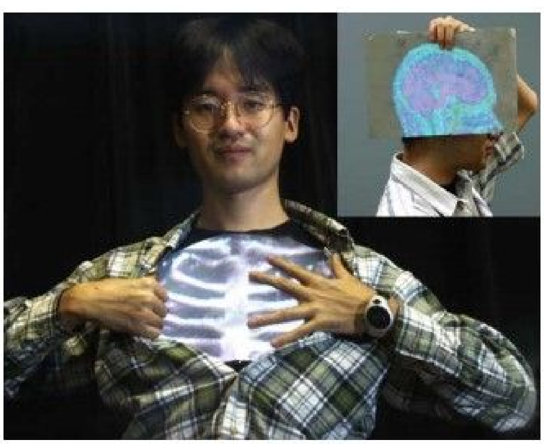


Image 6 : X'tal Vision

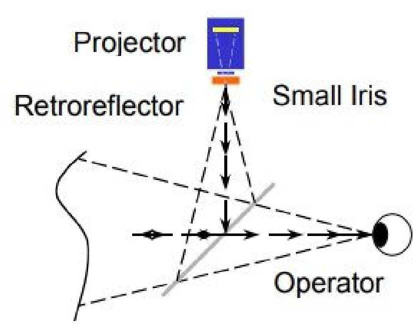


Image 7 : Configuration

4. 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 given Image - 5 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.

Image 8 : Optical Camouflage

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, 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.

Image 9 : [Active Camouflage]

The person wearing the cloak appears invisible because the background scene is being displayed onto the retroreflective material. At the same time, light rays from the rest of the world are allowed to reach the user's eye, making it seem as if an invisible person exists in an otherwise normal-looking world.

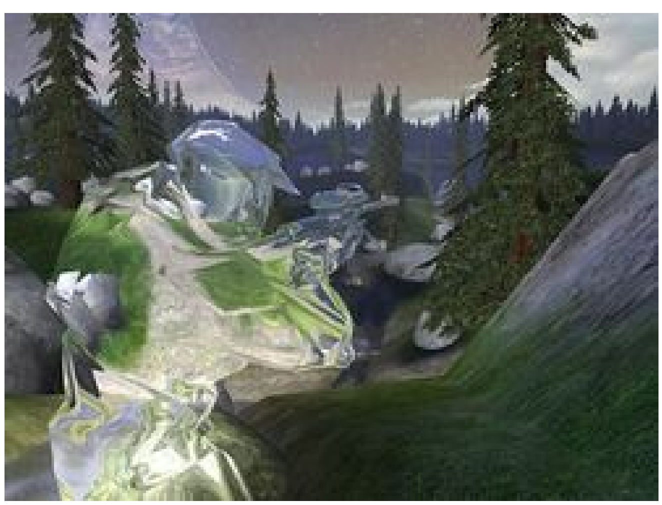


Image 10 : [A Soldier using active camouflage.]

What RPT does ?

The retro-reflector screen, together with the pinhole, ensures that the user always sees images with accurate occlusion relations. In the construction of an RPT system, screen shapes are arbitrary, i.e., any shape is possible. This is due to the characteristics of the retro-reflector, and the pinhole in the conjugate optical system. By using the same characteristics of an RPT system, binocular stereo vision becomes possible using only one screen with an arbitrary shape. The projector can be mounted on the head of a user, which we call an HMP (Head Mounted Projector) system.

How does a person become transparent ?

Light gets through things all the time. Visible light is not all the light there is. X-Rays for instance can travel through walls and clothing that is not transparent. They are light waves. Everything is mostly empty space (i.e. the space between the atoms, molecules, etc.). Solidity is only a relative factor of one density to another. To make this work without any distortions, you must make sure that every photon that hits your suite is transported and then sent out again, continues in the same direction. The path of the photon must for the observer be the same as the path it would go normally. Otherwise you get problems with the parallax. These problems mean that when you move head when you look for example at a desk with such a suit before it, the part of the desk with the suit before it will move more to the side than the rest of the desk. Mirages are the bending of light because of heat. They can render stuff behind them virtually invisible. Electromagnetic radiation (including light), much like all waves suffer from convergent (adding) and destructive (breaking down) radiation (fringe separation experiment-proof). So as to destroy all visible radiation around you, you could emit destructive visible radiation.

How to Photograph Retro-Reflective Material ?

Reflective Material returns light back to the original light source. When photographing reflective material with a flash camera the material will appear like it is "glowing" in the photograph. To decrease the retro reflected light intensity (or "glow") obtained in photographs, make one of the following adjustments.

1. Increase or decrease the light source using dimmer switches. Decreasing the light source will decrease the retro reflected light intensity, and increasing the light source will increase the retro reflected light intensity.
2. Increase or decrease the distance between the light source and the object being photographed. Moving the light source further away will decrease the retro reflected light intensity, and moving the light source closer will increase the retro reflected light intensity.
3. Increase or decrease the observation angle formed between the camera lens and the light source, relative to the object being photographed. An observation angle of 0°provides maximum retro reflected light intensity in the photograph. An observation angle greater than about 2° will eliminate any retro reflected light from returning to the camera lens and therefore from showing in the pictures.

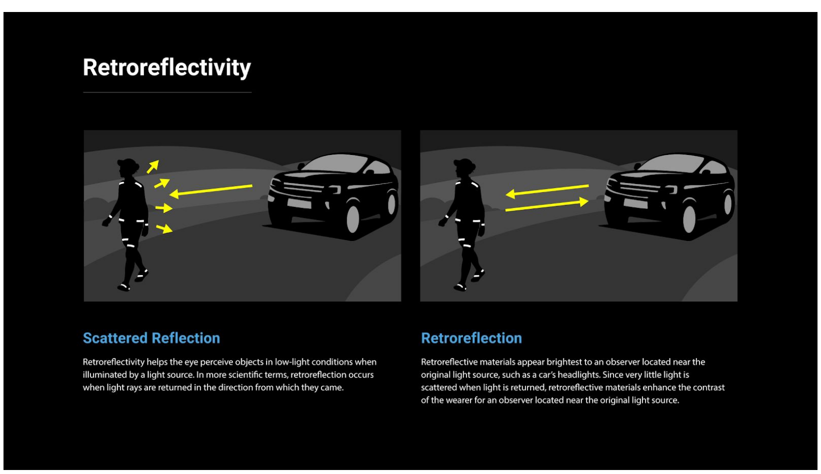


Image 11 : Retroreflectivity

Real-World Applications

This technology is basically used for invisibility purposes. Such technology is useful in defence for hiding from the enemies. The stealth planes have this application that they absorb all the radar waves coming to it and as a result of which the radar stations cannot detect it. So it can attack any time because it is hidden.

This is dangerous also. If this technique is used in the cockpit for making the floor transparent at landing, the pilot can land safely with seeing the runway Also, use it for other vehicles like cars. If you can see through the back of the car, you will put the car into the garage successfully.

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.

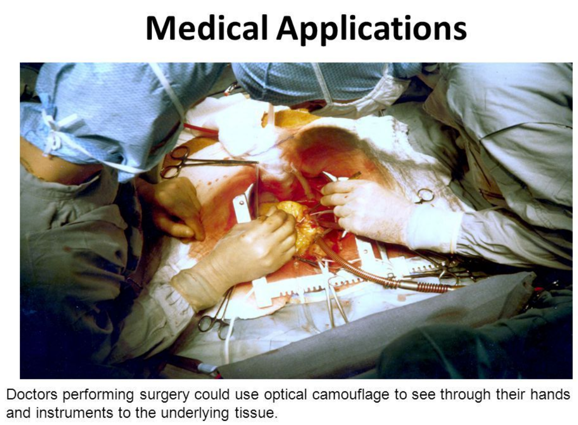
Image 12 : Optical Camouflage

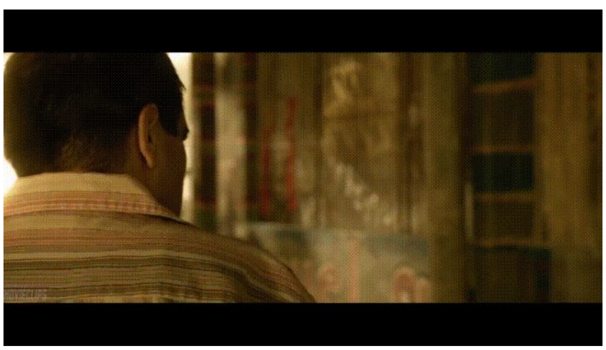
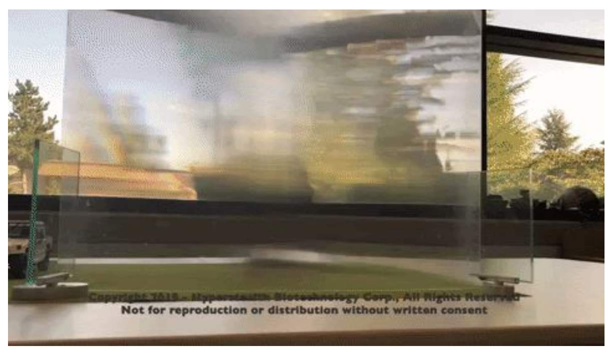
Providing a view of the outside in windowless rooms is one of the more fanciful applications of the technology, but one that might improve the psychological well-being of people in such environments.
Drivers backing up cars could benefit one day from optical camouflage. A quick glance backward through a transparent rear hatch or tailgate would make it easy to know when to stop.

Optical camouflage from Mission Impossible : Ghost Protocol

An optical camouflage scene from MCU

An optical camouflage from real life

 For making surgeries better.	 For landing in Airports.

 An optical camouflage from a movie.	 [A canadian company has created an invisibility shield]

Conclusion

Each technology has its own pace of development. This technology is still at its developing state. Even though in movies, invisibility is narrated, but the common man does not know the concept behind it. This technology should be used in the right applications so that it can be explored in a better way and become useful for the betterment of human life.

This amazing technology creates objects or human beings invisible or transparent. Though it has some limitations, it won't be for long as scientists continue to push the boundaries of the technology. 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. Pervasive gaming is 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.

REFERENCES

500px, 500px.com/photo/49604704/chameleon-by-Ralph-Reichert.

“090) Camouflage.” *Foxhugh Superpowers List*, 16 June 2020, foxsuperpowerlist.com/camouflage/.

“9 Animals That Use Forests as Camouflage.” *American Forests*, 3 Oct. 2019, www.americanforests.org/blog/9-animals-that-use-forests-as-camouflage/.

“Active Thermo-Optical Camouflage - Social Implications of Information Processing - Ghost in the Shell.” *Google Sites*, sites.google.com/site/cs3043ghostintheshell/technologies/active-thermo-optical-camouflage.

Beautifulcataya. “Flounder.” *Flickr*, Yahoo!, 7 Dec. 2007, www.flickr.com/photos/beautifulcataya/2094449388/.

Halopedia. “Active Camouflage.” *Halopedia*, Halopedia, 16 Jan. 2021, www.halopedia.org/Active_camouflage.

Inami, M., et al. “Optical Camouflage Using Retro-Reflective Projection Technology.” *The Second IEEE and ACM International Symposium on Mixed and Augmented Reality, 2003. Proceedings.*, doi:10.1109/ismar.2003.1240754.

Klappenbach, Laura. “How Do Common Animals Use Camouflage to Survive?” *ThoughtCo*, www.thoughtco.com/camouflage-129662.

Lamb, William Harris & Robert. “How Invisibility Cloaks Work.” *HowStuffWorks Science*, HowStuffWorks, 30 June 2020, science.howstuffworks.com/invisibility-cloak.htm.

“Leaf-Butterfly on the Hand: Butterfly, Beautiful Bugs, Beautiful Butterflies.” *Pinterest*, www.pinterest.com/pin/524247831351465 82/?d=t&mt=signup.

Reddy, M.Ashrith, et al. “Optical Camouflage Technology.” *International Journal of Engineering Research & Technology*, IJERT-International Journal of Engineering Research & Technology, 9 Nov. 2013, www.ijert.org/optical-camouflage-technology-2.

“Revealed In Nature Tours.” *Revealed In Nature 2.0*, www.revealedinnature.com/.

“Scientists Discover the Secrets behind the Cuttlefish's 3D 'Invisibility Cloak'.” *University of Cambridge*, 15 Feb. 2018, www.cam.ac.uk/research/news/scientists-discover-the-secrets-behind-the-cuttlefishs-3d-invisibility-cloak.

“White-Tailed Deer - Odocoileus Virginianus - NatureWorks.” *New Hampshire PBS*, nhpbs.org/natureworks/whitetaileddeer.htm.

“Optical Camouflage.” *Body Extended*, elab-kh-berlin.de/courses/body_extended/?p=445.