

Touchless holographic human-machine interfaces



By R. Douglas McPheters

Recently patented holographic actuation and control technology combines two well-known and well-developed technologies – holograms and wave source sensors.

These technologies are used to facilitate the precision operation of electronic and electro-mechanical equipment by simply passing a finger through holographic images of what would otherwise be the keys or buttons of that equipment.

Free-floating holographic images

Holograms were accidentally conceived in 1947 by Dennis Gabor, a Hungarian refugee, while he was working on a project related to the improvement of electron microscopes. He was awarded the Nobel Prize in 1971 for his contributions to the development of holographic technology. Since Dr. Gabor's discovery, holographic production techniques have steadily improved, yielding greater variety in the size, configurations, and characteristics available to consumers. Along the same continuum, sophisticated hologram applications have been developed for data storage, anti-counterfeit credit card imprinting, and Human-Machine Interfaces (HMIs).

Hologram types

Holograms can be recorded in several forms, including:

- Transmission holograms – The reproducing light source is located on the side of the hologram away from the viewer.
- Reflection holograms – The reproducing light source and the viewer are located on the same side of the hologram.
- Edge-lit holograms – The reproducing light is introduced into the edge of the material on which the hologram is recorded, and the light source path is contained in that material.

While these hologram types essentially involve static images, development of real-time holographic images is well underway, although that process currently requires a great deal of computing power.

Hologram recording

A conventional hologram is recorded by aiming two separate beams of laser light at film, using transmitters mounted on a shock-isolated platform. The platform eliminates distortions that can be caused by even the slightest movement of the equipment when the lasers are active. The fixtures holding the holographic film and the object to be replicated by the holographic image are also mounted on the shock-isolated platform. Everything must be precisely positioned in order to accurately replicate the object.

One laser produces the *object beam*, so named because it illuminates the object to be replicated before it reaches the holographic film.

The second laser produces the *reference beam*, which is aimed directly at the holographic film and does not illuminate the object.

The two beams therefore arrive at the holographic film by separate paths, which creates an interference pattern on the holographic film. This interference pattern acts as a diffraction pattern. The resulting holographic image is then developed in a process analogous to developing ordinary film. A finished hologram can be embossed on glass, acrylic, or other translucent materials for durability and ease of handling.

Reproducing holographic images

When a recorded hologram is illuminated by a light source similar to the reference beam that created it, the light source is refracted by the recorded hologram so an observer can see a reconstructed image of the object when looking into the light source from the appropriate angle.

A variety of light sources can be used for this purpose. In the case of a credit card holographic image, it is ambient light. In the case of display holograms, the light source may be a high-intensity halogen lamp. Looking ahead, light sources for holographic HMIs will include low power, low heat-producing LEDs.

Human-Machine Interfaces

In order to make most effective use of a holographic HMI, its completed hologram must be precisely aligned in relation to its reconstructing light source in order to achieve optimum image resolution, both in distance and at the proper angle from the light source to the hologram itself. How these factors affect the mechanics of the holographic HMI depend on the distances and angles involved in the positioning of the reference and object beams in relation to the object or graphics during the process of recording its hologram.

In the case of a transmission hologram, the reconstructing light source is located behind the hologram in relation to the operator. The distance from the light source to the hologram is chosen to duplicate the light path used to record the hologram. In this configuration, the reconstructing light source can be part of the holographic HMI.

In the case of a so-called reflection hologram (e.g., credit card

hologram), the reconstructing light source and the operator are located on the same side of the hologram. The light source may even be out of sight behind the operator, which may offer the advantage of reducing the size and weight of holographic HMIs.

Holographic image scans

A wide variety of wave source sensors of increasing accuracy and sensitivity is readily available for use in scanning the plane of the holographic image of a holographic HMI. Selecting the appropriate sensor turns on the configuration and size of those images, as well as the location of those images in relation to the HMI, and the number of potential selections offered to the operator of the HMI.

Once holographic images have been reproduced in the manner described above, wave sensors are positioned so as to detect when an operator's finger enters the space where each holographic image appears in front of the holographic HMI.

In the case of a holographic HMI offering an operator one choice such as an on/off power switch, a potential choice of hardware might be one diffuse reflection photoelectric sensor. When a tangible object enters the space which coincides with the holographic representation of the tactile power switch, the on/off signal is transmitted to the underlying electronic device.

Programmable emitter/detectors available on the commercial market allow the designer of a holographic HMI to adjust the position of this sweet spot to suit the needs of particular applications.

When a holographic HMI operator is offered more than one choice, multiple wave source sensors, or a single sensor can be used to scan the plane of the holographic HMI image using an X-Y

axis that is coplanar with the image plane. Scanning the plane of those images, the wave source detects the intrusion of a finger into the space, which coincides with the location of one of the holographic HMI operator choices. That detection is simultaneously transmitted to the underlying electronic device using the same electronic circuitry that would otherwise be used to transmit the signal generated by touching the conventional keys or buttons of the electronic device.

Holographic HMI applications

Holographic HMIs do not have any moving parts, so they can be used in difficult environments such as factory floors where corrosion, dirt, extreme temperatures, and shock degrade conventional HMIs.

Holographic HMIs are not actually touched, so they can be used in workplaces where cleanliness is essential such as clean rooms, operating rooms, or food processing plants. Holographic HMIs provide hands-on controls for skilled operators, while they neatly bypass all hygiene issues.

For consumer electronic applications, holographic HMIs offer color, convenience, and durability. For example, for the physically challenged, holographic HMIs provide controls for a variety of electronic devices that are easy to see and require less strength to operate than conventional HMIs. As an automotive example, all instruments and electronics can be operated by interacting with a single holographic control panel that floats in the driver's field of vision (Figure 1).

Evaluation platform

HoloTouch, Inc. recently introduced a holographic user interface that is programmable, and offers the operator the choice of up to

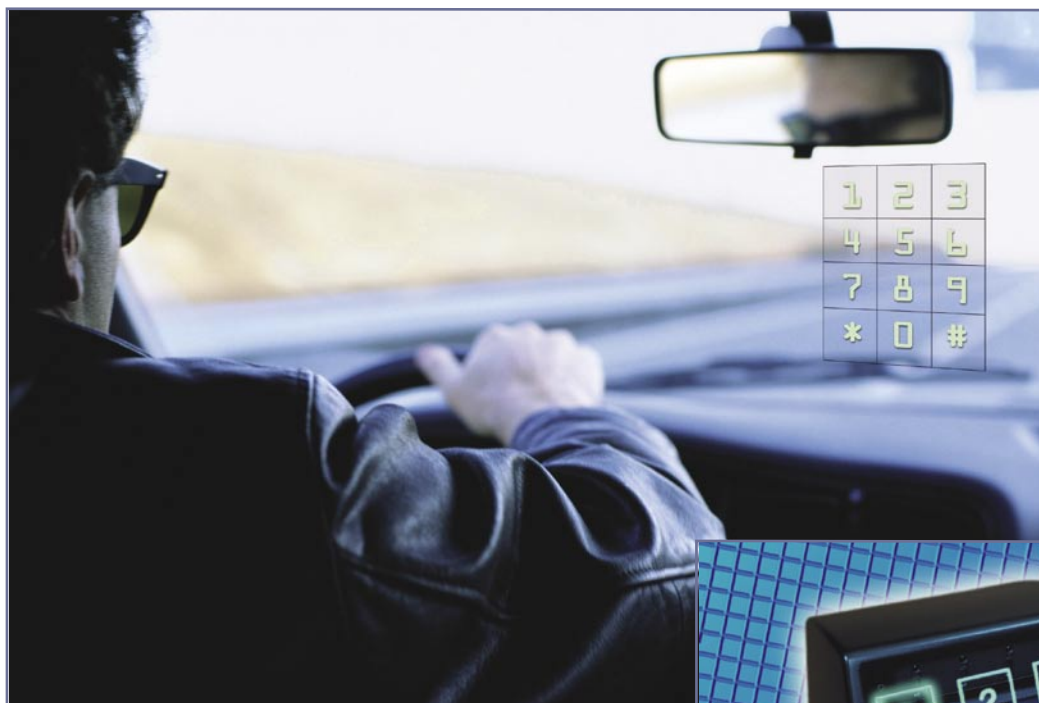


Figure 1



Figure 2

six commands. A command is selected by simply passing a finger through the holographic representation of the key that floats in the air several inches in front of the hardware. This compact unit uses a USB and other ports to deliver commands to and from a standard PC (Figure 2). Ω

R. Douglas McPheters invented and patented the technology described in this article and is President of HoloTouch, Inc., a Delaware corporation with offices in Darien, Connecticut. After receiving his undergraduate degree from Yale University, McPheters served as Chief Engineer of a submarine in the U.S. Atlantic Fleet, and was later awarded a Juris Doctor degree by the University of Pennsylvania.

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