Holograms: Images of the Future

Economic Times, Sept. 19, 1992

Faced with a growing number of fake credit cards, Visa and Mastercard in the early eighties decided to print holograms of their individual seals on the credit cards. When there was an alarming increase in fake driver's licences, the California Department of Motor Vehicles incorporated a hologram of the seal of the State on all driver's licences. Scientists at several laboratories are using holograms to improve imaging of cells and tissues of plants and other biological systems. Rock videos are now routinely produced with amazingly real graphics, thanks to advances in holography and computer generated graphics. These are but some of the examples of how holograms, or "3-D pictures" are revolutionizing several areas of technology.

In 1947, a Hungarian born physicist, Dennis Gabor, working at the Imperial College of Science and Technology in London, discovered a technique for photography, which had the potential for 3- dimensional effects. In the next few years not only did he develop the technique systematically, (including its use in his field of interest namely electron microscopy) but also coined the word hologram from the Greek holos (whole) and gramma (a letter). Though a lot of work on holography went on in the West and in the erstwhile Soviet Union, the technology needed for the production of quality holograms was not available and so the interest in holography was restricted to scientific laboratories.

All this changed in the sixties with the invention of the other landmark technology of the late twentieth century: Lasers. Laser light has certain remarkable properties which make it indispensable for producing holograms. It is exceptionally monochromatic i.e a red laser beam has only red light as opposed to ordinary red light which is a mixture of several colors with red dominating. It is very coherent and can be transmitted over great distances without the beam spreading. In fact, in a now classic experiment, lasers were used to find out the distance to the moon because a laser beam from earth can travel all the way to the moon without any appreciable spreading, and then be reflected back!

Holography, photography by wave front reconstruction, lens less photography; all these synonyms capture only a part of the "depth" of this fascinating technology. It is similar to ordinary photography and yet fundamentally different from it. In photographing an object, light from the object is captured by the camera lens and focussed onto a recording media, usually a film of some kind. The film is sensitive to light and thus carries an impression of the object which can be made permanent by the process of developing the film. The process of holography is quite unlike that of an ordinary photograph. Here a beam of laser light is split up into two parts. One beam is made to fall on the object to be photographed while the other (reference) beam goes to the photographic film. At the film, the beam from the object and the refers beam are made to combine to give a pattern. This film now is a laser hologram. If seen in laser light of the same color as the original light, it will give an image which in its 3 dimensional effect is breathtakingly similar to the object.

Of course, these laser holograms though fascinating were little more than enchanting toys and cute scientific curiosities. The next big breakthrough came in 1968 with the discovery of rainbow holograms. These, unlike other holograms, did not require a laser beam for viewing but could be seen in ordinary white light. After this important advance, it was only a matter of refining the technology to mass produce holograms by using chemical processes and making the holograms durable with plastic coating.

The striking 3-dimensional effect is not the only unusual property of holograms. An ordinary photograph if torn is essentially destroyed. Not so with a hologram; any piece of a hologram, even an extremely small one, will reproduce the entire image of the object, though with a lesser resolution. The process of producing holograms does not produce any negatives, unlike conventional photographs. Further, the quality of the hologram is not destroyed by dust and thus holograms are exceptionally durable. These and other distinctive properties are what makes holograms useful for a whole range of exciting technological applications.

The initial impetus for the development of holography came from the field of microscopy. Ordinary microscopes, impose severe limitations in the viewing of biological samples; there is a problem of depth of focus i.e. focussing on one level drives other deeper levels out of focus thus making it difficult to get a good perspective. One can make a hologram of the sample and view it at leisure with an ordinary microscope using it to study several levels of the image. X-ray holograms on the other hand, will give us a unique 3 dimensional view of viruses and bacteria.

Compact discs have revolutionized the audio industry with their durability and the fidelity of reproduction. Holograms have the potential of even greater advances in this technology because of the mind boggling density of information that can be recorded on them. CD ROMs (Read Only Memories), nowadays allow us to have whole books or even encyclopedias on single discs. Conventional computer memory devices work with magnetic recording and reading of data. Holographic techniques promise to increase the storage capacity and decrease the access time of memories to unheard figures. These ideas are being actively researched though their cost effectiveness is still in doubt.

But by far the most perceptible use of holography has been in industry. Holography is used to carry out stress analysis of very sensitive equipment like gyroscopes used in navigation of aircraft. It is also used to detect voids in layered objects like composite aircraft components and to carry out vibration analysis to infer properties of materials and defects. In the electronics industry, holography is being used to improve manufacturing of high precision components like ICs (Integrated Circuits). One of the major obstacles in the development of robotics has been pattern recognition. Patterns, contrasts, edges, etc. which humans recognize effortlessly, prove to be formidable problems for a machine. Holography is being applied to improve machine vision and it is not inconceivable that in the future, robots using holographic vision will move around without bumping with objects.

In the world of art and entertainment , holography made its debut with the opening in 1975 of a Museum of Holography in New York followed by one in Paris. The next obvious step

proved to be formidable; the development of holographic television which would allow 3 dimensional viewing. At the present moment, the technological obstacles for this seem unsurmountable. But tremendous improvements in computer technology have allowed generation of holographic effects on television which are simply stunning.

Holography is almost 45 years old. But unlike its contemporary the transistor, the applications of holography have not yet been completely explored. From computers to microscopy, communications to stress analysis , wherever its potential has been exploited, the results have been incredible. The twenty first century will undoubtedly see holography emerging as one of the major technologies in the service of humankind.