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A new technology matures

The next generation of computer storage has come of age, says S.Ananthanarayanan.

First it was the CD, which was optical storage in place of magnetic storage. Then the DVD, or the Digital Versatile Disc, which could record more than 6 times the data of a CD. Now it is the next step in optical storage – holographic storage, which can record and read back a thousand times the data in a fraction of the time!

The idea has been around for some years, but the practical technology has now been developed, says a report in ‘nature photonics’ of July 2008.

The CD and DVD

In the CD, the ‘1’s and ‘0’s of computer language are recorded as steps on a reflecting surface. For reading the data, the sequence of the steps are sensed by a light beam and fed to a computer to make sense out of the code. The light used, both for writing and reading, is laser light, which is a form of ‘orderly’ light waves, like a troop of soldiers in drill, rather than a stampede where nobody is ‘in step’. This kind of light is used because the technology demands it, but the information is just in the ‘ups’ and downs’ recorded in the disc.

The DVD uses light of a shorter wavelength and packs more ‘steps’ into the track. A further development is the ‘blue-ray’, which uses an even shorter wavelength and manages some seven times more storage, or even fourteen times more storage in the ‘double layer’ form.

But both CD and DVD are ‘optical methods’, which use only the digital property of ‘yes light’ or ‘no light’ and do not exploit the ‘wave nature’ of light, which enables a whole new chapter in storage and replay.

Holography

This is a method of recording the light waves scattered from an object, so that the record can be used to generate different views of the same object, with different images, in three dimensions, when viewed from different angles. A hologram, when viewed with both eyes, will thus show a ‘lifelike’ image, as if the two eyes were seeing different views from their respective positions and the brain were adding the images up!

The way it works is that if an object is illuminated, light falling on the object is scattered in all directions, including in the direction of the recording medium, say a photographic film. Now, if the light that illuminates the object also falls directly on the photo film, there will be two sources of light that illuminate the film. In the normal course, the light waves that arrive from the object as well as those that arrive directly are all in random positions of vibration and the illumination of the film is a uniform ‘average’.

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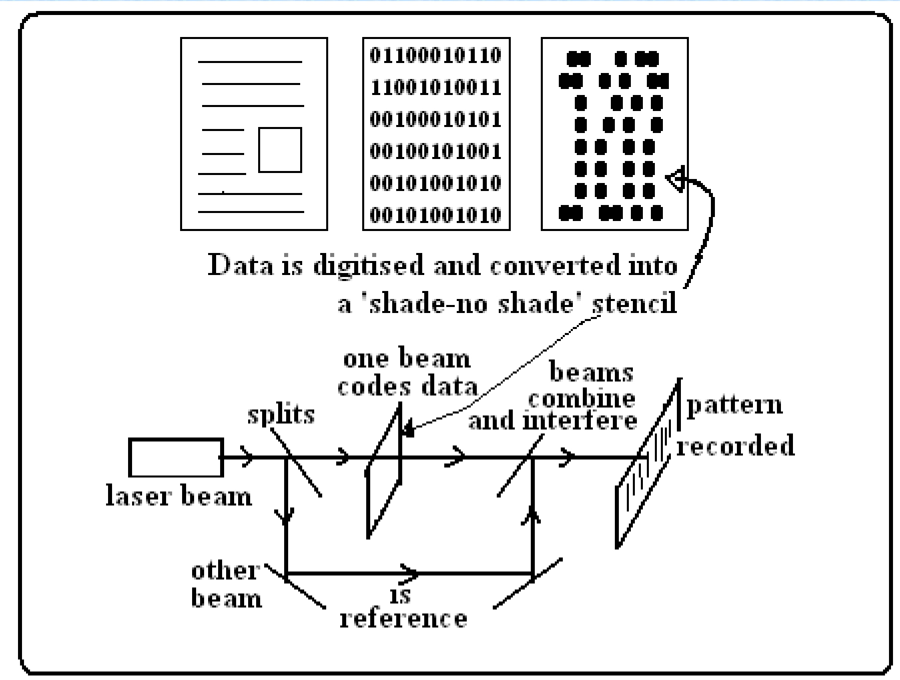
But if the light that is shone is a laser beam, there is a significant difference. In lasers, the light waves are all ‘in step’. The waves of light coming off the object, which have traversed different distances will arrive ‘out of step’ to different degrees, when they reach the photo film. The image on the film will then be a complex pattern of places where the waves add to each other and places where they cancel out. It can be shown that because one of the sources was the regular, original source, the interference pattern contains the information about the secondary, reflecting source. If the same light is now shone on the pattern recorded on the photo film, then, the pattern causes the light coming through to seem as if it were coming from the original object.



Viewing the laser source through the hologram will thus reproduce the image of the object, differently from each point of viewing, which is to say, differently for each eye and thus in three dimensions!

Holographic storage

An important aspect of this kind of storage is that the whole image has been stored in a single pattern of wave interference at each spot of the photo film. Each small area on the film thus has a picture of the whole original object, a case of capturing a ‘whole’ picture at one spot. If different pictures could be similarly stored at different parts of the photo film, then there would be ‘complete’ images of several objects stored on the same, small photo film.

A next step in this form of storage has been use not just a flat photo film, but a sheet with some depth and to record the interference pattern in a volume, rather than in an area. Shining the original illuminating beam through the volume has the same effect as before, it reproduces and image of the original object. The technology is thus to record and read back millions of bits of data with a single pulse of light, enabling fantastic transfer rates, compared to current methods.

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Recent development

The technology was not ready for commercialization for many years because of the engineering challenges. Recent advances in laser sources and recording materials have made a difference. An important development is how to record many images in a single sheet of medium. One method was to use laser beams incident at different angles. Using the same angle during replay then identified the original record. Another method has been recording at different depths in the medium. This method enable more than 10-fold increase in capacity of the medium.

The other important developments have been the reading devices, particularly the ***charge coupled device*** camera, which has a surface that can capture millions of bits of information at once, depending on the light falling on different parts of its surface. The device then allows the whole millions of bits captured by a single pulse of light to be read and transferred to a computer in almost the same short time taken for its recording.