Synthetic Holography

Also known as digital holography simulates the recording process of optical holography. Depending on the diffraction theory, the wave fronts scattered by objects are synthesized and analyzed by using computers. These objects are numerically specified or by means of mathematical models. During recent years, many interesting results have been achieved in digital holography owing to improvements in computer architecture, computational methods, and electro-optical technology. Digital holograms are a series of computer-generated images in sequential order and these images do not require to record the light distribution of the objects, unlike optical holograms. The research work of digital holograms is mainly inclined towards formation and rendering of images. It is possible to reconstruct the imaginary objects that do not exist physically in digital holography. Digital holograms are initially saved as a file directly and using a computer program they are reconstructed. They are simpler to record and reconstruct, but resolution is much lower than a holographic film.

The content for digital holograms can easily be produced by non-experts, and the printing process is comparatively inexpensive. Usually a three-dimensional graphical scene, a series of digital photographs or a short movie of a real object is enough for producing synthetic holograms.

An example: A diagrammatic representation of a digital hologram of a car headlight with integrated CAD data.

STEPS FOR CREATING SYNTHETIC HOLOGRAPHY:

The Process broadly three tasks:

1. **Computation** of the virtual scattered wavefront
2. **Encoding** the wavefront data, preparing it for display
3. **Reconstruction**: **Modulating** the interference pattern onto a coherent light beam by technological means, to transport it to the user observing the hologram.

Wavefront Computation:

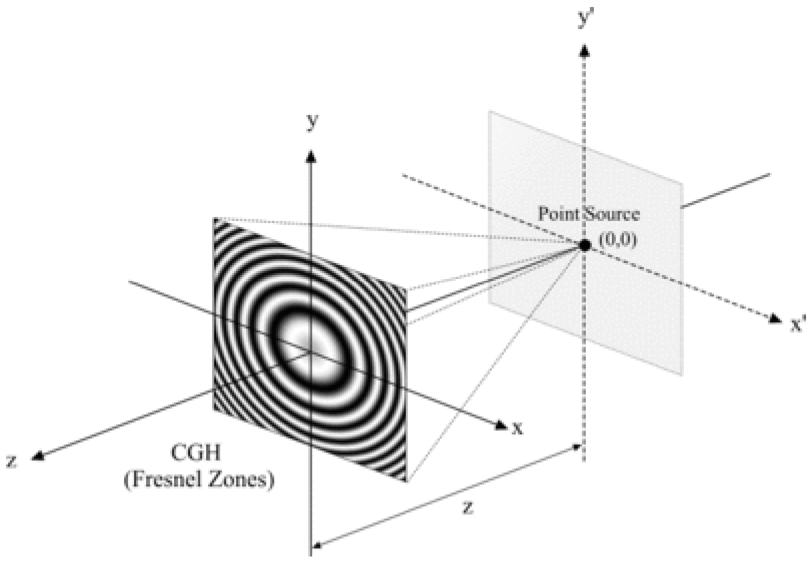
In the field of computational techniques the reported algorithms can be categorized in two main concepts.

Fourier transforms method:

Fourier transformation is used to simulate the propagation of each plane of depth of the object to the hologram plane. There are two steps in this process: computing the light field in the far observer plane, and then Fourier transforming this field back to the lens plane. These holograms are called Fourier Based Holograms. First synthetic holograms based on the Fourier transform could reconstruct only 2D images. The wavefront to be reconstructed by the hologram is the superposition of the Fourier transforms of each object plane in depth, modified by a quadratic phase factor.

Point Source holograms:

The second computational strategy is based on the point source concept, where the object is broken down in self-luminous points. An elementary hologram is calculated for every point source and the final hologram is synthesized by superimposing all the elementary holograms. This concept has been first reported by Waters whose major assumption originated with Rogers who recognized that a Fresnel zone plate could be considered a special case of the hologram proposed by Gabor. But, as far as most of the object points were non-zero the computational complexity of the point-source concept was much higher than in the Fourier



transformation concept. Some researchers tried to overcome this drawback by predefining and storing all the possible elementary holograms using special data storage techniques because of the huge capacity that is needed in this case, others by using special hardware.

Interference Pattern Encoding:

Once it is known what the scattered wavefront of the object looks like or how it may be computed, it must be fixed on a spatial light modulator (SLM). Basically, there are different types of SLMs available: Pure phase modulators (retarding the illuminating wave), pure amplitude modulators (blocking the illumination light), polarization modulators (influencing the polarization state of light) and SLMs which have the capability of combined phase/amplitude modulation. Two different approaches for amplitude-phase-modulation have been implemented. One is based on phase-only or amplitude-only modulation and consecutive spatial filtering, the other one is based on polarization holograms with variable orientation and magnitude of local birefringence.

Reconstruction:

The third issue is beam modulation and actual wavefront reconstruction. Masks may be printed, resulting often in a grained pattern structure since most printers can make only dots. Holographic displays are currently yet a challenge, although successful prototypes have been built. An ideal display for computer generated holograms would consist of pixels smaller than a wavelength of light with adjustable phase and brightness. Such displays have been called phased array optics.

Advantages:
Compared to a conventional optical holography, digital holograms have many advantages. These are as follows:

- Digital holograms have strong anti-disturb property.
- They are easy to be modified.
- They are difficult to be imitated.
- Digital holograms can be multiplexed.
- A series of digital photographs or a short movie of a real object is enough for producing digital holograms.