DIGITAL DECODING OF IN-LINE HOLOGRAMS

by

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ABSTRACT

In-line holography is a useful tool in the study of dynamic objects in three-dimensional space. A hologram is a specific non-linear coding which is recorded in the presence of coherent illumination (laser, microwave, ultrasound etc.). The physical reconstruction is done by reilluminating the hologram, and the resulting image is contaminated by the interfering twin-image. Here in this dissertation, a system of digital filters is presented, which is applied directly to the in-line hologram and maps the hologram into an image of the boundaries (edges) of the objects encoded in it, provided that the object distribution function is real. This technique bypasses physical reconstruction completely and gives a clear decoding of the objects. In the first stage of the system, the hologram is approximated as the DC shifted output of a linear system. An approximate inverse filter is used to obtain the desired object distribution from the hologram since the exact inverse is not realizable. The linear approximate inverse filter is a truncated series expansion of the inverse filter in the Fourier transform domain. The basis functions of the expansion are of the form $\cos nb(u^2+v^2)$, where u and v are the Fourier transform domain variables, b is a constant, and n is a positive integer. The first term in the expansion corresponds to conventional optical reconstruction, and the addition of successive terms suppresses the twin-image. Just a few terms is enough for satisfactory twin-image suppression. Since only a few terms are used in the approximation, the problems of inverse filtering are avoided. The twin-image component is a high amplitude broadband signal, therefore its suppression is essential for complicated object distributions before the edge detection phase. The edge-detection filter is a non-linear operator of finite support (typically 3 by 3), which replaces each pixel by the local estimate of spatially variant covariance ("covariance filter"). Once the background is reduced by the linear approximate filter, the performance of subsequent non-linear filtering is significantly improved. The details of the structures and the properties of the filters are given with their implementation results. Also, a detailed discussion on discrete and continuous mathematical models for in-line holography which emphasizes the systems approach is included.