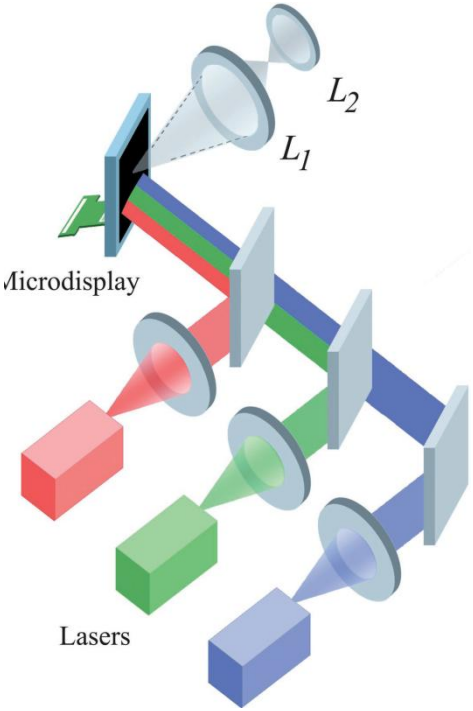
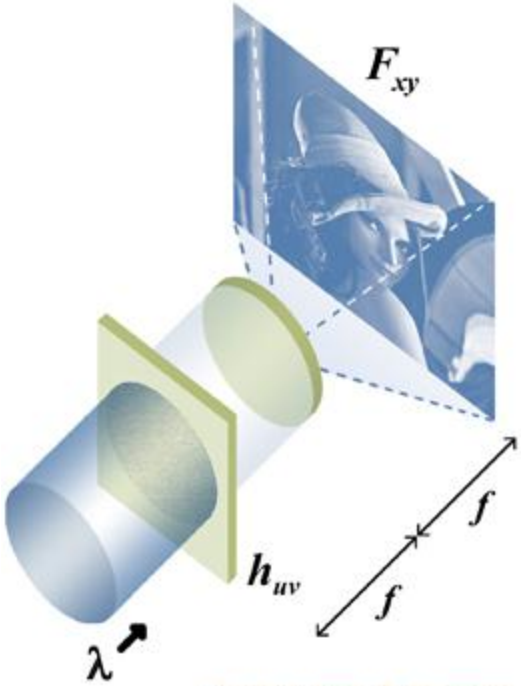
# ECE 299 Holography and Coherent Imaging

## Lecture 11. Computer Generated Holograms

David J. Brady
Duke University

# Holographic projectors




The relationship between hologram $h_{uv}$ and image $F_{xy}$ present at the back focal plane of a lens of focal length $f$, when illuminated by coherent monochromatic light of wavelength $\lambda$

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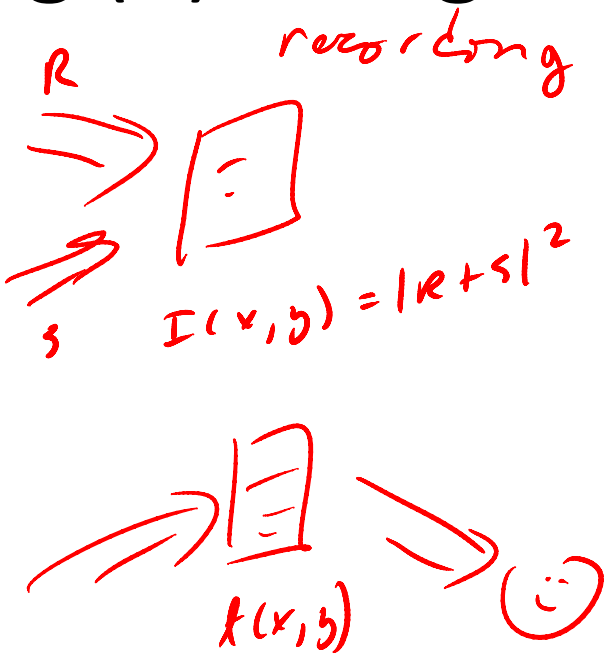
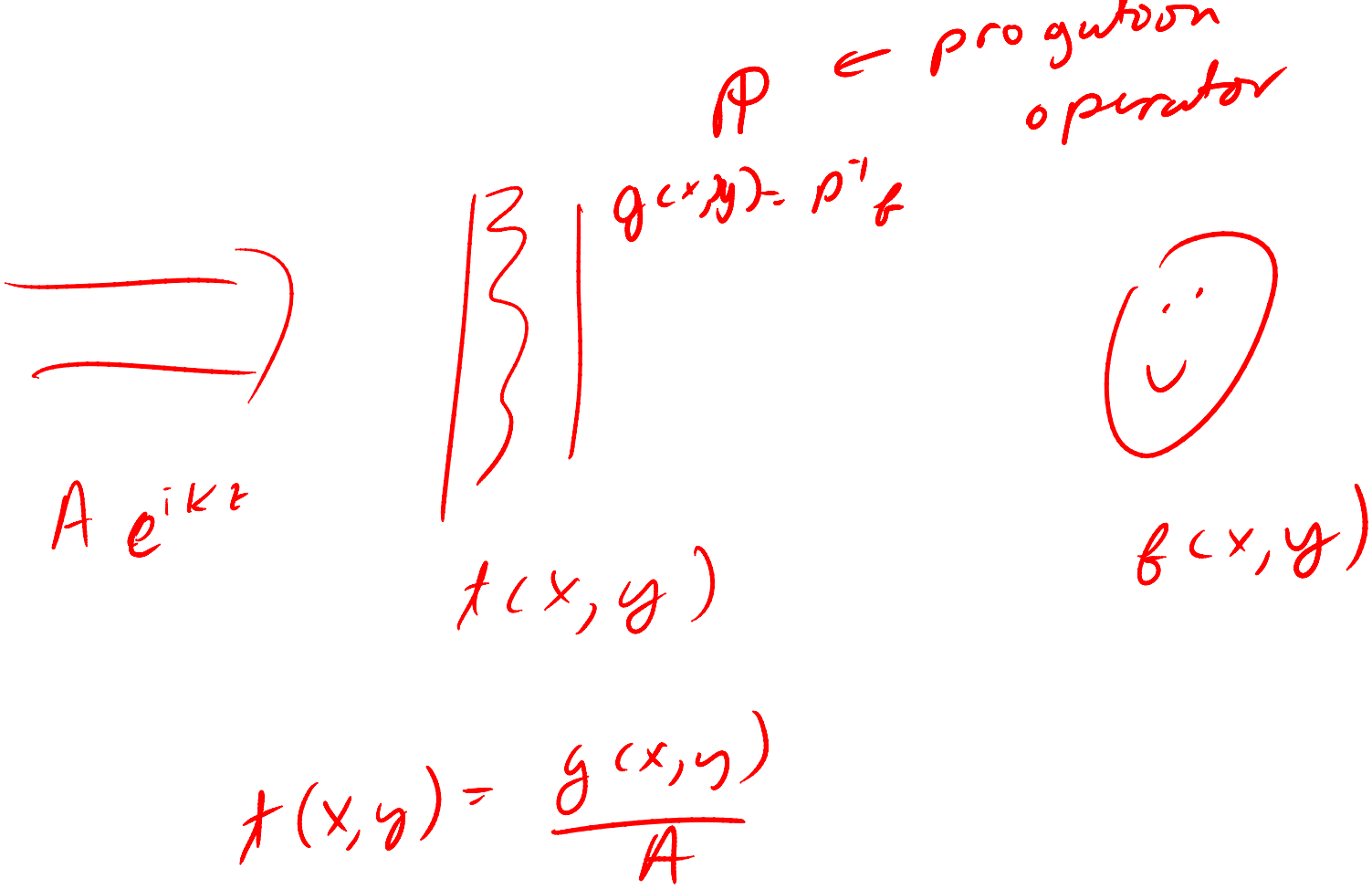
# Digital holography and (1) hologram recording (2) hologram reconstruction




Olt can refer to digital calculation + encoding of t(x,y)

or digital recording of I(x,y)

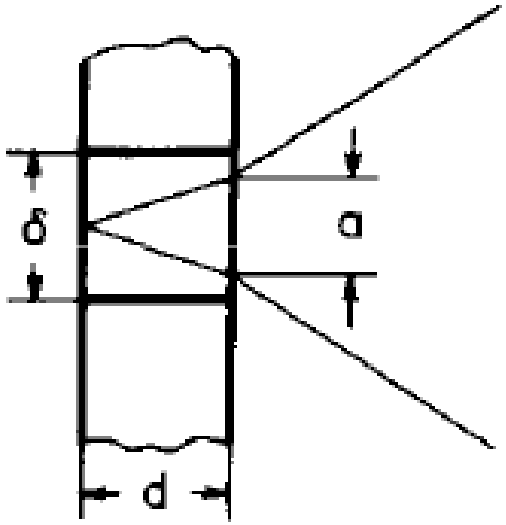
# Wave transformation by diffractive elements



# Geometric approximation for diffractive element

$$Q = \pi a / \delta = 2\pi\lambda d / \delta^2.$$

$$a = 2\lambda d / \delta.$$



# Coding

| Mode of operation | Structure | |
|---|---|---|
| | Index modulation | Surface relief |
| $\mathscr{T}$ | $\lvert\psi_t\rvert$: $\kappa(x)$, $d$<br>$\arg[\psi_t]$: $n(x)$, $d$ | $\lvert\psi_t\rvert$: 1 ($\kappa = 0$)<br>$\arg[\psi_t]$: $d(x)$, $n$ |
| $\mathscr{R}$ | $\lvert\psi_r\rvert$: $r(x)$<br>$\arg[\psi_r]$: $\pi$ [$\kappa = 0$] | $\lvert\psi_r\rvert$: 1 ($\kappa \neq 0$)<br>$\arg[\psi_r]$: $d(x)$ |

# Indirect Coding

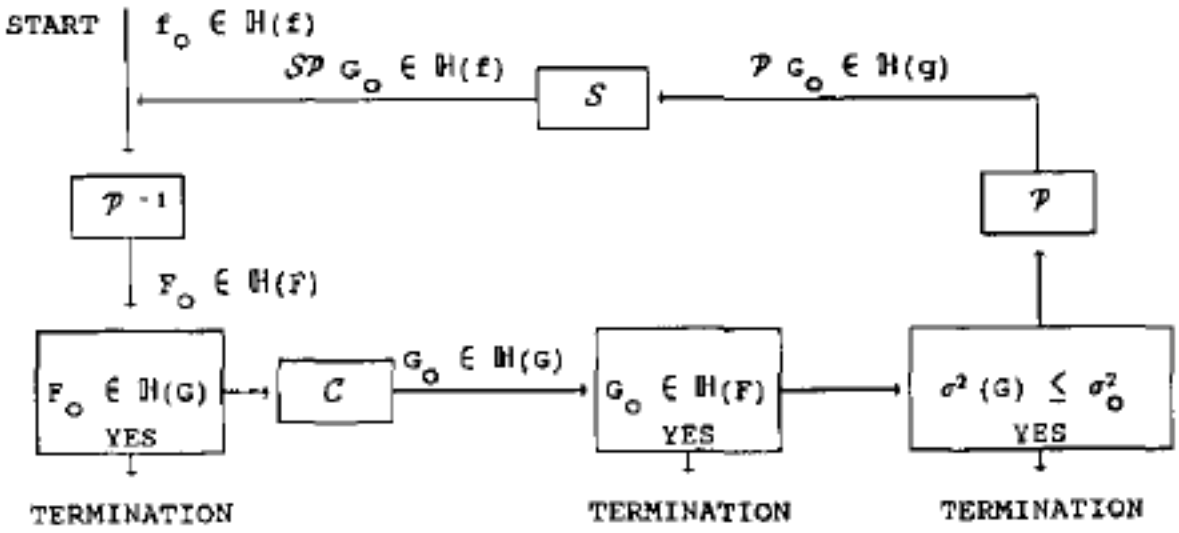
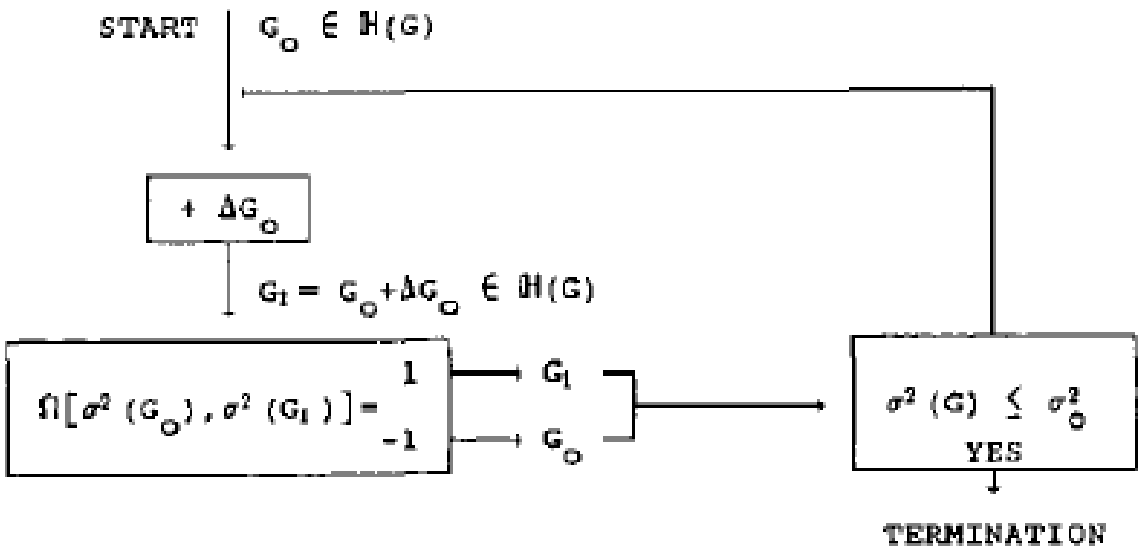



**Figure 11.** A flow diagram to illustrate the indirect coding approaches. The start is at the upper left and the decisions are indicated in the lower part. This approach can be non-iterative as well as iterative.

# Direct coding



# Direct Coding Strategy

B. R. Brown
A. W. Lohmann

## Computer-generated Binary Holograms*

B.R. Brown and A.W. Lohmann (1969). "Computer-generated Binary Holograms". *IBM Journal of Research and Development* (IBM) **13**: 160-168.

## Complex Spatial Filtering with Binary Masks

B. R. Brown and A. W. Lohmann

B. R. Brown and A. W. Lohmann, "Complex Spatial Filtering with Binary Masks," Appl. Opt. **5**, 967-969 (1966) http://www.opticsinfobase.org/abstract.cfm?URI=ao-5-6-967

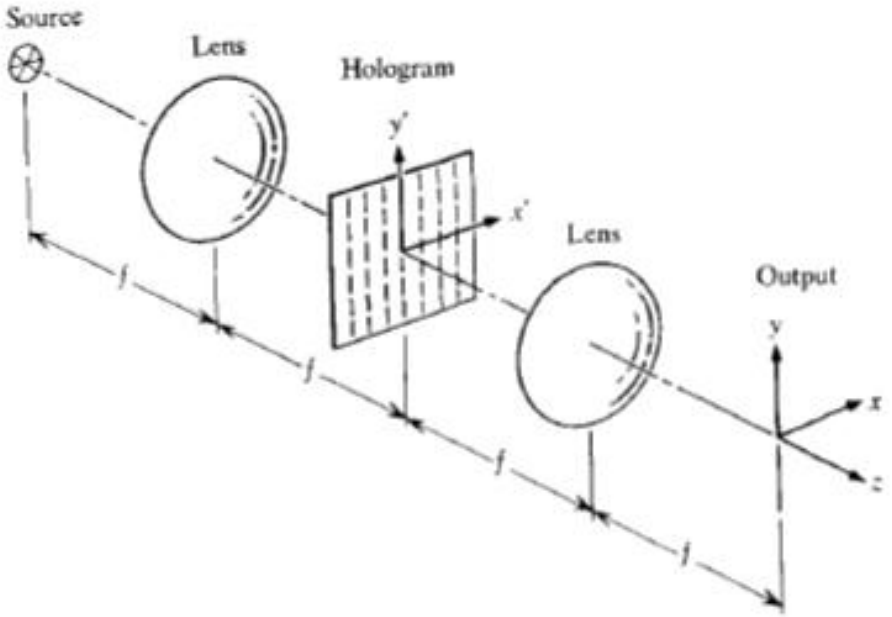
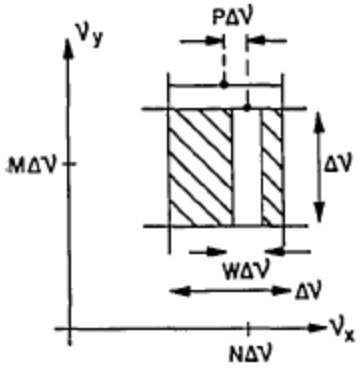
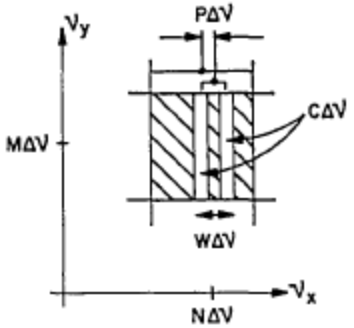



**Figure 1** Optical system for reconstructing Fourier holograms.

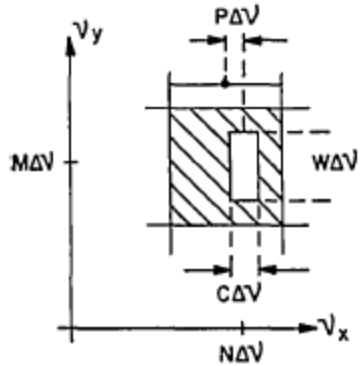
# Phase and amplitude coding




Case (a)




Case (b)




Case (c)

Fig. 3. Three ways for constructing the cell $(n,m)$. The parameters $W$ and $p$ that control amplitude and phase of the light emerging from this cell carry indices $(n,m)$. The slit width $c$ is a constant. Cases b and c are particularly suitable for automatic plotting.

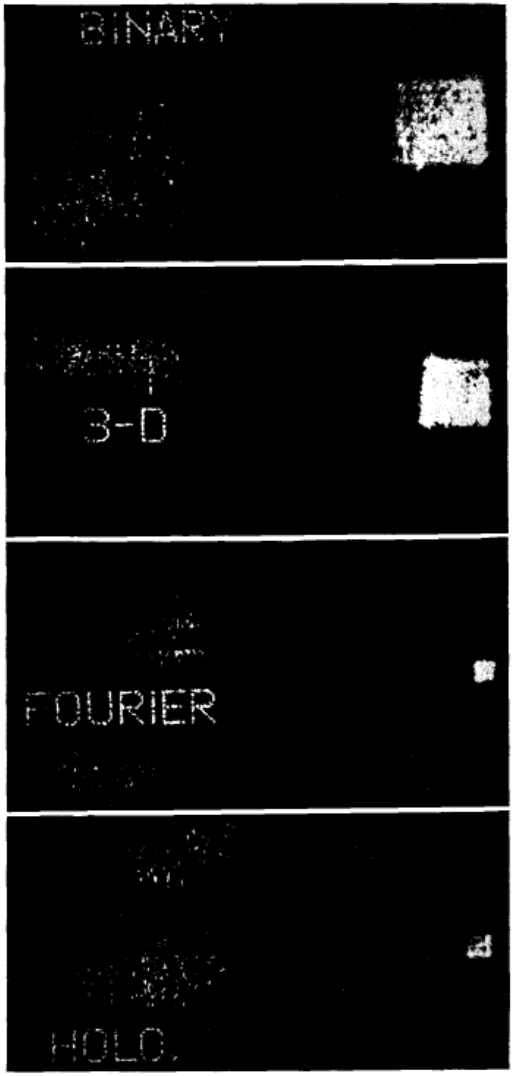



**Figure 11** Three-dimensional image having four planes spaced in depth; separation of planes is ten times that of Fig. 10.

# Phase and Amplitude Coding

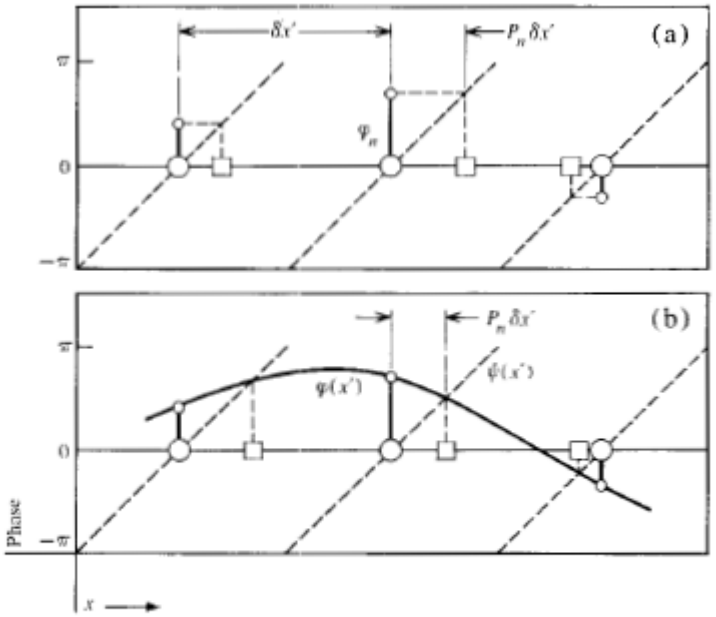



**Figure 7** Aperture position (squares) relative to sampling points (circles) determined by (a) phase $\varphi_n$ at sampling point and (b) phase at actual aperture position.

# Phase and amplitude coding in the Fourier Plane