

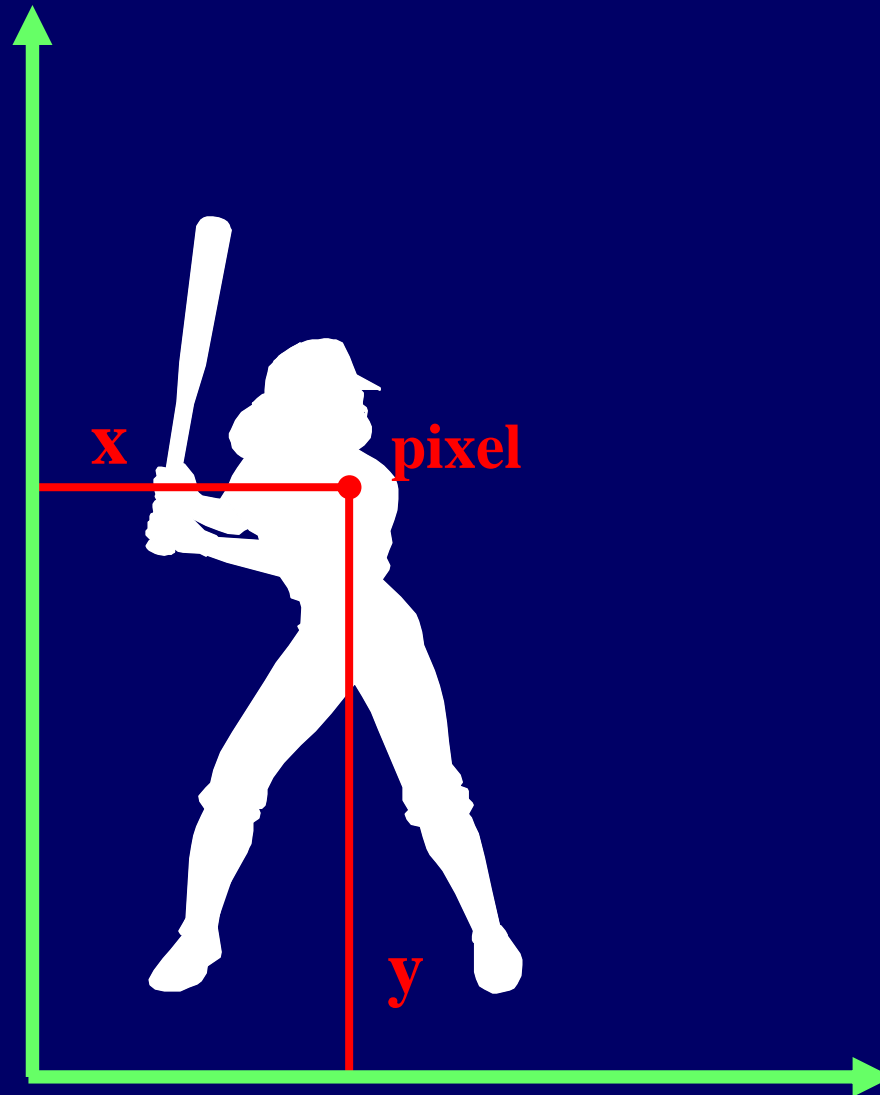
Immagini digitali tridimensionali di Beni Culturali



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Università di Firenze

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Immagine 2D



$x_1 \ y_1$

$x_2 \ y_2$

...

$x_N \ y_N$

Immagine 2D

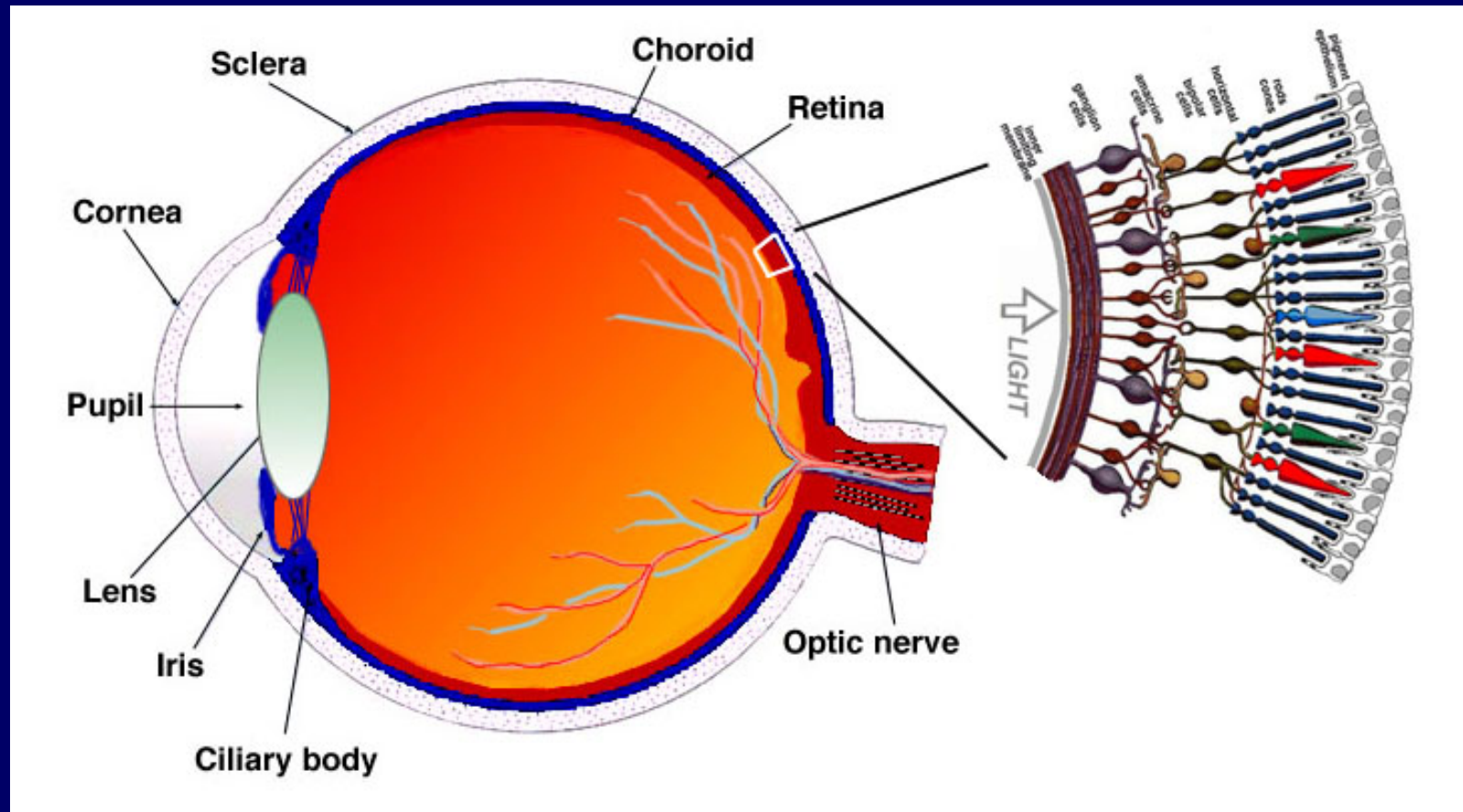


Immagine 2D

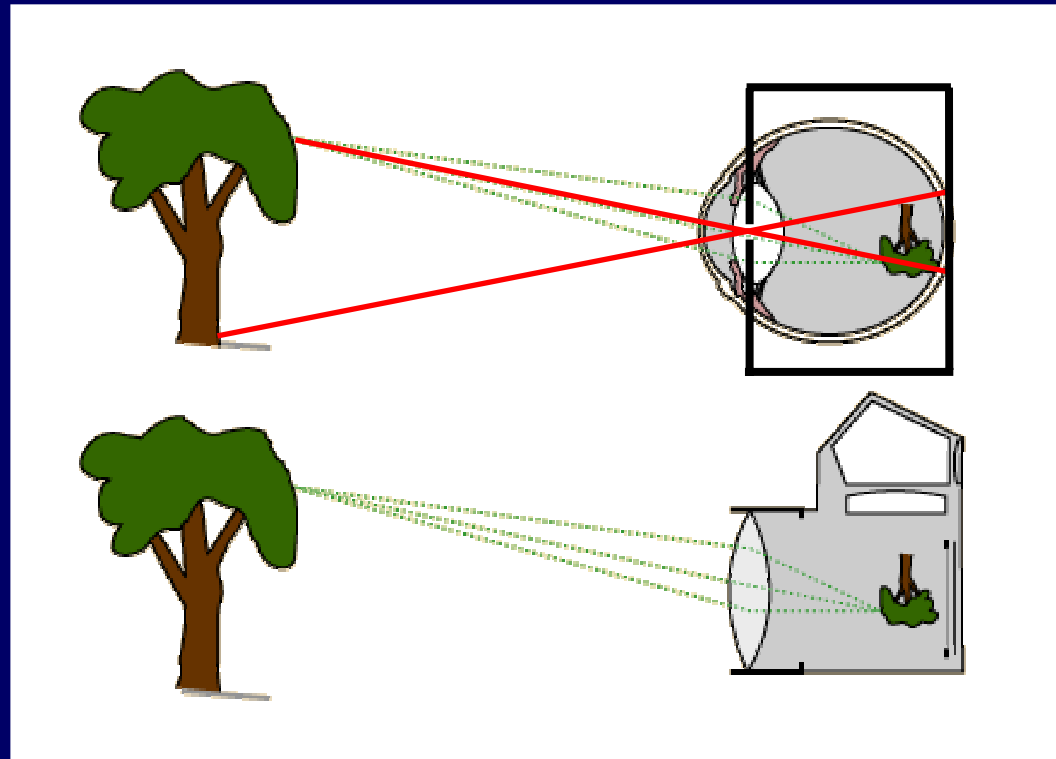
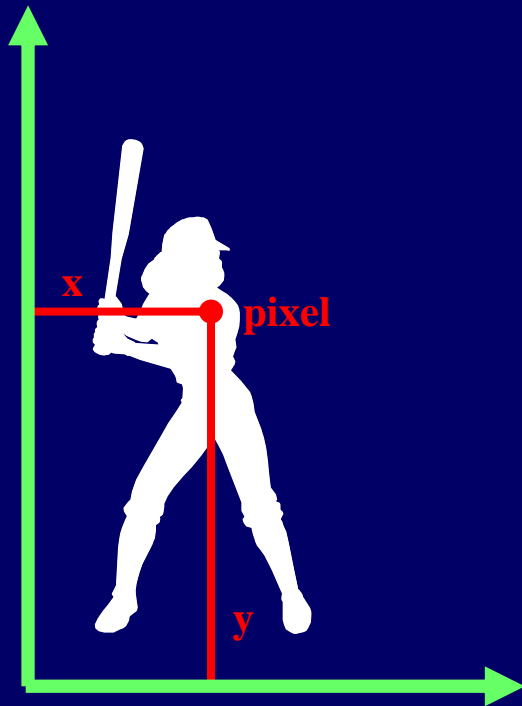


Immagine 2D

La preminenza dell'immagine 2D, sebbene il mondo fisico sia 3D, è dovuta alle caratteristiche fisiologiche del nostro sensore principale: l'occhio

I pipistrelli vedono con un sonar, quindi gestiscono direttamente informazione tridimensionale

Immagine 2D: le coordinate x e y

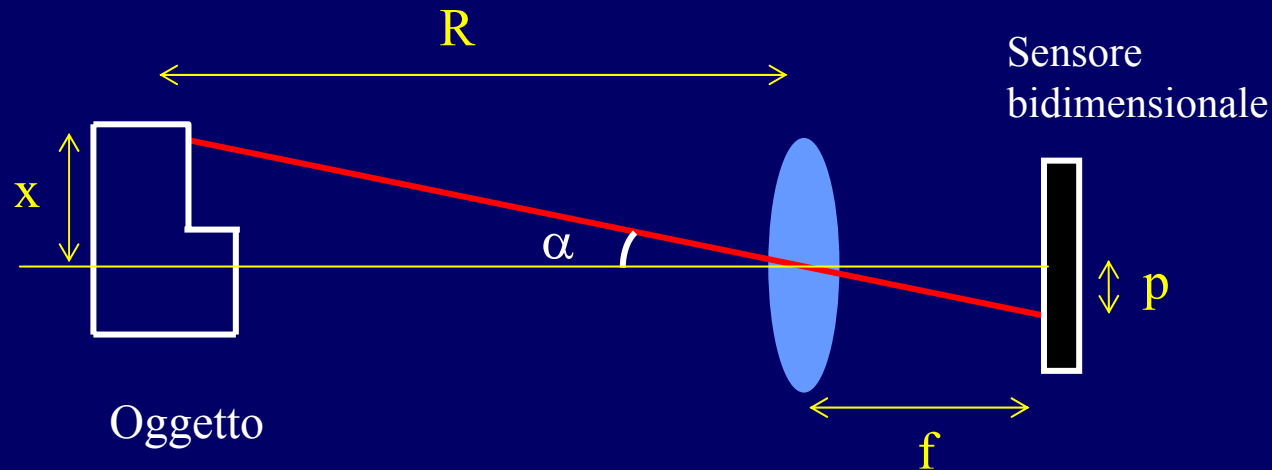


Coordinate
x, y dei pixel

Regole dell'ottica geometrica per
la formazione dell'immagine
(bidimensionale)

Scansione

Ottica geometrica per la formazione di immagini bidimensionali



$$\alpha \ll 1$$



$$x = \frac{R}{f} p$$

Scansione

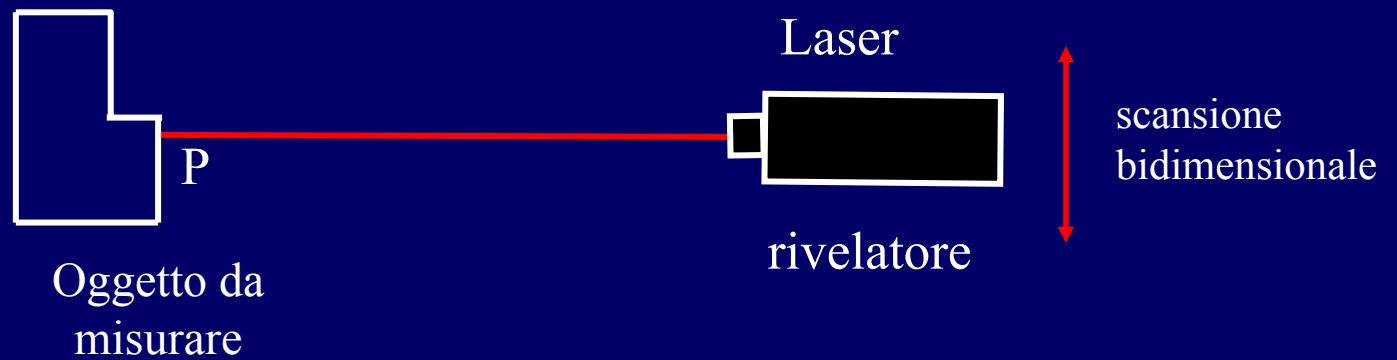
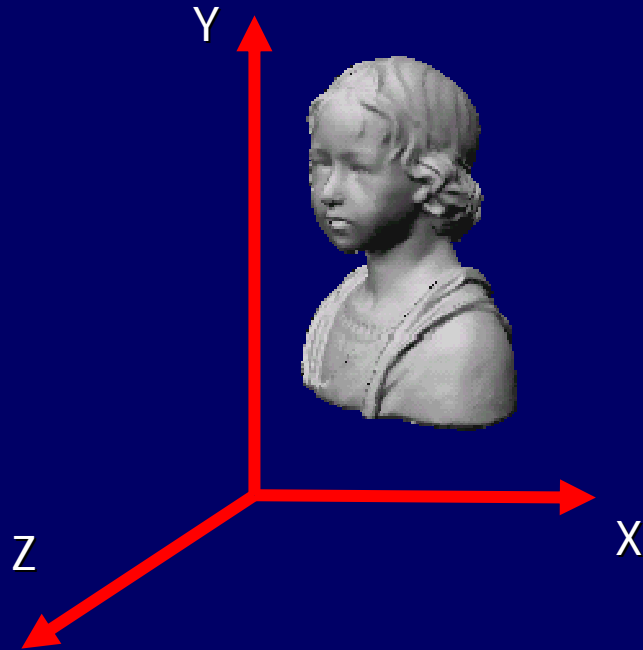


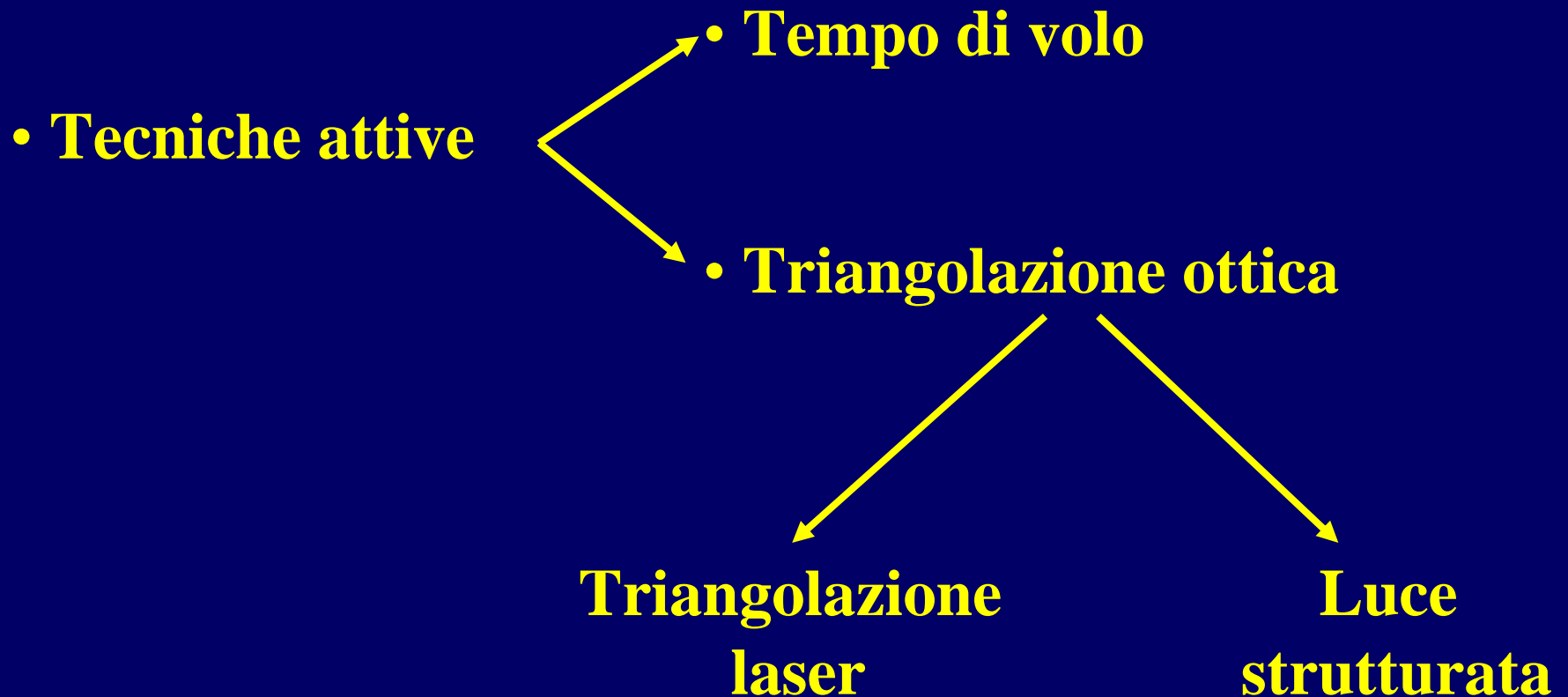
Immagine 3D



x_1	y_1	z_1
x_2	y_2	z_2
...		
x_N	y_N	z_N

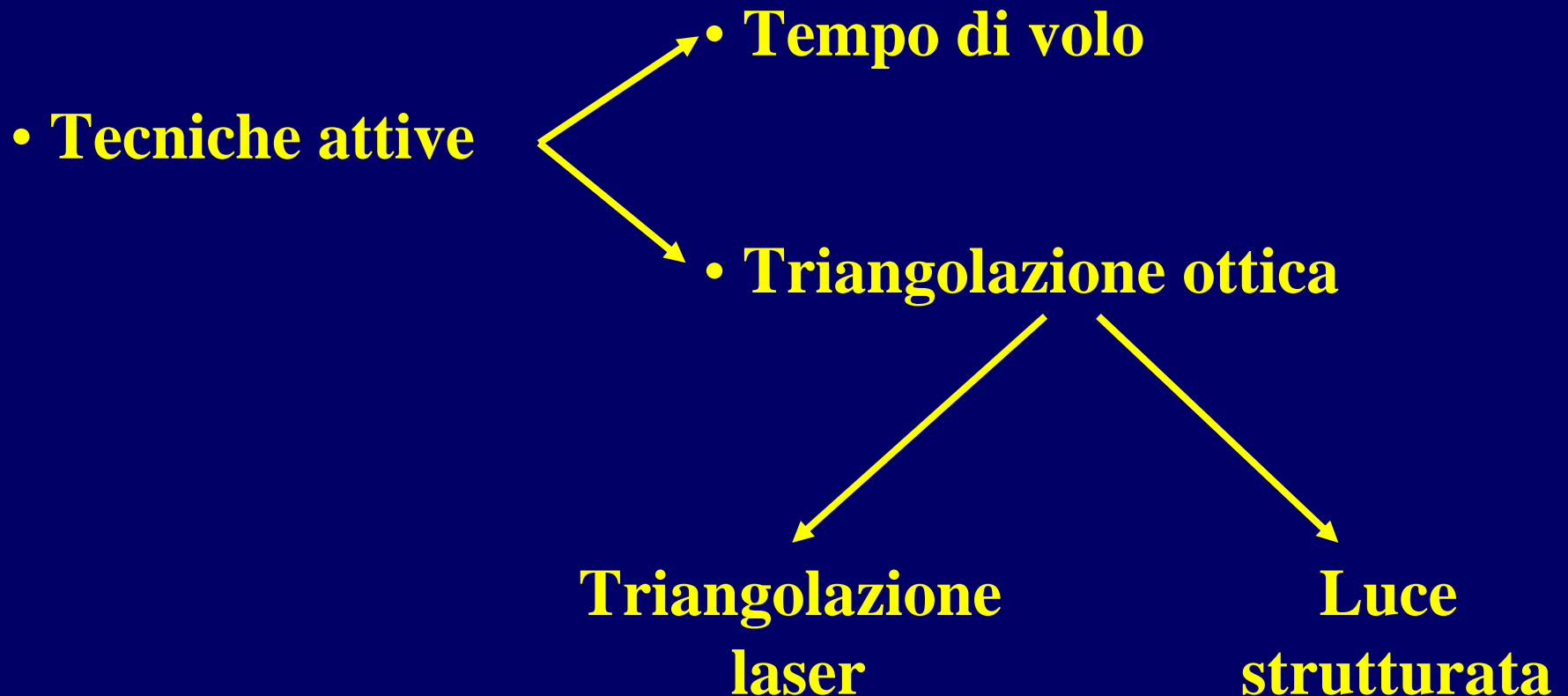
Tecniche di acquisizione 3D

• Tecniche passive —→ • Fotogrammetria



Tecniche di acquisizione 3D

• Tecniche passive —→ • **Fotogrammetria**



Fotogrammetria

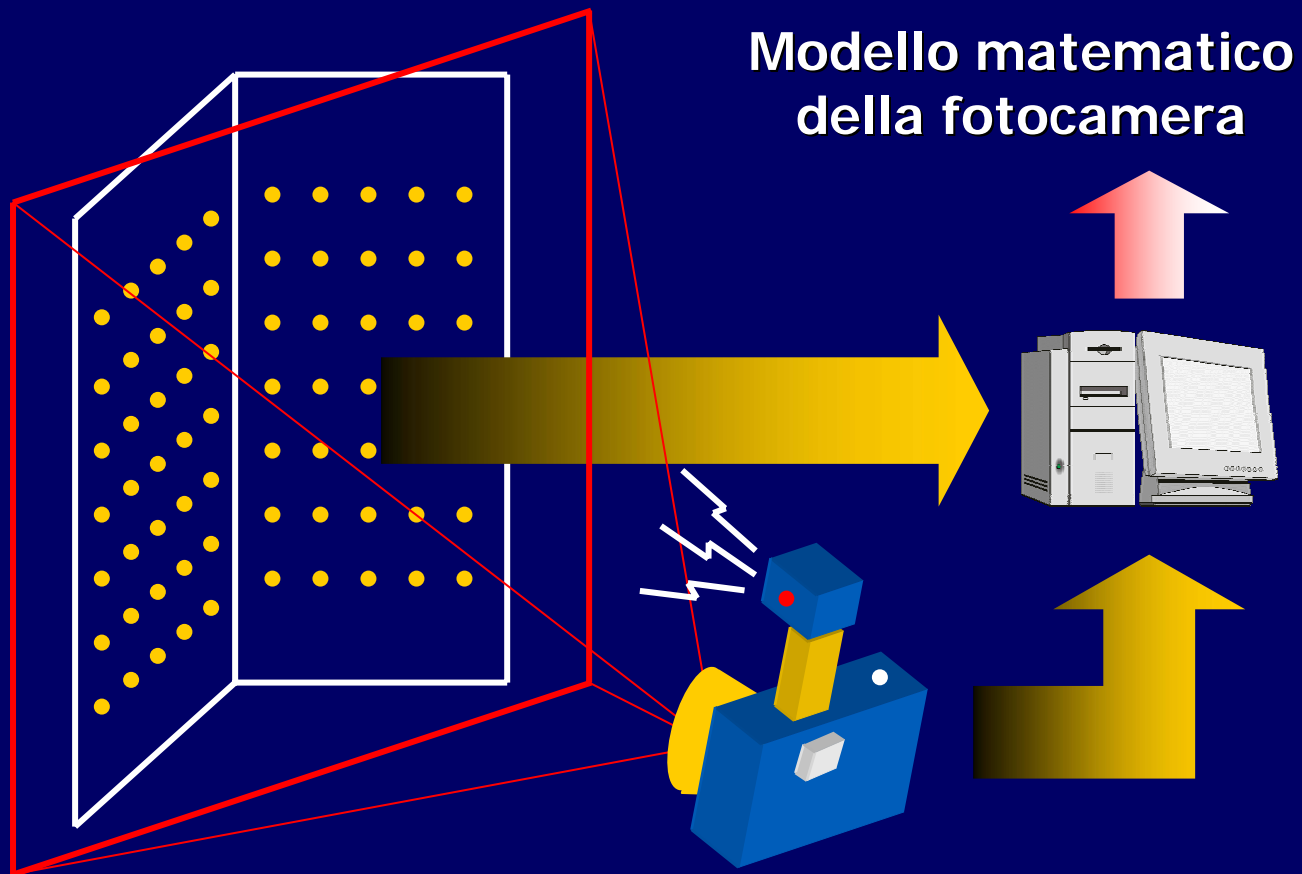


Fotogrammetria

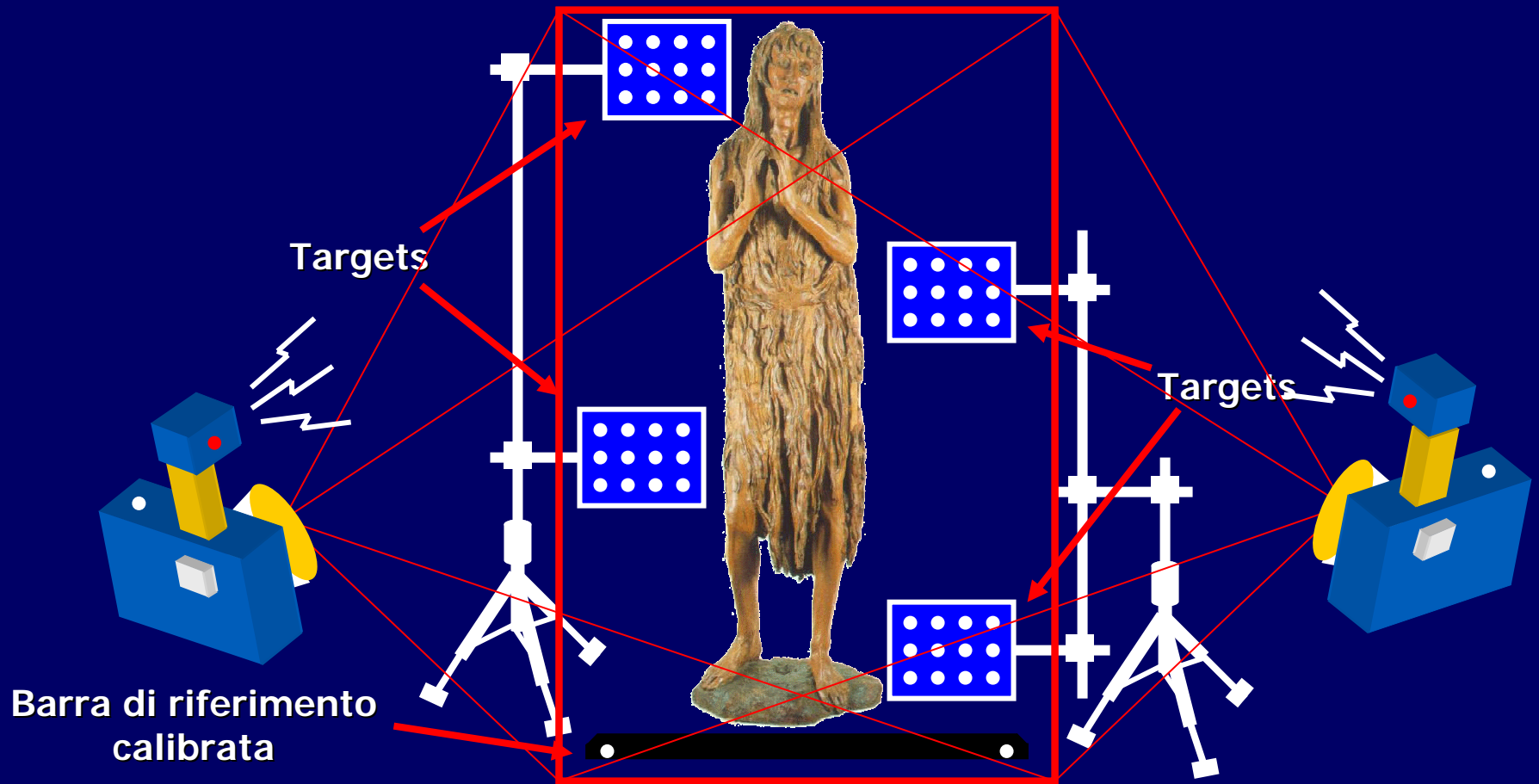


Fotogrammetria

Calibrazione della fotocamera digitale



Fotogrammetria



Fotogrammetria

Coppia di immagini stereoscopiche calibrate



Regole geometriche della parallasse



Profondità (z) dei punti dell'immagine

Immagine 3D ottenuta mediante fotogrammetria



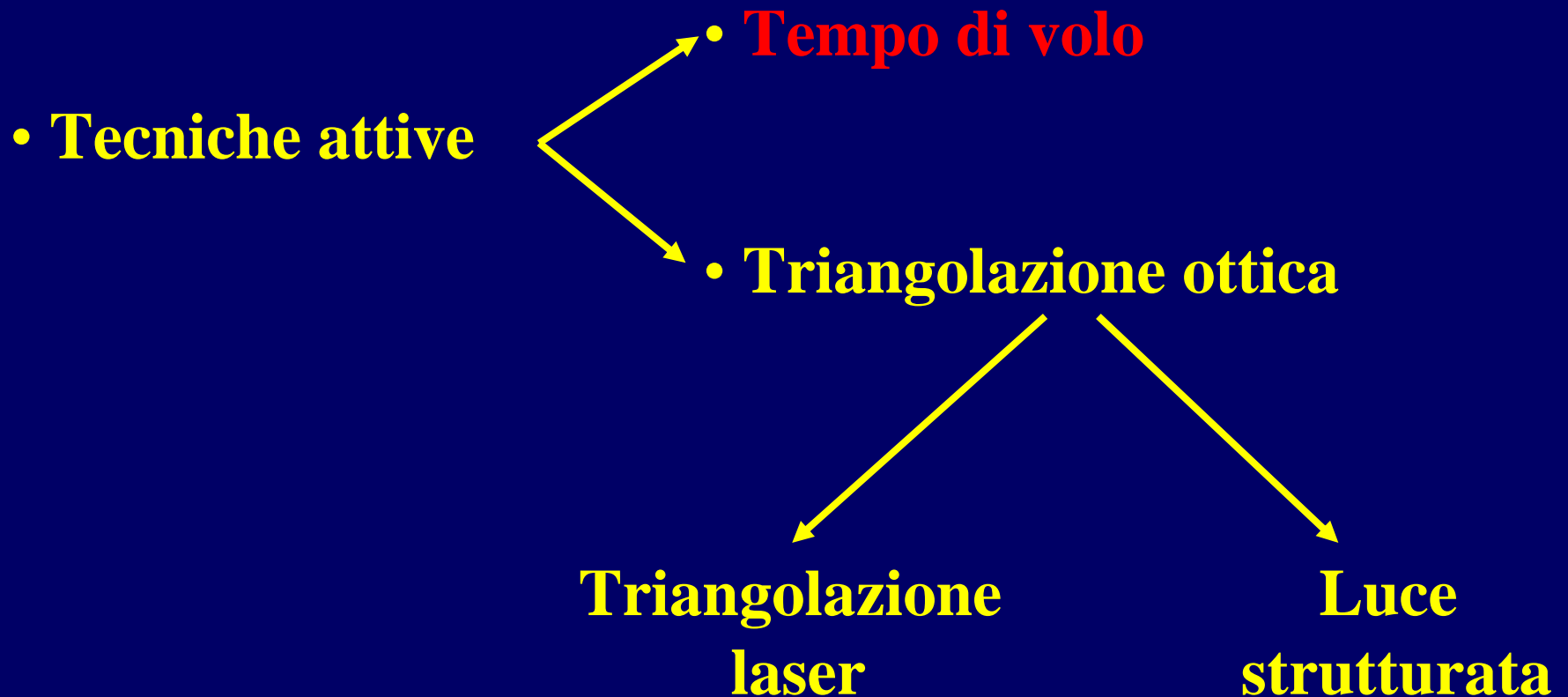
X: regole dell' ottica geometrica per la formazione dell'immagine

Y: regole dell' ottica geometrica per la formazione dell'immagine

Z: parallasse

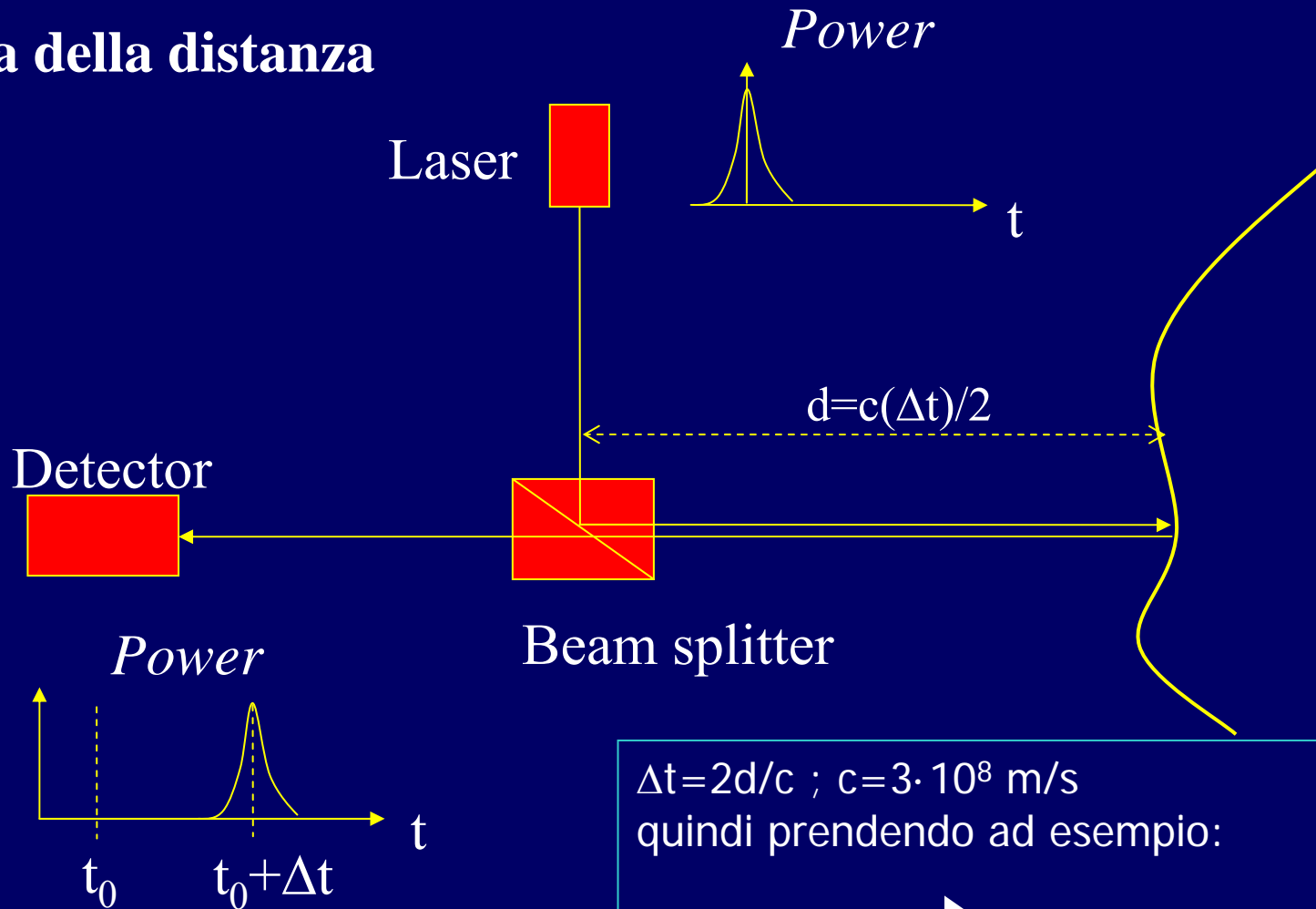
Tecniche di acquisizione 3D

• Tecniche passive —→ • Fotogrammetria



Tempo di volo

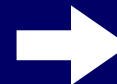
Misura della distanza



$$\Delta t = 2d/c ; c = 3 \cdot 10^8 \text{ m/s}$$

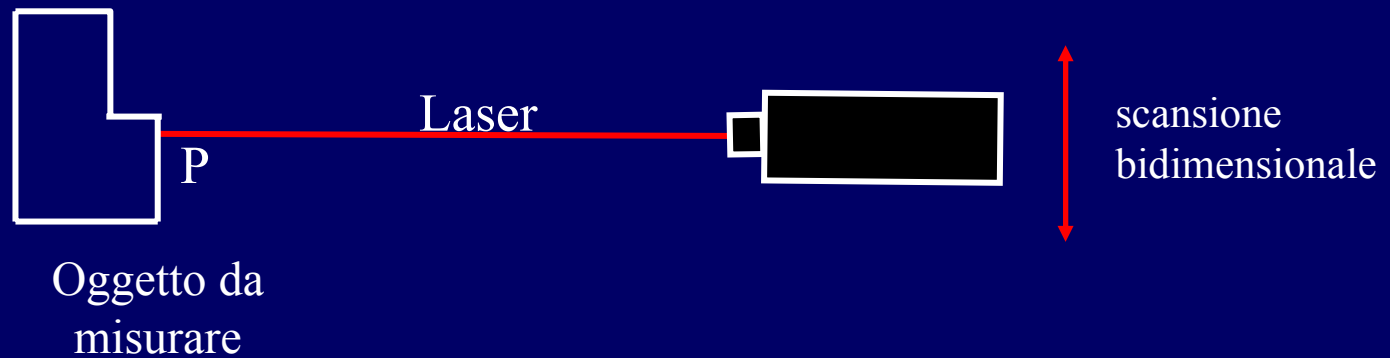
quindi prendendo ad esempio:

$$d = 1 \text{ m}$$



$$\Delta t = 6.67 \text{ ns}$$

Tempo di volo



Le coordinate x,y sono misurate mediante scansione

Immagine 3D ottenuta mediante scanner a tempo di volo

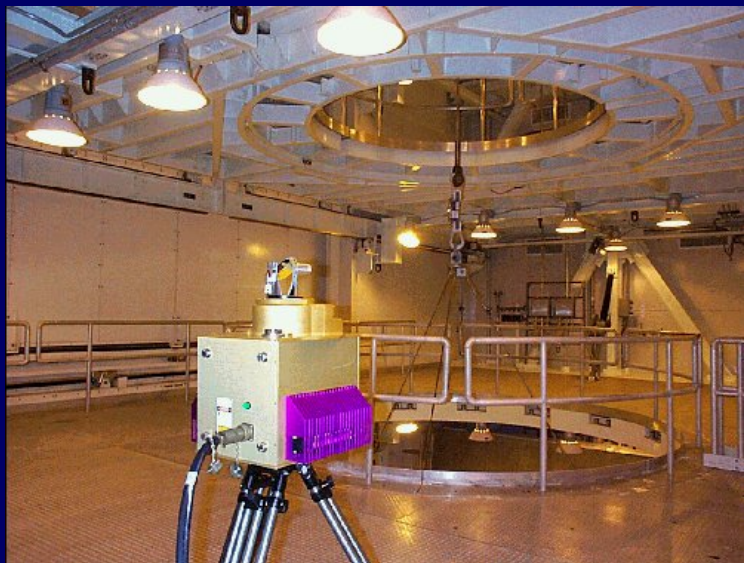


X: scansione

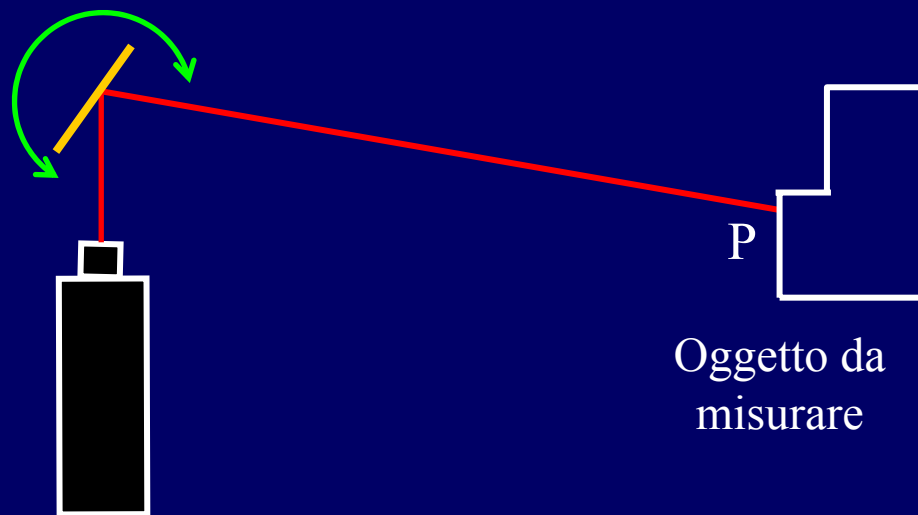
Y: scansione

Z: tempo di volo

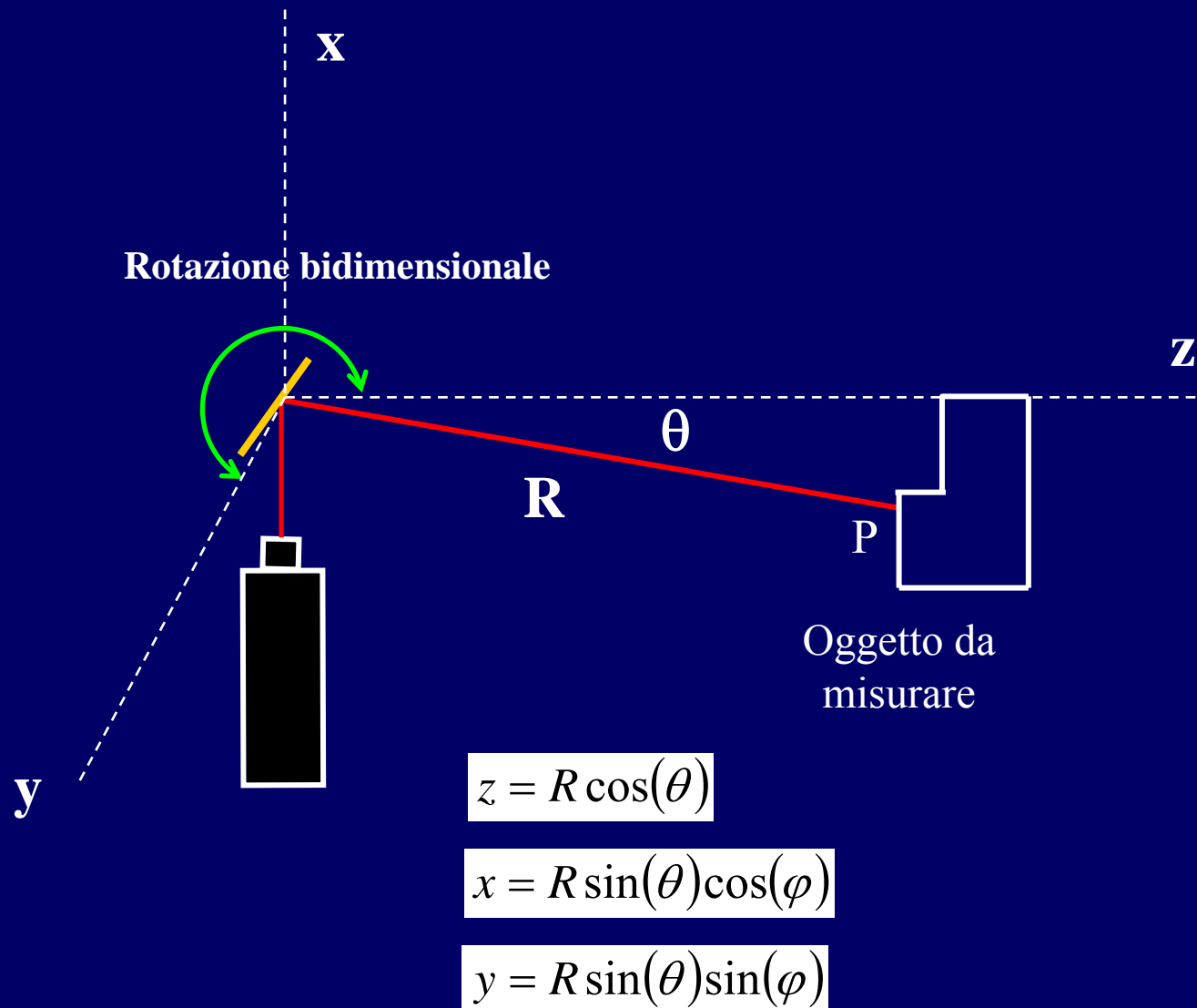
Scanner a tempo di volo



Rotazione bidimensionale

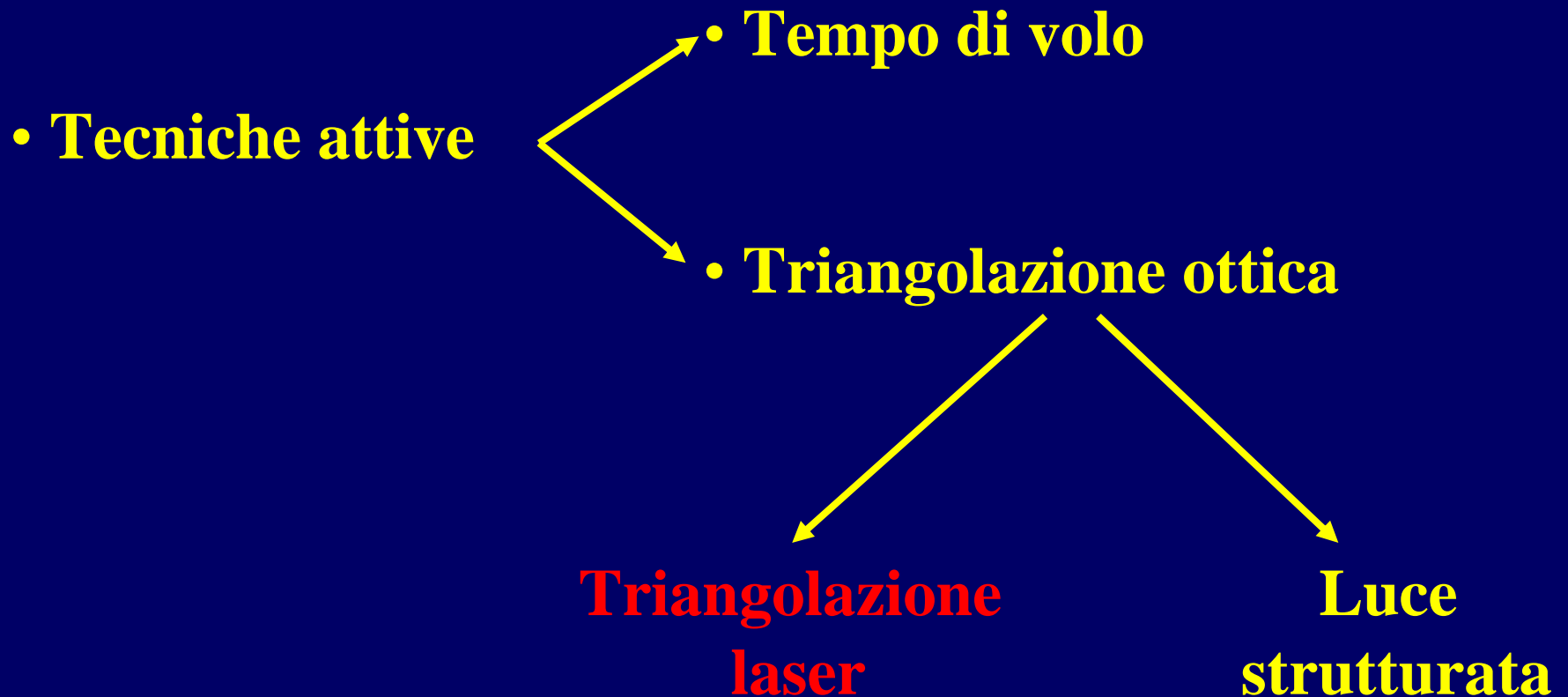


Tempo di volo

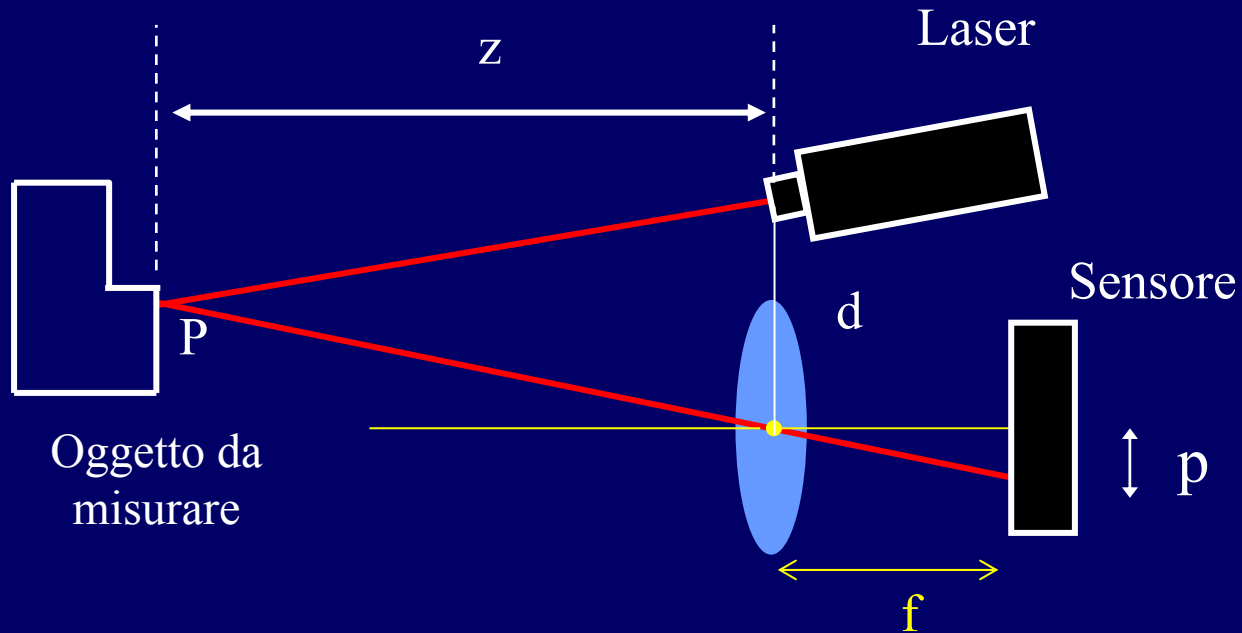


Tecniche di acquisizione 3D

• Tecniche passive —→ • Fotogrammetria



Triangolazione laser



$$\frac{p}{f} = \frac{\left(\frac{d}{2}\right)}{z}$$

$$z = \left(\frac{fd}{2}\right) \frac{1}{p}$$

p

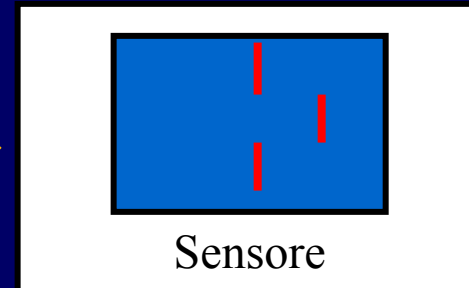
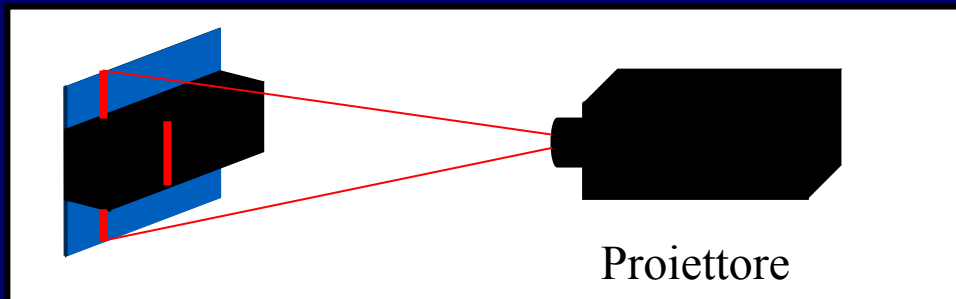


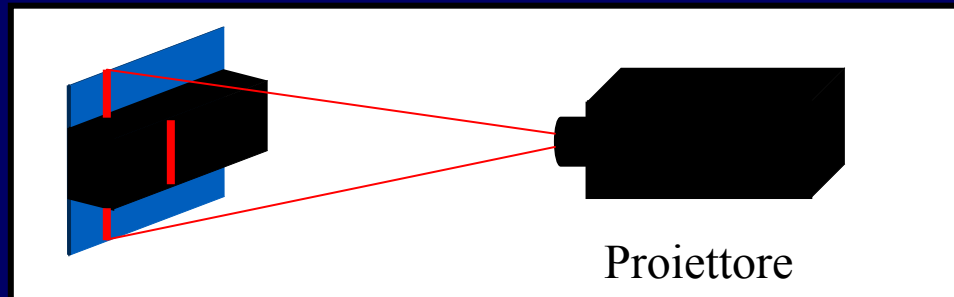
Immagine 3D ottenuta mediante triangolazione laser



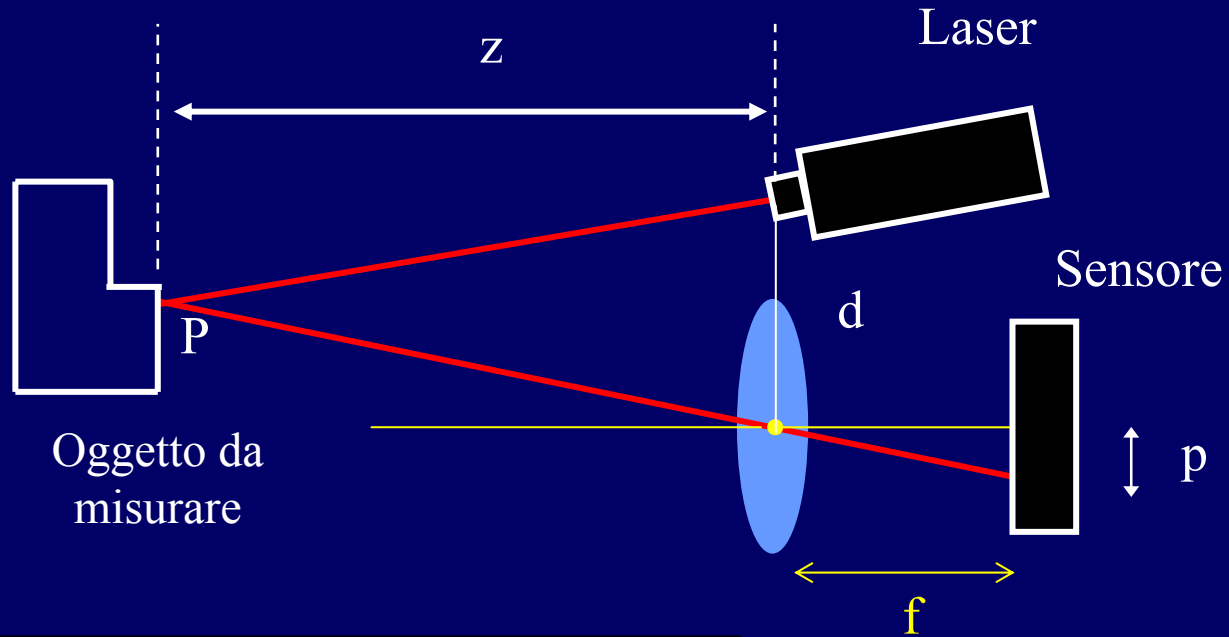
X: scansione

Y: regole dell' ottica geometrica per la formazione dell'immagine

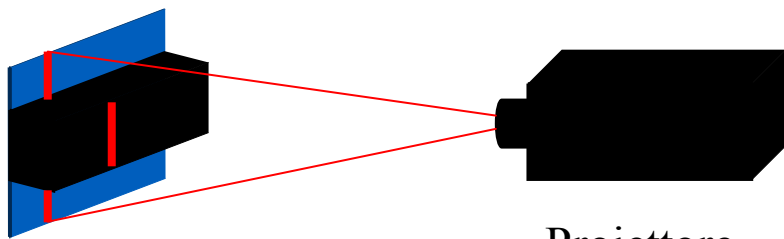
Z: regole dell' ottica geometrica per la formazione dell'immagine



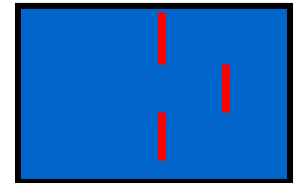
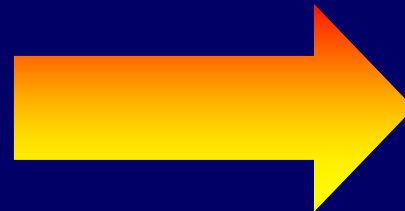
Triangolazione laser



$$z = \left(\frac{fd}{2} \right) \frac{1}{p}$$



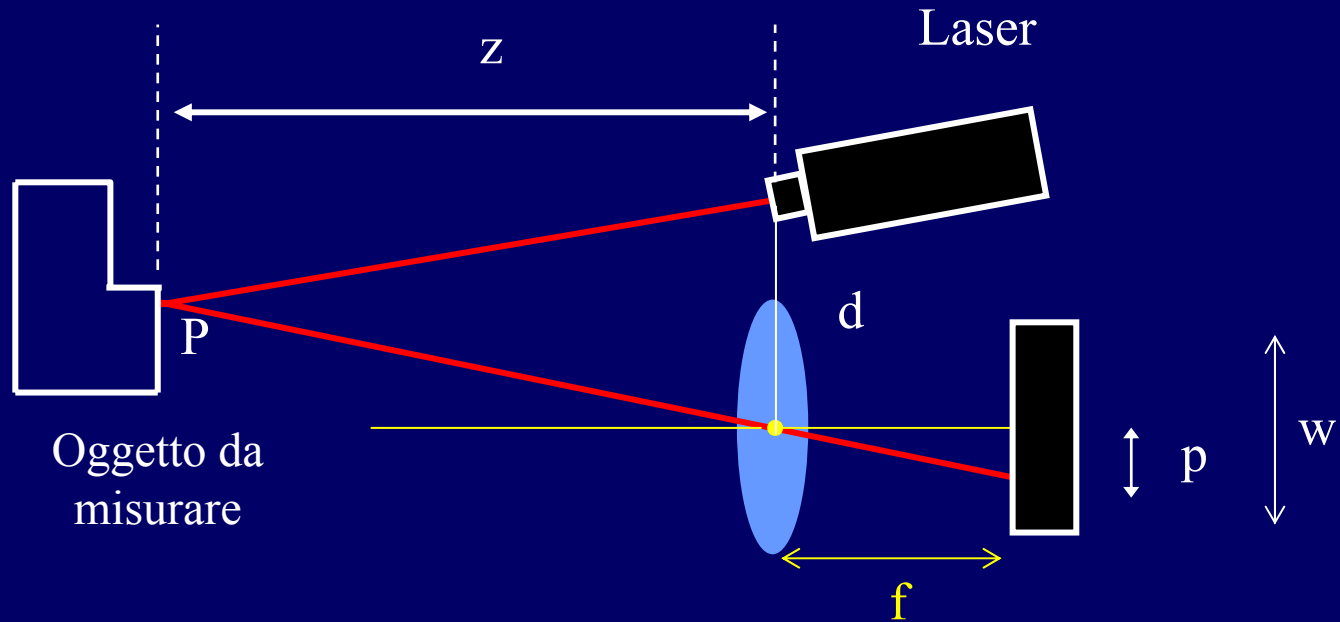
Proiettore



Sensore

$$\sigma_z = \frac{z^2}{fd} \sigma_p$$

Triangolazione laser



$$\sigma_z = \frac{z^2}{fd} \sigma_p$$

Accuratezza

$$\Delta_x = \frac{zw}{f}$$

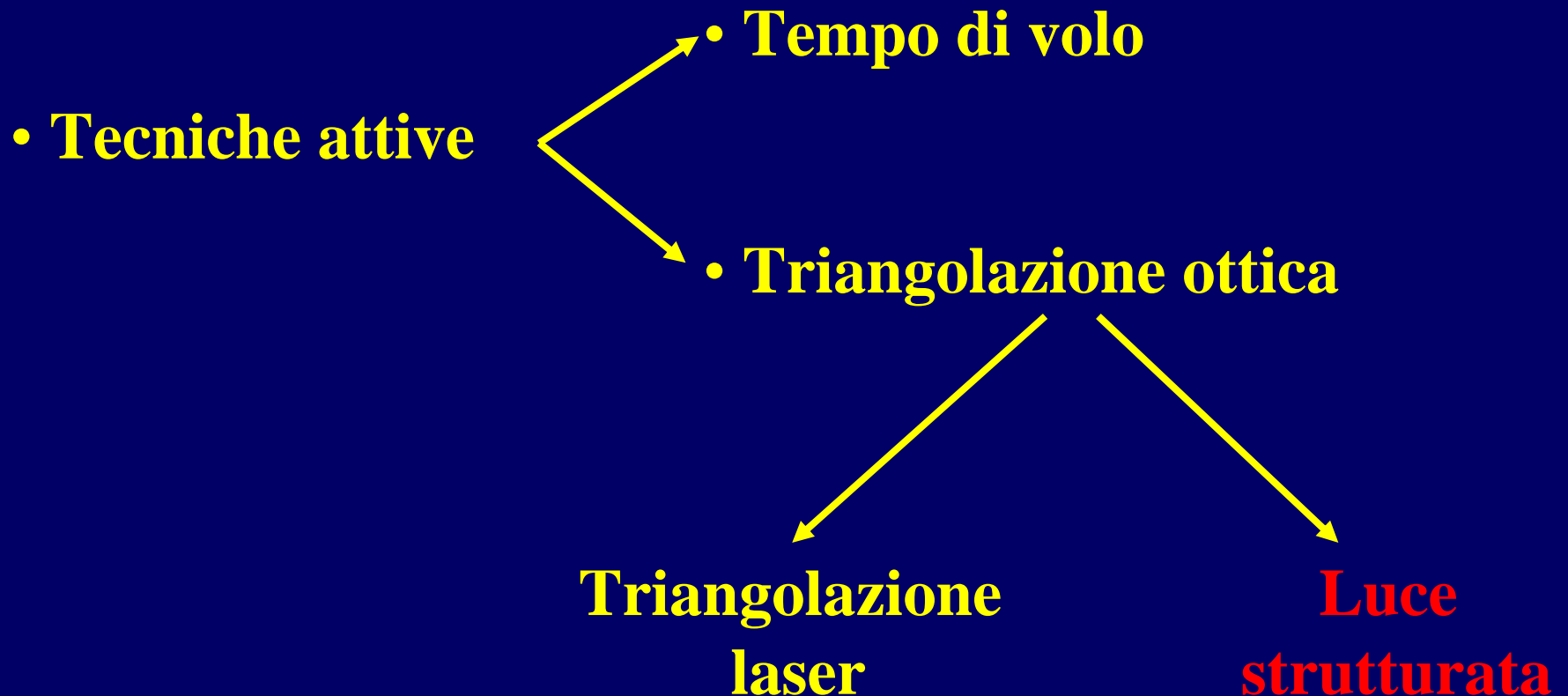
Campo inquadrato

Triangolazione laser



Tecniche di acquisizione 3D

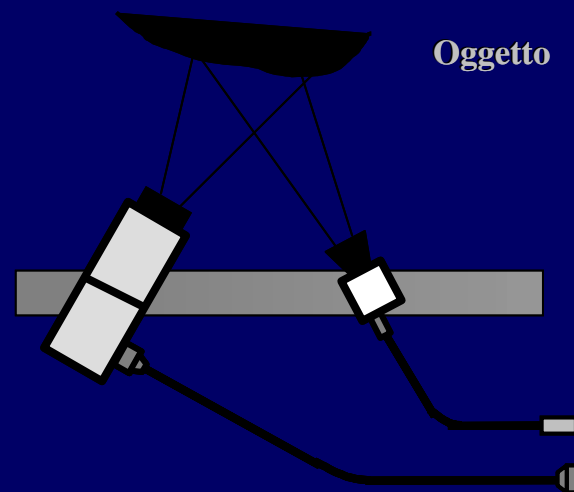
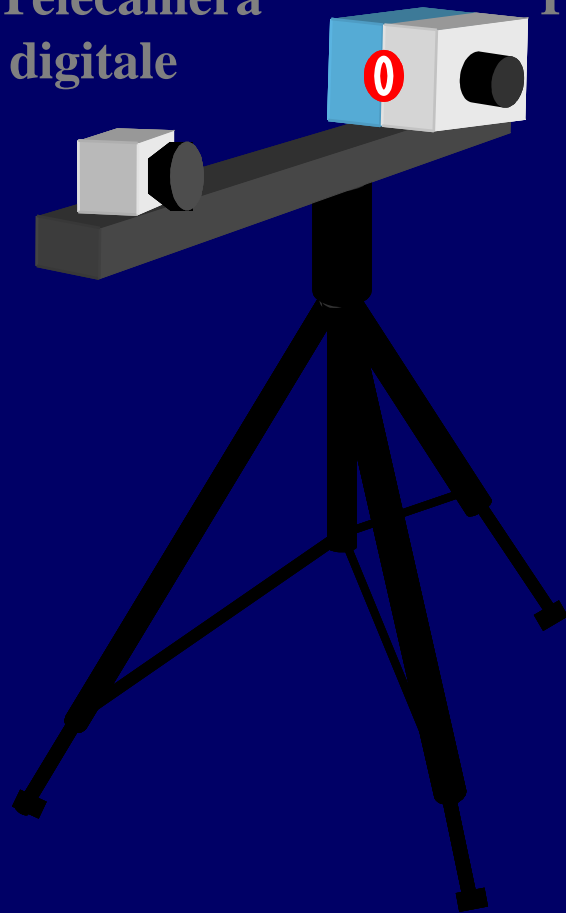
• Tecniche passive —→ • Fotogrammetria



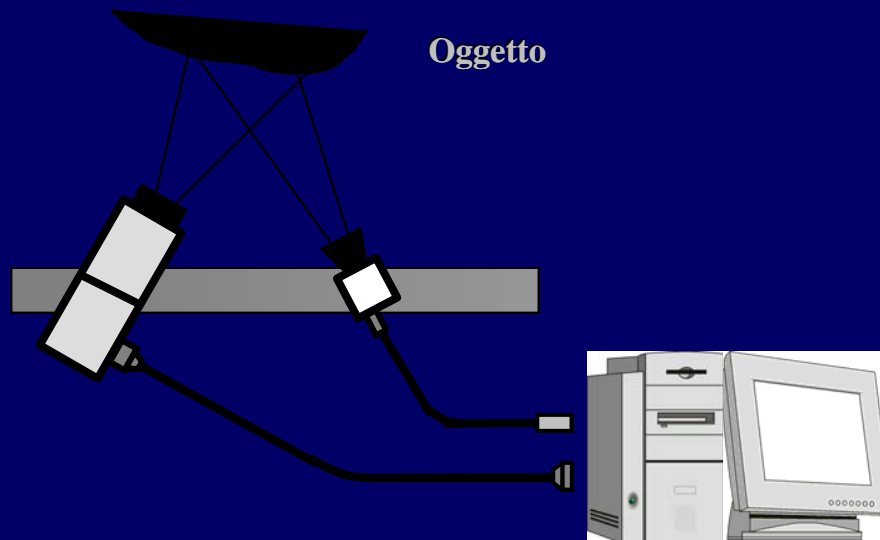
Luce strutturata

Telecamera
digitale

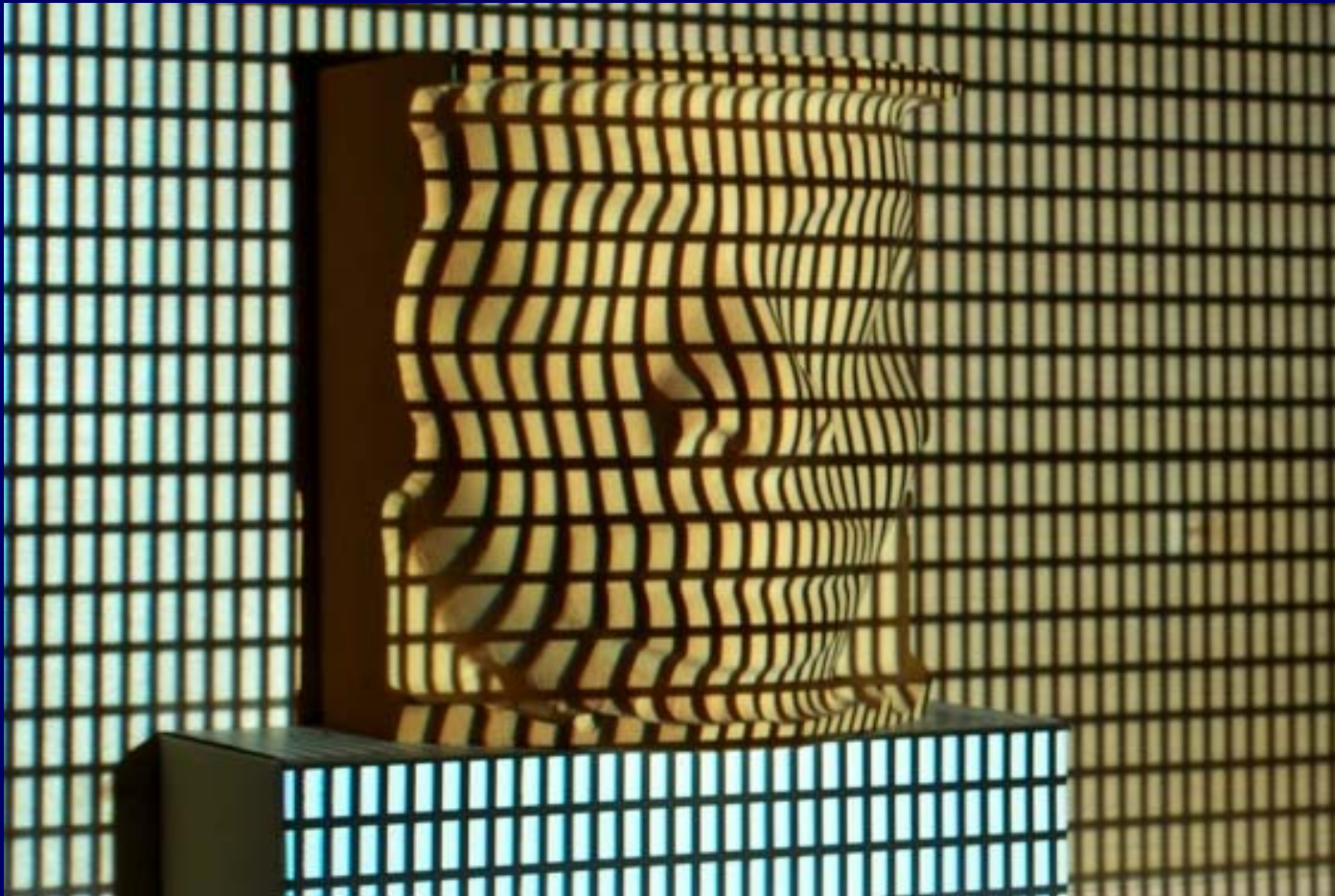
Proiettore LCD



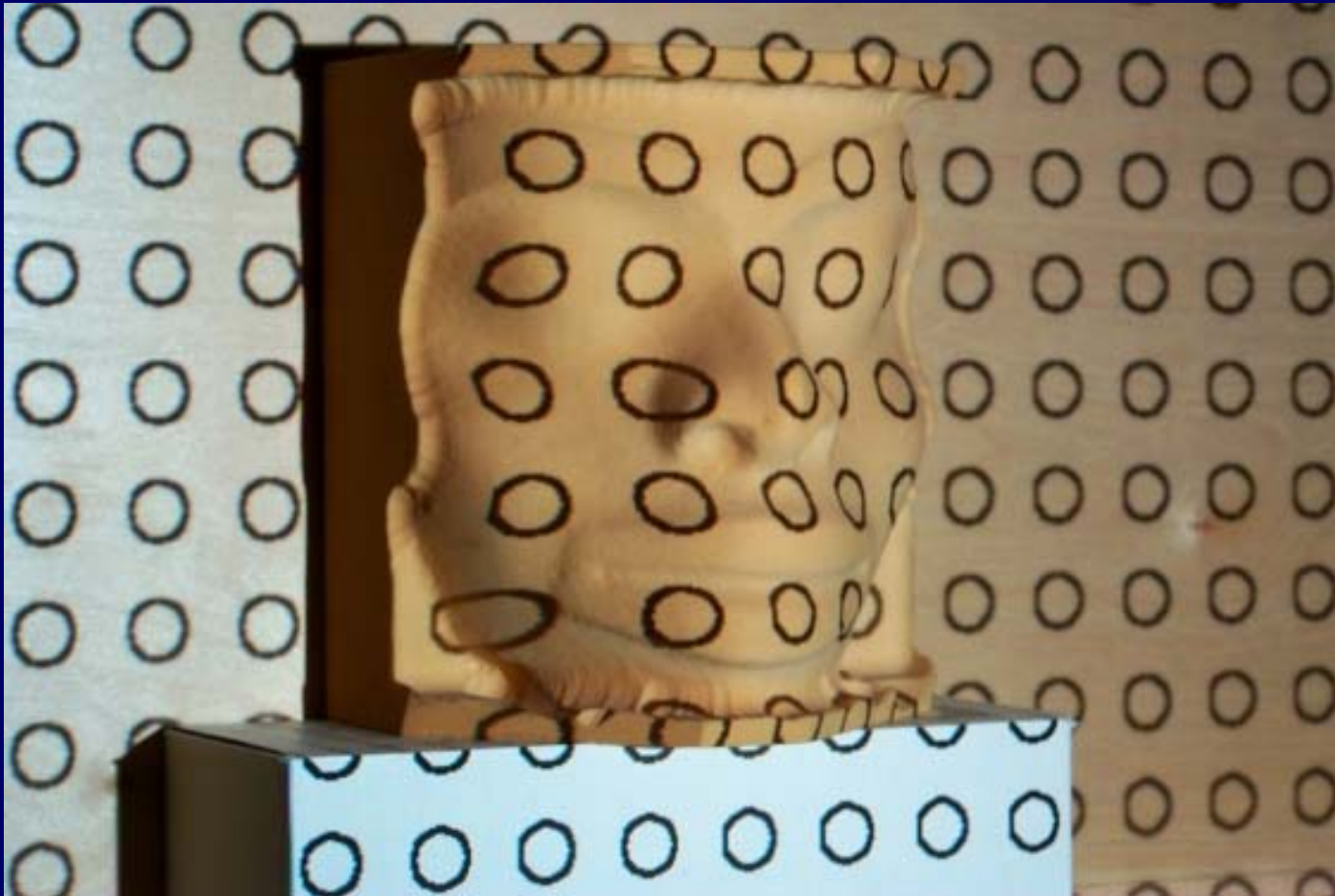
Luce strutturata



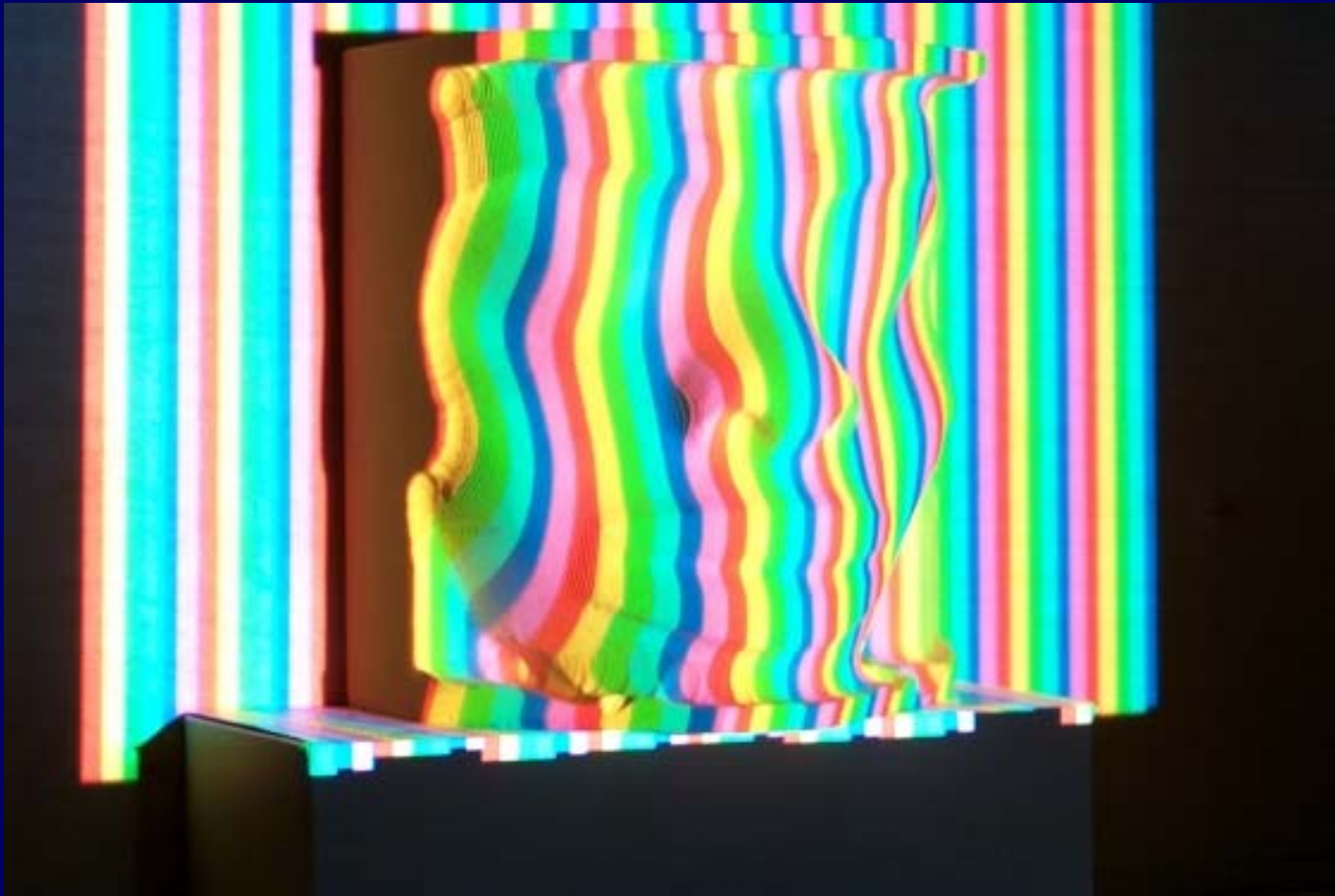
Luce strutturata



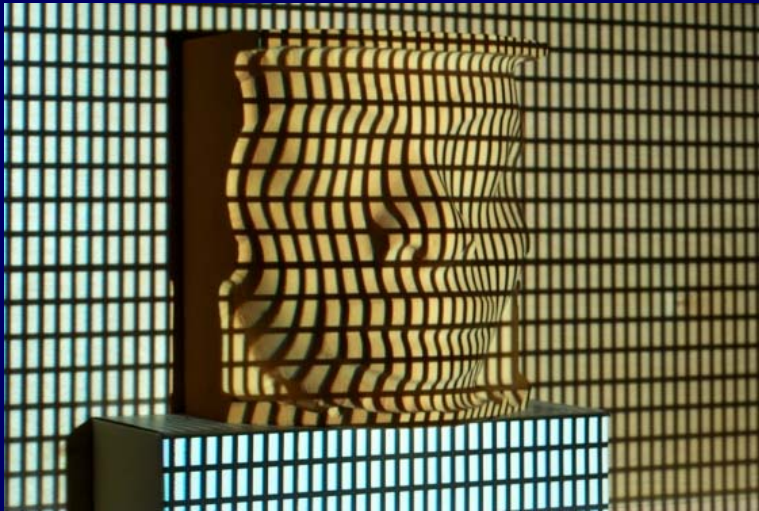
Luce strutturata



Luce strutturata



Luce strutturata



**Regole
dell'ottica
geometrica**



**per la
formazione
dell'immagine**

**Immagine 3D
(x,y,z)**