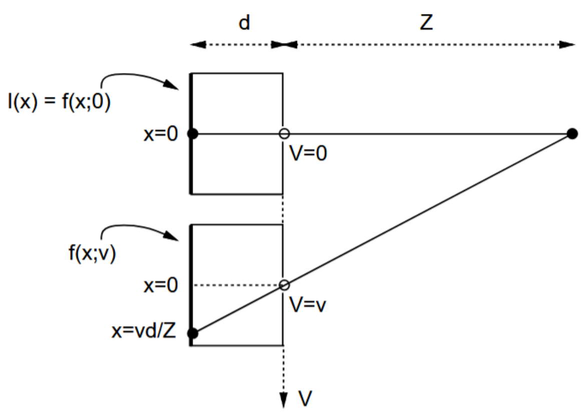
Range from stereo eqn derivations

Range from parallax (stereo)

1. Range info recovered from change in viewing position - stereo, structure from motion
2. Relies on assumption of **brightness constancy** - brightness of a point in the world is constant from different view points



V : represents the position of the camera pinhole
$Z(x)$: range (distance from pinhole to pt in the world) - depends on pinhole position v and distance of the pt
x : position on the sensor (position of pixel on the sensor)
d : distance from pinhole to sensor
$f(x;v)$ is the intensity function as measured through a pinhole camera system

$$f(x;v) = I(x - \frac{vd}{Z(x)})$$

Derived by similar triangles, see notebook on scribe.

For range, we want to find change in appearance of the world with respect to change in viewing position:

$$I_v(x) = \frac{\partial f(x;v)}{\partial v} = -\frac{d}{Z(x)} I'(x)$$

$I'(x)$ is the derivative of I with respect to x

So this represents the change in pixel intensity with respect to the change in pinhole position

$$I_x(x) = \frac{\partial f(x;v)}{\partial x} = I'(x)$$

Change in pixel intensity with respect to the change in pixel position on sensor (spatial parameter)

$$Z(x) = \frac{-dI_x(x)}{I_v(x))}$$

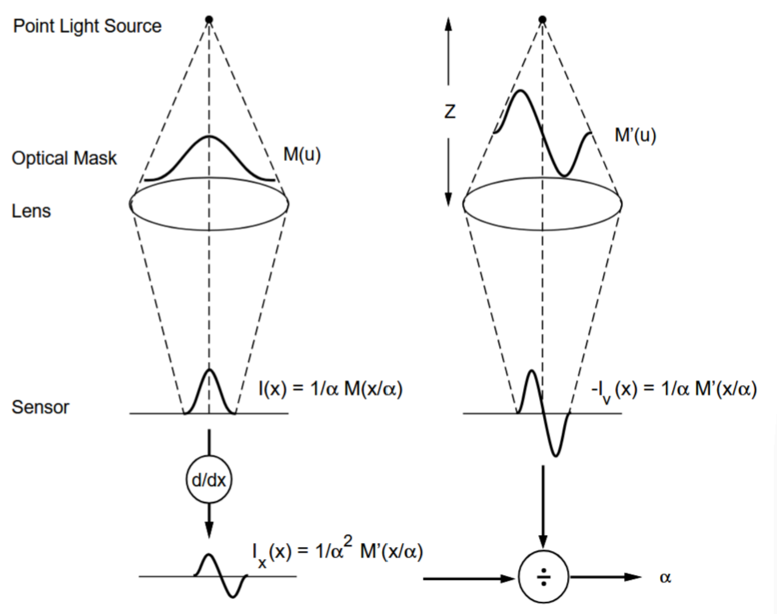
This formulation works but the "difficulty typically lies in obtaining an accurate and efficient measurement of the viewpoint derivative, $I_v(x)$"

1. the viewpoint derivative is approximated by stereo matching

Optical Differentiation

Direct method for measure of $I_x(x)$ and $I_v(x)$ from a single stationary camera and 2 optical attenuation masks.

1. The thin lens model captures light from multiple viewpoints and this viewpoint information is preserved until it collapses on the imaging plane.



World is a single point light source and thin lens system with a variable opacity mask in front $M(u)$ (mask function range $[0, 1]$) which attenuates the light by the value of the optical mask function

1. The image of the point source will be scaled and dilated version of the optical mask function

$$I(x) = \frac{1}{\alpha} M(\frac{x}{\alpha})$$

For a scale factor α
Then α is "easily" derived:

$$\alpha = 1 - \frac{d}{f} + \frac{d}{Z}$$

Optical Viewpoint Differentiation

Consider a mask with a single pinhole. By sliding the pinhole across the lens we produce multiple viewpoints.

$$f(x; v) = \frac{1}{\alpha} M(\frac{x}{\alpha} - v)$$

Generalized image intensity function for a mask centered at position v