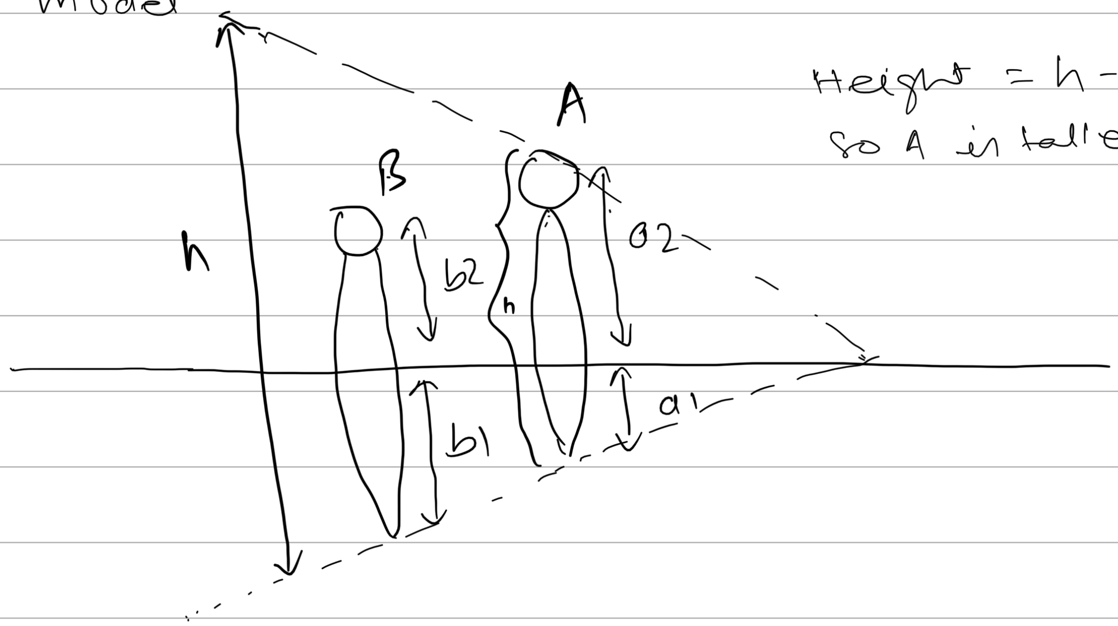
Pallav K 2 Pallav Kumar

(1) (i) yes, it is possible to determine who is taller in the real world from the picture using pinhole camera model



Height = h - x
so A is taller.

A is taller.

(ii) h_c = camera height

$$\frac{fh}{Z} = a_1 + a_2$$

$$\frac{fh_c}{Z} = a_1$$

$$\frac{h}{h_c} = \frac{a_1 + a_2}{a_1}$$

$$h_c = \frac{a_1 h}{a_1 + a_2}$$

(1.2)

h_b = height of B

$$\frac{f h_b}{z} = b_1 + b_2$$

$$\frac{f h_c}{z} = b_1$$

$$\frac{h_b}{h_c} = \frac{b_1 + b_2}{b_1}$$

$$h_b = \left(\frac{b_1 + b_2}{b_1}\right) h_c$$

$$h_b = \left(\frac{b_1 + b_2}{b_1}\right) \frac{\times h a_1}{a_1 + a_2} \qquad \left[h_c = \frac{h a_1}{a_1 + a_2}\right]$$

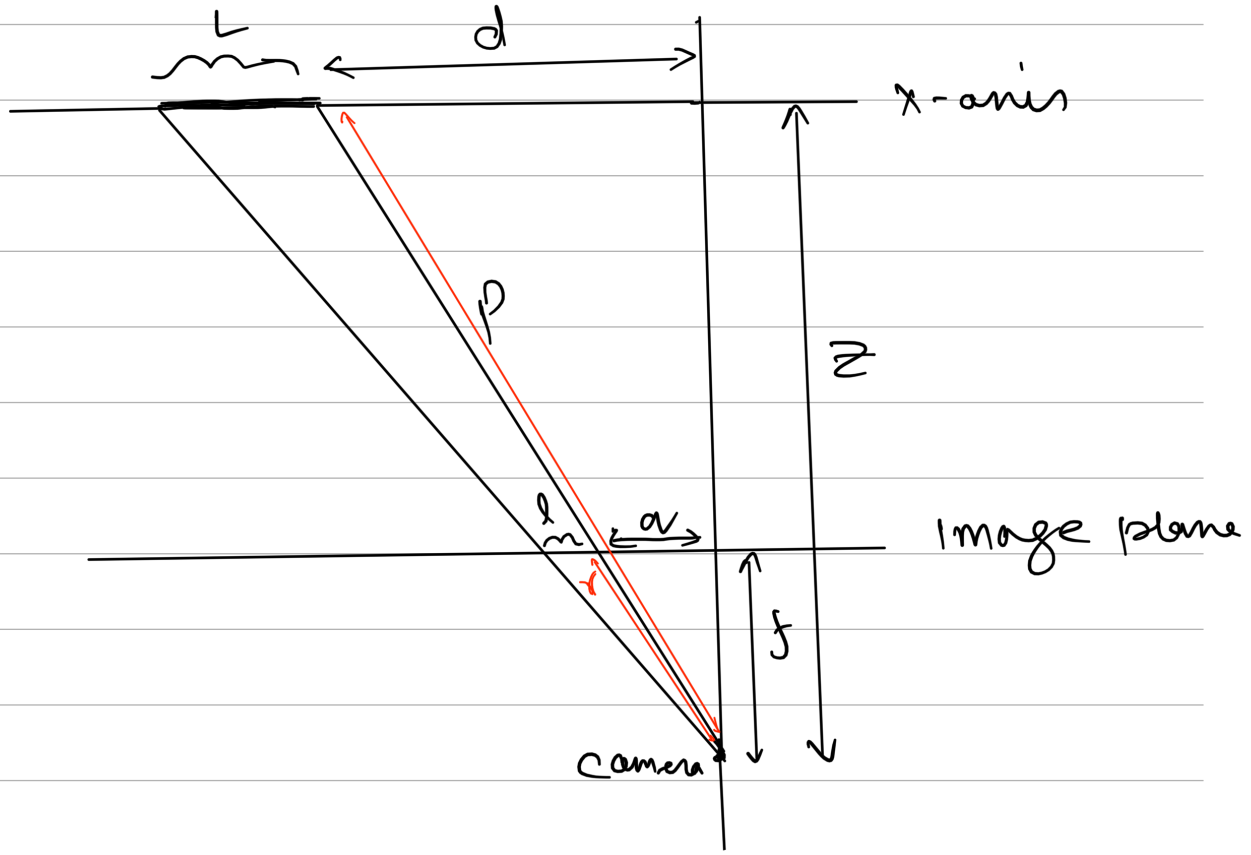
1.3)

$$\frac{f h_c}{z} = b_1$$

$$z = \frac{f h_c}{b_1}$$

$$= \frac{h a_1 f}{b_1 (a_1 + a_2)} \qquad \left[h_c = \frac{h a_1}{a_1 + a_2} \right]$$

Q 2) (i)



$$\frac{z}{f} = \frac{L + d}{l + a}$$

$$\frac{a}{d} = \frac{f}{z}$$

$$a = \frac{fd}{z}$$

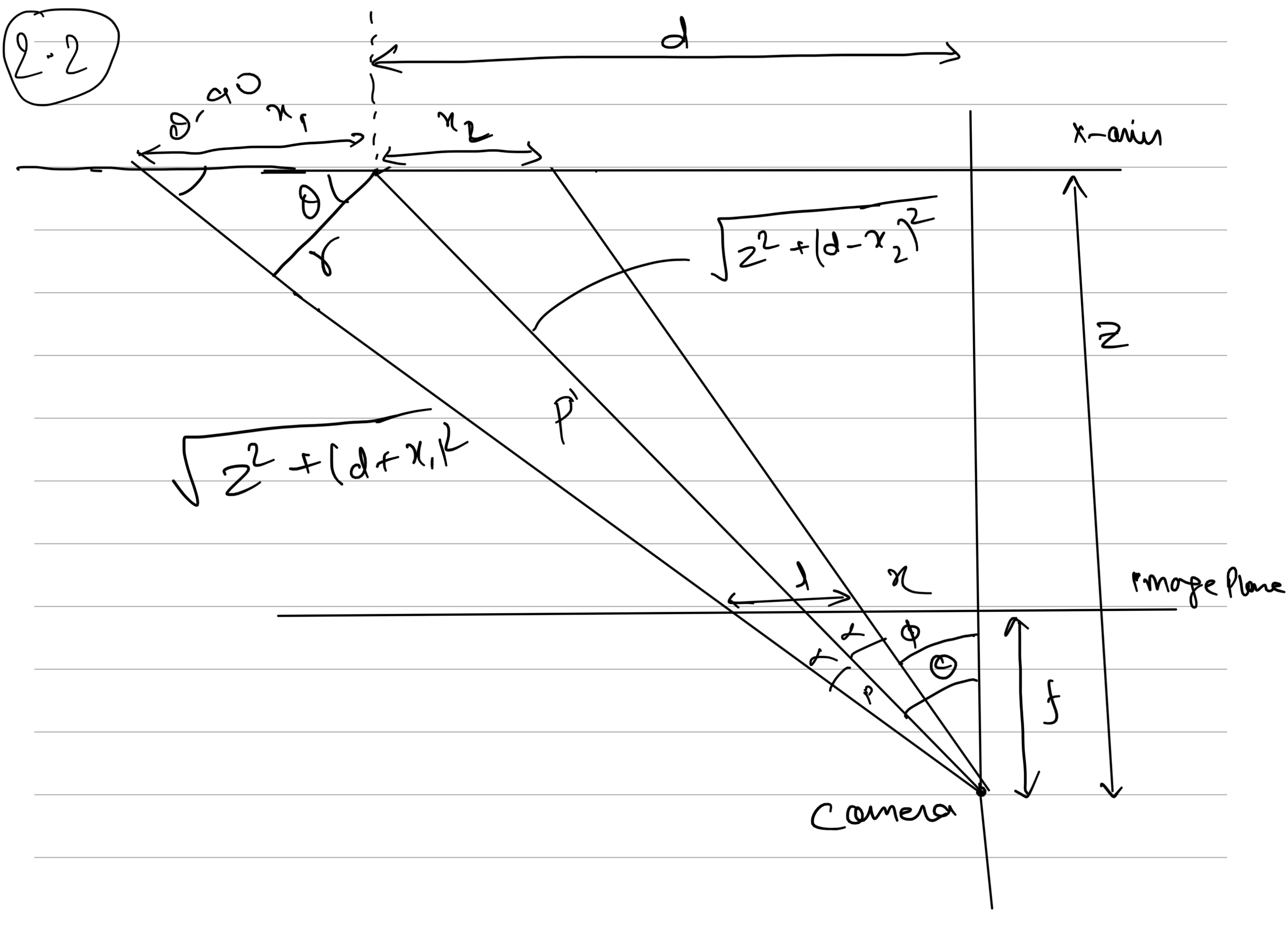
Thus,

$$l = \frac{f}{z}(L+d) - q$$

$$l = \frac{fL}{z} + \cancel{\frac{fd}{z}} - \cancel{\frac{fd}{z}}$$

$$l = \frac{fL}{z}$$

2.2



$$\cos\theta = \frac{z}{\sqrt{z^2 + (d+x_1)^2}}$$

$$\cos\phi = \frac{z}{\sqrt{z^2 + (d-x_2)^2}}$$

$$\cos\theta = \frac{r}{x_1} \qquad \cos\phi = \frac{r}{x_2}$$

$$\frac{r}{x_2} = \frac{z}{\sqrt{z^2 + (d-x_2)^2}}$$

$$x_2^2 = r^2\left(z^2 + (d-x_2)^2\right)/z^2$$

$$x_2^2 = \left[r^2 z^2 + r^2(d^2 - 2dx_2 + x_2^2)\right]/z^2$$

$$x_2^2 z^2 + 2r^2 d x_2 - r^2 x_2^2 = r^2 z^2 + r^2 d^2$$

$$x_2^2(z^2 - r^2) + 2r^2 d x_2 - r^2(z^2 + d^2) = 0$$

$$x_2 = \frac{-2r^2 d \pm \sqrt{4r^4 d^2 + 4(z^2 - r^2)(r^2 z^2 + r^2 d^2)}}{2(z^2 - r^2)}$$

$$= \frac{\cancel{2}\left(-r^2 d \pm \sqrt{r^4 d^2 + (r^2 z^4 + r^2 z^2 d^2 - r^4 z^2 - r^4 d^2)}\right)}{\cancel{2}(z^2 - r^2)}$$

$$x_2 = \frac{-r^2 d \pm r\sqrt{z^2(z^2+d^2-r^2)}}{(z^2-r^2)}$$

$$x_2 = \frac{-r^2 d \pm rz\sqrt{z^2+d^2-r^2}}{(z^2-r^2)}$$

$$\therefore x_1 = \frac{r^2 d \pm rz\sqrt{z^2+d^2-r^2}}{(z^2-r^2)}$$

$$L = x_1 + x_2 = \frac{2rz\sqrt{z^2+d^2-r^2}}{(z^2-r^2)}$$

$\because$ $l = \frac{fL}{z}$ (From ques 1)

$$l = \frac{2fr\cancel{z}}{\cancel{z}} \frac{\sqrt{z^2+d^2-r^2}}{(z^2-r^2)}$$

$$l = \frac{2fr\sqrt{z^2+d^2-r^2}}{(z^2-r^2)}$$

OR

$$\frac{d+x_1}{l+x} = \frac{z}{f} \Rightarrow l+x = \frac{f}{z}(d+x_1)$$

$$\frac{d-x_2}{x} = \frac{z}{f} \Rightarrow x = \frac{f}{z}(d-x_2)$$

$$l = \frac{f}{z}(d+x_1) - \frac{f}{z}(d-x_2)$$

$$= \frac{f}{z}(\cancel{d}+x_1-\cancel{d}+x_2)$$

$$= \frac{f}{z}(x_1+x_2)$$

$$= \frac{f}{z}\left(\frac{r^2 d \pm rz\sqrt{z^2+d^2-r^2}}{(z^2-r^2)} + \frac{-r^2 d^2 \pm rz\sqrt{z^2+d^2-r^2}}{(z^2-r^2)}\right)$$

3) ① $t = (t_x, t_y, t_z)$

$w = (w_x, w_y, w_z)$

$\dot{p} = -t - w \times p$

$$\begin{bmatrix} X' \\ Y' \\ Z' \end{bmatrix} = -\begin{bmatrix} t_x \\ t_y \\ t_z \end{bmatrix} - \begin{bmatrix} w_y Z - w_z Y \\ w_z X - w_x Z \\ w_x Y - w_y X \end{bmatrix}$$

where $x = \frac{fX}{Z}$ $y = \frac{fY}{Z}$

$\frac{x'}{f} = \frac{X'Z - Z'X}{Z^2}$ $\frac{y'}{f} = \frac{Y'Z - Z'Y}{Z^2}$

$\frac{x' Z^2}{f} = X'Z - Z'X$ — (ii)

$\frac{y' Z^2}{f} = Y'Z - Z'Y$ — (iii)

from eq(i):

$X' = -t_x - w_y Z + w_z Y$

$Y' = -t_y - w_z X + w_x Z$

$Z' = -t_z - w_x Y + w_y X$

$$\frac{x' Z^2}{f} = (-t_x - w_y Z + w_z Y) Z - (-t_z - w_x Y + w_y X) X$$

$$= -t_x Z - w_y Z^2 + w_z YZ + t_z X + w_x XY - w_y X^2$$

$$= -t_x Z - w_y Z^2 + \frac{w_z Z^2 y}{f} + \frac{t_z Z x}{f} + \frac{w_x Z^2 xy}{f^2} - \frac{w_y x^2 Z^2}{f^2}$$

$$x' = \frac{-f t_x}{Z} - f w_y + w_z y + \frac{t_z x}{Z} + \frac{w_x xy}{f} - \frac{w_y x^2}{f}$$

$$= \frac{-f t_x}{Z} + \frac{t_y x}{Z} + \frac{w_x xy}{f} - \frac{w_y x^2}{f} + w_z y - f w_y$$

$$\frac{y' Z^2}{f} = Y' Z - Z' Y$$

$$= (-t_y - w_z X + w_x Z) Z - (-t_z - w_x Y + w_y X) Y$$

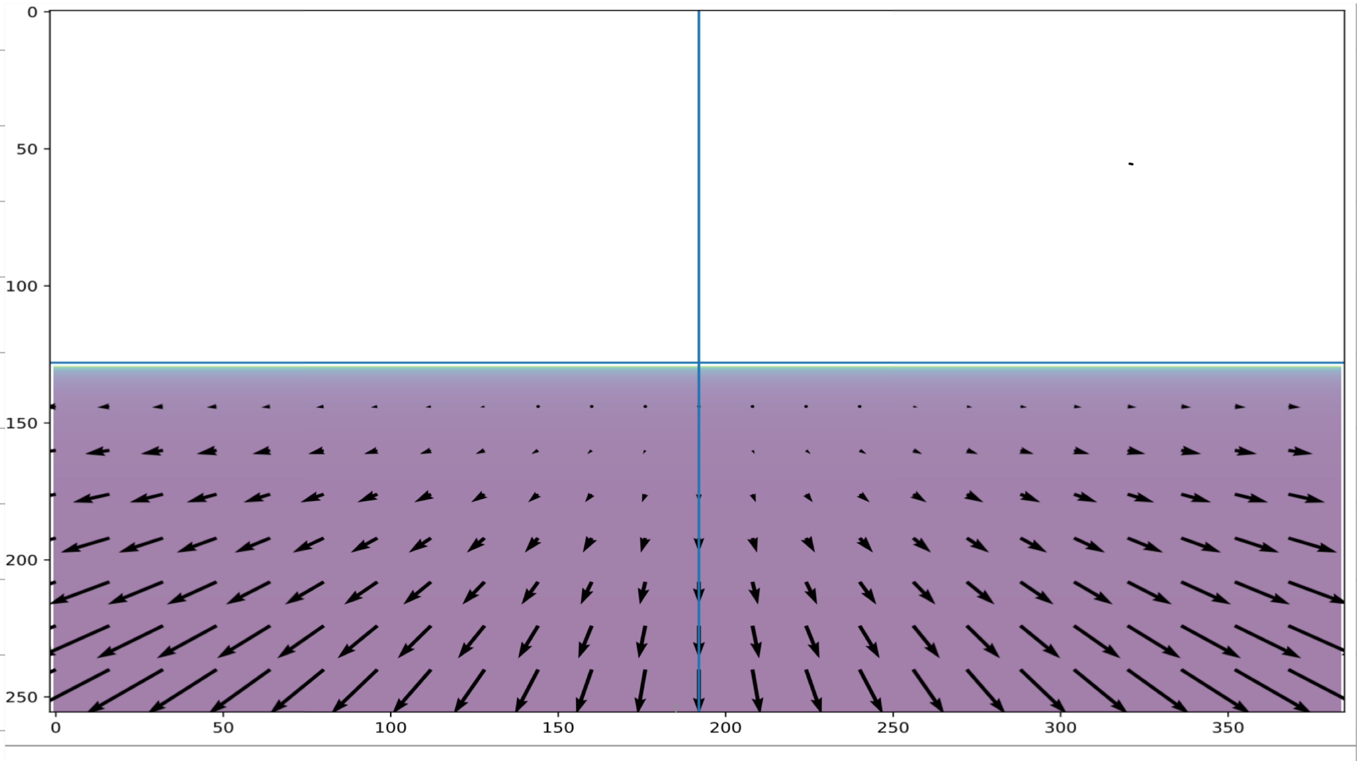
$$\frac{y' Z^2}{f} = -Z t_y - XZ w_z + w_x Z^2 + t_z Y + w_x Y^2 + w_y XY$$

$$= -t_y Z - \frac{Z^2 w_z x}{f} + Z^2 w_x + \frac{t_z y Z}{f} + \frac{w_x y^2 Z^2}{f^2} + \frac{w_y xy Z^2}{f^2}$$

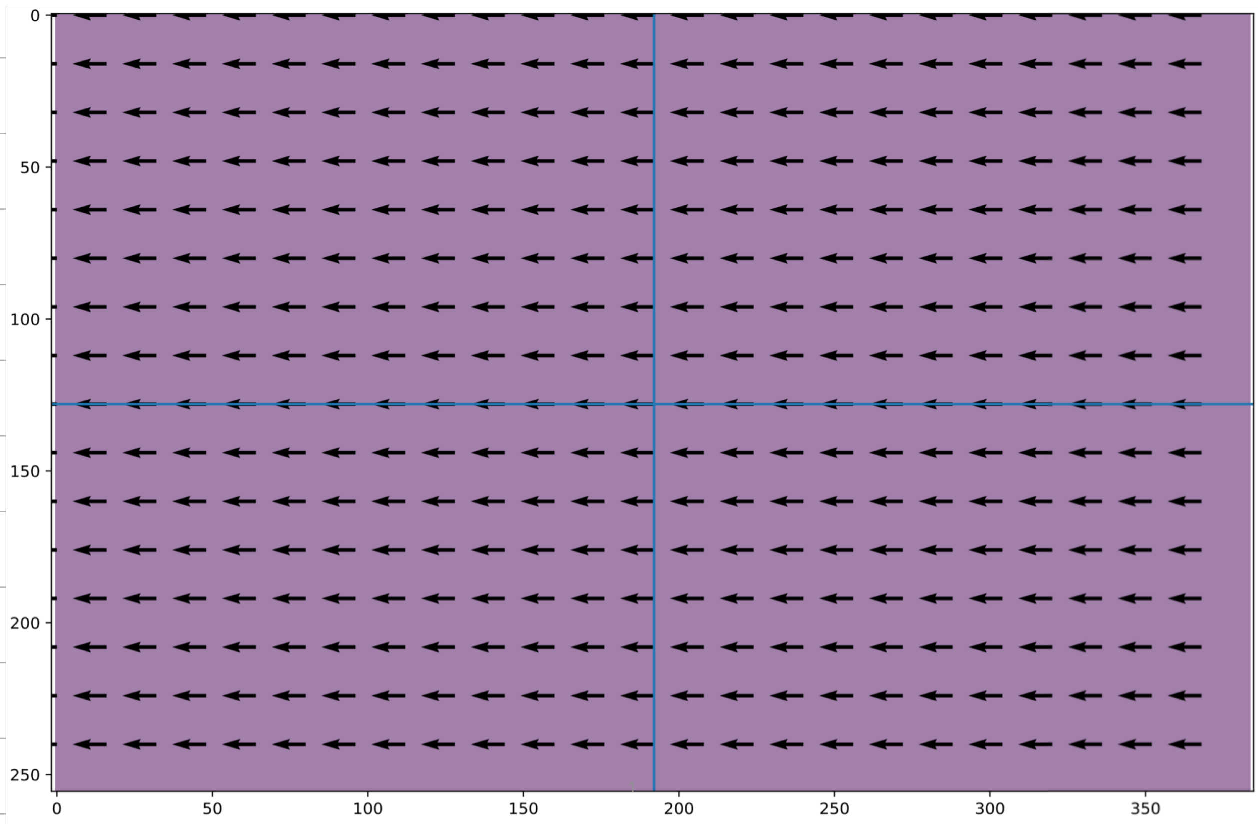
$$y' = \frac{-f t_y}{Z} + \frac{t_y y}{Z} + f w_x + \frac{w_x y^2}{f} - \frac{w_y xy}{f} - w_y x$$

$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} x' \\ y' \end{bmatrix} = \frac{1}{Z} \begin{bmatrix} -f & 0 & x \\ 0 & -f & y \end{bmatrix} \begin{bmatrix} t_x \\ t_y \\ t_z \end{bmatrix} + \begin{bmatrix} xy/f & -(\frac{x^2}{f} + f) & y \\ (y^2/f + f) & -xy/f & -x \end{bmatrix} \begin{bmatrix} w_x \\ w_y \\ w_z \end{bmatrix}$$

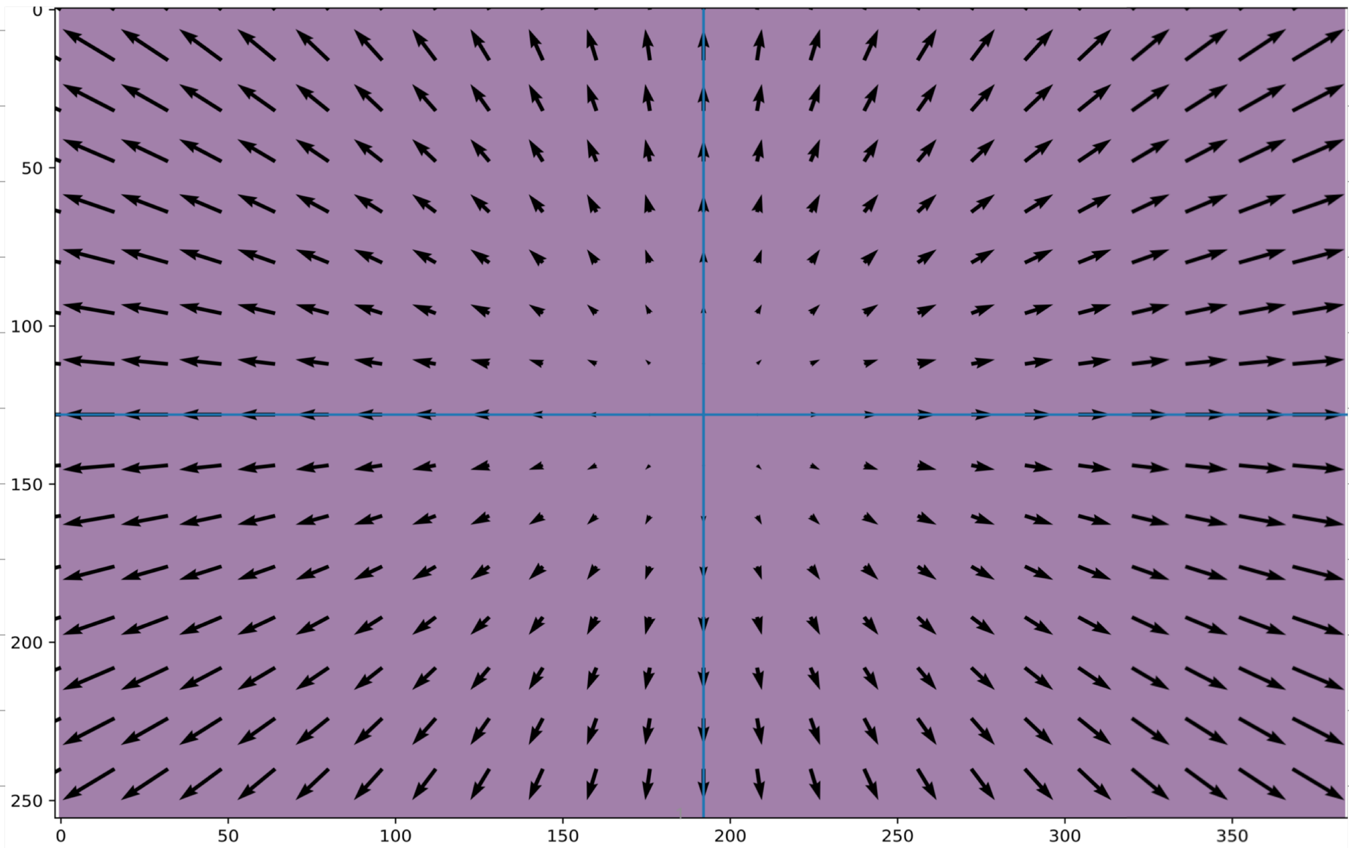
3.2) ① looking forward on a horizontal plane while driving on a flat road.



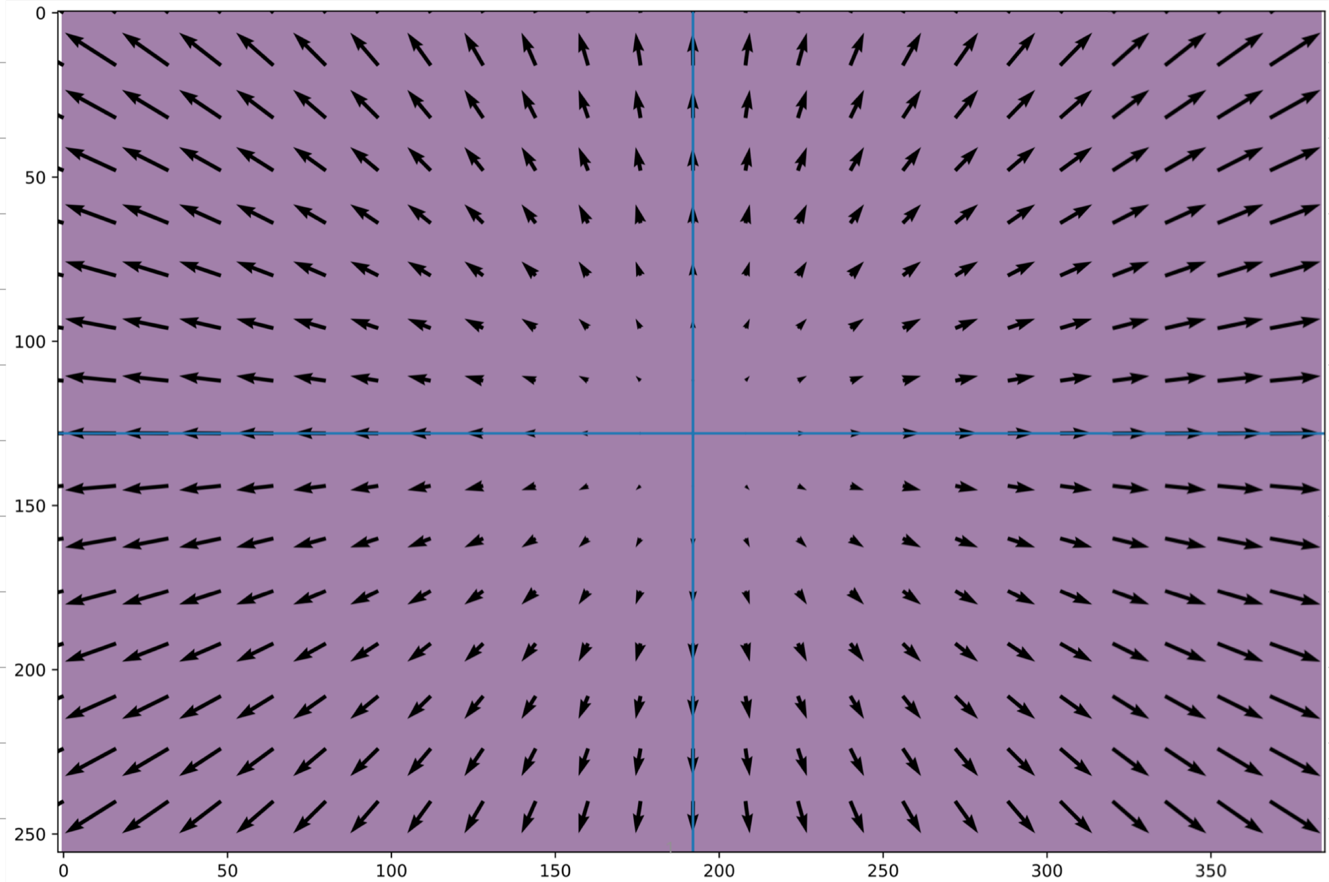
② sitting in a train and looking out over a flat field from a side window.



③ Flying into a wall head on



④ Flying into a wall but also translating horizontally and vertically.



5) Rotating in front of a wall about the Y-axis.

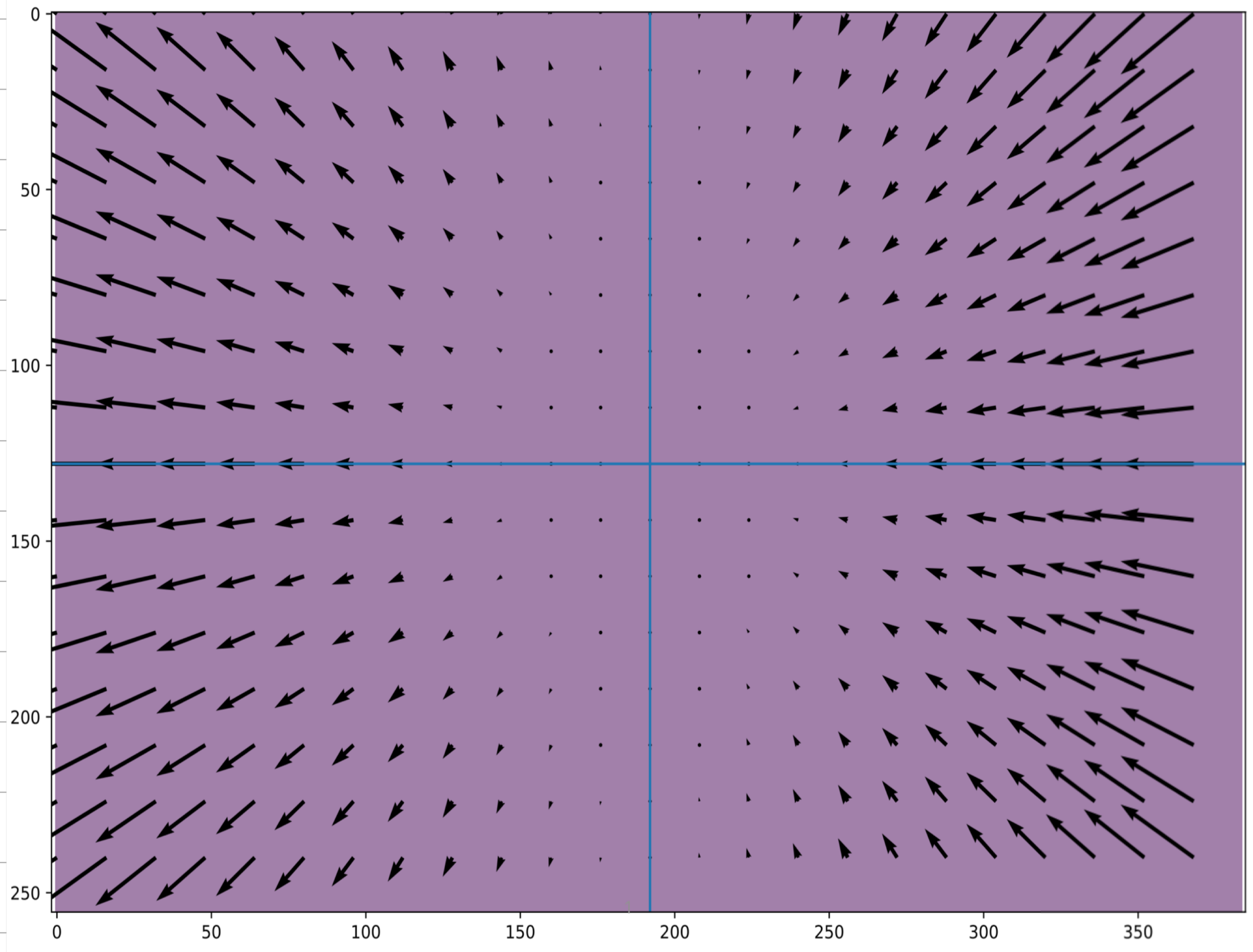


Fig 1 specular0_move_direction

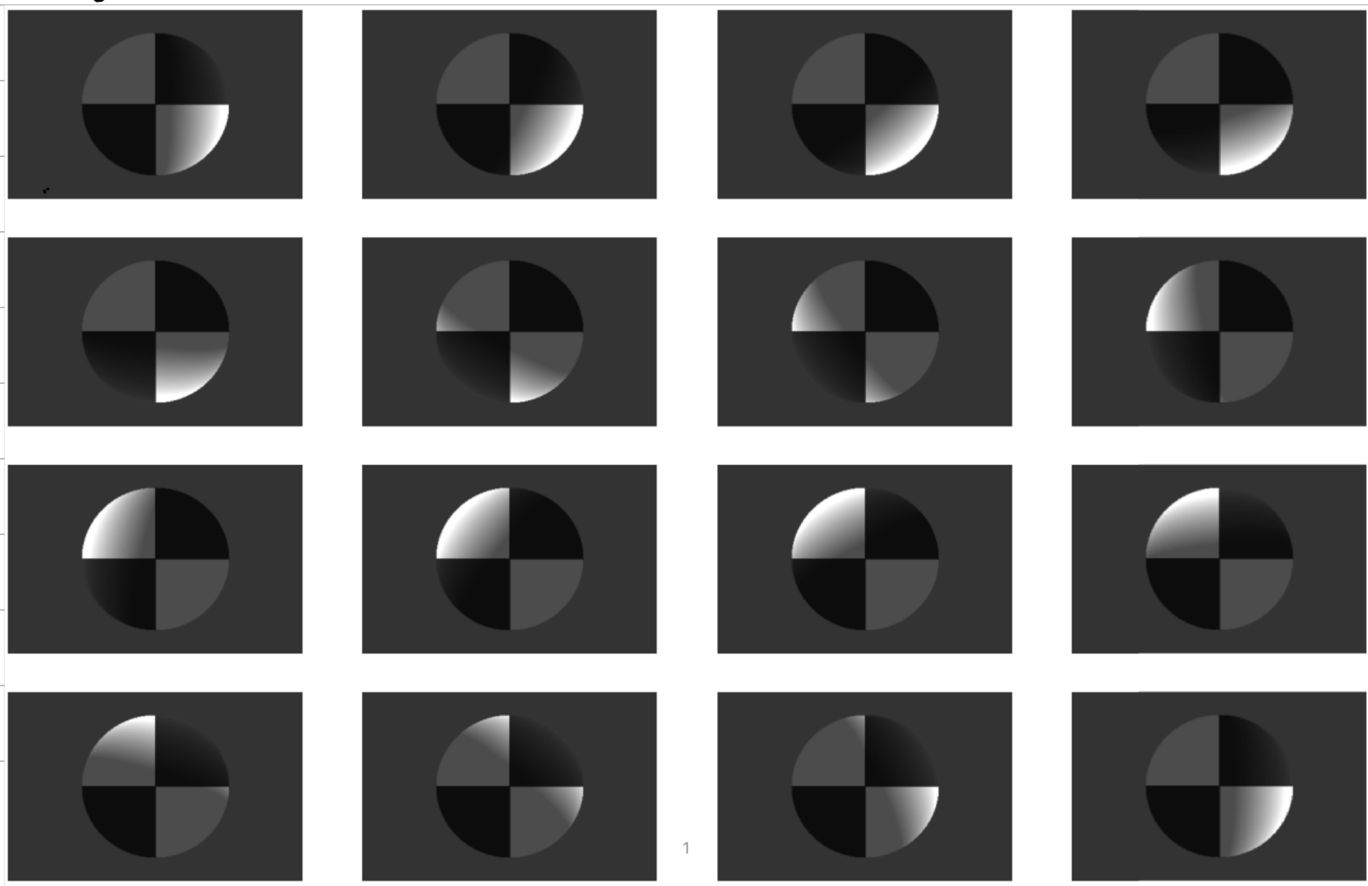


Figure2 Specular0 Move_Point

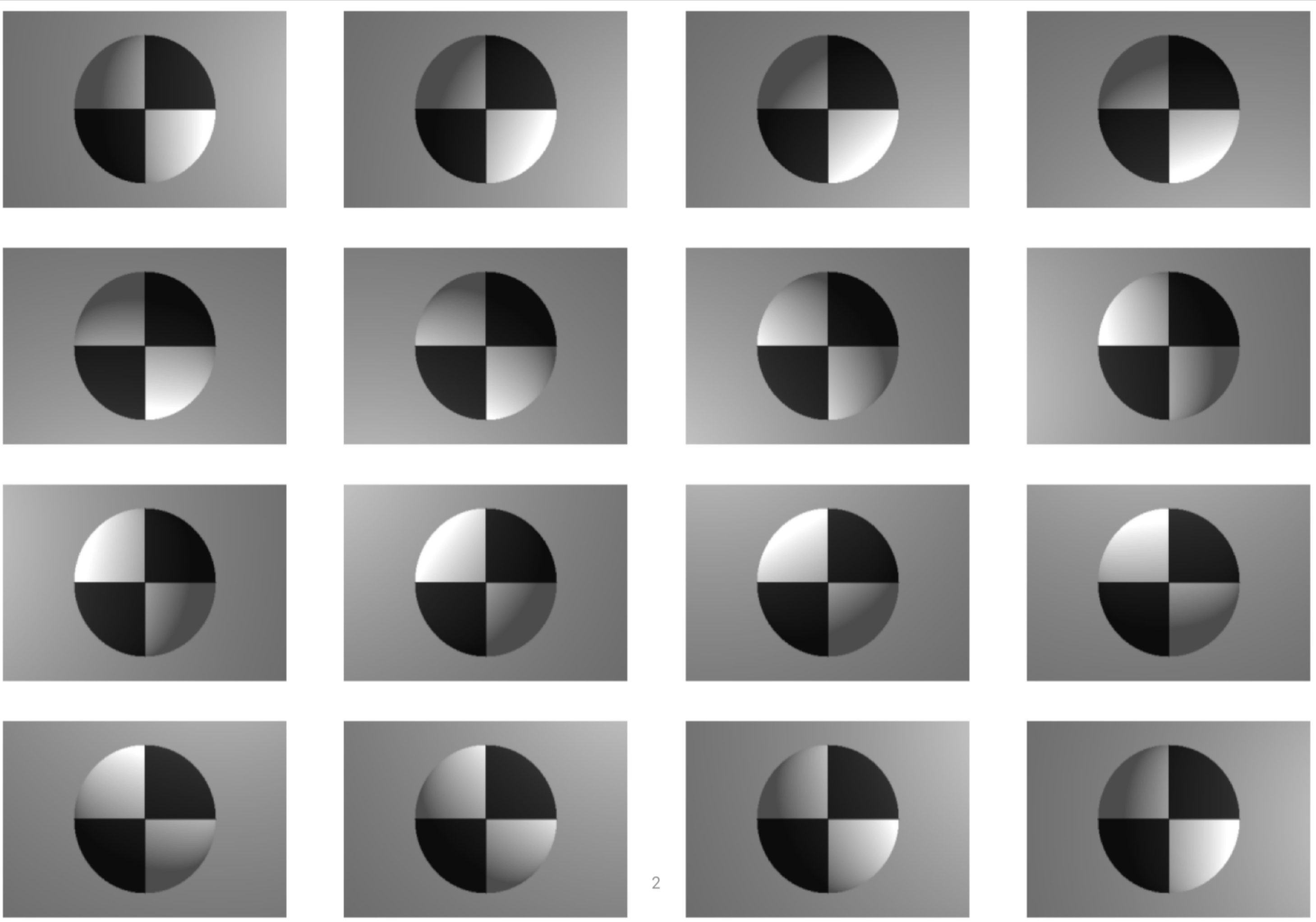


Fig 3 Specular1_Move_Direction

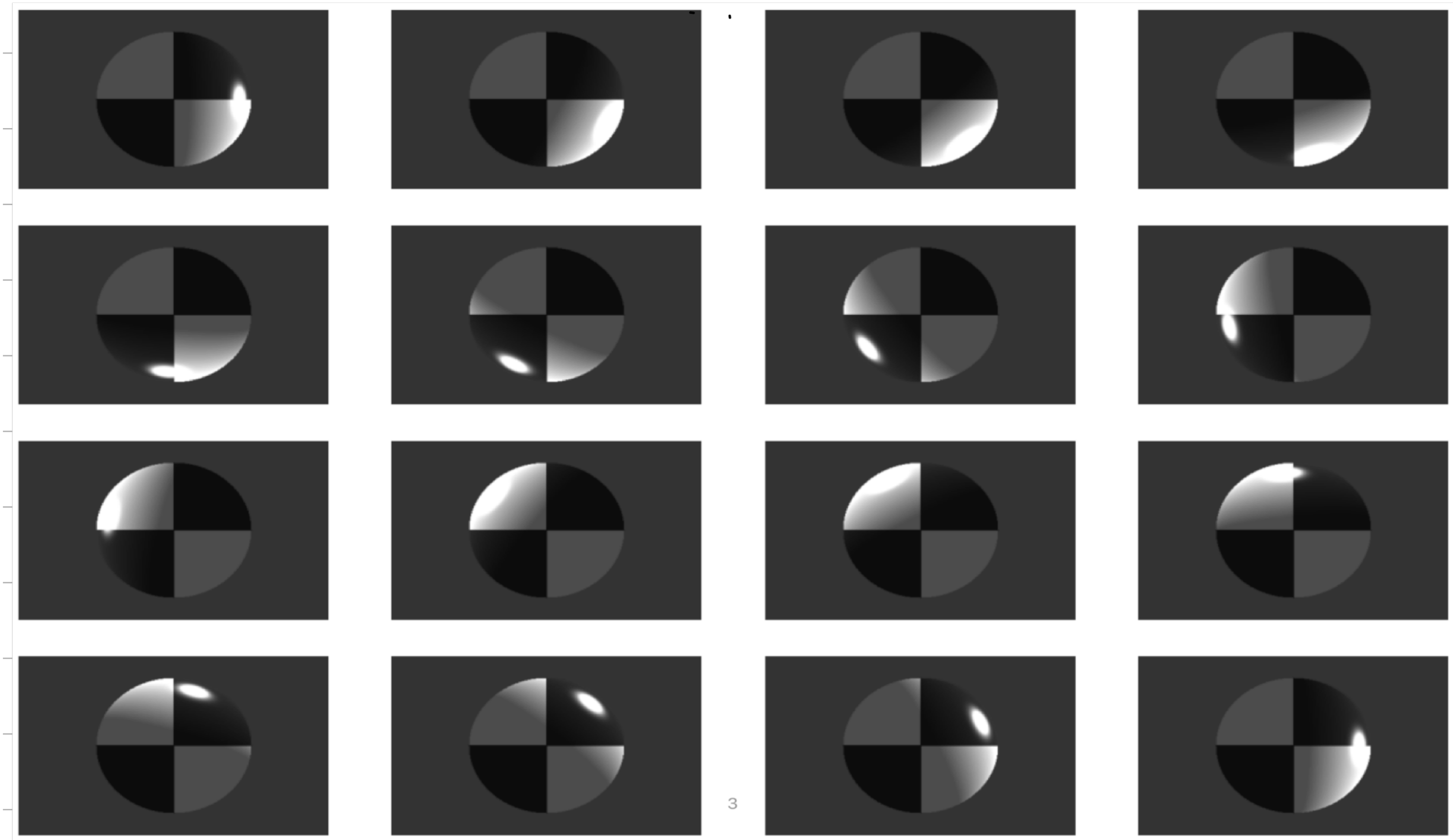


fig4 Specular1_Move_Point