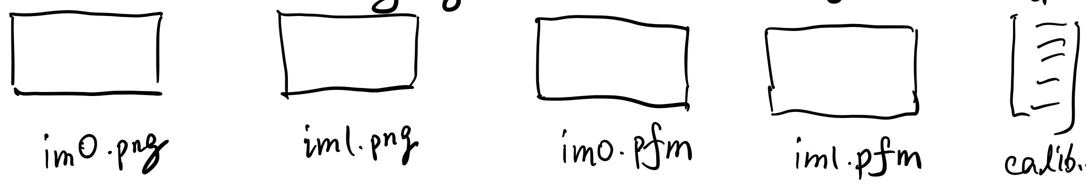
The middlebury dataset has already rectficated the images



$\underbrace{\text{im0.pfm} \quad \text{im1.pfm}}_{\text{dense (almost) disparity map}}$

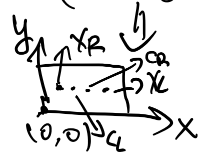
calib.txt
- baseline, b
- focal, f
- principal point difference
- width, height

→ w, h, doffs

☆. im0.pfm computed using im0.png & im1.png.

So, when calculating the real disparity value $d_{1,0} = X_L - X_R$

$= (X_L - 0) - (X_R - 0)$

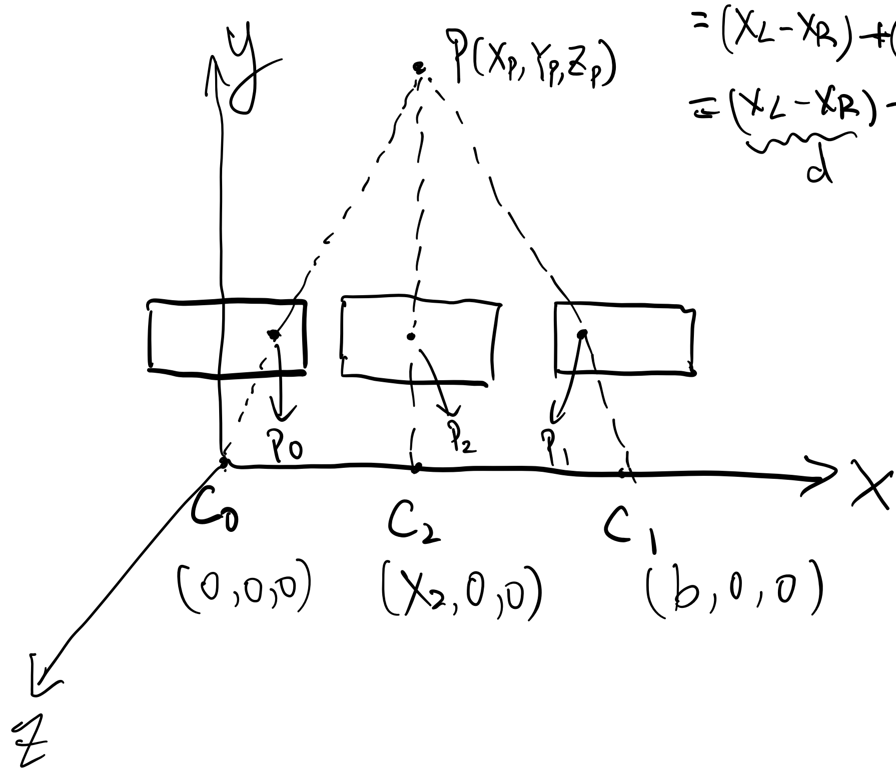


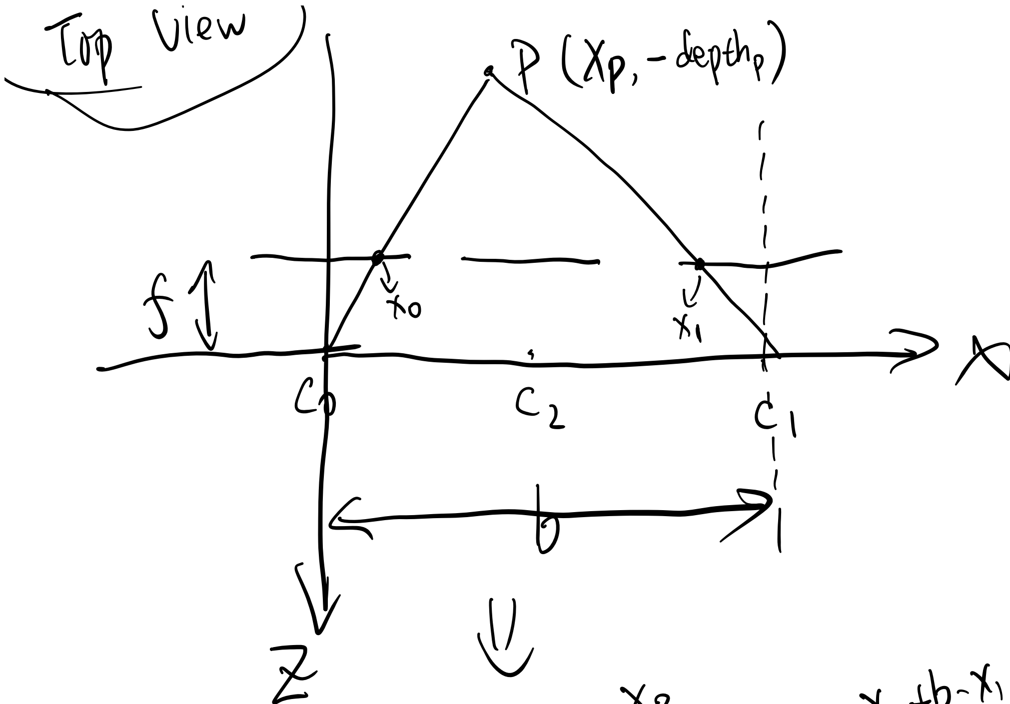
or $= (X_L - C_L) - (X_R - C_L)$

but actually $= (X_L - C_L) - (X_R - C_R)$

$= (X_L - X_R) + (C_R - C_L)$

$= \underbrace{(X_L - X_R)}_{d} + \boxed{doffs}$





$$\begin{cases} \dfrac{x_0}{f} = \dfrac{x_p}{depth_p} \\[2ex] \dfrac{b-x_1}{f} = \dfrac{b-x_p}{depth_p} \end{cases} \Rightarrow x_0+b-x_1 = \frac{f\cdot b}{depth_p}$$

$$x_0 - (x_1 - b)$$

$$= (x_L - c_L) - (x_R - c_R)$$

$$= d + doffs$$

$$\Rightarrow depth_p = \frac{f\cdot b}{d+doffs}$$

Image Warping. (forward) ordered $c_2 = c_L$ I_2 = all zeros.

Assume $x_2 > 0$, $y_2 > 0$, then for the left img.

ensures visibility makes sense

Left ① for i in range(0, h, -1):

for j in range(0, w):

$$d_{(2,0)x} = \frac{f\cdot x_2}{depth_{(i,j,0)}}, \quad d_{(2,0)y} = \frac{f\cdot y_2}{depth_{(i,j,0)}}$$

if $\begin{cases} 0 \le i - d_{(2,0)y} \le h-1 \\ 0 \le j - d_{(2,0)x} \le w-1 \end{cases}$ then

$$I_2^{(0)}[i - d_{(2,0)y},\ j - d_{(2,0)x}] = I_0[i,j]$$

$C_2 = C_1$

right

② for i in range(0, h, -1):

for j in range(0, w, -1):

$$d_{(2,1)x} = \frac{f \cdot (b - X_2)}{depth(i,j,1)} - doffs$$

if $\begin{cases} 0 \le i - d_{(2,1)y} \le h-1 \\ 0 \le j + d_{(2,1)x} \le w-1 \end{cases}$ then

$$I_2^{(1)}[i - d_{(2,1)y},\ j + d_{(2,1)x}] = I_1[i,j]$$

$$\Rightarrow I_2 = \frac{I_2^{(0)} \cdot \underbrace{(b - X_2)}_{d_0} + I_2^{(1)} \cdot X_2}{b}$$

$\Rightarrow$ only x disparity

$$\text{or} \quad I_2 = \frac{I_2^{(0)} \cdot \overbrace{\sqrt{(b-X_2)^2 + y_2^2}}^{d_1} + I_2^{(1)} \cdot \sqrt{X_2^2 + y_2^2}}{\boxed{\sqrt{(b-X_2)^2 + y_2^2} + \sqrt{X_2^2 + y_2^2}}}$$

$\boxed{d_0 \text{ or } d_1} \; \shortparallel$

$\Rightarrow$ x & y disparity

$$\text{or} \quad I_2 = \alpha \cdot [\gamma \cdot I_2^{(0)} + (1-\gamma) \cdot (a + b \cdot I_2^{(0)})]$$
$$+ (1-\alpha) \cdot [\gamma \cdot (\frac{I_2^{(1)} - a}{b}) + (1-\gamma) \cdot I_2^{(1)}]$$

$\Rightarrow$ the most complete, considering smoothness and where $\begin{cases} \gamma = 0.5 & \text{(if multiple new views are needed)} \\ \gamma = \lambda & \text{(if smoothness between the new view and the original views are needed).} \end{cases}$

between new original views.

(the use of γ aims to adjust the left and right img intensity according to each other).

where $\begin{cases} a = \dfrac{S_{ll} \cdot S_r - S_l \cdot S_{lr}}{S \cdot S_{ll} - (S_l)^2} \\ b = \dfrac{S \cdot S_{lr} - S_l \cdot S_r}{S \cdot S_{ll} - (S_l)^2} \end{cases}$ $\Rightarrow$ linear regression coefficients for $\underline{I^{(1)}_{(2)} = a + b \cdot I^{(0)}_{(2)}}$

$I_2^{(0)} = \{l_i\}$

$I_2^{(1)} = \{r_i\}$

where

$S = \Sigma 1$, $S_l = \Sigma l_i$, $S_r = \Sigma r_i$

$S_{lr} = \Sigma l_i \cdot r_i$, $S_{ll} = \Sigma l_i^2$, $S_{rr} = \Sigma r_i^2$

pixels locations excluding where there exists a hole in either of $I_2^{(0)}$ or $I_2^{(1)}$.

Filling the holes

simple method, $\Rightarrow$ mirror the intensities on the scanline.

holes

left, if #left pixels $\geq \frac{1}{2}$ #holes

holes lefe = left pixels

else: holes lefe = max lefe pixels $\times n$.

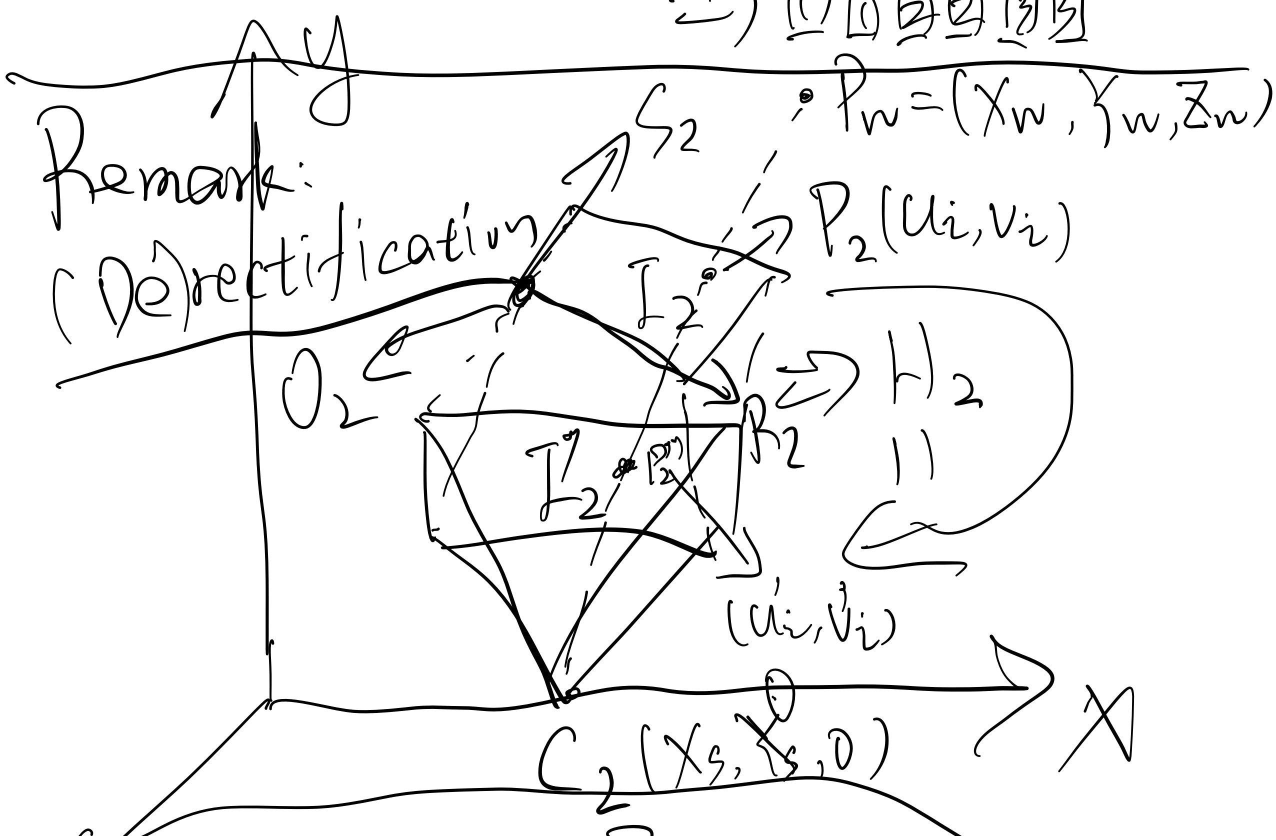
right ✓

1 2 3 & 6 holes

$\Rightarrow$ 1 1 2 2 3 3

Remark:

(De)rectification



$$\boxed{\vec{P}_{2w} = \vec{R}_2 \cdot u_i + \vec{S}_2 \cdot v_i + O_2}$$

$\Downarrow$

A point (u_i, v_i) in the original image coordinates has the 3D position $\Rightarrow P_{2w}$

$$\Rightarrow P'_{2w} = P_{2w} - C_2$$

$$= \underbrace{\left[R_2 \,|\, S_2 \,|\, O_2 - C_2 \right]}_{H_2} \cdot \begin{bmatrix} u_i \\ v_i \\ 1 \end{bmatrix}$$

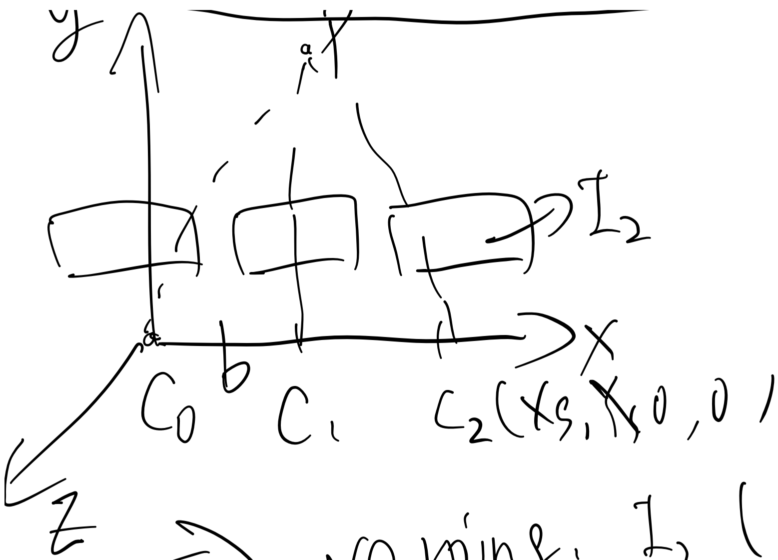
$$\Rightarrow P'_2 = \begin{bmatrix} [P'_{2w}]_x \\ [P'_{2w}]_y \end{bmatrix}$$

$$\boxed{\Rightarrow \begin{bmatrix} P_2 \\ 1 \end{bmatrix} = H_2^{-1} \cdot \begin{bmatrix} P'_2 \\ 1 \end{bmatrix}}$$

$\Downarrow$

Derectification

Expansion



$\Rightarrow$ warping I_2 (actually, if derectification is required, this should be I_2')

I_2 = all black

$C_2 = C_L \Rightarrow$ principal point

C_0 (and C_1)

for i in range (0, h, -1)

  for j in range (0, w)

$$d_{(2,0)x} = \frac{f \cdot x_s}{depth(i,j,0)} \quad \Big/ \quad d_{(2,1)x} = \frac{f \cdot (x_s - b)}{depth(i,j,1) + doffs}$$

$$\text{if} \begin{cases} 0 \le i - d_{(2,0)y} \le h-1 \\ 0 \le j - d_{(2,0)x} \le w-1 \end{cases}$$

$$I_2[i - d_{(2,0)y},\ j - d_{(2,0)x}] = I_0[i,j]$$