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Q6

$$e_{x,y}^{image} = \frac{-f}{\lambda - f} e_{x,y}^{camera} = -\frac{1}{50} e_{x,y}^{camera}$$

$$\Rightarrow e_{x,y}^{camera} = -50\, e_{x,y}^{image}$$

$$e^{image} = [-0.7464, -1]^T \Rightarrow e^{camera} = [37.32, 50]^T$$

$$f^{camera} = [20, 40]$$

$$|cd|^{image} = \frac{f}{\lambda' - f} |cd|^{camera} = \sqrt{(x_c - x_a)^2 + (y_c - y_d)^2}$$

$$|cd|^{image} = 0.5555$$

$$|cd|^{camera} = ? = |ef|^{camera} = \sqrt{(17.32)^2 + (10)^2}$$
$$= 20$$

$$\Rightarrow 0.5555 = \frac{1}{\lambda' - 1}(20)$$

$$\lambda' = 37\text{cm}$$

$$\therefore \text{Box height} = \cancel{47\text{cm}}\ 14\text{cm}$$

$$\Rightarrow \text{Box} = (20 \times 20 \times 14)\text{cm}^3$$

$$a_{x,y}^{camera} = \frac{37 - 1}{1} a_{x,y}^{image} = [27.32, 67.32]^T$$

$$b_{x,y}^{camera} = [10, 57.32]$$

$$c_{x,y}^{camera} = [20, 40]$$

$$d_{x,y}^{camera} = [37.32, 50]$$

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Q.6 Cont.

We know the box co-ordinates relative to the camera. We must find them relative to the base.

$$T_{base}^{camera} = \begin{bmatrix} \overbrace{\begin{matrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{matrix}}^{\text{ROTATION}} & \begin{matrix} 80 \\ -90 \\ 51 \end{matrix} \\ \begin{matrix} 0 & 0 & 0 \end{matrix} & 1 \end{bmatrix}$$

$$a^{base} = \begin{bmatrix} -1 & 0 & 0 & 80 \\ 0 & 0 & 80 & -90 \\ 0 & 1 & -1 & 51 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 27.32 \\ 67.32 \\ 37 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} -52.68 \\ -22.68 \\ 14 \\ 1 \end{bmatrix}$$

$$b^{base} = \begin{bmatrix} 70 \\ -32.68 \\ 14 \\ 1 \end{bmatrix}$$

etc.

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6 $f = 1 \quad \lambda = 50$

$$a = \begin{bmatrix} -0.7589 \\ -1.87 \end{bmatrix} \quad b = \begin{bmatrix} -0.2778 \\ -1.5922 \end{bmatrix} \quad c = \begin{bmatrix} -0.5556 \\ -1.1111 \end{bmatrix} \quad d = \begin{bmatrix} -1.0367 \\ -1.3889 \end{bmatrix}$$

$$e = \begin{bmatrix} -0.7464 \\ -1.0000 \end{bmatrix} \quad f = \begin{bmatrix} -0.4 \\ -0.8 \end{bmatrix}$$

$$e_{x,y}^{image} = \frac{-f}{\lambda - f} e_{x,y}^{camera} \Rightarrow e_{x,y}^{camera} = -50 e_{x,y}^{image}$$

$$e_{x,y}^{camera} = \begin{bmatrix} 37.32 \\ 50 \end{bmatrix} \quad f_{x,y}^{camera} = \begin{bmatrix} 20 \\ 40 \end{bmatrix}$$

$$|ef|^{cam} = |cd|^{cam} = 20 = \frac{\lambda' - f}{f} |cd|^{image}$$

$$|cd|^{image} = 0.5555 \Rightarrow \frac{\lambda' - f}{f} = 36 \Rightarrow \lambda' = 37\,cm$$

Box height = 14cm

$\Rightarrow$ Box dimensions = $(20 \times 20 \times 14)\,cm^3$

$$a_{x,y}^{cam} = \begin{bmatrix} 27.32 \\ 67.32 \end{bmatrix} \quad b_{x,y}^{cam} = \begin{bmatrix} 10 \\ 57.32 \end{bmatrix} \quad c_{x,y}^{cam} = \begin{bmatrix} 20 \\ 40 \end{bmatrix} \quad d_{x,y}^{cam} = \begin{bmatrix} 37.32 \\ 50 \end{bmatrix}$$

$$T_{base}^{camera} = \begin{bmatrix} -1 & 0 & 0 & 80 \\ 0 & 1 & 0 & -90 \\ 0 & 0 & -1 & 51 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad a^{base} = \begin{bmatrix} 52.68 \\ -22.68 \\ 14 \\ 1 \end{bmatrix}$$

$$b^{base} = \begin{bmatrix} 70 \\ -32.68 \\ 14 \\ 1 \end{bmatrix} \quad c^{base} = \begin{bmatrix} 60 \\ -50 \\ 14 \\ 1 \end{bmatrix} \quad d^{base} = \begin{bmatrix} 42.68 \\ -40 \\ 14 \\ 1 \end{bmatrix}$$

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$$\mu_{11} = \sum_{x,y} (x-x_c)(y-y_c)$$

$$\mu_{02} = \sum (y-y_c)^2$$

$$\mu_{20} = \sum (x-x_c)^2$$

$$\phi = \frac{1}{2}\text{Atan2}(2\mu_{11}, \mu_{20}-\mu_{02})$$

Atan2(x, y)
$\Rightarrow x \propto \sin\phi$, $y \propto \cos\phi$
$\tan^{-1}\left(\frac{x}{y}\right) = \phi$

Magnification : $\left|\frac{\lambda - f}{f}\right|$

f = focal length
λ = Distance from object