

Errata for *Robot Vision*

This is a list of known nontrivial bugs in *Robot Vision* (1986) by B.K.P. Horn, MIT Press, Cambridge, MA ISBN 0-262-08159-8 and McGraw-Hill, New York, NY ISBN 0-07-030349-5. Thanks go to those who found some of these problem areas in the book. If you know of any others, please advise the author by sending electronic mail to:

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Your help will be greatly appreciated. Thank you.

- Section 2.3, page 25. The expression for the diameter of the blur circle should be

$$\frac{d}{z'} |\bar{z}' - z'|,$$

- Section 3.2, bottom of page 48 and top of page 49, interchange “x-axis” and “y-axis” in the text.
- Section 3.2, page 49, figure 3-2: The circled “X” is not at the centroid—it should be further to the left and higher.
- Section 3.3, page 55, the formulae for the second moments in the middle of the page are missing the term $b(x, y)$ in the integrands:

$$\iint_I x^2 b(x, y) dx dy = \int x^2 v(x) dx \quad \& \quad \iint_I y^2 b(x, y) dx dy = \int y^2 h(y) dy.$$

- Section 6.1, page 104, near end of paragraph, after the sentence: “The transformation from the ideal image to that in the out-of-focus system is said to be a linear shift-invariant operation” add “(If we ignore the slight change in scale and overall brightness resulting from the change in the distance from the lens to the image plane).”
- Section 6.8, page 122: The equation below the middle of page should be:

$$L_\sigma(x, y) = \left(\frac{x^2 + y^2 - 2\sigma^2}{2\pi\sigma^6} \right) e^{-\frac{1}{2} \frac{x^2 + y^2}{\sigma^2}}.$$

The second sentence after this should read: “It has a central depression of magnitude $1/(\pi\sigma^4)$ and radius $\sqrt{2}\sigma$ surrounded by a circular wall of maximum height $e^{-2}/(\pi\sigma^4)$ and radius 2σ .”

- Section 6.9, page 125 after the last equation on the page it should say: "... and then drops smoothly to zero at $rB = 3.83171 \dots$ "
- Section 6.13, top of page 134: The integrand containing $\phi_{id}(\xi, \eta)$ has a spurious extra right parenthesis.
- Section 6.13, top of page 134: The integral for $\phi_{dd}(0, 0)$ is missing a $dx dy$.
- Section 6.13, middle of page 136: The expression for Φ_{id} should be

$$\Phi_{id} = H^* \Phi_{bb} + \Phi_{nb}$$

and the expression for Φ_{ii} should be

$$\Phi_{ii} = H^* H \Phi_{bb} + H \Phi_{nb} + H^* \Phi_{bn} + \Phi_{nn}$$

As a result, the expression of the MTF of the optimal filter should read:

$$H' = \frac{\Phi_{id}}{\Phi_{ii}} = \frac{H^* \Phi_{bb}}{H^* H \Phi_{bb} + \Phi_{nn}}.$$

- Section 7.1, just above middle of page 146: The first integral should contain $\tilde{F}(u, v)$, not $F(u, v)$ and $du dv$ instead of $dx dy$:

$$\tilde{f}(x, y) = \frac{1}{4\pi^2} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \tilde{F}(u, v) e^{+i(ux+vy)} du dv$$

- Section 7.1, just above middle of page 146: The second integral for $\tilde{f}(x, y)$ should contain $du dv$ instead of $dx dy$.
- Section 7.2, near bottom of page 147: The integral for $\tilde{f}(x, y)$ should contain $du dv$ instead of $dx dy$.
- Section 7.2, page 148. At the end of the section it should say something like: "... so that the Fourier transform of $f(x, y)$ times $g(x, y)$ equals

$$\sum_{k=-\infty}^{\infty} \sum_{l=-\infty}^{\infty} F \left(u - \frac{2\pi k}{w}, v - \frac{2\pi l}{h} \right),$$

a periodic superposition of copies of $F(u, v)$. It should be clear that $F(u, v)$, the Fourier transform of $f(x, y)$, can be recovered from this sum if $F(u, v)$ is zero for $|u| > \pi/w$ and for $|v| > \pi/h$, while $F(u, v)$ cannot be recovered uniquely when this condition is not satisfied."

- Section 7.4, page 151, the sum for F_{mn} should read:

$$F_{mn} = \sum_{k=0}^{M-1} \sum_{l=0}^{N-1} f_{kl} e^{-2\pi i(\frac{km}{M} + \frac{ln}{N})}.$$

and the sum for f_{kl} should read:

$$f_{kl} = \frac{1}{MN} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} F_{mn} e^{+2\pi i(\frac{km}{M} + \frac{ln}{N})}.$$

- Section 7.4, page 153, in two places: as above, the complex exponent needs a factor of 2.
- Section 7.8, page 155, problem 7-2: the formula given is for $g_{i,j}$, not $f_{i,j}$.
- Section 8.3, top of page 165, formula is lacking a scale factor:

$$\left(\frac{\partial E}{\partial x}\right)^2 + \left(\frac{\partial E}{\partial y}\right)^2 \approx \frac{1}{2\epsilon^2}((E_{i+1,j+1} - E_{i,j})^2 - (E_{i,j+1} - E_{i+1,j})^2).$$

- Section 9.10, page 201, figure 9-8: The number 44, near the lower left hand corner of the figure, and below the number 36, should be 144.
- Section 10.7, page 214: For consistency with what follows, the equation for $E(\theta_i, \phi_i)$ should perhaps read:

$$E(\theta_i, \phi_i) = E \frac{\delta(\theta_i - \theta_s) \delta(\phi_i - \phi_s)}{\sin \theta_i},$$

although it is correct as it stands, since $E(\theta_i, \phi_i)$ is zero except where $\theta_i = \theta_s$.

- Section 10.9, near top of page 219: Change formula to read:

$$L = \frac{1}{\pi} E \cos \theta_i \quad \text{for } \cos \theta_i \geq 0,$$

- Section 10.16, page 234, problem 10-3: This problem can be solved more easily if a spherical coordinate system is chosen that has the poles where the plane containing the local tangent plane intersects the horizon, rather than one with the poles at the nadir.
- Section 10.16, page 241, problem 10-17: Change second sentence in part (a) to read: “Demonstrate that the corners of this triangle lie in the directions $\hat{s}_3 \times \hat{s}_1$, $\hat{s}_2 \times \hat{s}_3$, and $\hat{s}_1 \times \hat{s}_2$.”
- Section 11.1, below middle of page 246: The equations for $x(\xi)$ and $y(\xi)$ should contain θ_0 instead of θ :

$$x(\xi) = x_0 + \xi \cos \theta_0 \quad \text{and} \quad y(\xi) = y_0 + \xi \sin \theta_0.$$

- Section 11.4, middle of page 256: the alternate solution is

$$z = z_0 - \frac{1}{2}(ax^2 + 2bxy + cy^2).$$

- Section 11-10, page 271, problem 11-7: In part (e), change the equation to

$$z(r) = z_0 \pm \frac{1}{2} \left(\sqrt{r^4 - k^2} - k \cos^{-1} \frac{k}{r^2} \right).$$

and add the phrase “when $r_0 = \sqrt{k}$.”

- Section 11-10, page 271, problem 11-9: In the second paragraph, change third sentence to read: “A hyperboloid of one sheet is an example of a ruled surface.”

- Section 11-10, page 275, problem 11-12: In part (b) there is a sign error—insert a minus sign before the λ s in the right hand sides of the equations. change the two equations to read:

$$\begin{aligned}(E(x, y) - R(p, q))R_p &= \lambda(q_{xy} - p_{yy}), \\ (E(x, y) - R(p, q))R_q &= \lambda(p_{xy} - q_{xx}).\end{aligned}$$

- Section 12.6, page 288, middle of the page: There is a λ missing in the correction terms. Change the iterative update equations to read:

$$\begin{aligned}u_{kl}^{n+1} &= \bar{u}_{kl}^n - \frac{\lambda}{1 + \lambda(E_x^2 + E_y^2)}(E_x \bar{u}_{kl}^n + E_y \bar{v}_{kl}^n + E_t)E_x, \\ v_{kl}^{n+1} &= \bar{v}_{kl}^n - \frac{\lambda}{1 + \lambda(E_x^2 + E_y^2)}(E_x \bar{u}_{kl}^n + E_y \bar{v}_{kl}^n + E_t)E_y.\end{aligned}$$

- Section 13.9, page 317, near bottom of page: Change equation to read:

$$F_d - \frac{\partial}{\partial x'} F_{d_{x'}} - \frac{\partial}{\partial y'} F_{d_{y'}} + \frac{\partial^2}{\partial^2 x'} F_{d_{x'x'}} + \frac{\partial^2}{\partial^2 y'} F_{d_{y'y'}} = 0.$$

- Section 16.6, page 374, end of second paragraph of section, change sentence to read: “In fact, the number of impulses per unit area on the Gaussian sphere approaches ρ times the inverse of the absolute value of the Gaussian curvature.”
- Section 16.13, page 397, problem 16-7: Change solution to part (b) to read:

$$R(\psi) = \frac{(ab)^2}{((a \cos \psi)^2 + (b \sin \psi)^2)^{3/2}}.$$

- Section 16.13, page 399, problem 16-9: Change equation in part (a) to read

$$\rho_{X \oplus Y}(\psi) = \rho_X(\psi) + \rho_Y(\psi).$$

- Section 17.5, page 416: There is a sign error in the sixth equation from the top. The term $((u - u_r)y + (v - v_r)x)$ in the integrand should instead be $((u - u_r)y - (v - v_r)x)$.
- Section 18.10, page 437, near bottom of page, the equation after the phrase: “The norm of a quaternion is given by” should read:

$$\|\dot{\mathbf{q}}\| = \sqrt{\dot{\mathbf{q}} \cdot \dot{\mathbf{q}}} = \sqrt{q^2 + \mathbf{q} \cdot \mathbf{q}}.$$

- Section 18.10, page 437, at the bottom of the page, change equation to read:

$$\dot{\mathbf{q}} = \cos \frac{\theta}{2} + \boldsymbol{\omega} \sin \frac{\theta}{2}.$$

- Section 18.10, page 438, second sentence in second paragraph from the top, change to: “Two antipodal points on this sphere correspond to a particular rotation.”

- Section 18.21, page 450, problem 18-5, change middle equation to read:

$$(\hat{p}\hat{q}) \cdot (\hat{p}\hat{q}) = (\hat{p} \cdot \hat{p})(\hat{q} \cdot \hat{q}) = (\hat{q}\hat{p}) \cdot (\hat{q}\hat{p}).$$

- shoul • Section A.1, page 454, after the law of cosines for the angles, add: “... and the so-called analogue formula is

$$\sin a \cos B = \cos b \sin c - \sin b \cos c \cos A.$$

- Section A.5.2, page 465, “The extrema of $f(x, y, z) = 0$ subject to...” should be just “The extrema of $f(x, y, z)$ subject to...”
- Section A.5.2, page 466, “We minimize $abc + \dots$ ” should be “We maximize $abc + \dots$ ”
- Section A.6.1, page 470, in the equation after “Using integration by parts, we see that” there is a prime missing on the $F_{f'}$ in the last integrand

$$\int_{x_1}^{x_2} \eta'(x) F_{f'} dx = [\eta(x) F_{f'}]_{x_1}^{x_2} - \int_{x_1}^{x_2} \eta(x) \frac{d}{dx} F_{f'} dx,$$

- Section A.6.2, page 473 last equation on the page should be

$$\Phi \equiv F + \sum_{i=1}^m \lambda_i(x) g_i(x, f_1, f_2, \dots, f_n, f'_1, f'_2, \dots, f'_n).$$