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. — in particular Liang Wang who translated the book into Chinese. If you know of any other problems, 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
$$\frac{d}{\bar{z}'}\left|\bar{z}' - z'\right|,$$
- 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:

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

- 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 $rB = 3.83171\ldots$"
- 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 6.14, top of page 128: The expression should be (missing π)
$$\bar{F}(\rho) = 2\pi R^2 \frac{J_1(\rho R)}{\rho R}$$
- 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:
$$\left(\frac{\partial E}{\partial x}\right)^2 + \left(\frac{\partial E}{\partial y}\right)^2 \approx \frac{1}{2\epsilon^2}\big((E_{i+1,j+1} - E_{i,j})^2 - (E_{i,j+1} - E_{i+1,j})^2\big).$$
- 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 $\hat{\mathbf{s}}_3 \times \hat{\mathbf{s}}_1$, $\hat{\mathbf{s}}_2 \times \hat{\mathbf{s}}_3$, and $\hat{\mathbf{s}}_1 \times \hat{\mathbf{s}}_2$."
- 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 λs in the right hand sides of the equations. change the two equations to read:
$$\big(E(x,y) - R(p,q)\big)R_p = \lambda(q_{xy} - p_{yy}),$$
$$\big(E(x,y) - R(p,q)\big)R_q = \lambda(p_{xy} - q_{xx}).$$
- 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:
$$u_{kl}^{n+1} = \overline{u}_{kl}^{n} - \frac{\lambda}{1+\lambda(E_x^2+E_y^2)}(E_x\overline{u}_{kl}^{n} + E_y\overline{v}_{kl}^{n} + E_t)E_x,$$
$$v_{kl}^{n+1} = \overline{v}_{kl}^{n} - \frac{\lambda}{1+\lambda(E_x^2+E_y^2)}(E_x\overline{u}_{kl}^{n} + E_y\overline{v}_{kl}^{n} + E_t)E_y.$$
- Section 12.7, page 293, drop the sentence "Moreover, rotations about the optical axis increase the measure that we used for the departure from smoothness"
- Section 13.5, page 311, focal length f missing in "This is a straight line connecting the point $f(u/w, v/w)$, for $s = 0$, to $f(a/c, b/c)$, as $s \to \infty$." after equations at top of page.
- 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:
$$R(\psi) = \frac{(ab)^2}{\big((a\cos\psi)^2 + (b\sin\psi)^2\big)^{3/2}}.$$
- 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 $\big((u-u_r)y + (v-v_r)x\big)$ in the integrand should instead be $\big((u-u_r)y - (v-v_r)x\big)$.
- Section 18.10, page 437, near bottom of page, the equation after the phrase: "The norm of a quaternion is given by" should read:
$$\|\mathring{q}\| = \sqrt{\mathring{q}\cdot\mathring{q}} = \sqrt{q^2 + \mathbf{q}\cdot\mathbf{q}}.$$

- Section 18.10, page 437, at the bottom of the page, change equation to read:
$$\mathring{q} = \cos\frac{\theta}{2} + \boldsymbol{\omega}\sin\frac{\theta}{2}.$$
- Section 18.10, page 438, second sentence in second paragraph form 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:
$$(\mathring{p}\mathring{q}) \cdot (\mathring{p}\mathring{q}) = (\mathring{p} \cdot \mathring{p})(\mathring{q} \cdot \mathring{q}) = (\mathring{q}\mathring{p}) \cdot (\mathring{q}\mathring{p}).$$

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 $abc + \ldots$” should be “We maximize $abc + \ldots$.”
- 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
$$\int_{x_1}^{x_2} \eta'(x) F_{f'}\, dx = \left[\eta(x) F_{f'}\right]_{x_1}^{x_2} - \int_{x_1}^{x_2} \eta(x) \frac{d}{dx} F_{f'}\, dx,$$
- Section A.6.2, page 473 last equation on the page should be
$$\Phi \equiv F + \sum_{i=1}^{m} \lambda_i(x) g_i(x, f_1, f_2, \ldots, f_n, f_1', f_2', \ldots, f_n').$$