Corrections: ROBUST and OPTIMAL CONTROL

Convention: Page xx is denoted as Pxx. Line xxx from the top of the page is denoted as $Lxxx$ while line xx from the bottom of the page is denoted as $-Lxx$.

1. P5, -L9, "be covered in an one or two" should be "be covered in a one or two"
2. P7, -L2, "Note that" should be "Note while"
3. P37, L2, $C_1 =$ and $B_1 =$ should be $C =$ and $B =$.
4. P75, -L6, "decreasingly order numbers" should be "decreasingly ordered numbers"
5. P80, L8, "maximally possible" should be "maximum possible"
6. P89, L3, "Then for any nonzero vector $u_0 \in \mathbb{C}^m$ the output ..." should be "Then for any nonzero vector $u_0 \in \mathbb{C}^m$ such that $G(z_0)u_0 = 0$ the output ..."
7. P105-107, Table 4.1, second entry from the bottom, DELETE

   $$\limsup_{t\to\infty} \|z(t)\| = \|G(j\omega_0)u_0\|$$

   This is not correct. (Thanks to Prof. Richard Braatz for pointing out th error.)

   Correspondingly delete lines 8 and 9 from the bottom of page 106.

   Also the discussion on page 107 should be changed to:

   It is interesting to see what this table signifies from the control point of view. To focus our discussion, let us assume that $u(t) = u_0 \sin \omega_0 t$ is a disturbance or a command signal on a feedback system, and $z(t)$ is the tracking error. Then we say that the system has good tracking behavior if $z(t)$ is small in some sense, for instance, $\limsup_{t\to\infty} \max_i |z_i(t)|$ is small. Note that

   $$\limsup_{t\to\infty} \max_i |z_i(t)| = \|G(j\omega_0)u_0\|_\infty \quad \text{(induced matrix } \infty \text{ norm)}$$

   for any given ω_0 and $u_0 \in \mathbb{R}^q$. Now if we want to track signals from various channels, that is if u_0 can be chosen to be any direction, then we would require that $\|G(j\omega_0)\|_\infty$ be small. Furthermore, if, in addition, we want to track signals of many different frequencies, we then would require that $\|G(j\omega_0)\|_\infty$ be small at all those frequencies. This interpretation enables us to consider the control system in the frequency domain even though the specifications are given in the time domain.
8. P114, -L9, "Hence the ∞ of .." should be "Hence the ∞ norm of .."
9. P119, L11, $u = \frac{(s+2)}{3}(r-n-d) - \frac{s-1}{3}d$ should be $u = \frac{(s+2)}{3}(r-n-d) + \frac{s-1}{3}d$.
10. P124, Corollary 5.6, add the following at the end of corollary: "or equivalently, $\det(I - P(s)\hat{K}(s))$ has no zeros in the closed right half plane."

11. P124, -L6, -L5, and -L3, "number of open rhp poles" should be "number of (closed) rhp poles"

12. P124, change Theorem 5.7 (ii) to "$(I - P(s)\hat{K}(s))^{-1}$ is stable." This correction does not affect any other results in the book.

13. P125, Theorem 5.8, a footnote on the Nyquist plot: the Nyquist contour is constructed so that all imaginary axis poles of P and K are counted as unstable ones.

14. P149, L11, "Theorem 6.3 holds" should be "Theorem 6.3 hold"

15. P152, -L7, "applies to multivariable system" should be "applies to multivariable systems"

16. P157, L5, "A_{11} is not asymptotically" should be "A_{11} is not asymptotically stable"

17. P159, -L6, "using the definition of $B(s)$" should be "using the definition of $\tilde{B}(s)$"

18. P162, Example can be simplified.

    The above bound can be tight for some systems. For example, consider an n-th order transfer function

$$G(s) = \sum_{i=1}^{n} \frac{b_i}{s + a_i},$$

with $a_i > 0$ and $b_i > 0$. Then $\|G(s)\|_\infty = G(0) = \sum_{i=1}^{n} b_i/a_i$ and $G(s)$ has the following state space realization

$$G = \left[\begin{array}{cccc|c} -a_1 & & & & \sqrt{b_1} \\ & -a_2 & & & \sqrt{b_2} \\ & & \ddots & & \vdots \\ & & & -a_n & \sqrt{b_n} \\ \hline \sqrt{b_1} & \sqrt{b_2} & \cdots & \sqrt{b_n} & 0 \end{array}\right]$$

and the controllability and observability Gramians of the realization are given by

$$P = Q = \left[\frac{\sqrt{b_i b_j}}{a_i + a_j}\right].$$

It is easy to see that $\sigma_i = \lambda_i(P) = \lambda_i(Q)$ and

$$\sum_{i=1}^{n} \sigma_i = \sum_{i=1}^{n} \lambda_i(P) = \mathrm{trace}(P) = \sum_{i=1}^{n} \frac{b_i}{2a_i} = \frac{1}{2}G(0) = \frac{1}{2}\|G\|_\infty.$$

In particular, let $a_i = b_i = \alpha^{2i}$, then $P = Q \to \frac{1}{2}I_n$, i.e., $\sigma_j \to \frac{1}{2}$ as $\alpha \to \infty$.

19. P218, -L7, delete "and $\|M\|_\infty = \overline{\sigma}(M(j\omega_0)) = \sigma_1$."
20. P222, -L17, "$\det(I + W_1\Delta W_2 K S_0) = (I + S_0 W_1 \Delta W_2 K)$" should be "$\det(I + W_1\Delta W_2 K S_0) = \det(I + S_0 W_1 \Delta W_2 K)$"
21. P248, L5, "$\triangleq$ " should be ":=" for consistence.
22. P248, -L8, $u = \Delta_u y_2$ should be $u_2 = \Delta_u y_2$.
23. P258, L2, "$N = \begin{bmatrix} I & \sqrt{2}I \\ -\sqrt{2}I & -I \end{bmatrix}$" should be "$N = \begin{bmatrix} -I & -\sqrt{2}I \\ \sqrt{2}I & I \end{bmatrix}$"
24. P280, L13, "in simple cases" should be "in these simple cases"
25. P363, L7, L8, L12, $B_1^* X + D_1^* C_1$ should be $B_1^* X_1 + D_1^* C_1$.
26. P457 -L8, "$\Phi = 0$" should be "$Q = 0$"
27. P488, -L1, $[W_1 \ PW_2^{-1}]$ should be $[W_1 \ KW_2^{-1}]$
28. P489, Figure 18.5, W_2 and W_2^{-1} should be swapped.
29. P490, equation (18.7) should be $(K_\infty^{-*} K_\infty^{-1} + I) \le \gamma^2 (K_\infty^{-*} + P_s^*) \tilde{M}_s^* \tilde{M}_s (K_\infty^{-1} + P_s)$.
30. P492, Theorem 8.10, $\underline{\sigma}(K_\infty)$ should be "$\overline{\sigma}(K_\infty)$", two times.
31. P494, L10,

    $$\overline{\sigma}(\tilde{M}_s) = \overline{\sigma}(M_s) = \left(\frac{1}{1 + \overline{\sigma}^2(W_2 P W_1)}\right)^{1/2}$$

    should be

    $$\overline{\sigma}(\tilde{M}_s) = \overline{\sigma}(M_s) = \left(\frac{1}{1 + \underline{\sigma}^2(W_2 P W_1)}\right)^{1/2}$$

32. P494, L8 and L9

    $$\overline{\sigma}^2(\tilde{M}_s) = \lambda_{max}(\tilde{M}_s^* \tilde{M}_s) = \frac{1}{1 + \lambda_{max}(P_s P_s^*)} = \frac{1}{1 + \overline{\sigma}^2(P_s)}$$

    should be

    $$\overline{\sigma}^2(\tilde{M}_s) = \lambda_{max}(\tilde{M}_s^* \tilde{M}_s) = \frac{1}{1 + \lambda_{min}(P_s P_s^*)} = \frac{1}{1 + \underline{\sigma}^2(P_s)}$$

    and

    $$\overline{\sigma}^2(\tilde{N}_s) = 1 - \overline{\sigma}^2(\tilde{M}_s) = \frac{\overline{\sigma}^2(P_s)}{1 + \overline{\sigma}^2(P_s)}.$$

    should be

    $$\overline{\sigma}^2(\tilde{N}_s) = 1 - \underline{\sigma}^2(\tilde{M}_s) = \frac{\overline{\sigma}^2(P_s)}{1 + \overline{\sigma}^2(P_s)}.$$

33. P587, reference no. 214, add "pp. 5-16" at the end.