

# Errata

for

*Systems and Control*

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**Note:** Negative line numbers are counted from the bottom of the page. Within displayed equations, matrices and vectors are counted as a single line. Last updated March 25, 2009.

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- page 7, fourth line of Example 1.1: change  $T = \mathbb{R}$  to  $t \in \mathbb{R}$
- page 10, first line after (1.4): insert the exponent into the equation  $\|\mathbf{v}\| = \mathbf{v}^T \mathbf{v}$  so it will read,  $\|\mathbf{v}\|^2 = \mathbf{v}^T \mathbf{v}$
- page 12, middle of the page: change “which implies that their second partial derivatives are equal.” to “which implies that their corresponding mixed second partial derivatives are equal.”
- page 23, Figure 1.11: reverse the direction of the arrow for Roll
- page 27: in the expression for  $I_z \dot{\omega}_z$ , after equation (1.50), delete  $\delta_f$  that post-multiplies the first term on the right-hand side, that is, change

$$2l_1 C_{\alpha f} \left( \delta_f - \frac{l_1 \omega_z + \dot{y}}{v_x} \right) \delta_f \quad \text{to} \quad 2l_1 C_{\alpha f} \left( \delta_f - \frac{l_1 \omega_z + \dot{y}}{v_x} \right)$$

- page 58: change  $A$  to  $\mathcal{A}$  in (2.16)
- page 64, last formula: the closing parenthesis is missing, that is, it should be

$$\mathbf{x}(t_1) = \mathbf{x}_0 + \frac{h}{2} (\mathbf{f}(t_0, \mathbf{x}_0, \mathbf{u}(t_0)) + \mathbf{f}(t_1, \mathbf{x}_1, \mathbf{u}(t_1))).$$

- page 72, the equation in the last line on this page: change to

$$\tau = -mgl \sin \theta,$$

where  $\tau = J\ddot{\theta}$  is the torque acting on the mass  $m$  and  $J = ml^2$  is the moment of inertia of the mass  $m$ .

- page 73, replace  $F$  with  $\tau$
- page 73, line 4: change this line to

$$\frac{d\tau}{d\theta} (0^\circ) = -mgl \cos 0^\circ = -mgl.$$

- page 73, line 6: change the equation in this line to

$$\tau = -mgl\theta.$$

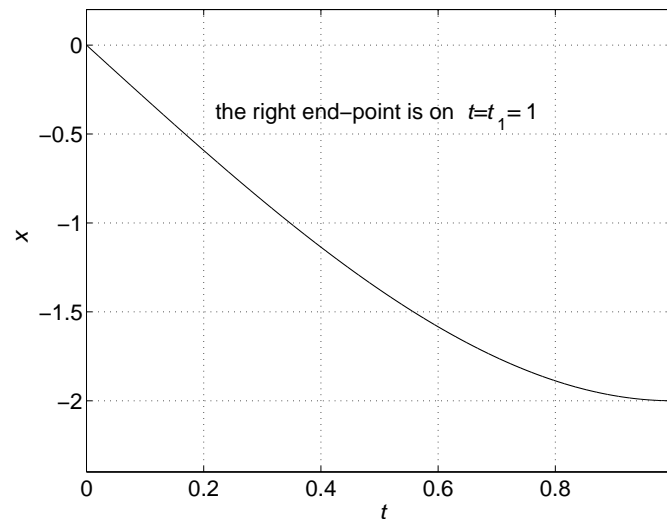
- page 73, Figure 2.13: Change  $F$  to  $\tau$ , “ $mg$ ” on the vertical axis to “ $mgl$ ”, and “slope= $-mg$ ” to “slope= $-mgl$ ”
- page 76, Example 2.14: in the line after the three displayed equations, replace “...above model of an equilibrium...” with “...above model about an equilibrium...”
- page 77: the linearized model of the engine-governor system (2.26) should include the term,

$$+ \begin{bmatrix} 0 \\ 0 \\ -1/I \end{bmatrix} \Delta u,$$

where  $u_e = \tau$

- page 119, line  $-3$ : delete the negative sign in front of 0 in the second row of the matrix  $\hat{T}$
- page 150, line 3 of Section 4.2: change  $\mathbf{f} : \mathbb{R} \times \mathbb{R}^n \rightarrow \mathbb{R}$  to  $\mathbf{f} : \mathbb{R} \times \mathbb{R}^n \rightarrow \mathbb{R}^n$
- page 154, line  $-2$ : change  $\dot{V}(t)$  to  $\dot{V}(\mathbf{x}(t))$
- page 165, line 6: change the minus sign to the plus sign in front of  $\frac{K_3}{50}$
- page 177, third line after the expression labelled as (4.48): change  $\mathcal{S} = B_R(\mathbf{0})$  to  $\mathcal{S} = \bar{B}_R(\mathbf{0})$
- page 182, line 6 of the proof of Theorem 4.8: change  $\psi_1(0) = \psi_2(0) = \psi_3(0)$  to  $\psi_1(0) = \psi_2(0) = \psi_3(0) = 0$
- page 183, line 2: change  $\psi_1(\|\mathbf{x}(t; t_0, \mathbf{x}_0)\|)$  to  $\psi_1(\|\mathbf{x}(t_0 + T; t_0, \mathbf{x}_0)\|)$
- page 188, line 1: delete “and” at the end of the line
- page 188: top of the page; insert condition 5 after condition 4. Condition 5 should read: “ $W(t, \mathbf{x})$  is bounded in  $\mathcal{S}$ ,”
- page 188, first line after (4.56): replace the first sentence in this line with the following sentence: “By condition 5, the function  $W$  is bounded in  $\mathcal{S}$ .”
- page 188: Condition 3 of Corollary 4.1—delete “and” at the end of the line
- page 188: Corollary 4.1; insert condition 5 after condition 4. Condition 5 should read: “ $W(t, \mathbf{x})$  is bounded in  $\mathcal{S}$ ,”

- page 188: add the following sentence after Corollary 4.1. “Note that if  $W(t, \mathbf{x}) = W(\mathbf{x})$ , that is, if  $W$  is time-invariant, then Condition 5 of Theorem 4.10 and Corollary 4.1 is not needed because  $W = W(\mathbf{x})$  being continuous on the compact set  $\mathcal{S}$  must be bounded in  $\mathcal{S}$ .”
- pages 195–197: the controller gain  $\rho$  in Example 4.9 should have been named using a different symbol than  $\rho$ , for example,  $\eta$ , to avoid confusion with  $\rho$  from pages 194–195
- page 204: Figure 4.18; change  $W = R$  to  $\dot{W} < 0$
- page 208: the minus sign is missing in the last line in (4.111), that is,  $x \leq \nu$  should be  $x \leq -\nu$
- page 213, line 3: replace  $t \rightarrow 0$  with  $t \rightarrow \infty$
- page 214, line –5; change  $\rho(\mathbf{x}^{k_i}, \Omega(\mathbf{x}^0))$  to  $\text{dist}(\mathbf{x}^{k_i}, \Omega(\mathbf{x}^0))$
- page 217: sixth line after **Notes**, change “liner” to “linear”
- page 219: in Exercise 4.6(b), replace  $\sum_0^\infty$  with  $\sum_{k=0}^\infty$
- page 228: In the first line of figure caption of Figure 5.2 change “area of surfaces” to “area of surface”
- page 230, line 1: change “unique” to “unique”
- page 242: replace Figure 5.9 in the text with the figure below



**Figure 5.9** A plot of the extremal,  $x(t) = -3t + t^3$ , of Example 5.8.

- page 264, line –3; change  $\mathbf{T}^{-1}\mathbf{b}\mathbf{R}^{-1}\mathbf{T}^T\mathbf{b}^T$  to  $\mathbf{T}^{-1}\mathbf{b}\mathbf{R}^{-1}\mathbf{b}^T\mathbf{T}^{-T}$

- page 276, last line before Example 5.17: make  $f$  bold so the equation in this line will read,  $\mathbf{x}(k_0 + 2) = \mathbf{f}(k_0 + 1, \mathbf{x}(k_0 + 1), \mathbf{u}(k_0 + 1))$

- page 277, line 11: insert the missing term,  $\frac{1}{2}(8 - 3u(0))^2$ , that is, line 11 should read as

$$\frac{\partial}{\partial u(0)} \left\{ 8 + \frac{1}{2}u^2(0) + \frac{1}{2}(8 - 3u(0))^2 + \frac{1}{2} \left( \frac{12(8 - 3u(0)) - 60}{19} \right)^2 \right\}$$

- page 284, line 2: replace “that” in front of “fact” with “the”, that is, change “...and use that fact that...” to “...and use the fact that...”
- page 284, line -3: insert “to” in front of “construct”, that is, change “Our goal is construct the control...” to “Our goal is to construct the control...”
- page 287, line 9: in the expression for  $C_1$  change  $e^{s1tf}$  to  $e^{s2tf}$  in the first term in the numerator

- page 288, line -1: change  $e_a$  to  $e_a^*$

- page 292: replace two times  $H(\mathbf{x}, \mathbf{u}, \mathbf{p})$  with  $\mathbf{H}(\mathbf{x}, \mathbf{u})$

- page 293: replace two lines of text after equation (5.93) with the following: “In the above manipulations, we assumed that  $\mathbf{p}$  is an explicit function of  $\mathbf{x}$ . If, on the other hand, we treat  $\mathbf{p}$  as an independent variable of the Hamiltonian function, that is,  $H = H(\mathbf{x}, \mathbf{u}, \mathbf{p})$ , then we obtain,”

- page 295: delete the middle line in the expression for  $u$ . That is,  $u$  should be defined as,

$$u = -\text{sign}(v) = \begin{cases} 1 & \text{if } v < 0 \\ -1 & \text{if } v > 0 \end{cases}$$

- page 333: Section 6.7 should be moved after Section 6.4 and before Section 6.5
- page 335, in **STEP 1** of the algorithm: replace  $\mathbf{T} \in \mathbb{R}^{(n-m) \times n}$  with  $\mathbf{T} \in \mathbb{R}^{n \times (n-m)}$
- page 363: in the last line of Lemma 6.5,  $a$  is missing in the exponent, that is, change  $e^{(t-t_0)}$  to  $e^{a(t-t_0)}$
- page 378, line 10: insert the minus sign in front of  $L_{\mathbf{f}}L_{\mathbf{g}_1}T_1$  and  $L_{\mathbf{f}}L_{\mathbf{g}_2}T_1$ , that is, this line should read,

$$-L_{\mathbf{f}}L_{\mathbf{g}_1}T_1 = L_{[\mathbf{f}, \mathbf{g}_1]}T_1 \quad \text{and} \quad -L_{\mathbf{f}}L_{\mathbf{g}_2}T_1 = L_{[\mathbf{f}, \mathbf{g}_2]}T_1.$$

- page 386, equation (7.82): change  $\mathbf{T}^{-1}\mathbf{x}$  to  $\mathbf{T}^{-1}(\mathbf{x})$

- page 394, line 7 after the caption of Figure 8.3: change “A car being driven 57.5 mph is fast to degree 0.25” to “A car being driven 57.5 mph is FAST to degree 0.25”, that is, the word “fast” should be “FAST”
- page 397: in Table 8.1 replace  $A(\cdot)B$  with  $A(\cdot)B$
- page 397: Table 8.1 fourth line down in the third column under  $A(\cdot)B$ , replace  $[a_1b_1, a_2b_2]$  with  $[a_1b_2, a_2b_2]$
- page 407, line 8 after Subsection 8.3 title: change “The support of the fuzzy sets  $A_\alpha$  and  $B_\beta$  in the IF-THEN rules...” to “The support of the fuzzy sets  $A_\alpha$  and  $B_\beta$  and the IF-THEN rules...”
- page 409, line –6: replace “This type of defuzzifier is called the *center average defuzzifier*.” with “This type of defuzzifier is called the *center average defuzzifier* or the *algebraic product defuzzifier*.”
- page 409, equation (8.3): the denominator should be  $\sum_{i=1}^M \min\{\mu_{A_i}(x), \mu_{B_i}(y)\}$ , that is, insert the comma between  $\mu_{A_i}(x)$  and  $\mu_{B_i}(y)$
- page 409: add after equation (8.3) the following sentence “The above type of defuzzifier is called the *center-of-gravity defuzzifier*.”
- page 412, line 1 of Example 8.8: replace “Subsection 2.4.2” with “Subsection 1.7.2”
- page 429, equation (8.47): change  $r = 1$  to  $i = 1$  in the line with the single summation sign
- page 449: Insert the following explanation into the line separating (8.123) and (8.124) before the phrase “We assume that”:  

The notation argmin (or arg min) stands for the argument,  $x^*$ , that yields the minimal value of the minimized function,  $f(x)$ . This is well-defined only if the minimal value of  $f(x)$  is reached at a single point. Thus,  $x^* = \arg \min_x f(x)$  holds if and only if  $x^*$  is the unique minimizer of  $f(x)$ .
- page 484: in the legend of Figure 9.11, replace “Plant output” with “Plant input”
- page 485: replace  $\mathbf{x}^{(k)}$  with  $\mathbf{x}(k)$  in (9.28)
- page 499, beginning of line –11: change  $t \rightarrow 0$  to  $t \rightarrow \infty$
- page 510: in Figure 9.30, replace strange symbols between voltage sources  $x_1$  and  $x_n$  with three dots
- page 530, line –6: replace  $H_n = [-1 \ 1]^n$  with  $H_n = [-1, 1]^n$
- page 530, line –2: replace  $H_2 = [-1 \ 1]^2$  with  $H_2 = [-1, 1]^2$

- page 556: in the line before equation (10.4) delete “the equation”
- page 556: replace equation (10.4) with

$$r \geq \frac{x_{\max} - x_{\min}}{2^l - 1}.$$

- page 557, line 7: interchange “phenotype” with “genotype”
- page 560, change (10.10) to

$$\frac{\sum_{\mathbf{x} \in H} f(\mathbf{x})}{f(k)} = \frac{\sum_{\mathbf{x} \in H} f(\mathbf{x}) e(H, k)}{f(k) e(H, k)}.$$

- page 560, equation (10.11): change  $m(H, k)$  to  $e(H, k)$
- page 561, inequality (10.15): change  $m(H, k)$  to  $e(H, k)$
- page 598, add the absolute value symbols in the equation for  $p_n$  in the middle of the page: it should read,

$$p_n = \frac{|\det(\mathbf{A}_n)|}{\sum_{i=1}^N |\det(\mathbf{A}_i)|}, \quad n = 1, 2, 3, 4.$$

- page 629, line 6: replace “Schwarz” with “Cauchy-Schwarz”
- page 634, line 6: change  $1 \leq i_1 \leq i_2 \leq \dots \leq i_p$  to  $1 \leq i_1 < i_2 < \dots < i_p \leq n$
- page 634, Theorem A.5: change  $1 \leq i_1 \leq i_2 \leq \dots \leq i_p$  to  $1 \leq i_1 < i_2 < \dots < i_p \leq n$
- page 638, line 6: in the equation, replace the minus sign with the plus sign
- page 694, second column, line -4: insert “409” in front of “464”
- page 695, third column: add to the item “Defuzzification, 408” two terms, “Algebraic product defuzzifier, 409 ” and “Center-of-gravity defuzzifier, 409”