Model Predictive Control: Theory and Design

Errata for First Edition, First Printing

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May 28, 2021

1. Page 3, five lines from bottom. Add D to \( G(x) \) expression: \( G(x) = C(d + A)^{-1}B + D \). Thanks to Jordan Jalving, Ranjeet Kumar, and Aapoosa Sampath of UW for pointing out this erratum.

2. Page 16, lines 12, 13, and 16. Put factor (1/2) in front of all terms on the right-hand sides of the se equations. Thanks to W. Krämer of T.H. Ingolstadt for pointing out this erratum.

3. Page 18, line 14. Change \( x^{0}_{N+2} \) to \( x^{0}_{N+1} \). Page 19, line 7. Change \( x^{0}_{N+1} \) to \( x^{0}_{N+2} \). Thanks to Ganzhou Wang of U. Stuttgart for pointing out this erratum.

4. Page 34, line 8. Remove \( C'R + 1 \) factor in front of \( (y(0) - CR(0)) \). On line 13, remove trailing \( C'R + 1 \) factor.

5. Page 35, first equation. Change first A to \( A' \).

6. Page 36, lines 12 and 13. Change the norm to norm squared on the right-hand sides of the \( V_{c} \) and \( V_{e} \) equations.


8. Page 53, Example 1.11. Change \( U^{2} \) to \( \sigma^{2} \) in the denominators of the first terms on the right-hand sides of the three differential equations.

9. Page 69, second to last displayed equation. Change \( x(k')P_{x}(x(k)) \) to \( x(N')P_{x}(x(N)) \). Thanks to Travis Arnold of UW for pointing out this erratum.

10. Page 76, (1.64). Change \( R_{0} \) to \( P_{0} \). Thanks to Megan Zagrobelny of UW for pointing out this erratum.

11. Page 77, part (c). Change \( e - (0,R) \) to \( e - N(0,R) \). Thanks to Cameron Cotten of UW for pointing out this erratum.

12. Page 79, last line. Change \( p_{x,y} \) to \( p_{x,y} \). Thanks to Alkold Sundarajan of UW for pointing out this erratum.

13. Page 82, Exercise 1.56. Change \( z_{xy} \) to \( r_{xy} \). Make the same change in Exercise 1.57, Lemma 1.14, and Exercise 1.58 (four places; page 83, lines 2, 5, 9, and 10 from the top). Thanks to W. Krämer of T.H. Ingolstadt for pointing out this erratum.

14. Page 84, Figure 1.13. Change \( y_{0} \) to \( y_{0} \).

15. Page 95. In the displayed equations, replace \( u^{0}(N-1; x(i)) \) and \( x^{0}(N; x(i)) \) with \( u^{0}(i + N-1; x(i)) \) and \( x^{0}(i + N; x(i)) \), respectively. Thanks to Phillip Maree of NTNU for pointing out this erratum.

16. Page 97, 9 lines from the top, change (2.8) to (2.6).
35. Page 140, fourth displayed equation. Change $K : ƒ \rightarrow B \rightarrow 0 \rightarrow A$ to $K : ƒ \rightarrow P \rightarrow B \rightarrow 0 \rightarrow A$.
36. Page 144, second displayed equation. Change the sum limit from $j = 1$ to $N = 1$ and $x(j)$ to $x(N)$.
37. Page 147, eighth line under section 2.6.1. In the statement involving $X_j$, change strict subset $\subset$ to subset $\subseteq$.
38. Page 149, third line. Change "has an interior" to "contains the origin in its interior." Fourth line. Change $U_{\xi}(x)$ to $U_{\xi}(x)$.
39. Page 149, line after third displayed equation and line after fourth displayed equation. Change $x' \in X_\xi(x)$ to $x' \in X_\xi(x)$ (two places).
40. Page 150, 13 lines from top. Replace $t \in l_{N-1}$ with $j \in l_{n-1}$. Thanks to Daniylo Mablyuta of U. Washington for pointing out this error.
41. Page 151, first displayed equation. In the last inequality, $N \beta$ should be changed to $N \beta + \beta x$.
42. Page 151, second line of text. Change $U_{\lambda}(x)$ to $U_{\lambda}(x)$.
43. Page 152, third displayed equation. Change $R_{\lambda}(x)$ to $R_{\lambda}(x)$.
44. Page 152, second line below the fourth displayed equation. Change $x'(N; x') \in X'_\lambda(x)$ so that $x' \in X'_\lambda(x)$ to $x'(N; x') \in X'_\lambda(x)$ so that $x' \in X'_\lambda(x)$.
45. Page 153, the displayed equation. $u$ and $y$ should be bolded, $u$, $y$.
46. Page 155, second line below the displayed equation. Add the word "that" after "such".
47. Page 158, first line after displayed equation. Change "or" to "for".
48. Page 160, last line before section 2.8.2. Change $X_{\lambda} := \{x \mid U_{\lambda}(x) \neq \emptyset\}$ to $X_{\lambda}(x) := \{x \mid U_{\lambda}(x, r) \neq \emptyset\}$.
49. Page 160, last line. Change to $d^* = d + I(y - h(x) - d_j)$, i.e., move the closing parenthesis. Thanks to Guanzhou Wang of U. Stuttgart for pointing out this error and several of the following errata.
51. Page 165, Add following state space realization in addition to $G(x)$ transfer function $A = \begin{bmatrix} 0.85725 & 0.804179 \\ -0.014716 & -0.051399 \end{bmatrix}$, $B = \begin{bmatrix} 8.56490 \\ 0.804181 \end{bmatrix}$, $C = \begin{bmatrix} -0.043717 \\ 0 \end{bmatrix}$.
52. Page 168, seventh line. Change "Because quadratic programs ..." to "Because efficient programs exist for solving QPs ...". Thanks to Florian Brunner of U. Stuttgart for pointing out this error.
53. Page 172, Exercise 2.4. Change $p = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$ to $p = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$.
54. Page 177, Exercise 2.12. Change the text "...the fact that $x'(N; x') \in X'_\lambda(x)$ to ...the fact that $x'(N; x') \in X'_\lambda(x)$.
55. Page 178, Exercise 2.15. Change $N_e \geq 0$ to $N_e \geq 1$.
56. Page 197, second line above third displayed equation. Change "subsets of $\mathbb{R}^m$" to "subsets of $\mathbb{R}$."
76. Page 334, last line. Change $dx_i(k - 1)$ to $dx_i(k)$. Thanks to Ming Ge of Imperial College for pointing out this erratum.
77. Page 337, fourth line. Change final $Q$ to $GQ^*$. Thanks to Ming Ge of Imperial College for pointing out this erratum.
78. Page 340. Starting at line 7, change in which we have used the identity (see Exercise 1.47)
\[
p_{m+1}(a | b) = \int p_{m+1}(a | b, c)p({\dot b}a | x)dc
\]
to in which we have used the second identity in Exercise 1.47 and the Markov property, which implies that
\[
p(y(k + 1) | x(k + 1), y(k)) = p(y(k + 1) | x(k + 1))
\]
Thanks to Ming Ge of Imperial College for pointing out this erratum.
79. Page 343, line 4 in boxed recursion. Change $w_i(k + 1) = w_i(k) \frac{\sum_{j=1}^{N} e_j \phi_j(r_j, w_i(k) + \phi_j(r_j, w_i(k)))}{\sum_{j=1}^{N} e_j \phi_j(r_j, w_i(k) + \phi_j(r_j, w_i(k)) + e_j \phi_j(r_j, w_i(k))}}$ to $w_i(k + 1) = \mu_i(k) \frac{\sum_{j=1}^{N} e_j \phi_j(r_j, w_i(k) + \phi_j(r_j, w_i(k)))}{\sum_{j=1}^{N} e_j \phi_j(r_j, w_i(k) + \phi_j(r_j, w_i(k)) + e_j \phi_j(r_j, w_i(k))}}$. Thanks to Ming Ge of Imperial College for pointing out this erratum. See also page 331.
80. Page 341, last sentence before 4.7.6. Change "increases with sample size" to "increases with time".
81. Page 346, second displayed equation. Change $P \rightarrow P$ to $P (two times)$. Thanks to Ming Ge of Imperial College for pointing out this erratum.
82. Page 360, Exercise 4.12, seventh line from bottom. Drop the trailing $C R^{-1}$ in formula for $L(k)$.
83. Page 364, Exercise 4.25, third displayed equation. Change $P \rightarrow P$ (two times). Thanks to Ming Ge of Imperial College for pointing out this erratum.
84. Page 371, last line. Change $x \rightarrow \tilde x$. Thanks to Paolo Fagani of Imperial College for pointing out this erratum and several of the Chapter 5 errata that follow.
85. Page 380, line 6 of paragraph after Proposition 5.3. Change $\tilde x(0) = \tilde x(0) - x(0)$ to $\tilde x(0) = x(0) - \tilde x(0)$.
86. Page 381, second line from bottom. Replace $V_i^0(\cdot)$ with $V_i^0(\cdot)$, and $k_i(\cdot)$ with $k_i(\cdot)$. Last line. Replace $V_i^0(x)$ with $V_i^0(\tilde x)$.
87. Page 382. Step 1 of robust control algorithm. Change $K(x - z) \rightarrow k(\tilde x - z)$. Thanks to He Kong of the University of Newcastle for pointing out this erratum.
88. Page 384, first line after last displayed equation. Change $\tilde x(0), e(0)$ to $\tilde x(0), e(0)$.
89. Page 386 (middle) and Page 395 (top). Change $A = BK$ to $A = BK$.
90. Page 386, second line from bottom. Change "$\tilde x(0)$ lies in $\Omega (0)$" to "$\tilde x(0)$ lies in $\Omega (0)$".
91. Page 387, third line. Change $\tilde x(i) = (\tilde x(i), e(i))$ to $\tilde x(i) = (\tilde x(i), e(i))$.
to
\[ \Delta V_n^\dagger(z, \tilde{x}, \tilde{r}, w, \tilde{u}) - V_n^\dagger(Az + \tilde{B}\tilde{r} + B\tilde{b}(z, \tilde{x}, \tilde{r}), \tilde{u} + \delta(x, \tilde{r}) - V_n^\dagger(z, \tilde{x}, \tilde{r}) \leq -c_1 \left\| \tilde{x} - 2\tilde{u}, \tilde{r} \right\|^2 + \Gamma \delta \tilde{u} \]

where \( k \) is a Lipschitz constant for \( V_n^\dagger(\cdot) \).

111. Page 398, last paragraph. Change \( W \) to \( A \) (two places).

112. Page 406, Exercise 5.5. Change \( d_H(A \oplus \mathbb{C}, \mathbb{B} \oplus \mathbb{C}) = d_H(A, \mathbb{B}) \) to \( d_H(A \oplus \mathbb{C}, \mathbb{B} \oplus \mathbb{C}) \leq d_H(A, \mathbb{B}) \).

Thanks to Dr. Sasa V. Rakovic for pointing out this erratum.

113. Page 406, Exercise 5.5, delete the phrase, "satisfying \( y \equiv A \)".

114. Page 406, Exercise 5.6, delete the phrase, "satisfying \( A \equiv \mathbb{B} \)".

115. Page 406, Exercise 5.8, replace \( + \) with \( \Theta \) (two places).

116. Page 417, last two lines of last displayed equation, include missing factors \( (1/2)p_{j 1} \) and \( (1/2)p_{j 2} \), in front of \( x_{10}(N) \) and \( x_{10}(N) \) terms. Thanks to Ganzhou Wang for pointing out this erratum.

117. Page 447, Assumption 6.12. Change (a) to: The systems \( (A_i, B_i) \), \( i = 1, 2 \), are stabilizable, in which \( A_i = \text{diag}(A_{ij}, A_{2i}) \) and \( B_i = \begin{bmatrix} B_{ij} \ & \ B_{2i} \end{bmatrix} \). Change (e) to: \( N \leq \max_{i \leq 10} n_{ij} \), in which \( n_{ij} \) is the number of unstable modes of \( A_i \).

118. Page 447, delete the following sentence.

Let \( \Sigma_j \) denote the solution of the Lyapunov equation
\[ \Sigma_j = \Sigma_j A_j^T + \Sigma_j = -N_j Q_{j1} N_j^T \]

Then change the first two sentences on page 448 from

We further define the matrices
\[ \Sigma_i = \text{diag}(\Sigma_{i1}, \Sigma_{i2}) \quad i \in 1, 2 \]

These matrices satisfy the Lyapunov equations

to the single sentence:

We further define the matrices \( \Sigma_{1}, \Sigma_{2} \) as the solutions to the Lyapunov equations.

Thanks to Brett Stewart of UW for pointing out this erratum.

119. Page 448, change \( u_1 \in U_1 \) \( u_2 \in U_2 \) to \( u_1 \in U_1 \) \( u_2 \in U_2 \) in the displayed equation before the last paragraph.

120. Page 450, last two lines of last displayed equation, include missing factors \( p_{j1} \) and \( p_{j2} \) in front of \( x_{10}(N) \) and \( x_{10}(N) \) terms. Same change on first displayed equation on page 451. Thanks to Ganzhou Wang for pointing out this erratum.

121. Page 452, Figure 6.6, change \( \Omega \) to \( \Upsilon \).

122. Page 457, optimization problem (6.28), change \( \min \) argument \( X_{12} \) to \( X_{11}, X_{12} \).