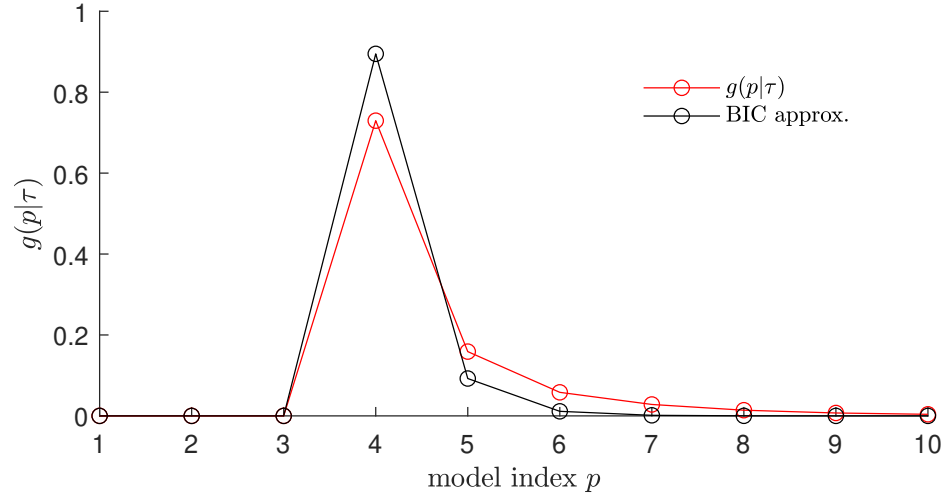


# Data Science and Machine Learning: Mathematical and Statistical Methods

## Errata

(Last Update 5th May 2022)

1. Page 33, definition of the Hilbert matrix:  $\mathbf{H}_p = \int_0^1 [1, u, \dots, u^{p-1}]^\top [1, u, \dots, u^{p-1}] du$ .
2. Page 37, line 3 from the top: replace  $\mathbb{E}Y_i$  with  $\mathbb{E}_{\mathbf{x}}Y_i$ .
3. Page 38, lines 3,4 in second paragraph: replace  $\ell_{\mathcal{T}_k}$  symbol with  $\ell_{C_k}$ .
4. Page 38, first line in displayed equation: replace  $\ell_{\mathcal{T}_k}$  symbol with  $\ell_{C_k}(g_{\mathcal{T}_k})$ .
5. Page 57, Figure 2.16. There was a mistake in the drawing of the BIC approximation. The actual BIC approximation matches the posterior density quite well:



6. Page 72, Line -2: ... in terms of the probability ... (remove repeated “the”).
7. Page 74, Lines 6 and 10 of `accrejgamma.py`: The parameter `lam` should be replaced with 4 for the proposal pdf `g`.
8. Page 74, Line -3. ... from state  $x_{t-1}$  to state  $x_t$  ...
9. Page 78, Algorithm 3.27 input: Replace  $q(\mathbf{x}, \mathbf{y})$  with  $q(\mathbf{y} | \mathbf{x})$ .
10. Page 85, Line 7: 0.025 and 0.975 quantiles
11. Page 98, Figure 3.10. Change “unnormalized” to “normalized” in the caption. Also, 0.4,0.2 should be 0.4, 0.2.
12. Page 100, Line -8:  $(1 - \alpha v)$  should be  $(1 - \alpha)v$ .
13. Page 103, line above 4th statement of Algorithm 3.4.4:  $X_{(1)}$  should be  $\mathbf{X}_{(1)}$ .
14. Page 104, Line 2:  $\lceil \cdot \rceil$  should be  $\lfloor \cdot \rfloor$ .

15. Page 108, Lines 5 and 11:  $\mathbb{E}S(\lambda)$  should be  $S(\lambda)$ .
16. Page 109, Line 12: 1.6 should be 0.6.
17. Page 110, Line -2: ... bits that *do not* match ...
18. Page 111, Caption of Figure 3.15: ... that *do not* match ...
19. Page 111, Line 4 under Figure 3.15: “maximize” should be “minimize”
20. Page 112, Lines 1-2: “Note that ...”. Should be deleted.
21. Page 112, Line 3: 200 should be 100.
22. Page 112, Line 8: “maximizer” should be “minimizer”
23. Page 112, Line 12: “maximum” should be “minimum”
24. Page 124, Equation (4.9):  $S(X; \theta)$  should be  $S(X | \theta)$
25. Page 145, Line 1 of Example 4.6: This refers to Figure 4.4, not Figure 4.8.
26. Page 149, Line -1:  $|d_{im} - d_{jm}|$  should be divided by 2.
27. Page 156, Line -5:  $u_\ell^\top$  should be  $\mathbf{u}_\ell^\top$ .
28. Page 151, Line -5: Figure 4.12 depicts the ellipsoid  $\mathbf{x}^\top \Sigma^{-1} \mathbf{x} = 1$ .
29. Page 160, Exercise 5:  $\mathbf{F}(\theta)$  should be  $\mathbf{F}(\theta)/n$ .
30. Page 162: Line 12:  $\Sigma^{1/2} \mathbf{x}$  should be  $\Sigma^{-1/2} \mathbf{x}$ .
31. Page 162: Lines 17 and 20:  $\Sigma^{1/2}(\mathbf{x}_i - \boldsymbol{\mu})$  should be  $\Sigma^{-1/2}(\mathbf{x}_i - \boldsymbol{\mu})$ .
32. Page 178: fourth line below Table 5.1: replace “qualitative” with “quantitative”.
33. Page 179, Line 5: For independent  $Y_1, \dots, Y_n$ , where each  $Y_i$  corresponds to the factor values  $u_{i1}, \dots, u_{ir}$ , let
34. Page 179, fourth line in Example 5.5: replace “row-wise” with “column-wise” and the vector  $\mathbf{y}$  with  $\mathbf{y} = [9.2988, 8.2111, 9.0688, 8.2552, 9.4978, \dots, 8.9485]^\top$ .
35. Page 179, Line -6. Estimation of  $\boldsymbol{\beta}$  ...
36. Page 181, formula for  $R_{\text{adjusted}}^2$  at the bottom: replace  $n - p - 1$  in the formula with  $n - p$ .
37. Page 184, formula for  $F_i$  should have the norms squared:
$$F_i = \frac{\|\mathbf{Y}^{(i)} - \mathbf{Y}^{(i-1)}\|^2 / p_i}{\|\mathbf{Y} - \mathbf{Y}^{(d)}\|^2 / (n - p)} .$$
38. Page 211, Exercise 12 (b):  $\mathbf{P}_{ii}$  should be  $(1 - \mathbf{P}_{ii})$ ; that is 1 minus the  $i$ -th leverage.

39. Page 219, Line -2: ... only  $\beta_1$  is regularized.
40. Page 221, Line 8: ... one obtains the so-called ...
41. Page 222, 5th line after Definition 6.1:  $\kappa(\mathbf{x}, \mathbf{x}')$  should be  $\kappa(\mathbf{x}', \mathbf{x})$ .
42. Page 235, Line 7:  $\int_0^1 (g''(x))^2 dx$  instead of  $\int_0^1 (g'')^2 dx$ .
43. Page 247, Algorithm 6.8.1, Line 1:  $\mathbb{R}^p$  should be  $\mathbb{R}^n$ .
44. Page 248, Algorithm 6.8.2, Line 1: Set  $\mathbf{B} \leftarrow (n\gamma\mathbf{I}_p)^{-1}$ .
45. Page 255, Line 5: Remove “ $\mathbf{L} = \mathbf{I}$  (identity matrix)”, as  $\mathbf{L}$  is not the identity matrix.
46. Page 260, equation above (7.13): Put a transpose  $^\top$  on the first  $\mu_0$  and  $\mu_1$ .
47. Page 261, Line 4 of middle paragraph: In the formula for  $b$ , put a transpose  $^\top$  on the first  $\mu_0$  and  $\mu_1$ .
48. Page 264, Line 8: Replace  $g_X(\mathbf{x})$  with  $g_X(\mathbf{x}|\boldsymbol{\theta})$
49. Page 273, 3rd line under Figure 7.9: The results are summarized in Table 7.6.
50. Page 288. Replace  $x_2 \leq -20.5$  with  $x_1 \leq -20.5$  in Figure 8.2 and in the referring text.
51. Page 289, Lines 4–5 of Section 8.2:  $x_1$  should be  $x_2$ .
52. Page 290, first line under Algorithm 8.2.1: change  $R_{v_T}$  and  $R_{v_F}$  to  $\mathcal{R}_{v_T}$  and  $\mathcal{R}_{v_F}$ . In the same line, the prediction functions should be  $g^T$  and  $g^F$ .
53. Page 290, first displayed equation:  $\mathbb{R}_v$  should be  $\mathcal{R}_v$ .
54. Page 291, line 2:  $g^v(\mathbf{x})$  should be  $g^w(\mathbf{x})$ .
55. Page 308, BaggingExample.py, line starting with “ids = ”: replace `x_test` with `x_train`, twice.
56. Page 310, Algorithm 8.6.1. Delete line 3 and replace line 4 with: Train a decision tree  $g_{\mathcal{T}_b^*}$  via Algorithm 8.2.1, where each split is performed using  $m$  randomly selected features out of  $p$ .
57. Page 313, formula (8.21):  $g_0$  should be  $g_0(\mathbf{x})$ .
58. Page 316, formula (8.23). Delete  $g_{b-1}(\mathbf{x}_i)$ .
59. Page 327, warning box: ...  $j$ -th node in the  $(l-1)$ -st layer with the  $i$ -th node in the  $l$ -th layer.
60. Page 329, line 2: Section 4.39 should be Equation (4.39).
61. Page 329, line 12 from below: change  $y_{i-k}$  to  $y_{i-k+1}$ .

62. Page 331, last displayed equation:

$$\frac{\partial C}{\partial \mathbf{b}_l} = \frac{\partial z_l}{\partial \mathbf{b}_l} \frac{\partial C}{\partial z_l} = \delta_l, \quad l = 1, \dots, L.$$

63. Page 333, line 4 of Example 9.4: “inputs  $y$ ” should be “inputs  $\mathbf{x}$ ”.

64. Page 333, lines –8, –7:  $\theta$  should be  $\boldsymbol{\theta}$  (three times).

65. Page 335, Algorithm 9.4.2, Line 2: ... using  $\frac{\partial C}{\partial \mathbf{g}} = 1$  ...

66. Page 336, the secant condition  $\mathbf{C}_t \mathbf{g}_{t-1} = \boldsymbol{\delta}_{t-1}$  should read  $\mathbf{C}_t \mathbf{g}_t = \boldsymbol{\delta}_t$ , and the definitions on the next line should read  $\boldsymbol{\delta}_t := \boldsymbol{\theta}_t - \boldsymbol{\theta}_{t-1}$  and  $\mathbf{g}_t := \mathbf{u}_t - \mathbf{u}_{t-1}$ .

67. Page 336, Equation (9.7): replace  $\mathbf{C}_{t+1}$  with  $\mathbf{C}_t$  and  $\mathbf{C}_t$  with  $\mathbf{C}_{t-1}$  to obtain:

$$\mathbf{C}_t = \left( \mathbf{I} - v_t \mathbf{g}_t \boldsymbol{\delta}_t^\top \right)^\top \mathbf{C}_{t-1} \left( \mathbf{I} - v_t \mathbf{g}_t \boldsymbol{\delta}_t^\top \right) + v_t \boldsymbol{\delta}_t \boldsymbol{\delta}_t^\top, \quad v_t := (\mathbf{g}_t^\top \boldsymbol{\delta}_t)^{-1}.$$

68. Page 337, Equation (9.9): replace  $i$  with  $j$  two times.

69. Page 337, line 3: change “At each iteration” to “At the final iteration”.

70. Page 337, line 5: change “By iterating this recursion” to “By iterating the recursion (9.7)”.

71. Page 338, Algorithm 9.4.3, second line from top: the equation  $\mathbf{C}_h = \left( \mathbf{I} - v_j \boldsymbol{\delta}_j \mathbf{g}_j^\top \right) \mathbf{C}_{t-1} \left( \mathbf{I} - v_j \mathbf{g}_j \boldsymbol{\delta}_j^\top \right) + v_j \boldsymbol{\delta}_j \boldsymbol{\delta}_j^\top$  should read  $\mathbf{C}_t = \left( \mathbf{I} - v_t \boldsymbol{\delta}_t \mathbf{g}_t^\top \right) \mathbf{C}_{t-1} \left( \mathbf{I} - v_t \mathbf{g}_t \boldsymbol{\delta}_t^\top \right) + v_t \boldsymbol{\delta}_t \boldsymbol{\delta}_t^\top$ .

72. Page 338, line 2 from below: identities should read  $\boldsymbol{\delta}_t = \boldsymbol{\theta}_t - \boldsymbol{\theta}_{t-1}$  and  $\mathbf{g}_t = \mathbf{u}_t - \mathbf{u}_{t-1}$ .

73. Page 339, Equation (9.10): the summation should go to  $t$ , not  $h$ . On the next line  $\mathbf{u}_k$  should also be changed to  $\mathbf{u}_t$ .

74. Page 340, line 3 and 4 from above: Replace  $\boldsymbol{\delta}_{t-1}$  with  $\boldsymbol{\delta}_t$  two times.

75. Page 340, second displayed line:

$$[p_0, p_1, p_2, p_3] = [1, 20, 20, 1].$$

76. Page 341, Line 3: Remove the line  $\mathbf{S} = \text{RELU}$ .

77. Page 351, Exercise 7(b): In the displayed formula,  $\mathbf{B}$  should be replaced with  $\mathbf{B}^{-1}$ .

78. Page 353, in Exercise 8: replace  $\mathbf{C}_{t+1}$  with  $\mathbf{C}_t$  and  $\mathbf{C}_t$  with  $\mathbf{C}_{t-1}$ .

79. Page 361, 3rd line in the proof of Theorem A.3:  $\{v_i\}$  should be  $\{v_i\}$ .

80. Page 362, First sentence in paragraph above Theorem A.4: ... the matrix  $\mathbf{P}$  projects any vector in  $\mathcal{V}$  onto itself.

81. Page 362, Sentence above Theorem A.4: ... where  $\mathbf{U}$  is not ...

82. Page 376, last displayed equation: Replace  $[x_1, x_2]$  with  $\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ .
83. Page 377, Lines 6,7:  $u_n$  should be  $u_m$  and  $\mathbb{C}^n$  should be  $\mathbb{C}^m$ .
84. Page 378, line 3: Replace  $\mathbf{V}^\top$  with  $\mathbf{V}$ .
85. Page 380, third line from below: change  $b_{i-k}$  to  $b_{i-k+1}$ .
86. Page 386, equation A.35: replace  $\sum_{j=0}^{\infty} \frac{\sin(2j+1)}{2j+1}$  with  $\sum_{k=1}^{\infty} \frac{\sin(kx)}{k}$ .
87. Page 394, line 5: ... can be computed with the aid ... (missing “the”)
88. Page 385, halfway: ... counting measure on  $\mathbb{Z}^d$ .
89. Page 400, first two lines of Section B.1.2:  $f : \mathbb{R}^k \rightarrow \mathbb{R}^m$ ,  $g : \mathbb{R}^m \rightarrow \mathbb{R}^n$ , and  $g \circ f$  is a function from  $\mathbb{R}^k$  to  $\mathbb{R}^n$ .
90. Page 401, Line –1: By Theorem A.8 ...
91. Page 405, Line 8: replace “ $f(\mathbf{x} + t_1 \mathbf{d}) \geq f(\mathbf{x}) + t_1 \mathbf{v}^\top \mathbf{d}$  and  $f(\mathbf{x} + t_2 \mathbf{d}) \geq f(\mathbf{x}) + t_2 \mathbf{v}^\top \mathbf{d}$  for some subgradient  $\mathbf{v}$ ” with “ $f(\mathbf{a}) \geq f(\mathbf{b}) + (\mathbf{a} - \mathbf{b})^\top \mathbf{v}$  for some subgradient  $\mathbf{v}$ ” and replace “Subtracting the last two equations” with “Substituting with  $\mathbf{a} = \mathbf{x} + t_1 \mathbf{d}$  and  $\mathbf{b} = \mathbf{x} + t_2 \mathbf{d}$ ”.
92. Page 404, last two lines: replace  $H$  with  $\mathbf{H}$ .
93. Page 414, Section B.3.4: Replace  $\ell$  with  $\ell_\tau$ .
94. Page 417, line 2 of 3-rd paragraph: replace  $i$  with  $j$  in “the equalities  $g_j(\mathbf{x}) + s_j = 0$  for all  $i$ .”
95. Page 418, line 2: replace  $\mathbf{B}^\top$  with  $\mathbf{B}$ .
96. Page 433, displayed equation in the proof of Theorem C.4: replace  $|\mathbf{J}_{\mathbf{g}^{-1}}(\mathbf{z})|$  with  $|\det(\mathbf{J}_{\mathbf{g}^{-1}}(\mathbf{z}))|$ .
97. Page 439, line 4: is equal to  $\Gamma(\alpha)\lambda^{-\alpha}$  times ...
98. Page 442, 4th line from the bottom:  $x \geq c$  should be  $x > c$ .
99. Page 445, halfway on the page:  $|e^{ix} - 1| = \left| \int_0^x i e^{i\theta} d\theta \right| \leq \left| \int_0^x |i e^{i\theta}| d\theta \right| = |x|$ .
100. Page 446, displayed equation below (C.37):  $O(t/n)$  should be  $o(t/n)$ , and in the next displayed equation,  $o(1)$  should be  $o(1/n)$ .
101. Page 448, line 2:  $O(t^3/n^{3/2})$  should be  $o(t^2/n)$ .
102. Page 450, first displayed equation after (C.39): The  $\Sigma$  in the denominator should be  $\Sigma_n$ .
103. Page 451: Delete “ln” after “An application ... yields”

104. Page 451, line starting with “asymptotically negligible”: Replace  $n$  with  $-n$  in the exponent.
105. Page 456, Sentence under (C.47): Similar to the one-dimensional case ( $d = 1$ ), replacing the factor  $1/n$  with  $1/(n - 1)$  gives an unbiased estimator, called the *sample covariance matrix*.
106. Page 457, last line of Example C.13:  $g'(\theta)$  should be  $l'(\theta)$ .
107. Page 511, line 13 from above: ‘expectation of’.