Third and fourth printings

Chapter 2

page 22 Eq. 5: Change "$P(error, x)$" to "$p(error, x)$"

page 27 *line -1* above Sect. 2.3.1: Change "gets smaller, as it should." to "gets larger, as it should." [Figure 2.3 is altered to have $\theta_b < \theta_a$.]

page 34 Eq. 44: Change "$\mathbf{\Phi\Lambda}^{-1/2}$" to "$\mathbf{\Phi\Lambda}^{-1/2}\mathbf{\Phi}^t$"

page 47 Equation 75: The $\mathbf{\Sigma}_1$ and $\mathbf{\Sigma}_2$ are interchanged. (This error also appears in Keinosuke Fukunaga, **Introduction to Statistical Pattern Recognition** (2nd ed.) Academic Press 1990, Eq. 3.150, page 98.) Equation 75 should read:

$$\begin{aligned} k(\beta) &= \frac{\beta(1-\beta)}{2}(\boldsymbol{\mu}_1 - \boldsymbol{\mu}_2)^t \left[(1-\beta)\mathbf{\Sigma}_1 + \beta\mathbf{\Sigma}_2\right]^{-1}(\boldsymbol{\mu}_1 - \boldsymbol{\mu}_2) \\ &\quad + \frac{1}{2}\ln\frac{(1-\beta)\mathbf{\Sigma}_1 + \beta\mathbf{\Sigma}_2}{|\mathbf{\Sigma}_1|^{1-\beta}|\mathbf{\Sigma}_2|^{\beta}}. \end{aligned}$$

page 47 *third line after Eq. 75*: Change "that minimizes $e^{-k(\beta)}$" to "that minimizes $P^{\beta}(\omega_1)P^{1-\beta}(\omega_2)e^{-k(\beta)}$"

page 48 Example **2**, *line +3*: Change "4.11," to "4.11157,"

page 48 Example **2**, *line +4*: Change "0.016382." to "0.008191."

page 48 Example **2**, second paragraph: Change "A tighter bound" to "A slightly tighter bound"

page 48 Example **2**, second paragraph, *line +2*: Change "0.016380" to "0.008190."

page 53 Bottom equation (for w_0): Change "= 1.2" to "= -1.75"

page 58 In the figure, the entry for $P(c_3|x_1)$ should be changed from 0.1 to 0.2.

page 59 *top equation*: Change

$$\begin{aligned} &= 0.25 \times 0.6 \times 0.4 \times 0.5 \times 0.4 \\ &= 0.012. \end{aligned}$$

to

$$\begin{aligned} &= 0.25 \times 0.6 \times 0.6 \times 0.5 \times 0.4 \\ &= 0.018. \end{aligned}$$

page 60 Equation 99: Change "$\mathbf{X}$" to "$\mathbf{x}$" in two places

page 61 *third line after Eq. 101*: Change "α 0.066" to "α 0.042"

page 61 *fourth line after Eq. 101*: Change "$P(x_1|c_1, b_2) = 0.63$ and $P(x_2|c_1, b_2) = 0.37$" to "$P(x_1|c_1, b_2) = 0.73$ and $P(x_2|c_1, b_2) = 0.27$"

page 61 Eq. 102: Replace equation by "$P(\mathbf{a}, \mathbf{b}|\mathbf{x}) = P(\mathbf{a}|\mathbf{x})P(\mathbf{b}|\mathbf{x})$"

page 71 Problem **20**, part (c), *line +2*: Change "standard deviation σ^2" to "standard deviation σ"

page 71 Problem **21**, *line +2*: Change "standard deviation σ^2" to "standard deviation σ"

page 73 Problem **34**, *line +6–7*: Change "assume the distributions" to "assume $P(\omega_1) = P(\omega_2) = 0.5$ and the distributions"

page 73 Problem **34**, part c), *line +4*: Change "Bayes error is 0.5." to "Bayes error is 0.25."

Chapter 3

page 87 *line -5*: Change "$l(\boldsymbol{\theta})p(\boldsymbol{\theta})$" to "$l(\boldsymbol{\theta}) + \ln p(\boldsymbol{\theta})$"

page 97 *line +3*: Change "Problem 17" to "Problem 18'

page 99 Caption to first figure, change "starts our as a flat" to "starts out as a flat"

page 102 *line 5*: Change "*invarinace*" to "*invariance*"

page 102 *first line after Eq. 54*: Change "paramter" to "parameter"

page 104 Eq. 62: Change "$= \frac{P(\mathcal{D}|\mathbf{s},\boldsymbol{\theta})}{\sum_{\mathcal{D}\in\bar{\mathcal{D}}} P(\mathcal{D}|\mathbf{s},\boldsymbol{\theta})}$" to "$= \frac{P(\mathcal{D},\mathbf{s}|\boldsymbol{\theta})}{\sum_{\mathcal{D}\in\bar{\mathcal{D}}} P(\mathcal{D},\mathbf{s}|\boldsymbol{\theta})}$"

page 107 First unnumbered equation: Change "$\mathbf{c}(\mathbf{x})$" to "$\mathbf{c}(\mathbf{x}_k)$"

page 107 *2 lines above Eq. 71*: Change "Problem 30" to "Problem 31"

page 111 *line -6*: Change "its determinant is an $O(d^2)$" to "its determinant is an $O(d^3)$"

page 111 Eq. 74: Change the annotations above the equation from "$O(dn)\quad O(nd^2)\quad O(1)\quad O(d^2n)\quad O(n)$" to "$O(dn)\quad O(nd^3)\quad O(1)\quad O(d^3)\quad O(n)$"

page 126 *first line of the equation at the middle of the page*: Change

$$Q(\boldsymbol{\theta};\ \boldsymbol{\theta}^0) = \mathcal{E}_{x_{41}}[\ln p(\mathbf{x}_g, \mathbf{x}_b;\ \boldsymbol{\theta}|\boldsymbol{\theta}^0;\ \mathcal{D}_g)]$$

to

$$Q(\boldsymbol{\theta};\ \boldsymbol{\theta}^0) = \mathcal{E}_{x_{41}}[\ln p(\mathbf{x}_g, \mathbf{x}_b;\ \boldsymbol{\theta})|\mathcal{D}_g;\ \boldsymbol{\theta}^0]$$

page 127 *lines -2– -1*: Change "$x_{41} = 2$, so that $\mathbf{x}_4 = \binom{2}{4}$" to "$x_{41} = 1$, so that $\mathbf{x}_4 = \binom{1}{4}$"

page 133 Figure 3.10, change the label on the horizontal arrow from "a_{12}" to "a_{22}"

page 138 Algorithm 5, line 5: Change "$\hat{a}_{ij}(z-1)$" to "$\hat{a}_{ij}(z)$"

page 138 Algorithm 5, line 6: Change "$\hat{b}_{ij}(z-1)$" to "$\hat{b}_{ij}(z)$"

page 143 Problem **11**, second and third lines after first equation: Change "$p_2(\mathbf{x})$ by a normal $p_1(\mathbf{x}) \sim N(\boldsymbol{\mu}, \boldsymbol{\Sigma})$" to "$p_1(\mathbf{x})$ by a normal $p_2(\mathbf{x}) \sim N(\boldsymbol{\mu}, \boldsymbol{\Sigma})$"

page 143 Problem **11**: Second equations: Change "$\mathcal{E}_2$" to "$\mathcal{E}_1$" in two places

page 143 Problem **11**, last line: Change "over the density $p_2(\mathbf{x})$" to "over the density $p_1(\mathbf{x})$"

page 149 Problem **31**, *line 1*: Change "suppose a and b are positive constants and" to "suppose a and b are constants greater than 1 and"

page 151 Problem **38 (b)** bottom equation on page: Change "$(\boldsymbol{\mu}_1 - \boldsymbol{\mu}_2)^2$" to "$(\mu_1 - \mu_2)^2$"

page 156 Computer exercise 2, after the equation: Change "calculate a density" to "calculate the density"

page 156 Computer exercise 2. After "x_2 feature of category ω_2." add "Assume your priors on the parameters are uniform throughout the range of the data."

page 159 Computer exercise **13** table, sample 4 under ω_1: Change "`AD`" to "`ADB`"

Chapter 4

page 173 *Algorithm 1*, *line 5*: Change "$\mathbf{x} \in \omega_i$" to "$\mathbf{x}_j \in \omega_i$"

page 173 *line after Eq. 28*: Change "each output unit" to "each category unit"

page 173 *two lines above Eq. 29*: Change "activation function function" to "activation function"

page 178 *line +3*: Change "Becuase" to "Because"

page 185 *line 1*: Change "$O(dn^2)$" to "$O(dn)$"

page 192 *line -7*: Change "is that that in the extreme cases the" to "is that in the extreme cases when the"

page 194 *3 lines above numbered list*: Change "we should deman" to "we should demand"

page 194 *one line above numbered list*: Change "Cox-Jaynes axioms):" to "Cox-Jaynes axioms), which includes:"

page 196 *Algorithm 4*, *line 4*: Change the small element below from "$\mathbf{x} \notin \omega_i$" to "$\mathbf{x}' \notin \omega_k$"

page 196 *Algorithm 4*, *line 5*: Replace equation portion by "$\lambda_j \leftarrow \min[\max[D(\hat{\mathbf{x}}, \mathbf{x}'), \epsilon], \lambda_m]$"

page 200 *line -8*: Change "Jayne" to "Jaynes"

page 202 Problem **6** part (c), first line: Change "increases" to "increase"

page 207 Problem **26** part (d), first line: change "Calculate the probability" to "Estimate through simulation the probability"

page 207 Problem **26** delete part (e)

page 213 Replace reference [23] with: "Edwin T. Jaynes and G. Larry Bretthorst, *Probability Theory: The Logic of Science*, Cambridge U. Press, 2003."

Chapter 5

page 218 Figure 5.3, bottom sub-figure: The pink "ambiguous" region should not include the three small triangles $\Delta H_{14}H_{23}H_{24}$, $\Delta H_{24}H_{13}H_{34}$, $\Delta H_{34}H_{12}H_{23}$ nor the quadralateral $\Box H_{14}H_{34}H_{24}H_{12}$.

page 220 sentence before Eq. 5, Change "this in turn suggest" to "this in turn suggests"

page 221 *line +8*: Change "Figure 5.6 shows" to "Figure 5.5 shows"

page 221 *line -11*: Change "$O(\hat{d}^k)$" to "$O(d^k)$"

page 229 Caption to Figure 5.12, *line +4*: Change "this sequence is $\mathbf{y}_2$, $\mathbf{y}_3$, $\mathbf{y}_1$, $\mathbf{y}_3$" to "this sequence is $\mathbf{y}_1 + \mathbf{y}_2 + \mathbf{y}_3$, $\mathbf{y}_2$, $\mathbf{y}_3$, $\mathbf{y}_1$, $\mathbf{y}_3$"

page 250 Equation 79: Change "$\mathbf{a}(k)$" to "$\mathbf{b}(k)$"

page 251 Algorithm 11, *line 5*: Change "$\mathbf{a}$" to "$\mathbf{b}$"

page 252 *second unnumbered equation below Eq. 84, middle*: Change "$-\eta\mathbf{e}^t(k)\mathbf{e}^{+t}(k)$" to "$-\eta\mathbf{e}^t(k)\mathbf{e}^{+}(k)$"

page 254 line after Eq. 90: Change "constant, positive-definite" to "constant, symmetric, positive-definite"

page 255 First (unnumbered) equation on page: Change the first term in parentheses on the right-hand side from "$\eta^2\mathbf{YRY}^t\mathbf{YRY}$" to "$\eta^2\mathbf{YRY}^t\mathbf{YRY}^t$"

page 255 Eq. 92: Last term on the right-hand-side, change "$\eta^2\mathbf{RY}^t\mathbf{R}$" to "$\eta^2\mathbf{RY}^t\mathbf{YR}$"

page 266 *line +3*: Change "that $\mathbf{y} \in \mathcal{Y}_1$" to "that $\mathbf{y}_k \in \mathcal{Y}_1$"

page 266 Eq. 113: Change "$\hat{\mathbf{a}}_i^t\mathbf{y}_k$" to "$\hat{\mathbf{a}}_1^t\mathbf{y}_k$"

page 266 *9 lines above Sect. 5.12.2*: Change "we construct $(c-1)c\hat{d}$-dimensional" to "we construct $(c-1)c\ \hat{d}$-dimensional" (that is, add a space)

page 266 *8 lines above Sect. 5.12.2*: Change "into $c\hat{d}$-dimensional" to "int $c\ \hat{d}$-dimensional" (that is, add a space)

page 271 Problem **2**, *line +1*: Change "$\mathbf{w}^t\mathbf{x}$" to "$\mathbf{w}_i^t\mathbf{x}$"

page 272 Problem **7**, *line +3*: Change "may not be linearly" to "may not be totally linearly"

page 274 Problem **22**, second term on the right-hand side change "$(\mathbf{a}^t\mathbf{y} - (\lambda_{12} - \lambda_{22}))^2$" to "$(\mathbf{a}^t\mathbf{y} + (\lambda_{12} - \lambda_{22}))^2$"

page 275 Problem **27**, last line: Change "by Eq. 85." to "by Eq. 95."

page 278 Problem **1**, part (a), *line +1*: change "data in in order" to "data in order"

page 278 Problem **1**, part (a), *line +2*: change "use $\eta(k) = 0.1$." to "use $\eta(k) = 0.01$."

page 278 First heading after the table: Change "**Section 5.4**" to "**Section 5.5**"

page 278 Computer Exercise 1: Change "(Algorithm 1) and Newton's algorithm (Algorithm 2) applied" to "(Algorithm 1) and the Perceptron criterion (Eq. 16) applied"

page 278 Second heading after the table: Delete "**Section 5.5**"

page 279 *line +1*: Change "length is greater than the pocket" to "length is greater than with the pocket"

Chapter 6

page 291 Two lines before Eq. 3: Change "hidden-to-output weights, w_{ij}" to "hidden-to-output weights, w_{kj}"

page 292 After Eq. 19, *line +3*: Change "activiation" to "activation"

page 293 Figure 6.5: Change "w_{ij}" to "w_{ji}"

page 294 Algorithm 2, *line 3*: Change "$\Delta w_{kj} \leftarrow$" to "$\Delta w_{kj} \leftarrow 0$"

page 295 Second paragraph in Section 6.3.3: Change "indpendently selected" to "independently selected"

page 302 *line +3–4*: Change "weights merely leads" to "weights merely lead"

page 305 *line 10*: Change "ratio of such priors." to "ratio of such priors, though this need not ensure minimal error."

page 314 *line +6*: Change "weight changes are response" to "weight changes are a response"

page 330 *line -2– -1*: Change "While it is natural" to "It is natural"

page 337 Problem **8**, pagt (b) *line +2*: Change "if the sign if flipped" to "if the sign is flipped"

page 340 Problem **26**, equation: Change "$-b\ net$" to "$-2b\ net$" in three places

page 346 Problem **10**, part (c), *line +3*: Change "$\mathbf{x}_5 = (0, 0, 0)^t$" to "$\mathbf{x}_5 = (0, 0, 1)^t$"

Chapter 7

page 352 Caption to Figure 7.1, *line -1*: Change "$0 \leq \alpha \leq 2^{10}$" to "$0 \leq \alpha < 2^{10}$"

Chapter 8

page 396 *2 lines above Sect. 8.3*: Change "knowledge if of greatest" to "knowledge is of greatest"

page 405 Table at top, x_2 entry in fifth row under ω_1, change ".48" to ".44"

page 409 *line -7*: Change "queries involves" to "queries involve"

page 413 8.5, lines 3 – 4: Change "nucleic acids" to "bases"

page 416 Algorithm 2, line 2: Change "$\mathcal{F}(\mathbf{x})$" to "$\mathcal{F}$"

page 416 Algorithm 2, line 3: Change "$\mathcal{G}(\mathbf{x})$" to "$\mathcal{G}$"

page 416 Algorithm 2, line 11: Change "$\mathcal{G}(0)$" to "1"

page 416 Algorithm 2, lines 9–12: These lines are indented too far to the right. They should be moved the same distance to the left so the **if** of line 9 is directly under the **while** of line 7, and lines 10–12 are indented slightly farther to the right.

page 416 *line -1*: Change "$\mathcal{F}(\mathbf{x})$" to "$\mathcal{F}$"

page 417 *lines -9 – -4*, Replace last full paragraph by "Consider target string $\mathbf{x}$. Each location j (for $j < m$) defines a suffix of $\mathbf{x}$, that is, $\mathbf{x}[j+1, \ldots, m]$. The *good-suffix function* $\mathcal{G}(j)$ returns the starting location of the right-most instance of another occurrence of that suffix (if one exists). In the example in Fig. 8.8, $\mathbf{x} =$ `estimates` and thus $j = 8$ defines the suffix `s`. The right-most occurrence of another `s` is 2; therefore $\mathcal{G}(8) = 2$. Similarly $j = 7$ defines the suffix `es`. The right-most occurrence of another `es` is 2; therefore $\mathcal{G}(7) = 1$. No other suffix appears repeatedly within $\mathbf{x}$, and thus $\mathcal{G}$ is undefined for $j < 7$."

page 424 *line -7, right-hand side of equation*: Change "$\alpha x \beta$" to "$\alpha \gamma \beta$"

page 424 *line -5*: Change "x is an intermediate or terminal symbol" to "γ is a string made up of intermediate or terminal symbols"

page 424 *line -4*: Change "as x in" to "as γ in"

page 425 *top equation*: Change "x" to "γ"

page 245 *line +1* Change "and x an intermediate or termal symbol" to "and γ is a string made up of intermediate or terminal symbols"

page 425 *line +3*: Change "rewriting of I by x." to "rewriting of I by γ."

page 438 Problem **5**, *line +2*: Change "Eqs. 1 and 5." to "Eqs. 1 and 5 for the case of an arbitrary number of categories."

page 438 Problem **6** after the first set of equations: Replace the $i^*(\boldsymbol{\alpha})$ equation by "$i*(\alpha) = i(\alpha P^a(\omega_1) + (1-\alpha)P^b(\omega_1), ..., \alpha P^a(\omega_c) + (1-\alpha)P^b(\omega_c))$"

page 438 Problem **6** last line before part (a): Replace line by "then we have $i^* \geq \alpha i_a + (1-\alpha) i_b$."

page 446 Table, sample 12: Change "D" to "E"

page 447 Computer exercise **3**, part b): Change "{C, D, J, L, M}" to "{C, E, J, L, M}"

Chapter 9

page 460 Table for rank $r = 3$, third row: Change "$\mathbf{x}_1\ OR\ \mathbf{x}_3\ OR\ \mathbf{x}_3$" to "$\mathbf{x}_1\ OR\ \mathbf{x}_3\ OR\ \mathbf{x}_4$"

page 461 *Equation 6, in the lower limit on the summation*: Change "$r-2$" to "$r = 2$"

page 468 Five lines after Eq. 12: Change "regardless the *amount*" to "regardless of the *amount*"

page 468 *two lines above Eq. 16*: Change "error rate $\Pr[g(\mathbf{x};\ \mathcal{D})] = y$" to "error rate $\Pr[g(\mathbf{x};\ \mathcal{D})] \neq y$"

page 468 *Eq. 16, lhs*: Change "$\Pr[g(\mathbf{x};\ \mathcal{D})] = y$" to "$\Pr[g(\mathbf{x};\ \mathcal{D})] \neq y$"

page 468 *Eq. 17, lhs*: Change "$\Pr[g(\mathbf{x})] = y$" to "$\Pr[g(\mathbf{x})] \neq y$"

page 468 *Eq. 17, rhs*: Change "$\Pr[y_B(\mathbf{x}) = y]$" to "$\Pr[y_B(\mathbf{x}) \neq y]$"

page 469 *Eq. 21*: Change "$e^{-1/2u^2}$" to "$e^{-u^2/2}$"

page 474 Caption to Figure: Change "and jackknife estimate" to "and whose jackknife estimate"

page 497 Equation 58: Change "$\boldsymbol{\mu}_r$" to "$\boldsymbol{\theta}_r$" in two places

page 505 Take the heading "**Section 9.4**" and move it to the top of the page, i.e., between Problems **20** and **21**.

page 507 Problem **39** part **2**, last line: Change "full circle" to "full circular disk"

page 508 Problem **45**, *line +2*: Change "$N(\boldsymbol{\mu}, \boldsymbol{\Sigma})$" to "$N(\boldsymbol{\mu}_r, \boldsymbol{\Sigma}_r)$"

Chapter 10

page 526 *line -1* Change "In the absense" to "In the absence"

page 529 *line -1*: Change "as given by Eq. 17." to "that is, each point belongs in only one cluster."

page 541 *line +9*: Change "this is a symmetric functions" to "this is a symmetric function"

page 541 two lines after Eq. 52: Change "Tanimoto coefficient or *Tanimoto distance*" to "Jaccard coefficient or *Jaccard distance*"

page 541 In margin: Change "TANIMOTO DISTANCE" to "JACCARD DISTANCE"

page 545 *line -6*: Change "Furthermore, $\mathbf{S}_B$" to "Furthermore, $\mathbf{S}_W$"

page 549 *Eq. 75, middle line, rhs, subscript on the summation*: Change "$\mathbf{x} \in \mathcal{D}_i$" to "$\mathbf{x} \in \mathcal{D}_j$"

page 549 Eq. 76: Change "$\mathbf{m}$" to "$\mathbf{m}_i$" on the righthand side.

page 552 *Algorithm 4, line 5*: Change "$c = \hat{c}$" to "$\hat{c} = c$"

page 553 *one line above* **The Nearest-Neighbor Algorithm**: Change "$O(cn^2d)$" to "$O(n^2(c+d))$"

page 556 *Algorithm 5, line 5*: Change "$c = \hat{c}$" to "$\hat{c} = c$"

page 557 *line 14 of Sect. 10.10*: Change "decrease rapidly until $\hat{c} = c$" to Change "decrease rapidly until $c = \hat{c}$"

page 558 Last full paragraph, *line +1*: Change "This result agrees with out statement" to "This result agrees with our statement"

page 559 *last three lines*: Change "For reasons that will become clear, each d-dimensional pattern is augmented (with $x_0 = 1$) and normalized" to "Each d-dimensional pattern is augmented (with $x_0 = 1$) and, for reasons that will become clear, normalized"

page 571 *line -1*: Change "Jacobean" to "Jacobian"

page 573 Eq. 107: Put the lower limit underneath the summation sign, that is, change "$\sum_{i<j}$" to "$\sum\limits_{i<j}$"

page 573 Eq. 109: Put the lower limit underneath the summation sign, that is, change "$\sum_{i<j}$" to "$\sum\limits_{i<j}$"

page 574 First equation: Put the lower limit underneath the summation sign, that is, change "$\sum_{i<j}$" to "$\sum\limits_{i<j}$"

page 574 Third equation: Put the lower limit underneath the summation sign, that is, change "$\sum_{i<j}$" to "$\sum\limits_{i<j}$"

page 576 Eq. 112: Put the lower limit underneath the summation sign, that is, change "$\sum_{i<j}$" to "$\sum\limits_{i<j}$"

page 577 Chaption Figure 10.28, line -3: Change "sensed point, thought" to "sensed point, though"

page 577 Eq. 113: Change "$\boldsymbol{\phi}_i$" to "$(\boldsymbol{\phi}_i - \mathbf{w}_{ki}(t))$"

page 584 Problem **4** part (a), right-hand side: Change "$\mathbf{x}_i$" to "x_j"

page 585 Problem **4** part (b): Change "$\hat{\boldsymbol{\theta}}_i$" to "$\hat{\boldsymbol{\theta}}$" in two places only on the right-hand side of the equation.

page 589 Problem **24** part (b), Change "the trace criterion" to "the determinant criterion"

Appendix

page 608 Section A.2.5 *line +5*: Change "In this case the absolute value of the determinant" to "In this case the determinant"

page 624 Equation 98: Change "$n\Gamma(n-1)$"to "$(n-1)\Gamma(n-1)$"

Index

page 645 column 2, insert an entry for: "Jaccard coefficient, 541"

page 648 column 1, entry for metric, Tanimoto: delete reference to page "541"