

Errata for

Foundations of Computational Imaging

A Model Based Approach

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For copies from the *first* printing

This document lists all known errors in the **first printing** of the book. To identify your printing, look in the upper left of the copyright page, where a row of digits appears. The smallest number in the row is the printing number.

So if you have the first printing, it should look like this:

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10 9 8 7 6 5 4 3 2 1

Section 1 lists the errors that were corrected in the second printing, and Section 2 lists the errors found after the second printing was produced. A first-printing copy needs the corrections from both sections.

If you find any error, please email me at bouman@purdue.edu or Charles.Bouman@gmail.com, and I will add your error to this list, so it can be corrected in future printings of the book.

Thank you so much for your support!

Charles A. Bouman

1 First Printing Corrections:

This section contains the list of errors that were corrected in the second printing of the book. If you own a copy of the book printed on or before 2024, use both these

1. Chapter 1: page 6: line 10: (Thanks Jim Fowler!)
 “Then the “thickness” of the manifold at the location $X_r, r \neq s$, is approximately σ_s .
 $\Rightarrow$
 “Then the “thickness” of the manifold at this location is approximately σ_s .”

2. Chapter 2: page 18:
 “... to determine the function, $T : \mathfrak{R}^n \rightarrow \Omega$, that...”
 $\Rightarrow$
 “... to determine the function, $T : \mathfrak{R}^p \rightarrow \Omega$, that...”

3. Chapter 2: page 19: footnote: (Thanks Jim Fowler!)

$$\lim_{n \rightarrow \infty} P_\theta \{|\theta - \hat{\theta}| > \varepsilon\} = 0$$

$$\Rightarrow$$

$$\lim_{n \rightarrow \infty} P_\theta \{|\theta - \hat{\theta}_n| > \varepsilon\} = 0$$

4. Chapter 3: page 36:
 “Since the combination of ε and $X_0, \dots, X_{n-1}$ is jointly Gaussian, ...”
 $\Rightarrow$
 “Since the combination of ε and $X_1, \dots, X_{n-1}$ is jointly Gaussian, ...”

5. Chapter 4: page 57: “Example 4.2” $\rightarrow$ “Example 4.1”

6. Chapter 5: page 73: (Thanks Vivek Goyal!)
 The constant α in equation (5.29) is defined differently from the constant α in the previous sections and in particular in equation (5.13).

So in order to keep the definition of α consistent with the previous section, the following corrections should be made to equations in Section 5.3.3.

(5.23 correction)	$d^{(k)} = -\sigma^2 \nabla f(x^{(k)})$
(5.28 correction)	$d^{(k)} = A^t(y - Ax^{(k)}) - \sigma^2 Bx^{(k)}$
(5.29 correction)	$\alpha^{(k)} = \frac{\ d^{(k)}\ ^2}{\ d^{(k)}\ _H^2}$

7. Chapter 7: page 100: line 10: (Thanks Jim Fowler!)
 “Moreover, if the function $f(x)$ is strictly convex, than any such global minimum will be unique.”
 $\Rightarrow$
 “Moreover, if the function $f(x)$ is strictly convex, then any such global minimum will be unique.”

8. Chapter 8: page 114: bottom of page

“It can be shown that in fact the constraint is met for any potential function ... that the influence function is convex for $\Delta < 0$.”

$\Rightarrow$

“It can be shown that in fact the constraint is met for any symmetric potential function whose associated influence function, $\rho'(\Delta)$, is monotone increasing near $\Delta = 0$, and concave for $\Delta > 0$. (See problem 3)”

9. Chapter 8: page 118: line 14: above equation (8.23): (Thanks Jim Fowler!)

“...where it can be shown that (See problem 4)...”

$\Rightarrow$

“...where it can be shown that...”

Actually, there is a missing problem that should have label

`\label{hw:DerivativesForGeneralLineSearch}`.

10. Chapter 8: page 120: Problem 3

Reword problem to be:

“Assume that potential function $\rho(\Delta)$ has the following properties:

a) $\rho(\Delta)$ is a symmetric function of Δ ,

b) $\rho'(\Delta)$ is defined for $\Delta > 0$,

c) $\lim_{\Delta \downarrow 0} \rho'(\Delta) \geq \lim_{\Delta \uparrow 0} \rho'(\Delta)$,

d) $\rho'(\Delta)$ is concave for $\Delta > 0$.

Then prove that the symmetric bound surrogate function of (8.17) produces an upper bound to the true function.”

11. Chapter 9: Page 135:

“The cart moves toward the bottom of the function $f(x)$, but it is restricted by...”

$\Rightarrow$

“The cart moves toward the bottom of the function $u(x)$, but it is restricted by...”

12. Chapter 9: Page 147: Problem 9(a):

The v should be a y .

13. Chapter 9: Page 148: Problem 10:

(This correction is in addition to the Second Printing correction of Section 2 item 21.) There is a missing square in the formula for $F(v)$ and some errors in the specification of the distributions for X and W . It should be:

Define the proximal map of $u(x)$ as

$$F(v) = \arg \min_{x \in \mathbb{R}^N} \left\{ u(x) + \frac{1}{2\sigma^2} \|x - v\|^2 \right\}$$

a) Show that when $u(x; y) = \frac{1}{2} \|y - Ax\|_{\Lambda}^2$, then

$$F(v; y) = v + (I + A^t \Lambda A)^{-1} A^t \Lambda (y - Av) .$$

where the function $F(v; y)$ shows the explicit dependence on y .

b) Show that $F(v; Y)$ has an interpretation as the MAP estimate of X given Y under the assumption that

$$Y = AX + W ,$$

where X and W are independent Gaussian random vectors with $X \sim N(v, \sigma^2 I)$ and $W \sim N(0, \Lambda^{-1})$.

14. Chapter 10: Page 154: line 7: (Thanks Jim Fowler!)

“When $F(x)$ and $H(x)$ are the proximal maps from equation (10.3),...”

⇒

“When $F(x)$ and $H(x)$ are the proximal maps from equations (10.2) and (10.3),...”

Actually, this is because there is a missing reference of equations~(\ref{eq:ProximalMap1}) and~(\ref{eq:ProximalMap2})

15. Chapter 10: Page 168: Problem 1(b):

“Hint: Choose $u^* = \sigma^2 \nabla f(\hat{x})$ ” ⇒ “Hint: Choose $u^* = -\sigma^2 \nabla f(\hat{x})$ ”

16. Chapter 14: Page 224, line 8: (Thanks Jim Fowler!)

$$P\{X_s = x_s | X_r \text{ for } r \neq s\} = P\{X_s = x_s | X_{\partial r}\} ,$$

⇒

$$P\{X_s = x_s | X_r \text{ for } r \neq s\} = P\{X_s = x_s | X_{\partial s}\} ,$$

17. Chapter 14: Page 224, line 10: (Thanks Jim Fowler!)

$$P\{X_s \in A | X_r \text{ for } r \neq s\} = P\{X_s \in A | X_{\partial r}\} ,$$

⇒

$$P\{X_s \in A | X_r \text{ for } r \neq s\} = P\{X_s \in A | X_{\partial s}\} ,$$

18. Chapter 14: Page 224, line 17: (Thanks Jim Fowler!)

$$p(x) \neq \prod_{s \in S} p(x_s | x_{\partial r})$$

⇒

$$p(x) \neq \prod_{s \in S} p(x_s | x_{\partial s})$$

19. Appendix B: Page 315, line 14: (Thanks Jim Fowler!)

“Intuitively, a function is nonexpansive if it has a Lipschitz constant less than one.”

⇒

“Intuitively, a function is contractive if it has a Lipschitz constant less than one.”

2 Second Printing Corrections:

This section contains the list of errors for the second printing of the book. Use this list if your book was printed on or after 2025.

1. Chapter 2: Problem 5b: Page 31 (Thanks Harel Dor!)
 “Prove that if for all i, j , X_i and X_j are uncorrelated”
 $\Rightarrow$
 “Prove that if for all $i \neq j$, X_i and X_j are uncorrelated”
2. Chapter 2: Chapter Problems: Problem 13: Page 32
 “d) Calculate an expression for the conditional variance of X given Y .”
 $\Rightarrow$
 “d) Calculate an expression for the conditional **covariance** of X given Y .”
3. Chapter 3: Page 43 (Thanks Harel Dor!)
 In equation (3.15) and the density expression below it, the sum is over $r \in W$, but W is undefined; it should be the prediction window W_P defined on page 42.
4. Chapter 3: Problem 3: Page 45 (Thanks Harel Dor!)
 Part b) does not specify the prediction variance needed for the plots. It should read: “Plot $S_X(\omega)$ and $R_X(n)$ for $\rho = 0.5$ and $\rho = 0.95$, with $\sigma^2 = 1$.”
5. Chapter 3: Problem 6: Page 45 (Thanks Harel Dor!)
 The condition “if $x_n = 0$ for $n \leq 0$ and $n > N$ ” is both incorrectly stated and unnecessary, since x_n is only defined for $0 \leq n \leq N - 1$ and circular convolution requires no such condition. The problem should simply read: “Show that $y = Ax$, where A is a circulant matrix.”
6. Chapter 4: Property 4.2: Page 56
 “A stationary discrete time-zero-mean Gaussian random process”
 $\Rightarrow$
 “A stationary discrete-time zero-mean Gaussian random process”
7. Chapter 4: Section 4.6: Page 58
 “we may formally define for a GMRF.”
 $\Rightarrow$
 “we may formally define a GMRF.”
8. Chapter 5: Section 5.3: Page 70
 “because H is formed by the sum of two positive-definite matrices”
 $\Rightarrow$
 “because H is the sum of a positive semidefinite and positive definite matrix”
 $A^t A$ is positive semidefinite in general; $\sigma^2 B$ is positive definite, which is what makes the eigenvalues of H strictly positive.
9. Chapter 5: Section 5.4: Pages 76–77
 In the definition of l_s below the equation for h_s , the two conditions are reversed:
 “ $l_s = h_s$ if $s < 0$, and $l_s = 0$ if $s \geq 0$ ”
 $\Rightarrow$

“ $l_s = h_s$ if $s > 0$, and $l_s = 0$ if $s \leq 0$ ”

L is the strictly lower triangular part of H , so l_s is supported on positive indices, as Example 5.2 already assumes. Also, in Example 5.2 the left-hand sides l_s and d_s of the closing display should be l_n and d_n , to match the right-hand sides.

10. Chapter 5: Section 5.4: Page 77

In the frequency domain error update equation above the definition of $P(\omega)$:

$$“\varepsilon^{(k+1)}(\omega) = \left(\frac{-L^*(\omega)}{L(\omega) + h_0} \right)^k \varepsilon^{(0)}(\omega)”$$

$\Rightarrow$

$$“\varepsilon^{(k)}(\omega) = \left(\frac{-L^*(\omega)}{L(\omega) + h_0} \right)^k \varepsilon^{(0)}(\omega)”$$

Iterating the matrix update k times from $\varepsilon^{(0)}$ gives the k^{th} iterate with exponent k .

11. Chapter 6: Figure 6.2: Page 88

In the first row of the table, the weak-spring potential:

$$“\min \{|\Delta|^2, T\}”$$

$\Rightarrow$

$$“\min \{|\Delta|^2, T^2\}”$$

The text’s definition with T^2 is correct: the transition then occurs at $|\Delta| = T$, as the caption of Figure 6.1 states.

12. Chapter 6: Section 6.3: Page 89 (Thanks Vivek Goyal!)

“... and $\forall \lambda \in \mathfrak{R}$,

$$\rho(\lambda a + (1 - \lambda)) \leq \lambda \rho(a) + (1 - \lambda) \rho(b) .”$$

$\Rightarrow$

“... and $\forall \lambda \in [0, 1]$,

$$\rho(\lambda a + (1 - \lambda)b) \leq \lambda \rho(a) + (1 - \lambda) \rho(b) .$$

13. Chapter 7: Section 7.2: Page 100

In the paragraph introducing line search, two sentences call the starting point $x^{(k)}$ while the equations that follow use $x^{(k-1)}$ as the start and $x^{(k)}$ as the result:

“start with an initial value, $x^{(k)}$ ” and “passing through the initial point $x^{(k)}$ ”

$\Rightarrow$

“start with an initial value, $x^{(k-1)}$ ” and “passing through the initial point $x^{(k-1)}$ ”

14. Chapter 8: Section 8.1: Page 110

“it must also be the case that $f(\tilde{x}^*) < f(x')$ ”

$\Rightarrow$

“it must also be the case that $f(\tilde{x}^*) \leq f(x')$ ”

The two surrogate conditions give $f(\tilde{x}^*) \leq q(\tilde{x}^*; x') \leq q(x'; x') = f(x')$, and the inequality can hold with equality, for example when x' is already the minimizer.

15. Chapter 8: Section 8.2: Page 111

... substitute for $f(x)$ in the optimization.

$\Rightarrow$

... substitute for $q(x)$ in the optimization.

16. Chapter 8: Problem 3: Page 120

“d) $\rho'(\Delta)$ is a concave for $\Delta > 0$.”

$\Rightarrow$

“d) $\rho'(\Delta)$ is concave for $\Delta > 0$.”

17. Chapter 9: Page 127: footnote

“take vales in the extended real line”

$\Rightarrow$

“take values in the extended real line”

18. Chapter 9: Problem 1: Page 146

“Then prove that $g: \mathbb{R}^N \rightarrow \mathbb{R}$ is a proper, closed, and convex function.”

$\Rightarrow$

“Then prove that $g: \mathbb{R}^N \rightarrow \mathbb{R} \cup \{\infty\}$ is a proper, closed, and convex function.”

and also

“Let $f: \mathcal{A} \rightarrow \mathbb{R}$ is a convex function...”

$\Rightarrow$

“Let $f: \mathcal{A} \rightarrow \mathbb{R}$ be a continuous convex function on the non-empty closed convex set $\mathcal{A} \subset \mathbb{R}^N, \dots$ ”

19. Chapter 9: Problem 2: Page 146

Corrected problem notation:

Consider the optimization problem

$$\hat{x} = \arg \min_{\substack{x \in \mathbb{R}^N \\ Cx - b \in \mathbb{R}^K}} f(x) ,$$

where $x \in \mathbb{R}^N$, $b \in \mathbb{R}^K$, and $C \in \mathbb{R}^{K \times N}$. Then define the new vector

$$z = \begin{bmatrix} x \\ y \end{bmatrix}$$

where $y \in \mathbb{R}^K$ and $y = Cx - b$. Then show that there is an equivalent constrained optimization problem with the form

$$\hat{x} = \arg \min_{\substack{z \in \mathbb{R}^{+(N+K)} \\ Bz = c}} \tilde{f}(z) ,$$

for $\tilde{f}(z) = f(x)$ and some appropriately chosen matrix B and vector c . The variable y is sometimes referred to as a **slack variable**.

20. Chapter 9: Problem 9: Page 147

$$H(y) = (I + \sigma^2 B)^{-1} v .$$

⇒

$$H(y) = (I + \sigma^2 B)^{-1} y .$$

21. Chapter 9: Problem 10: Page 148

This correction is in addition to the First Printing correction of Section 1 item 13.

$$F(v; y) = v + (I + A^t \Lambda A)^{-1} A^t \Lambda (y - Av) .$$

⇒

$$F(v; y) = v + \left(\frac{1}{\sigma^2} I + A^t \Lambda A \right)^{-1} A^t \Lambda (y - Av) ,$$

22. Chapter 9: Problem 11 part a: Page 148

$$H(y) = F^{-1} (I + \sigma^2 \Lambda)^{-1} F v ,$$

⇒

$$H(y) = F^{-1} (I + \sigma^2 \Lambda)^{-1} F y ,$$

23. Chapter 10: Figure 10.4 caption: Page 155

“then the results is the conventional MAP estimate”

⇒

“then the result is the conventional MAP estimate”

24. Chapter 10: Theorem 10.2: Page 159

In the proof of the reverse direction of Theorem 10.2, the choice of u^* has the wrong sign:

“and we choose $u^* \in \sigma^2 \nabla f(x^*)$ ”

⇒

“and we choose $u^* \in -\sigma^2 \nabla f(x^*)$ ”

25. Chapter 10: Page 165 (Thanks Harel Dor!)

In the text above and below equation (10.25), the components $\mathbf{w}_k$ should not be bold; they should be typeset as w_k . Bold $\mathbf{w}$ denotes only the full stacked state.

26. Chapter 12: Example 12.7: Page 195

“ $P\{X_n = m\} = \pi_m$ for $0 \leq m < M - 1$ ”

⇒

“ $P\{X_n = m\} = \pi_m$ for $0 \leq m < M$ ”

27. Chapter 12: Page 197

“the so-called Aikake information criterion (AIC)”

⇒

“the so-called Akaike information criterion (AIC)”

28. Chapter 12: Page 198: Step 3b (Thanks Harel Dor!)

“ $\text{MDL}(M) \leftarrow \text{MDL}(M, \theta^*)$ ”

⇒

“ $\text{MDL}(M) \leftarrow \text{MDL}(M, \theta_M^*)$ ”

-
29. Chapter 14: Page 225
 “Cliques are sets of point which are all neighbors”
 $\Rightarrow$
 “Cliques are sets of points which are all neighbors”
30. Chapter 14: Page 231
 “so by the Hammersly–Clifford theorem”
 $\Rightarrow$
 “so by the Hammersley–Clifford theorem”
31. Chapter 14: Figure 14.3 caption: Page 232
 “Notice that the probably that $X_s = 1$ increases”
 $\Rightarrow$
 “Notice that the probability that $X_s = 1$ increases”
32. Chapter 14: Page 233
 “by a outer boundary of values, B .”
 $\Rightarrow$
 “by an outer boundary of values, B .”
33. Chapter 16: Page 266
 “While assuming this type of product can be extremely useful”
 $\Rightarrow$
 “While assuming this type of product form can be extremely useful”
34. Chapter 17: Page 289
 The cross-reference is broken and prints as “Section ??”. The sentence should end:
 “...in a manner similar to that used for the potential functions in Section 8.3.”
35. Chapter 17: Problem 3: Page 303
 The summation index should be j , not i , in both sums:
 $Y = \sum_{i=1}^N Z_j$ and $\lambda = \sum_{i=1}^N \lambda_j$
 $\Rightarrow$
 $Y = \sum_{j=1}^N Z_j$ and $\lambda = \sum_{j=1}^N \lambda_j$
36. Appendix A: Problem 3: Page 313
 “...on the convex set $\mathcal{A} \subset \mathbb{R}^N$, then it is a continuous function for all $x \in \mathcal{A}$.”
 $\Rightarrow$
 “...on the convex set $\mathcal{A} \subset \mathbb{R}^N$, then it is a continuous function for all $x \in \text{int}(\mathcal{A})$.”
37. Appendix B: Page 318
 “By Theorems B.5 and B.6”
 $\Rightarrow$
 “By Properties B.5 and B.6”

3 Minor Corrections and Clarifications:

The following are minor corrections and clarifications that do not directly affect the reader's understanding, but should be incorporated in any future printing.

These apply to both printings.

1. Chapter 2: Problem 16: Page 33 (Thanks Harel Dor!)
The matrix A is the only matrix in the problem whose dimensions are not given; it should be defined as $A \in \mathbb{R}^{M \times N}$.
2. Chapter 3: Example 3.1: Page 40
“we will assume that $X_n = 0$ when $n < 0$ ”
 $\Rightarrow$
“we will assume that $X_n = 0$ when $n \leq 0$ ”
The prediction error $\mathcal{E}_1$ uses X_0 , so the assumption should cover $n = 0$. Problem 10 of Chapter 3 already states the assumption this way.
3. Chapter 3: Example 3.2: Page 43
“As before, we will assume that $X_s = 0$ when $s_1 < 0$ or $s_2 < 0$.”
 $\Rightarrow$
“As before, we will assume that $X_s = 0$ when $s_1 \leq 0$ or $s_2 \leq 0$.”
The same clarification as in Example 3.1: the prediction window uses pixels with zero or negative coordinates, so the assumption should cover them.
4. Chapter 3: Problem 10: Page 47 (Thanks Harel Dor!)
There is a spurious comma in the equation defining $\hat{C}$, between the sum and the equals sign.
5. Chapter 7: Page 102 (Thanks Harel Dor!)
In the KKT conditions, there is no separation between each condition and its equation; a comma should follow each “such that” clause.
6. Chapter 7: Section 7.3: Page 104
Below the constrained ICD update equation:
“enforces that the updated pixel is positive”
 $\Rightarrow$
“enforces that the updated pixel is nonnegative”
At $\alpha = -x_s$ the updated pixel is exactly zero.
7. Chapter 8: Section 8.3: Page 113
“the best choice tends to depend on the specific structure of the potential function being minimized”
 $\Rightarrow$
“the best choice tends to depend on the specific structure of the potential function”
The potential function is bounded by the surrogate; the MAP cost function is what is minimized.