

Real World Algorithms: A Beginners Guide

Errata to First Printing

Last updated 19 December 2017

This document lists the changes that should be made to *Real World Algorithms* to correct mistakes that made their way to printing, to improve infelicities that the author spotted too late, or update the material with something that the author did not know at the time of writing the book.

There are three different kinds of changes noted here. In all of them the date that they became known to the author is given at the first line of each item. The name of the person who suggested the change is also given at the end of each change.

► **Page 1** line 1 _____ 1 Jan 1

These are technical or typographical errors.

Page 1 line 1 _____ 1 Jan 1

These are changes that improve the book, even if they do not correct an error. They include small rewordings, or material that became known to the author after the book was published.

Page 1 line 1 _____ 1 Jan 1

These are minor fixes that although they do not make a big difference they do hurt the author. Some of them might strain the reader's eye to see where the improvement is exactly.

- **Page xii** line 2 _____ 24 Apr 2017
they can proved $\wedge \rightarrow$ they can be proved (S. Subramanya)
Page 8 line -8 and -2 _____ 12 Aug 2017
big-Oh $\wedge \rightarrow$ big O
Page 9 line 4 _____ 12 Aug 2017
big-Ohs $\wedge \rightarrow$ big Os
Page 9 line -11 _____ 12 Aug 2017
In terms of big-Oh notation, we have by definition that $\wedge \rightarrow$ In terms of big O notation, we have,
by definition, that
- **Page 10** line -14 _____ 01 Apr 2017
hear $\wedge \rightarrow$ year (P. Tsanakas)
- **Page 11** line -2 _____ 01 Apr 2017
 $f(n) = e^x \wedge \rightarrow f(n) = e^n$ (P. Tsanakas)
Page 13 line -11 _____ 12 Aug 2017
big-Oh $\wedge \rightarrow$ big O
- **Page 13** line -8 _____ 12 Aug 2017
This is called “big-Omega,” or $\Omega(n)$, and the precise definition $\wedge \rightarrow$ This is
called “big Omega,” $\Omega(f(n))$; the precise definition
Page 13 line -6 _____ 12 Aug 2017
Having defined big-Oh and big-Omega $\wedge \rightarrow$ Having defined big O and big Omega
Page 13 line -5 _____ 12 Aug 2017
big-Theta $\wedge \rightarrow$ big Theta
- **Page 20** line -4 _____ 30 Mar 2017
line 3 $\wedge \rightarrow$ line 4
- **Page 20** line -3 _____ 30 Mar 2017
line 11 $\wedge \rightarrow$ line 12
- **Page 20** line -1 _____ 30 Mar 2017
line 6 $\wedge \rightarrow$ line 7
Page 40 line 17 _____ 12 Aug 2017
Using big-Oh notation $\wedge \rightarrow$ Using the big O notation
- **Page 57** line 2 _____ 24 Apr 2017
When you insert an item in the queue, you increase the index of the head;
similarly, when you remove an item from the queue, you increase the index
of the tail. $\wedge \rightarrow$ When you insert an item in the queue, you increase the index
of the tail; similarly, when you remove an item from the queue, you increase
the index of the head. (S. Subramanya)

- **Page 65** line 2 _____ 06 Mar 2017
011110 $\wedge \rightarrow$ 011011
- **Page 71** algorithm 3.1, line 1 _____ 26 Mar 2017
Size $\wedge \rightarrow$ SizePQ
- **Page 73** line -11 _____ 24 Apr 2017
root of the three $\wedge \rightarrow$ root of the tree (S. Subramanya)
- **Page 80**, line -6 _____ 25 May 2017
Joyces's $\wedge \rightarrow$ Joyce's
- **Page 80**, line -5 _____ 29 Jun 2017
41% $\wedge \rightarrow$ 53%
- Page 91, line -17* _____ 14 Dec 2017
"1110" $\wedge \rightarrow$ "1110"
- **Page 95** figure 4.1, caption _____ 21 Apr 2017
encryption $\wedge \rightarrow$ decryption
- **Page 140**, line -2 to -1 _____ 17 Jul 2017
SHA-2 (Secure Hash Standard-2) $\wedge \rightarrow$ SHA-2 (Secure Hash Algorithm 2)
- Page 144, line 2* _____ 21 Apr 2017
command packet $\wedge \rightarrow$ *command packet*
- **Page 145**, line -14 _____ 01 Jun 2017
 $OR_3 \wedge \rightarrow OR_2$
- **Page 145**, line -12 _____ 01 Jun 2017
Alice $\wedge \rightarrow OR_1$.
- **Page 147**, line -13 _____ 17 Jul 2017
SHA-224. $\wedge \rightarrow$ SHA-224,
- **Page 157** figure 6.6, caption _____ 21 Mar 2017
weigthed $\wedge \rightarrow$ weighted
- **Page 166** figure 6.13, second panel, label under t _____ 21 Apr 2017
13 $\wedge \rightarrow$ 13/ $-\infty$
- **Page 166** figure 6.13, fourth panel, label under t _____ 21 Apr 2017
13 $\wedge \rightarrow$ 13/ $-\infty$

- **Page 166** figure 6.13, fifth panel, label under t _____ 21 Apr 2017
 $-\text{inf}ty \wedge \rightarrow -\infty$
Page 178, algorithm 7.1, line 12 _____ 23 Apr 2017
 $\text{ExtractMinFromPQ}(pq) \wedge \rightarrow \text{ExtractMinFromPQ}(pq)$
- **Page 179**, line 10 _____ 24 Apr 2017
line 11 $\wedge \rightarrow$ line 14 (S. Subramanya)
- **Page 179**, line 12 _____ 24 Jul 2017
line 11 $\wedge \rightarrow$ line 14
- **Page 180**, line 13 _____ 26 Mar 2017
lines 1–7 $\wedge \rightarrow$ lines 1–10
Page 181, line –4 _____ 23 Jul 2017
re-weighting $\wedge \rightarrow$ reweighting
- **Page 182**, figure 7.11 _____ 22 Jul 2017
link $0 \xrightarrow{0} 2 \wedge \rightarrow 0 \xrightarrow{4} 2$ and link $0 \xrightarrow{8} 3 \wedge \rightarrow 0 \xrightarrow{7} 3$
Page 182, figure 7.11, caption _____ 23 Jul 2017
re-weighted $\wedge \rightarrow$ reweighted
- **Page 184**, line –12, exercise 1 _____ 19 Dec 2017
a better path goes through u , we can check whether $u \wedge \rightarrow$ a better path goes through v , we can check whether v
Page 206, line 1 _____ 23 Apr 2017
Euros $\wedge \rightarrow$ euros
- **Page 214**, line 8 _____ 04 Apr 2017
 $P_{B_j} \wedge \rightarrow B_{P_j}$
- **Page 217**, line –3 _____ 04 Apr 2017
page 3 $\wedge \rightarrow$ page 6
- **Page 217**, line –2 _____ 04 Apr 2017
page 4 $\wedge \rightarrow$ page 5
Page 222, figure 9.6 _____ 28 Apr 2017
change line arrow to stealth shape
- **Page 229**, line –16 _____ 04 May 2017
support $\wedge \rightarrow$ supported

- **Page 230, line -3** _____ 23 Apr 2017
 If there are n voters, then candidate A gets $(60 \times 2)n = 120n$ points \rightsquigarrow If there are $100m$ voters, candidate A gets $(60 \times 2)m = 120m$ points
- **Page 230, line -2** _____ 23 Apr 2017
 $(60 + 2 \times 40)n = 140n \rightsquigarrow (60 + 2 \times 40)m = 140m$
- **Page 230, line -2** _____ 23 Apr 2017
 $40n \rightsquigarrow 40m$
- **Page 231, heading 10.2** _____ 23 Apr 2017
 Shulze \rightsquigarrow Schulze
- **Page 233, algorithm 10.1, line 4** _____ 23 Apr 2017
 $P[i][j] \rightsquigarrow P[i, j]$
- **Page 234, line -8** _____ 04 May 2017
 $P[i, j] \rightsquigarrow P[c_i, c_j]$
- **Page 234, line -7** _____ 04 May 2017
 $P[j, i] \rightsquigarrow P[c_j, c_i]$
- **Page 234, line -6** _____ 04 May 2017
 $P[i, j] - P[j, i] \rightsquigarrow P[c_i, c_j] - P[c_j, c_i]$
- _____ 28 Apr 2017
 $(k + 1) \rightsquigarrow k + 1$
- **Page 238, algorithm 10.2, line 6** _____ 23 Apr 2017
 $S[i][j] \rightsquigarrow S[i, j]$
- **Page 238, algorithm 10.2, line 9** _____ 23 Apr 2017
 $S[i][j] \rightsquigarrow S[i, j]$
- **Page 241, algorithm 10.3, second line of output** _____ 23 Apr 2017
 $s[i, j_k] > s[j_k, i] \rightsquigarrow S[i, j_k] > S[j_k, i]$
- _____ 23 Apr 2017
 Page 244, algorithm 10.4
 all $pred$ and $dist \rightsquigarrow pred$ and $dist$
- **Page 249, algorithm 11.1** _____ 24 Apr 2017
 a array of items \rightsquigarrow an array of items (S. Subramanya)

- **Page 249, algorithm 11.1** _____ 24 Apr 2017
 a element we are searching for $\wedge \rightarrow$ an element we are searching for (S. Subramanya)

- Page 249, figure 11.1** _____ 28 Apr 2017
 Change the array to [114 , 480 , 149 , 903 , 777 , 65 , 680 , 437 , 4 , 181 , 613 , 551 , 10 , 31 , 782 , 507]; we need not use sequential search in a sorted array.

- **Page 254, line -5** _____ 24 Apr 2017
 figure 11.3 $\wedge \rightarrow$ figure 11.6

- **Page 260, algorithm 11.2** _____ 24 Apr 2017
 a element we are searching for $\wedge \rightarrow$ an element we are searching for (S. Subramanya)

- **Page 260, algorithm 11.2, line 10** _____ 24 Apr 2017
 NULL; $\wedge \rightarrow$ NULL

- **Page 261, algorithm 11.3** _____ 28 Jul 2017
 TranspositionSearch(A, s) $\wedge \rightarrow$ TranspositionSearch(L, s)
Page 261, algorithm 11.3 _____ 24 Apr 2017
 a list of items, $\wedge \rightarrow$ a list of items

- **Page 261, algorithm 11.3** _____ 24 Apr 2017
 a element we are searching for $\wedge \rightarrow$ an element we are searching for (S. Subramanya)

- **Page 261, algorithm 11.3, line 12** _____ 25 Apr 2017
 NULL; $\wedge \rightarrow$ NULL

- **Page 262, algorithm 11.4** _____ 24 Apr 2017
 a array of items $\wedge \rightarrow$ an array of items (S. Subramanya)

- **Page 262, algorithm 11.4** _____ 24 Apr 2017
 a element we are searching for $\wedge \rightarrow$ an element we are searching for (S. Subramanya)

- **Page 264, algorirthm 11.5** _____ 25 Apr 2017
 SecretarySearch(A, s) $\wedge \rightarrow$ SecretarySearch(A)

- **Page 264, algorithm 11.5** _____ 24 Apr 2017
 a array of items $\wedge \rightarrow$ an array of items (S. Subramanya)

- **Page 264**, algorithm 11.5, line 4 _____ 24 Apr 2017
 $\text{Compare}(A[i], A[b]) \wedge \rightarrow \text{Compare}(A[i], A[c])$ (S. Subramanya)
- **Page 264**, algorithm 11.5, line 6 _____ 25 Apr 2017
 $i \leftarrow m + 1 \wedge \rightarrow i \leftarrow m$
- **Page 267**, line 18 _____ 6 May 2017
 Unless you are not psychic $\wedge \rightarrow$ Unless you are psychic
- **Page 268**, algorithm 11.6 _____ 24 Apr 2017
 a element we are searching for $\wedge \rightarrow$ an element we are searching for (S. Subramanya)
- **Page 270**, figure 11.14b, last row _____ 31 May 2017

$$\begin{array}{ccc} l = 7 & \wedge \rightarrow & l = 8 \\ m = 7 & & m = 8 \end{array}$$
 (I. Kafetzaki)
- **Page 276**, line -2 _____ 02 May 2017
 one's complement $\wedge \rightarrow$ ones' complement
- **Page 278**, algorithm 11.7 _____ 24 Apr 2017
 a element we are searching for $\wedge \rightarrow$ an element we are searching for (S. Subramanya)
- **Page 287**, algorithm 12.1 _____ 24 Apr 2017
 a array of items $\wedge \rightarrow$ an array of items (S. Subramanya)
- **Page 289**, algorithm 12.2 _____ 24 Apr 2017
 a array of items $\wedge \rightarrow$ an array of items (S. Subramanya)
- **Page 291**, algorithm 12.3 _____ 24 Apr 2017
 a array of items $\wedge \rightarrow$ an array of items (S. Subramanya)
- **Page 298**, caption of figure 12.6b _____ 28 Apr 2017
 $1 \wedge \rightarrow \text{one}$
- **Page 299**, algorithm 12.4 _____ 24 Apr 2017
 a array of items $\wedge \rightarrow$ an array of items (S. Subramanya)
- **Page 310**, figure 12.12, third panel _____ 08 May 2017
 $i \rightarrow 5 \wedge \rightarrow i \rightarrow 37$

- Page 333, line –11 _____ 09 May 2017
minimal perfect mapping \leadsto *minimal perfect mapping*
- Page 340, line –3 _____ 09 May 2017
456, 976 \leadsto 456, 976
- Page 343, figure 13.5 _____ 09 May 2017
4, 847 \leadsto 4, 847
- Page 343, figure 13.5 _____ 09 May 2017
126, 033 \leadsto 126, 033
- Page 343, figure 13.5 _____ 09 May 2017
3, 276, 872 \leadsto 3, 276, 872
- Page 346, line 3 _____ 09 May 2017
binary fractional number \leadsto *binary fractional number*
- Page 353, line –12 _____ 23 Jul 2017
An successful search \leadsto An unsuccessful search
- Page 359, line –9 _____ 13 May 2017
z-values \leadsto z-values
- Page 359, line –9 _____ 13 May 2017
z-axis \leadsto z-axis
- Page 361, line 7 _____ 31 May 2017
the number of frequency peaks in the song, and there is even a notation for it: \leadsto being the number of frequency peaks in the song, and there is even a notation for it:
- Page 361, line 16 _____ 31 May 2017
move “of” to the next line
- Page 362, line –1 _____ 31 May 2017
the data are not the \leadsto the data are not in the
- Page 367, line 7 _____ 13 May 2017
 $(1 - 1/m)^{m(\frac{k}{m})} \leadsto (1 - 1/m)^{m(\frac{k}{m})}$
- Page 370, figure 13.20, third panel _____ 13 May 2017
The solid arrows should emanate from “this”.
- Page 383, table 14.1 _____ 14 May 2017
letter \leadsto letters
- Page 385, line 3 _____ 14 May 2017
Move J. to next line.
- Page 386, line 9, 12, 19 _____ 25 May 2017
Gibb’s \leadsto Gibbs’s

Page 387, line 25 _____ 16 May 2017
 “ineligible” $\wedge \rightarrow$ “ineligible.”

► Page 390, line 3 _____ 16 May 2017
 six $\wedge \rightarrow$ five

► Page 396, figure 14.8, fourth panel _____ 17 May 2017
 $H = 0.40 \wedge \rightarrow H = 0.940$

► Page 397, line -9 _____ 16 May 2017
 tox $\wedge \rightarrow$ to

► Page 400, figure 14.10 _____ 08 Jun 2017
 $\{1, 2, \dots, 14\}$: outlook $\wedge \rightarrow \{1, 2, \dots, 15\}$: outlook (V. Malandrakis)

Page 414, line 3 _____ 12 Aug 2017
 because in terms of the big-Oh notation it is $\wedge \rightarrow$ because in terms of the big O notation they are

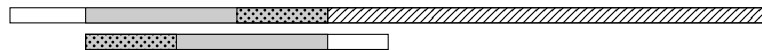
Page 417, line -3 _____ 26 Feb 2017
 Witten, Frank, and Hall $\wedge \rightarrow$ Witten, Frank, Hall, and Pal

Page 430, line -17 _____ 23 May 2017
 at the start of a string $\wedge \rightarrow$ at the start of the string

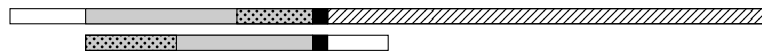
Page 430, line -16 _____ 23 May 2017
 at the end of a string is its *suffix* $\wedge \rightarrow$ at the end of the string is a *suffix*

► Page 430, line -4 _____ 14 Sep 2017
 all A, AB, and ABA are $\wedge \rightarrow$ substrings A and ABA are (P. Mpellos)

► Page 431, fourth graphic _____ 23 May 2017

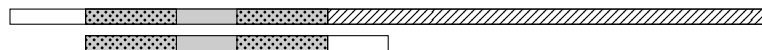


$\wedge \rightarrow$

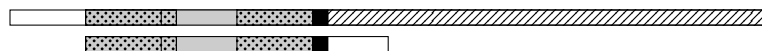


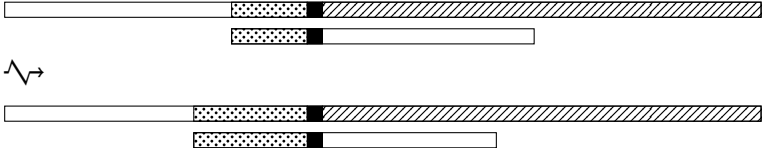
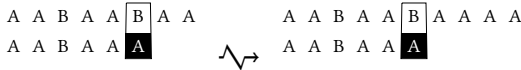
► Page 431, line -10 _____ 23 May 2017
 of the pattern $\wedge \rightarrow$ of the matched pattern

► Page 431, fifth graphic _____ 23 May 2017



$\wedge \rightarrow$



- Page 431, line -1 _____ 24 May 2017
longer shifts \leadsto longer shifts
- Page 432, line -9 _____ 24 May 2017
So we get: \leadsto So we get, indicating the mismatched character:
- Page 432, second graphic _____ 23 May 2017
- 
- Page 432, line 7 _____ 24 May 2017
AABAABAA \leadsto AABAABAAAA
- Page 432, third graphic _____ 24 May 2017
- 
- Page 432, line -4 _____ 24 May 2017
define its length to be zero \leadsto define its border length as zero
- Page 433, line 13 _____ 25 May 2017
borders array \leadsto border array
- Page 434, algorithm 15.2, line 9 _____ 02 Jun 2017
 $p[i] \leadsto p[j]$ (A. Tsalapatis)
- Page 435, figure 15.5 caption _____ 24 May 2017
Another trace the Knuth-Morris-Pratt algorithm; the borders array is at the bottom. \leadsto Another trace of the Knuth-Morris-Pratt algorithm; the border array is at the bottom.
- Page 437, line 3 _____ 25 May 2017
borders array \leadsto border array
- Page 440, line 12 _____ 30 May 2017
mattern \leadsto pattern
- Page 441, figure 15.3b _____ 30 May 2017

• • • • • S E P T E M B E R • • • • •
 E M B E R

$r = 1$

\curvearrowright

• • • • • S E P T E M B E R • • • • •
 E M B E R

$r = 1$

Page 449, line 16 _____ 23 May 2017
 50-50 \curvearrowright 50-50

► Page 462, line 10 _____ 20 May 2017
 line 6 \curvearrowright line 7

► Page 463, line 4 _____ 20 May 2017
 change \curvearrowright maybe fix

► Page 466, lines 18, 21, 23 _____ 20 May 2017
 ECC \curvearrowright EEC

► Page 467, lines 12, 19, 23 _____ 20 May 2017
 ECC \curvearrowright EEC

► Page 467, paragraph -2 _____ 22 May 2017

Rewrite the paragraph as follows:

To tackle this kind of question, we must adopt a systematic approach. We have a set of voters, $V = \{v_1, v_2, \dots, v_n\}$, and a set of weights, $W = \{w_1, w_2, \dots, w_m\}$. A voter v_i has a weight w_j given by a mapping $f: V \rightarrow W$. For a decision to be taken, it needs to meet a *quota* Q . In the example of the EEC, we have $Q = 12$. The setup of V , W , f , and Q is called a *voting game*.

► Page 468, line 3 _____ 21 May 2017
 such as \curvearrowright such that

► Page 468, line 4 _____ 21 May 2017
 in obtaining losing coalition \curvearrowright in obtaining a losing coalition

► Page 468, line 14 _____ 21 May 2017
 ECC \curvearrowright EEC

► Page 468, line -7 _____ 21 May 2017
 then then \curvearrowright then the

- Page 468, lines -3 to -1 _____ 30 May 2017
 As an example, take four voters $V = \{A, B, C, D\}$ with corresponding weights $W = \{4, 2, 1, 3\}$ and quota $Q = 6$. The critical coalitions are (we underline the critical voters) $\{\underline{A}, \underline{B}\}$, $\{\underline{A}, \underline{D}\}$, $\{\underline{A}, \underline{B}, C\}$, $\{\underline{A}, B, D\}$, $\{\underline{A}, C, \underline{D}\}$, $\{\underline{B}, \underline{C}, \underline{D}\}$.
 $\wedge \rightarrow$
 As an example, let us take four voters A, B, C, D with corresponding weights equal to 4, 2, 1, 3, and quota $Q = 6$. The critical coalitions then are, underlining the critical voters: $\{\underline{A}, \underline{B}\}$, $\{\underline{A}, \underline{D}\}$, $\{\underline{A}, \underline{B}, C\}$, $\{\underline{A}, B, D\}$, $\{\underline{A}, C, \underline{D}\}$, and $\{\underline{B}, \underline{C}, \underline{D}\}$.
- Page 472, line -1 _____ 05 Sep 2017
 zero $\wedge \rightarrow$ one (N. Batsal)
- Page 473, line 1 _____ 05 Sep 2017
 one $\wedge \rightarrow$ zero (N. Batsal)
- Page 479, line -4 _____ 21 May 2017
 primes $\wedge \rightarrow$ composites
- Page 479, lines -4 to -3 _____ 21 May 2017
 $n(1/2 + 1/3 + 1/5 \cdots + 1/k) \wedge \rightarrow n(1/2 + 1/3 + 1/5 + \cdots + 1/k)$
- Page 479, line -3 _____ 21 May 2017
 $(1/2 + 1/3 + 1/5 \cdots + 1/k) \wedge \rightarrow (1/2 + 1/3 + 1/5 + \cdots + 1/k)$
- Page 485, output _____ 23 May 2017
Output: (r, q) , such that $n = 2^r q \wedge \rightarrow$ **Output:** (r, q) , such that $n = 2^r q$ with q odd
- Page 498, reference 219 _____ 26 Mar 2017
 Ian H. Witten, Eibe Frank, and Mark A. Hall. *Data Mining: Practical Machine Learning Tools and Techniques*. Morgan Kaufmann Publishers Inc., San Francisco, CA, 3rd edition, 2011.
 $\wedge \rightarrow$
 Ian H. Witten, Eibe Frank, Mark A. Hall, and Christopher J. Pal. *Data Mining: Practical Machine Learning Tools and Techniques*. Elsevier, Cambridge, MA, 4th edition, 2016.
- Page 502, first column _____ 12 2017
 big-Oh ($O(f(n))$) $\wedge \rightarrow$ big O ($O(f(n))$)
 big-Omega ($\Omega(f(n))$) $\wedge \rightarrow$ big Omega ($\Omega(f(n))$)
 add big Theta ($\Theta(f(n))$), 13

► **Page 503, second column** _____ 20 May 2017

European Economic Community (ECC) $\wedge \rightarrow$ European Economic Community (EEC)

Page 504, first column, line –15 _____ 23 Jul 2017

re-weighting $\wedge \rightarrow$ reweighting