

# Real World Algorithms: A Beginners Guide

## Errata to First Printing

Last updated 28 July 2017

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. The date shows when they became known.

**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 pain the author's eye. Some of them might strain the reader's eye to see where the improvement is exactly.

- 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 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 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 80, line -6 \_\_\_\_\_ 25 May 2017  
Joyces's  $\wedge \rightarrow$  Joyce's
- Page 80, line -5 \_\_\_\_\_ 29 Jun 2017  
41%  $\wedge \rightarrow$  53%
- 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  
weighed  $\wedge \rightarrow$  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  
 $-inf ty \wedge \rightarrow -\infty$   
*Page 178, algorithm 7.1, line 12* \_\_\_\_\_ 23 Apr 2017  
 $\text{ExtractMinFromPQ}(pq) \wedge \rightarrow \text{ExtractMinFromPQ}(pq)$
- **Page 179**, lines 10, 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 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  $\wedge \rightarrow$  If there are  $100m$  voters, candidate  $A$  gets  $(60 \times 2)m = 120m$  points
- Page 230, line -2 \_\_\_\_\_ 23 Apr 2017  
 $(60 + 2 \times 40)n = 140n \wedge \rightarrow (60 + 2 \times 40)m = 140m$
- Page 230, line -2 \_\_\_\_\_ 23 Apr 2017  
 $40n \wedge \rightarrow 40m$
- Page 231, heading 10.2 \_\_\_\_\_ 23 Apr 2017  
Shulze  $\wedge \rightarrow$  Schulze
- Page 233, algorithm 10.1, line 4 \_\_\_\_\_ 23 Apr 2017  
 $P[i][j] \wedge \rightarrow P[i, j]$
- Page 234, line -8 \_\_\_\_\_ 04 May 2017  
 $P[i, j] \wedge \rightarrow P[c_i, c_j]$
- Page 234, line -7 \_\_\_\_\_ 04 May 2017  
 $P[j, i] \wedge \rightarrow P[c_j, c_i]$
- Page 234, line -6 \_\_\_\_\_ 04 May 2017  
 $P[i, j] - P[j, i] \wedge \rightarrow P[c_i, c_j] - P[c_j, c_i]$
- Page 236, line -4 \_\_\_\_\_ 28 Apr 2017  
 $(k + 1) \wedge \rightarrow k + 1$
- Page 238, algorithm 10.2, line 6 \_\_\_\_\_ 23 Apr 2017  
 $S[i][j] \wedge \rightarrow S[i, j]$
- Page 238, algorithm 10.2, line 9 \_\_\_\_\_ 23 Apr 2017  
 $S[i][j] \wedge \rightarrow S[i, j]$
- Page 241, algorithm 10.3, second line of output \_\_\_\_\_ 23 Apr 2017  
 $s[i, j_k] > s[j_k, i] \wedge \rightarrow S[i, j_k] > S[j_k, i]$
- Page 244, algorithm 10.4 \_\_\_\_\_ 23 Apr 2017  
all *pred* and *dist*  $\wedge \rightarrow$  *pred* and *dist*

- **Page 249, algorithm 11.1** \_\_\_\_\_ 24 Apr 2017  
a array of items  $\leadsto$  an array of items (S. Subramanya)
- **Page 249, algorithm 11.1** \_\_\_\_\_ 24 Apr 2017  
a element we are searching for  $\leadsto$  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 260, algorithm 11.2** \_\_\_\_\_ 24 Apr 2017  
a element we are searching for  $\leadsto$  an element we are searching for (S. Subramanya)
- **Page 260, algorithm 11.2, line 10** \_\_\_\_\_ 24 Apr 2017  
NULL;  $\leadsto$  NULL
- **Page 261, algorithm 11.3** \_\_\_\_\_ 28 Jul 2017  
TranspositionSearch( $A, s$ )  $\leadsto$  TranspositionSearch( $L, s$ )
- Page 261, algorithm 11.3* \_\_\_\_\_ 24 Apr 2017  
a list of items,  $\leadsto$  a list of items
- **Page 261, algorithm 11.3** \_\_\_\_\_ 24 Apr 2017  
a element we are searching for  $\leadsto$  an element we are searching for (S. Subramanya)
- **Page 261, algorithm 11.3, line 12** \_\_\_\_\_ 25 Apr 2017  
NULL;  $\leadsto$  NULL
- **Page 262, algorithm 11.4** \_\_\_\_\_ 24 Apr 2017  
a array of items  $\leadsto$  an array of items (S. Subramanya)
- **Page 262, algorithm 11.4** \_\_\_\_\_ 24 Apr 2017  
a element we are searching for  $\leadsto$  an element we are searching for (S. Subramanya)
- **Page 264, algorithm 11.5** \_\_\_\_\_ 25 Apr 2017  
SecretarySearch( $A, s$ )  $\leadsto$  SecretarySearch( $A$ )
- **Page 264, algorithm 11.4** \_\_\_\_\_ 24 Apr 2017  
a array of items  $\leadsto$  an array of items (S. Subramanya)

- Page 264, algorithm 11.5, line 4 \_\_\_\_\_ 24 Apr 2017  
 $\text{Compare}(A[i], A[b]) \rightsquigarrow \text{Compare}(A[i], A[c])$  (S. Subramanya)
- Page 262, algorithm 11.6 \_\_\_\_\_ 24 Apr 2017  
 a element we are searching for  $\rightsquigarrow$  an element we are searching for (S. Subramanya)
- Page 264, algorithm 11.5, line 6 \_\_\_\_\_ 25 Apr 2017  
 $i \leftarrow m + 1 \rightsquigarrow i \leftarrow m$
- Page 267, line 18 \_\_\_\_\_ 6 May 2017  
 Unless you are not psychic  $\rightsquigarrow$  Unless you are psychic
- Page 270, figure 11.14b, last row \_\_\_\_\_ 31 May 2017  

$$\begin{array}{ccc} l = 7 & \rightsquigarrow & l = 8 \\ m = 7 & & m = 8 \end{array}$$
 (I. Kafetzaki)
- Page 276, line -2 \_\_\_\_\_ 02 May 2017  
 one's complement  $\rightsquigarrow$  ones' complement
- Page 278, algorithm 11.7 \_\_\_\_\_ 24 Apr 2017  
 a element we are searching for  $\rightsquigarrow$  an element we are searching for (S. Subramanya)
- Page 298, caption of figure 12.6b \_\_\_\_\_ 28 Apr 2017  
 $1 \rightsquigarrow \text{one}$
- Page 310, figure 12.12, third panel \_\_\_\_\_ 08 May 2017  
 $i \rightarrow 5 \rightsquigarrow i \rightarrow 37$
- Page 333, line -11 \_\_\_\_\_ 09 May 2017  
 minimal perfect mapping  $\rightsquigarrow$  *minimal perfect mapping*
- Page 340, line -3 \_\_\_\_\_ 09 May 2017  
 $456, 976 \rightsquigarrow 456, 976$
- Page 343, figure 13.5 \_\_\_\_\_ 09 May 2017  
 $4, 847 \rightsquigarrow 4, 847$
- Page 343, figure 13.5 \_\_\_\_\_ 09 May 2017  
 $126, 033 \rightsquigarrow 126, 033$
- Page 343, figure 13.5 \_\_\_\_\_ 09 May 2017  
 $3, 276, 872 \rightsquigarrow 3, 276, 872$

- Page 346, line 3 \_\_\_\_\_ 09 May 2017  
*binary fractional number*  $\rightarrow$  *binary fractional number*
- Page 353, line -12 \_\_\_\_\_ 23 Jul 2017  
 An successful search  $\rightarrow$  An unsuccessful search
- Page 359, line -9 \_\_\_\_\_ 13 May 2017  
*z-values*  $\rightarrow$  *z-values*
- Page 359, line -9 \_\_\_\_\_ 13 May 2017  
*z-axis*  $\rightarrow$  *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:  $\rightarrow$  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  $\rightarrow$  the data are not in the
- Page 367, line 7 \_\_\_\_\_ 13 May 2017  
 $(1 - 1/m)^{m(\frac{k}{m})} \rightarrow (1 - 1/m)^{m(\frac{k}{m})}$
- 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  $\rightarrow$  letters
- Page 385, line 3 \_\_\_\_\_ 14 May 2017  
 Move J. to next line.
- Page 386, line 9, 12, 19 \_\_\_\_\_ 25 May 2017  
 Gibb’s  $\rightarrow$  Gibbs’s
- Page 387, line 25 \_\_\_\_\_ 16 May 2017  
 “ineligible”  $\rightarrow$  “ineligible.”
- Page 390, line 3 \_\_\_\_\_ 16 May 2017  
 six  $\rightarrow$  five
- Page 396, figure 14.8, fourth panel \_\_\_\_\_ 17 May 2017  
 $H = 0.40 \rightarrow H = 0.940$
- Page 397, line -9 \_\_\_\_\_ 16 May 2017  
 tox  $\rightarrow$  to

► Page 400, figure 14.10 \_\_\_\_\_ 08 Jun 2017

$\{1, 2, \dots, 14\}$ : outlook  $\searrow \rightarrow \{1, 2, \dots, 15\}$ : outlook (V. Malandrakis)

Page 417, line -3 \_\_\_\_\_ 26 Feb 2017

Witten, Frank, and Hall  $\searrow \rightarrow$  Witten, Frank, Hall, and Pal

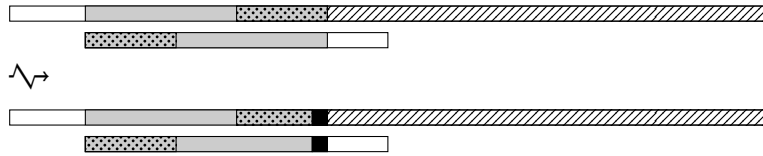
Page 430, line -17 \_\_\_\_\_ 23 May 2017

at the start of a string  $\searrow \rightarrow$  at the start of the string

Page 430, line -16 \_\_\_\_\_ 23 May 2017

at the end of a string is its *suffix*  $\searrow \rightarrow$  at the end of the string is a *suffix*

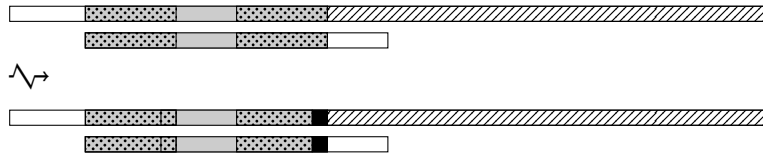
► Page 431, fourth graphic \_\_\_\_\_ 23 May 2017



► Page 431, line -10 \_\_\_\_\_ 23 May 2017

of the pattern  $\searrow \rightarrow$  of the matched pattern

► Page 431, fifth graphic \_\_\_\_\_ 23 May 2017



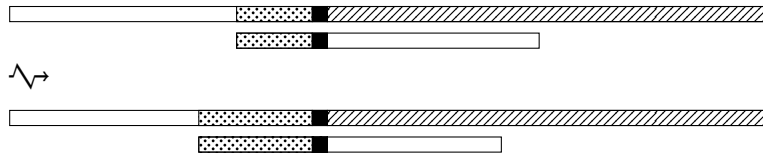
Page 431, line -1 \_\_\_\_\_ 24 May 2017

longer shifts  $\searrow \rightarrow$  longer shifts

► Page 432, line -9 \_\_\_\_\_ 24 May 2017

So we get:  $\searrow \rightarrow$  So we get, indicating the mismatched character:

► Page 432, second graphic \_\_\_\_\_ 23 May 2017



► Page 432, line 7 \_\_\_\_\_ 24 May 2017

AABAABAA  $\searrow \rightarrow$  AABAABAAAA



- Page 432, third graphic \_\_\_\_\_ 24 May 2017

$$\begin{array}{ccccccc}
 A & A & B & A & A & \boxed{B} & A & A \\
 A & A & B & A & A & \boxed{A} & & 
 \end{array}
 \rightsquigarrow
 \begin{array}{ccccccc}
 A & A & B & A & A & \boxed{B} & A & A & A & A \\
 A & A & B & A & A & \boxed{A} & & & & 
 \end{array}$$

- Page 432, line -4 \_\_\_\_\_ 24 May 2017

define its length to be zero  $\wedge$  define its border length as zero

- Page 433, line 13 \_\_\_\_\_ 25 May 2017

borders array  $\searrow$  border array

- Page 434, algorithm 15.2, line 9 \_\_\_\_\_ 02 Jun 2017

$p[i] \rightsquigarrow p[j]$  (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.  $\searrow$  Another trace of the Knuth-Morris-Pratt algorithm; the border array is at the bottom.

- Page 437, line 3 \_\_\_\_\_ 25 May 2017

borders array  $\searrow$  border array

- Page 440, line 12 \_\_\_\_\_ 30 May 2017

matter  $\rightsquigarrow$  pattern

- Page 441, figure 15.3b \_\_\_\_\_ 30 May 2017

. . . . . S E P T E M B E R . . . . .  
 E M B E R

$$r = 1$$

. . . . . S E P T E M B E R . . . . .  
 E M B E R

$$r = 1$$

- Page 449, line 16 \_\_\_\_\_ 23 May 2017

$$50-50 \searrow \rightarrow 50-50$$

- Page 462, line 10 \_\_\_\_\_ 20 May 2017

line 6  $\searrow \rightarrow$  line 7

- Page 463, line 4 \_\_\_\_\_ 20 May 2017

change  $\wedge \rightarrow$  maybe fix

- Page 466, lines 18, 21, 23 \_\_\_\_\_ 20 May 2017  
ECC  $\leadsto$  EEC
- Page 467, lines 12, 19, 23 \_\_\_\_\_ 20 May 2017  
ECC  $\leadsto$  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  $\leadsto$  such that
- Page 468, line 4 \_\_\_\_\_ 21 May 2017  
in obtaining losing coalition  $\leadsto$  in obtaining a losing coalition
- Page 468, line 14 \_\_\_\_\_ 21 May 2017  
ECC  $\leadsto$  EEC
- Page 468, line –7 \_\_\_\_\_ 21 May 2017  
then then  $\leadsto$  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)  $\{\underline{A}, \underline{B}\}$ ,  $\{\underline{A}, \underline{D}\}$ ,  $\{\underline{A}, \underline{B}, C\}$ ,  $\{\underline{A}, B, D\}$ ,  $\{\underline{A}, C, \underline{D}\}$ ,  $\{\underline{B}, \underline{C}, \underline{D}\}$ .  
 $\leadsto$   
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 479, line –4 \_\_\_\_\_ 21 May 2017  
primes  $\leadsto$  composites
- Page 479, lines –4 to –3 \_\_\_\_\_ 21 May 2017  
 $n(1/2 + 1/3 + 1/5 \dots + 1/k) \leadsto n(1/2 + 1/3 + 1/5 + \dots + 1/k)$

► **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 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