Real World Algorithms: A Beginners Guide
Errata to the First Printing

Last updated 8 February 2018

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 as 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.
they can be proved

and its last element is the \((n-1)th\) and so its last element is the \((n-1)th\)

Move “\(y;\)” to previous line.

big-Oh \(\rightarrow\) big O

big-Ohs \(\rightarrow\) big Os

In terms of big-Oh notation, we have by definition that \(\rightarrow\) In terms of big O notation, we have, by definition, that

Move “of” to the next line.

This is called “big-Omega,” or \(\Omega(n)\), and the precise definition \(\rightarrow\) This is called “big Omega,” \(\Omega(f(n))\); the precise definition

Having defined big-Oh and big-Omega \(\rightarrow\) Having defined big O and big Omega

big-Theta \(\rightarrow\) big Theta

Using big-Oh notation \(\rightarrow\) Using the big O notation
Page 41, lines −4 to −3 30 Jan 2018
Room 6 still has one unvisited room \(\rightarrow\) Room 5 still has one unvisited room
(Yi-Ming Lai)

Page 57, line 4 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. \(\rightarrow\) 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 \(\rightarrow\) 011011

Page 71, algorithm 3.1, line 1 26 Mar 2017
Size \(\rightarrow\) SizePQ

Page 73, line −11 24 Apr 2017
root of the three \(\rightarrow\) root of the tree
(S. Subramanya)

Page 80, line −6 25 May 2017
Joyces’s \(\rightarrow\) Joyce’s

Page 80, line −5 29 Jun 2017
41% \(\rightarrow\) 53%

Page 84, line 6 30 Jan 2018
by assigning it to \(wc\) in line 13 \(\rightarrow\) by assigning to it \(wc\) in line 13
(Yi-Ming Lai)

Page 91, line −17 14 Dec 2017
“1110” \(\rightarrow\) “1110”

Page 95, figure 4.1, caption 21 Apr 2017
An encryption \(\rightarrow\) A decryption

Page 140, lines −2 to −1 17 Jul 2017
SHA-2 (Secure Hash Standard-2) \(\rightarrow\) SHA-2 (Secure Hash Algorithm 2)

Page 144, line 2 21 Apr 2017
command packet \(\rightarrow\) command packet

Page 145, line −14 01 Jun 2017
\(OR_3\) \(\rightarrow\) \(OR_2\)
Page 145, line –12
Alice \(\rightarrow\) OR

Page 147, line –13
SHA-224. \(\rightarrow\) SHA-224,

Page 157, figure 6.6, caption
weighted \(\rightarrow\) weighted

Page 162, line –1
\(\text{prev, that is, } \text{prev}[i] \rightarrow \text{pred, that is, } \text{pred}[i]\) \(\text{(Yi-Ming Lai)}\)

Page 165, lines –2 to –1
move line break before “then”

Page 166, figure 6.13, second panel, label under \(t\)
\(13 \rightarrow \infty\)

Page 166, figure 6.13, fourth panel, label under \(t\)
\(13 \rightarrow \infty\)

Page 166, figure 6.13, fifth panel, label under \(t\)
\(-\infty \rightarrow \infty\)

Page 170, figure 7.1, caption
Breaking lines into paragraphs \(\rightarrow\) Breaking paragraphs into lines \(\text{(Yi-Ming Lai)}\)

Page 178, algorithm 7.1, line 12
\(\text{ExtractMinFromPQ}(pq) \rightarrow \text{ExtractMinFromPQ}(pq)\)

Page 179, line 10
\(\text{line 11} \rightarrow \text{line 14}\) \(\text{(S. Subramanya)}\)

Page 179, line 12
\(\text{line 11} \rightarrow \text{line 14}\)

Page 180, line 13
lines 1–7 \(\rightarrow\) lines 1–10

Page 181, line –4
re-weighting \(\rightarrow\) reweighting

Page 182, figure 7.11
link \(0 \rightarrow 2 \rightarrow 0 \rightarrow 2\) and link \(0 \rightarrow 8 \rightarrow 3 \rightarrow 0 \rightarrow 3\)
Page 182, figure 7.11, caption re-weighted ▶ reweighted 23 Jul 2017

Page 184, line –12, exercise 1 ▶ a better path goes through u, we can check whether u ▶ a better path goes through v, we can check whether v 19 Dec 2017

Page 196, line 10 ▶ We underline edges ▶ We underline nodes ▶ (Yi-Ming Lai) 30 Jan 2018

Page 206, line 1 ▶ Euros ▶ euros 23 Apr 2017

Page 214, line 8 ▶ $P_{B_j}$ ▶ $B_{P_j}$ 04 Apr 2017

Page 217, line –3 ▶ page 3 ▶ page 6 04 Apr 2017

Page 217, line –2 ▶ page 4 ▶ page 5 04 Apr 2017

Page 219, line 10 ▶ from node 4 to nodes 3 and 2 ▶ from node 4 to nodes 2 and 1 (Yi-Ming Lai) 30 Jan 2018

Page 222, figure 9.6 ▶ arrow tips ▶ 28 Apr 2017

Page 229, line –16 ▶ support ▶ supported 04 May 2017

Page 230, line –3 ▶ If there are $n$ voters, then candidate $A$ gets $(60 \times 2)n = 120n$ points ▶ If there are $100m$ voters, candidate $A$ gets $(60 \times 2)m = 120m$ points 23 Apr 2017

Page 230, line –2 ▶ $(60 + 2 \times 40)n = 140n$ ▶ $(60 + 2 \times 40)m = 140m$ 23 Apr 2017

Page 230, line –2 ▶ $40n$ ▶ $40m$ 23 Apr 2017

Page 231, heading 10.2 ▶ Shulze ▶ Schulze 23 Apr 2017
Page 233, algorithm 10.1, line 4  
\[ P[i][j] \rightarrow P[i, j] \]

Page 234, line -8  
\[ P[i, j] \rightarrow P[c_i, c_j] \]

Page 234, line -7  
\[ P[j, i] \rightarrow P[c_j, c_i] \]

Page 234, line -6  
\[ P[i, j] - P[j, i] \rightarrow P[c_i, c_j] - P[c_j, c_i] \]

Page 236, line -4  
\( (k + 1) \rightarrow k + 1 \)

Page 238, algorithm 10.2, line 6  
\[ S[i][j] \rightarrow S[i, j] \]

Page 238, algorithm 10.2, line 9  
\[ S[i][j] \rightarrow S[i, j] \]

Page 241, algorithm 10.3, second line of output  
\[ s[i, j_k] > s[j_k, i] \rightarrow S[i, j_k] > S[j_k, i] \]

Page 242, line 6  
\( D \) would beat \( B, C, \) and \( D, \) while \( A \) would beat \( C, B \) would beat \( D \) \( \rightarrow \) \( D \) would beat both \( B \) and \( C, \) while \( A \) would beat \( C, B \) would beat \( C \)  
\( (Yi-Ming Lai) \)

Page 244, algorithm 10.4  
all \( \text{pred} \) and \( \text{dist} \) \( \rightarrow \) \( \text{pred} \) and \( \text{dist} \)

Page 249, algorithm 11.1  
a array of items \( \rightarrow \) an array of items  
\( (S. Subramanya) \)

Page 249, algorithm 11.1  
a element we are searching for \( \rightarrow \) an element we are searching for  
\( (S. Subramanya) \)

Page 249, figure 11.1  
Change the array to:

\[
\begin{array}{ccccccccccccc}
\end{array}
\]

We need not use sequential search in a sorted array.
Page 250, line −3 ................................................................. 30 Jan 2018
real and complex parts \( \mapsto \) real and imaginary parts  
(Yi-Ming Lai)

Page 254, line −5 .................................................................. 24 Apr 2017
figure 11.3 \( \mapsto \) figure 11.6

Page 259, line −8 .................................................................. 30 Jan 2018
whether the match is in the head of the list \( \mapsto \) whether the match is not in the head of the list  
(Yi-Ming Lai)

Page 260, algorithm 11.2 ......................................................... 24 Apr 2017
a element we are searching for \( \mapsto \) an element we are searching for  
(S. Subramanya)

Page 260, algorithm 11.2, line 10 ............................................. 24 Apr 2017
NULL; \( \mapsto \) NULL

Page 261, algorithm 11.3 ......................................................... 28 Jul 2017
TranspositionSearch(\( A \), \( s \)) \( \mapsto \) TranspositionSearch(\( L \), \( s \))

Page 261, algorithm 11.3 ......................................................... 24 Apr 2017
a list of items, \( \mapsto \) a list of items

Page 261, algorithm 11.3 ......................................................... 24 Apr 2017
a element we are searching for \( \mapsto \) an element we are searching for  
(S. Subramanya)

Page 261, algorithm 11.3, line 12 ............................................. 25 Apr 2017
NULL; \( \mapsto \) NULL

Page 262, algorithm 11.4 ......................................................... 24 Apr 2017
a array of items \( \mapsto \) an array of items  
(S. Subramanya)

Page 262, algorithm 11.4 ......................................................... 24 Apr 2017
a element we are searching for \( \mapsto \) an element we are searching for  
(S. Subramanya)

Page 262, line 1 ..................................................................... 30 Jan 2018
the same search as in figure 11.11 \( \mapsto \) the same search as in figure 11.10  
(Yi-Ming Lai)

Page 264, algorithm 11.5 ......................................................... 25 Apr 2017
SecretarySearch(\( A \), \( s \)) \( \mapsto \) SecretarySearch(\( A \))
Page 264, algorithm 11.5

\[ \text{a array of items} \rightarrow \text{an array of items} \]
(S. Subramanya)

Page 264, algorithm 11.5, line 4

\[ \text{\texttt{Compare}}(A[i], A[b]) \rightarrow \text{\texttt{Compare}}(A[i], A[c]) \]
(S. Subramanya)

Page 264, algorithm 11.5, line 6

\[ i \leftarrow m + 1 \rightarrow i \leftarrow m \]

Page 267, line 18

\[ \text{Unless you are not psychic} \rightarrow \text{Unless you are psychic} \]

Page 268, algorithm 11.6

\[ \text{a element we are searching for} \rightarrow \text{an element we are searching for} \]
(S. Subramanya)

Page 270, figure 11.14b, last row

\[ l = 7 \rightarrow l = 8 \]
\[ m = 7 \rightarrow m = 8 \]
(I. Kafetzaki)

Page 275, line –2

\[ \text{\texttt{one’s complement}} \rightarrow \text{\texttt{ones’ complement}} \]

Page 278, algorithm 11.7

\[ \text{a element we are searching for} \rightarrow \text{an element we are searching for} \]
(S. Subramanya)

Page 287, algorithm 12.1

\[ \text{a array of items} \rightarrow \text{an array of items} \]
(S. Subramanya)

Page 289, algorithm 12.2

\[ \text{a array of items} \rightarrow \text{an array of items} \]
(S. Subramanya)

Page 291, algorithm 12.3

\[ \text{a array of items} \rightarrow \text{an array of items} \]
(S. Subramanya)

Page 297, line –5

\[ \text{we want to have} \ A[i] \geq A[i] \rightarrow \text{we want to have} \ A[0] \geq A[i] \]
(Yi-Ming Lai)

Page 298, figure 12.6b, caption

\[ 1 \rightarrow \text{one} \]
Page 299, algorithm 12.4                          24 Apr 2017
a array of items ↦ an array of items (S. Subramanya)

Page 310, figure 12.12, third panel                   08 May 2017
i → 5 ↦ i → 37
Page 327, line −16, exercise 2                          20 Dec 2017
characters like “|”, “_”, and “+” ↦ characters like “|”, “_”, and “+”

Page 327, line −15, exercise 3                          20 Dec 2017
The in-place array merge, algorithm 12.7 ↦ The in-place array merge, algorithm 12.7,
Page 333, line −11                                    09 May 2017
minimal perfect mapping ↦ minimal perfect mapping
Page 340, line −3                                     09 May 2017
456, 976 ↦ 456,976
Page 343, figure 13.5                                 09 May 2017
4, 847 ↦ 4,847
Page 343, figure 13.5                                 09 May 2017
126, 033 ↦ 126,033
Page 343, figure 13.5                                 09 May 2017
3, 276, 872 ↦ 3,276,872

Page 343, line 8                                      30 Jan 2018
in line 4 ↦ in line 3 (Yi-Ming Lai)
Page 346, line 3                                     09 May 2017
binary fractional number ↦ binary fractional number

Page 353, line −12                                   23 Jul 2017
An successful search cannot take longer than a successful one ↦ A successful search cannot take longer than an unsuccessful one
Page 359, line −9                                   13 May 2017
z-values ↦ z-values
Page 359, line −9                                   13 May 2017
z-axis ↦ 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: ↦ 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
the data are not in the

\[(1 - 1/m)^{(\frac{k}{m})} \land (1 - 1/m)^{(\frac{k}{m})}\]

The solid arrows should emanate from “this”.

Our hash algorithms take a specific input and produce a specific output. (Yi-Ming Lai)

Page 385, line 3
Move “J.” to the next line.

Gibb’s

“ineligible”

six

we get the values shown in figure 14.7

\[H = 0.40 \land H = 0.940\]

tox

\{1, 2, \ldots, 14\}: outlook \land \{1, 2, \ldots, 15\}: outlook

(V. Malandrakis)

happens in the normal branch

(Yi-Ming Lai)
11

Page 402, algorithm 15.2, line 1  30 Jan 2018

\[ r \leftarrow \text{CreateMap()} \quad dt \leftarrow \text{CreateMap()} \]  
(Yi-Ming Lai)

Page 413, figure 14.12  22 Dec 2017

add label "high" on the first, left, edge emanating from the root node

Page 414, line 3  12 Aug 2017

because in terms of the big-Oh notation it is \( O \) because in terms of the big O notation they are

Page 417, line 3  26 Feb 2017

Witten, Frank, and Hall \( \Rightarrow \) Witten, Frank, Hall, and Pal

Page 426, figure 15.1  03 Feb 2018

Change the gray letters from 40% gray to gray.

Page 427, graphics  03 Feb 2018

Change the gray letters from 40% gray to gray.

Page 428, second and fourth graphics  03 Feb 2018

Change the gray letters from 40% gray to gray.

Page 430, line 17  23 May 2017

at the start of a string \( \Rightarrow \) at the start of the string

Page 430, line 16  23 May 2017

at the end of a string is its suffix \( \Rightarrow \) at the end of the string is a suffix

Page 430, line 4  14 Sep 2017

all A, AB, and ABA are \( \Rightarrow \) substrings A and ABA are  
(P. Mpellos)

Page 431, fourth graphic  23 May 2017

\[ \Rightarrow \]

Page 431, line 10  23 May 2017

of the pattern \( \Rightarrow \) of the matched pattern

Page 431, fifth graphic  23 May 2017

\[ \Rightarrow \]
So we get: \[\text{longer shifts}\] 

**Page 432, second graphic**

\[
\begin{array}{cccccccc}
\end{array}
\]

\[\rightarrow\]

**Page 432, line 7**

AABAABAA \[\rightarrow\] AABAABAAAA

**Page 432, third graphic**

\[
\begin{array}{cccccccc}
\end{array}
\]

**Page 432, fifth graphic**

Change the gray letters from 40% gray to gray.

**Page 432, line –4**

de/fin\(e\) its length to be zero \[\rightarrow\] define its border length as zero

**Page 433, line 13**

borders array \[\rightarrow\] border array

**Page 434, algorithm 15.2, line 9**

\(p[i] \rightarrow p[j]\) (A. Tsalapatis)

**Page 434, line 4**

to a queue \(q \rightarrow\) to the queue \(q\)

**Page 435, figure 15.5 caption**

Another trace the Knuth-Morris-Pratt algorithm; the borders array is at the bottom. \[\rightarrow\] Another trace of the Knuth-Morris-Pratt algorithm; the border array is at the bottom.

**Page 437, line 3**

borders array \[\rightarrow\] border array

**Page 439, figure 15.8**

Change the gray letters from 40% gray to gray.
Try using a different data structure, like a hash table or a set, instead. 

Try then using a different data structure, like a hash table, instead.

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.
such as \( \wedge \rightarrow \) such that

in obtaining losing coalition \( \wedge \rightarrow \) in obtaining a losing coalition

ECC \( \wedge \rightarrow \) EEC

then then \( \wedge \rightarrow \) then the

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) \{A, B\}, \{A, D\}, \{A, B, C\}, \{A, B, D\}, \{A, C, D\}, \{B, C, D\}.

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: \{A, B\}, \{A, D\}, \{A, B, C\}, \{A, B, D\}, \{A, C, D\}, and \{B, C, D\}.

Voter D has a greater voting weight than voter B

( Yi-Ming Lai )

Voter D has a greater voting weight than voter B

(Yi-Ming Lai)

zero \( \wedge \rightarrow \) one

(N. Batsal)

one \( \wedge \rightarrow \) zero

(N. Batsal)
Table 16.3 was built with data from 2008. To update it for 2016, it should be as follows:

Table 16.3
2016 U.S. electoral college number of electors and Banzhaf measure.

<table>
<thead>
<tr>
<th>State</th>
<th>Electors</th>
<th>Banzhaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>55</td>
<td>0.471</td>
</tr>
<tr>
<td>TX</td>
<td>38</td>
<td>0.298</td>
</tr>
<tr>
<td>FL</td>
<td>29</td>
<td>0.223</td>
</tr>
<tr>
<td>NY</td>
<td>29</td>
<td>0.224</td>
</tr>
<tr>
<td>IL</td>
<td>20</td>
<td>0.153</td>
</tr>
<tr>
<td>PA</td>
<td>20</td>
<td>0.153</td>
</tr>
<tr>
<td>OH</td>
<td>18</td>
<td>0.136</td>
</tr>
<tr>
<td>GA</td>
<td>16</td>
<td>0.121</td>
</tr>
<tr>
<td>MI</td>
<td>16</td>
<td>0.121</td>
</tr>
<tr>
<td>NC</td>
<td>15</td>
<td>0.114</td>
</tr>
<tr>
<td>NJ</td>
<td>14</td>
<td>0.106</td>
</tr>
<tr>
<td>VA</td>
<td>13</td>
<td>0.098</td>
</tr>
<tr>
<td>WA</td>
<td>12</td>
<td>0.091</td>
</tr>
<tr>
<td>AZ</td>
<td>11</td>
<td>0.083</td>
</tr>
<tr>
<td>IN</td>
<td>11</td>
<td>0.083</td>
</tr>
<tr>
<td>MA</td>
<td>11</td>
<td>0.083</td>
</tr>
<tr>
<td>TN</td>
<td>11</td>
<td>0.083</td>
</tr>
<tr>
<td>MD</td>
<td>10</td>
<td>0.076</td>
</tr>
<tr>
<td>NY</td>
<td>10</td>
<td>0.076</td>
</tr>
<tr>
<td>MD</td>
<td>10</td>
<td>0.076</td>
</tr>
<tr>
<td>MD</td>
<td>10</td>
<td>0.076</td>
</tr>
</tbody>
</table>

In 2015 California’s Banzhaf measure is about 20.65 times that of Vermont. In 2016 California’s Banzhaf measure is about 20.48 times that of Vermont.

Page 485, algorithm 16.11 23 May 2017
Output: \((r, q)\), such that \(n = 2^r q\) with \(q\) odd.


► Page 502, first column 12 2017
big-Oh ($O(f(n)) \rightarrow O(f(n))$)
big-Omega ($\Omega(f(n)) \rightarrow \Omega(f(n))$)
add big Theta ($\Theta(f(n))$), 13

Page 502, first column 09 May 2017
added binary fractional number

► Page 503, second column 20 May 2017
European Economic Community (EEC) $\rightarrow$ European Economic Community (EEC)

Page 504, first column 23 Jul 2017
graph re-weighting $\rightarrow$ graph reweighting

Page 504, first column 03 Feb 2018
remove length (move to path, length)

► Page 505, first column 30 Jan 2018
Lember-Ziv-Welch $\rightarrow$ Lempel-Ziv-Welch (Yi-Ming Lai)

Page 505, second column 09 May 2017
added mapping, minimal perfect

Page 506, first column 03 Feb 2018
add path, length