Errata for Edition 1 of Coding the Matrix, January 13, 2017

Your copy might not contain some of these errors. Most do not occur in the copies currently being sold as April 2015.

- Section 0.3: “... the input is a pre-image of the input” should be “... the input is a pre-image of the output”.

- Figure 4 in Section 0.3.8: The figure should be as follows:

```
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
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<tr>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
</tr>
</tbody>
</table>
```

- Definition 0.3.14: “there exists \( x \in A \) such that \( f(x) = z \)” should be “there exists \( x \in D \) such that \( f(x) = z \).”

- Section 4.0.4.4: “...the cryptographer changes the scheme simply by removing ♠ as a possible value for \( p \)” should be “... as a possible value for \( k \).”

- Section 0.5.4: At the end of the section labeled Mutating a set,

```
>>> U=S.copy()
>>> U.add(5)
>>> S
{1, 3}
```

should end with

```
>>> S
{6}
```

- Problem 0.8.5: “row(p)” should be “row(p, n)”.

- Section 1.4.1: “Using the fact that \( i^2 = 1 \)” should be “Using the fact that \( i^2 = -1 \)”

- Section 1.4.5: The diagram illustrating rotation by 90 degrees is incorrect. The dots should form vertical lines to the left of the y-axis.

- Task 1.4.8 and 1.4.9: The figures accompanying these tasks are incorrect; they involve rotation by -90 degrees (i.e. 90 degrees clockwise) instead of 90 degrees (i.e. 90 degrees counterclockwise).

- Task 1.4.10: `image.file2image(filename)` returns a representation of a color image, namely a list of lists of 3-tuples. For the purpose of this task, you must transform it to a representation of a grayscale image, using `image.color2gray(·)`. Also, the pixel intensities are numbers between 0 and 255, not between 0 and 1. In this task, you should assign to `pts` the list of complex numbers \( x + iy \) such that the image intensity of pixel \((x, y)\) is less than 120.

- Task 1.4.11: The task mentions `pts` but `S` is intended.

- Section 2.3: “We’ve seen two examples of what we can represent with vectors: multisets and sets.” Actually, we’ve only seen multisets.
• Section 2.4.1: “or from $[-4, 4]$ to $[-3, -2]$” should be “or from $[-4, -4]$ to $[-3, -2]$”.

• Example 2.6.8: For $\alpha = 0.75, \beta = 0.25$, $\alpha u_2 + \beta v_2$ should be $[6.25, 0]$, not $[6.25, -2]$.

• Section 2.8.3: “Here is an example of solving an instance of the $3 \times 3$ puzzle” should be “Here is an example of one step towards solving an instance of the $3 \times 3$ puzzle.”

• Example 2.9.1: “Consider the dot-product of $[1, 1, 1, 1, 1]$ with $[10, 20, 0, 40, 100]$” should be “Consider the dot-product of $[1, 1, 1, 1, 1]$ with $[10, 20, 0, -100]$.”

• Section 2.9.2: “...in terms of five linear equations...” should be “...in terms of three linear equations...”.

• Example 2.9.5: $\text{cost} = \text{Vec}(D, \{\text{hops : $2.50/ounce}$, \text{malt : $1.50/pound}$, \text{water : $0.006$}, \text{yeast : $0.45/gram$}\})$

should be

$\text{cost} = \text{Vec}(D, \{\text{hops : $2.50/ounce}$, \text{malt : $1.50/pound}$, \text{water : $0.006$, yeast : $0.45/gram$}\})$

• Definition 2.9.6: “A linear equation is an equation of the form $a \cdot x = \beta$, where ... is a vector variable.” should be “A linear equation is an equation of the form $a \cdot x = \beta$, where ... $x$ is a vector variable.”

• Example 2.9.7: The total energy is not 625J but is 0.0845J, as the Python shows.

• Quiz 2.9.9: The total energy consumed in the last row of the table should be 1 J, not 1 W.

• Definition 2.9.10: “In general, a system of linear equations (often abbreviated linear system) is a collection of equations:

$$a_1 \cdot x = \beta_1$$

$$a_2 \cdot x = \beta_2$$

$$\vdots$$

$$a_m \cdot x = \beta_m$$

where $x$ is a vector variable. A solution is a vector $\hat{x}$ that satisfies all the equations.”

should be

“In general, a system of linear equations (often abbreviated linear system) is a collection of equations:

$$a_1 \cdot x = \beta_1$$

$$a_2 \cdot x = \beta_2$$

$$\vdots$$

$$a_m \cdot x = \beta_m$$

where $x$ is a vector variable. A solution is a vector $\hat{x}$ that satisfies all the equations.”

• Quiz 2.9.13: The solution should be “The dot-products are $[2, 2, 0, 0]$.”

• Quiz 2.9.14: The solution should be $[14, 20, 26, 32]$.

• Example 2.9.17:
  - “The password is $\hat{x} = 10111$” should be “The password is $\hat{x} = 10111$”,
  - “Harry computes the dot-product $a_1 \cdot \hat{x}$” should be “Harry computes the dot-product $a_1 \cdot \hat{x}$”
- "Harry computes the dot-product $a_2 \cdot \hat{x}$" should be "Harry computes the dot-product $a_2 \cdot \hat{x}$"
- "Carole lets Harry log in if $\beta_1 = a_1 \cdot \hat{x}, \beta_2 = a_2 \cdot \hat{x}, \ldots, \beta_k = a_k \cdot \hat{x}.\)" should be "Carole lets Harry log in if $\beta_1 = a_1 \cdot \hat{x}, \beta_2 = a_2 \cdot \hat{x}, \ldots, \beta_k = a_k \cdot \hat{x}.\)"

- Example 2.9.28: "Eve can use the distributive property to compute the dot-product of this sum with the password even though she does not know the password:

\[
(01011 + 11110) \cdot \hat{x} = 01011 \cdot \hat{x} + 11110 \cdot \hat{x}
\]

should be

"Eve can use the distributive property to compute the dot-product of this sum with the password $\hat{x}$ even though she does not know the password:

\[
(01011 + 11110) \cdot \hat{x} = 01011 \cdot \hat{x} + 11110 \cdot \hat{x}
\]

- Task 2.12.8: “Did you get the same result as in Task ????” should be “Did you get the same result as in Task 2.12.7?”

- Quiz 3.1.7: the solution

```python
def lin_comb(vlist,clist):
    return sum([coeff*v for (c,v) in zip(clist, vlist)])
```

should be

```python
def lin_comb(vlist,clist):
    return sum([coeff*v for (coeff,v) in zip(clist, vlist)])
```

- Section 3.2.4: The representation of the old generator $[0,0,1]$ in terms of the new generators $[1,0,0]$, $[1,1,0]$, and $[1,1,1]$ should be

\[
[0,0,1] = 0[1,0,0] - 1[1,1,0] + 1[1,1,1]
\]

- In Example 3.2.7, “The secret password is a vector $\hat{x}$ over $GF(2)$... the human must respond with the dot-product $a \cdot \hat{x}$" should be “The secret password is a vector $\hat{x}$ over $GF(2)$... the human must respond with the dot-product $a \cdot \hat{x}$.”

- Example 3.3.10: “This line can be represented as Span $\{[1, -2, -2]\}$” should be “This line can be represented as Span $\{[-1, -2, 2]\}$”

- In Example 3.5.1, “There is one plane through the points $u_1 = [1, 0, 4.4], u_2 = [0, 1, 4], and $u_3 = [0, 0, 3]$” should be “There is one plane through the points $u_1 = [1, 0, 4.4], u_2 = [0, 1, 4], and $u_3 = [0, 0, 3]$”.

- Section 4.1.4: The pretty-printed form of $M$ should be

```python
>>> print(M)
    # 0 ?
---------
a | 2 1 3
b | 20 10 30
```
for some order of the columns.

• Quiz 4.1.9: The given implementation of mat2rowdict will not work until you have implemented the getitem procedure in mat.py.

• Quiz 4.3.1: The pretty-printed form of mat2vec(M) should be

```python
g>>> print(mat2vec(M)) ('a', '#') ('a', '?') ('a', '@') ('b', '#') ('b', '?') ('b', '@')-------------------------------------------------2 3 1 20 30 10```

for some order of the columns.

• Quiz 4.4.2: The pretty-printed form of transpose(M) should be

```python
g>>> print(transpose(M)) a b ------ # | 2 20 @ | 1 10 ? | 3 30```

for some order of the rows. Also, in the solution, the upper-case F should be replaced with a lower-case f.

• Example 4.6.6: The matrix-vector product should be \[[1, -3, -1, 4, -1, -1, 2, 0, -1, 0]\].

• Definition 4.6.9: "An \(n \times n\) upper-triangular matrix \(A\) is a matrix with the property that \(A_{ij} = 0\) for \(j > i\)" should be "for \(i > j\)."

• Section 4.7.2: “Applying Lemma 4.7.4 with \(v = u_1\) and \(z = u_1 - u_2\)” should be “Applying Lemma 4.7.4 with \(v = u_2\) and \(z = u_1 - u_2\)”

• Section 4.7.4: “because it is the same as \(H \ast c\), which she can compute” should be “because it is the same as \(H \ast \tilde{c}\), which she can compute”

• Section 4.11.2: “and here is the same diagram with the walk 3 e 2 e 4 2 shown” should be “and here is the same diagram with the walk 3 c 2 e 4 e 2 shown”

• Example 4.11.9: \(g \circ f([x_1, x_2])\) should be \([x_1 + x_2, x_1 + 2x_2]\).

• Example 4.11.15: The last matrix (in the third row) should be \[\begin{bmatrix}{7} & {19} \\ {4} & {8}\end{bmatrix}\]. a superscript “\(T\)” indicating transpose:

\[\begin{bmatrix}{7} & {4} \\ {19} & {8}\end{bmatrix}^T\]

• Example 4.13.15: \(xvec_1\) should be \(x_1\) and \(xvec_2\) should be \(x_2\).

• The description of Task 4.14.2 comes before the heading “Task 4.14.2”.

• Section 4.15 (Geometry Lab): position is used synonymously with location.

• Section 4.14.6: “Hint: this uses the special property of the order of \(H\)’s rows” should be “Hint: this uses the special property of the order of \(H\)’s columns.”

• Problem 4.17.10 is the same as Problem 4.17.5.
Problem 4.17.18: “For this procedure, the only operation you are allowed to do on $A$ is vector-matrix multiplication, using the $\ast$ operator: $v \ast A$.” should be “For this procedure, the only operation you are allowed to do on $B$ is vector-matrix multiplication, using the $\ast$ operator: $v \ast B$.”

Problem 4.17.21: $xvec_2$ should be $x_2$.

Section 5.3.1: The Grow algorithm should be:

```python
def Grow(V):
    B = ∅
    repeat while possible:
        find a vector $v$ in $V$ that is not in Span $B$, and put it in $B$.
```

Example 5.3.2: “Finally, note that Span $B = \mathbb{R}^2$ and that neither $v_1$ nor $v_2$ alone could generate $\mathbb{R}^3$.” should be “Finally, note that Span $B = \mathbb{R}^3$.”

Section 5.4.3: “Let $D$ be the set of nodes, e.g. $D = \{\text{Pembroke, Athletic, Main, Keeney, Wriston}\}$” should be “Let $D = \{\text{Pembroke, Athletic, Bio-Med, Main, Keeney, Wriston, Gregorian}\}$”.

Section 5.9.1: “The first vector $a_1$ goes horizontally from the top-left corner of the whiteboard element to the top-right corner” should be “The first vector $a_1$ goes horizontally from the top-left corner of the top-left sensor element to the top-right corner” and “The second vector $a_2$ goes vertically from the top-left corner of whiteboard to the bottom-left corner” should be “The second vector $a_2$ goes vertically from the top-left corner of the top-left sensor element to the bottom-left corner.”

$$L = \begin{bmatrix}
0,0,0, & [1,0,0], & [0,1,0], & [1,1,0], & [0,0,1], & [1,0,1], & [0,1,1], & [1,1,1]
\end{bmatrix}$$

should be

$$L = \begin{bmatrix}
0,0,0, & [1,0,0], & [0,1,0], & [1,1,0], & [0,0,1], & [1,0,1], & [0,1,1], & [1,1,1]
\end{bmatrix}$$

Section 5.9.1, diagram: The point in the bottom-left-back of the cube should be labeled (0,1,1) but is labeled (0,1,0).

Section 5.9.5: In “For the third basis vector $a_2$...” and “Remember that $a_2$ points from the camera center to the top-left corner of the sensor array, so $a_2 = (-.5, -.5, 1)^T$, $a_2$ should be $a_3$, and $a_3 = [0,0,1]$. The third vector in cb has an extra 0.”

“The third vector $c_3$ goes from the origin (the camera center) to the top-right corner of whiteboard.” should be “The third vector $c_3$ goes from the origin (the camera center) to the top-left corner of the whiteboard.”

Section 5.12.1:

Section 5.12.6: The vector $\begin{bmatrix} x_1 \\ xvec_2 \\ 1 \end{bmatrix}$ should be $\begin{bmatrix} x_1 \\ x_2 \\ 1 \end{bmatrix}$

Section 5.12.6: After Task 5.12.2, “Let $[y_1,y_2,y_3] = Hx$” should be “Let $[y_1,y_2,y_3] = \hat{H}x$”.

Problem 5.14.18: “Write and test a procedure $\text{superset\_basis}(S, L)$” should be “Write and test a procedure $\text{superset\_basis}(T, L)$”.

Lemma 6.2.13 (Superset-Basis Lemma) states
For any vector space $V$ and any linearly independent set $A$ of vectors, $V$ has a basis that contains all of $A$.

but should state

For any vector space $V$ and any linearly independent set $A$ of vectors belonging to $V$, $V$ has a basis that contains all of $A$.

- Example 6.3.3: $V$ is defined to be the null space of $egin{bmatrix} 0 & 1 & -1 & 0 \\ 1 & 0 & 0 & -1 \end{bmatrix}$ but should be defined to be the null space of $\mathbf{0}$, $\mathbf{1}$, $\mathbf{-1}$, $\mathbf{0}$.

- Problem 6.7.3: The output condition says

  for $i = 1, 2, \ldots, k$,

  $\text{Span } S = \text{Span } S \cup \{z_1, z_2, \ldots, z_i\} - \{w_1, w_2, \ldots, w_k\}$

but should say

  for $i = 1, 2, \ldots, k$,

  $\text{Span } S = \text{Span } S \cup \{z_1, z_2, \ldots, z_i\} - \{w_1, w_2, \ldots, w_k\}$

- Section 7.7.1: $\text{xvec}_1$ and $\text{xvec}_2$ should be $x_1$ and $x_2$

- Section 7.7.4: “Generating $\text{mathbf{u}}$” should be “Generating $\text{u}$.

- Section 7.8.3: “We can represent the factorization of 1176 by the list $\{2, 3\}$, indicating that 1176 is obtained by multiplying together three 2’s and two 5’s” should be “We can represent the factorization of 1176 by the list $\{2, 3\}$, indicating that 1176 is obtained by multiplying together three 2’s, one 3, and two 7’s”, and “1176 = 23\,52” should be “1176 = 2\,3\,172”.

- Task 7.8.7: For $x = 61$, the factored entry has $2 \cdot 3 \cdot 7 = 13$. This should be $2 \cdot 3 \cdot 7 \cdot 13$.

- Task 7.8.9: “gcd(a, b)” should be “gcd(a - b, N)”.

- Section 9.2: In new spec for $\text{project_orthogonal}(b, \text{vlist})$, output should be “the projection $b^*$ of $b$ orthogonal to the vectors in vlist”.

- Example 9.1.1: The math is misformatted; there should be a line-break just before $b_2$. That is, the math should state that $b_1 = \{-1, -3.5, 0.5\}$ and that $b_2 = b_1 - \frac{b_2}{v_2}v_2 = b_1 - \frac{1}{2}[0, 3, 3] = [-1, -2, 2]$.

- Section 9.6.6: “These vectors span the same space as input vectors $u_1, u_2, \ldots, w_1, \ldots, w_n^*$.” The * in $w_n^*$ should not be there.

- Section 9.6.6: In the pseudocode for $\text{find_orthogonal_complement}$, the last line should be

  \text{Return}

- Proof of Lemma 10.6.2: The first line of the last sequence of equations,

  $\omega^{r-c} = (\omega^{r-c})^0 + (\omega^{r-c})^1 + (\omega^{r-c})^2 + \ldots + (\omega^{r-c})^{n-2} + (\omega^{r-c})^{n-1}$

should be

  $\omega^{r-c}z = \omega^{r-c}((\omega^{r-c})^0 + (\omega^{r-c})^1 + (\omega^{r-c})^2 + \ldots + (\omega^{r-c})^{n-2} + (\omega^{r-c})^{n-1})$

- Task 10.9.16: The procedure $\text{image_round}$ should also ensure the numbers are between 0 and 255.

- Proof of Lemma 11.3.6: “Let $\mathcal{V}^*$ be the space dual to $\mathcal{V}$” should be “Let $\mathcal{V}$ be the annihilator of $\mathcal{V}$”, and “the dual of the dual” should be “the annihilator of the annihilator”.

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• Section 11.3.3: “...we provide a module svd with a procedure factor(A) that, given a Mat A, returns a triple (U, Sigma, V) such that A = U * Sigma * V.transpose” should end “such that A = U * Sigma * V.transpose()”

• Proof of Lemma 11.3.11: “which equals (∥a1∥2 + · · · + ∥am∥2) + (∥a1∥V 2 + · · · + ∥am∥V 2)” should be “which equals (∥a1∥2 + · · · + ∥am∥2) − (∥a1∥V 2 + · · · + ∥am∥V 2)”

• Section 11.3.5, Proof of Theorem 11.3.12: There is a corrected proof at http://codingthematrix.com/proof-that-first-k-right-singular-vectors-span-closest-space.pdf.

• Section 11.3.10: There is a corrected proof at http://codingthematrix.com/proof-that-U-is-column-orthogonal.pdf.

• Task 11.6.6. “To help you debug, applying the procedure to with” should be “To help you debug, applying the procedure with”

• Section 11.4.1: The procedure SVD.solve(A) should take the vector b as a second argument: SVD.solve(A, b).

• Section 11.6 (Eigenfaces Lab): {x, y for x in range(166) for y in range(189)} should be {(x, y) for x in range(166) for y in range(189)}.

• Section 12.1.2: The diagonal matrix Λ is used shortly before it is defined.


• Section 12.8.1: xvec2(t) should be just x2(t).

• Section 12.8.1: In the equation

\[
\begin{bmatrix}
x_1^{(t)} \\
x_2^{(t)}
\end{bmatrix}
= (SΛS−1)^t
\begin{bmatrix}
x_1^{(0)} \\
x_2^{(0)}
\end{bmatrix}
\]

λ should be Λ.

• Section 12.8.1: xvec2(t) should be x2(t) and xvec2(0) should be x2(0).

• Section 12.8.4: “Once consecutive addresses have been requested in timesteps t and t + 1, it is very likely that the address requested in timestep t + 1 is also consecutive” should end “that the address requested in timestep t + 2 is also consecutive.”

• Section 12.12.1: “The theorem in Section 12.8.2...” There is no theorem in that section; the theorem (the Perron-Frobenius Theorem) is not stated in the text.

• Section 12.12.3: The eigenvector given for the test case for Task 12.12.3 is wrong; the correct eigenvector is roughly {1: 0.5222, 2: 0.6182, 3: 0.5738, 4: 0.0705, 5: 0.0783, 6: 0.0705}. 

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