List of errors

The first print of the book *Robotics: Fundamental Concepts and Analysis* (2006) contained several typing and other mistakes which may lead to confusion for the reader. All these and other minor ones have been corrected in the second print published in May 2008. For those readers who have a copy of the first print, here is a list of some of the major typographical errors and mistakes in the text, formulas and figures.

- Equation (2.16) on page 29, the $(2,2)$ in the matrix has a sign mistake. The term “$-s_1c_2s_3 - c_1c_3$” should be “$-s_1c_2s_3 + c_1c_3$”.
- Page 35, third line from bottom – ”(see Section 2.9,...)” should be “(see Section 2.8,...)”.
- Line below equation (2.38) – part of the statement “and that the four-dimensional .... is an eigenvector of $A_B[T]$.” is incorrect. This has been deleted in the second print.
- First line of equation (2.49) on page 48 should read as
  \[
  \begin{bmatrix}
  i-1
  
  
  \end{bmatrix}_i = [R(X_{i-1}, \alpha_{i-1})]\begin{bmatrix}
  i
  
  \end{bmatrix}_i
  \]
  square brackets and “,” are missing.
- In Example 2.5, the coordinate systems $\{L_i\}, i = 1,1,2,3$ are not defined or shown in figure 2.22. The coordinate systems $\{L_i\}, i = 1,2,3$ are attached to the three rotary joints $R_i, i = 1,2,3$ at the base of the parallel manipulator. Hence, a line has been added below the table on page 56 – “It may be noted that $\{L_1\}, \{L_2\},$ and $\{L_3\}$ are coordinate systems attached to the three rotary joints $R_1$, $R_2$, and $R_3$, respectively.”
- In figure 2.23 on page 58, the symbol “1” near the arrowhead denoting the axis of $\theta_3$ rotation should be removed.
- In Exercise 2.1, the symbols “$A^P_1$, $A^P_2$, and $A^P_3$” should be “$A_p^1$, $A_p^2$, and $A_p^3$”. The uppercase $A^P$ denotes $4 \times 1$ vector.
- In Exercise problems 2.3 and 2.11, it is easier to visualize the orientations and estimate by using any 3D CAD software. It may be noted that the opposite faces of a dice add up to 7.
- In Exercise problem 2.15 – The arrangement of first three joints is similar to a PUMA 560.
- Page 68, the reference by Sangamesh D. R. .... is now available as
- Second line from bottom, page 73 – “1. $n = 6$ ....or $n < 3$ for a ...” should read as “1. $n = 6$ ....or $n = 3$ for a ...”
- Figure 3.3, page 76 – $\tilde{Y}_A$ should read as $\tilde{Y}_0$. 

1
• Page 76, first line of Example 3.5 – “... shown in Figs 2.17 and 2.18,...” should read as “... shown in Figs 2.18 and 2.19,...”.

• Page 78, in the Algorithm $r_{ij} \Rightarrow \theta_4, \theta_5$ and $\theta_6$, the values of $\theta_5$ are incorrect. It should read as:

  $\theta_5 = 0, \quad \text{and} \quad \theta_5 = \pi$

• Page 79, equation after equation (3.23), the subscript $K_4$ should read as $K_3$.

• Page 83, the superscript on the first rotation matrix is incorrect. Equation (3.26) should read as:

  $\frac{3}{6}[R] = \frac{0}{3}[R]^T \theta_6[R]$

• Page 84, (3,1) is incorrect. $\theta_4$ is obtained as

  $\theta_4 = \text{Atan}2((3,3)/s_5, -(1,3)/s_5)$

• Page 85, two lines below equation (3.29) – “[see Eqn 2.7...” should read as “[see Eqn (2.5.1)...”.

• Page 85, last paragraph – the line “...first matrix $({i-1}[T])_m..$” should read as “...first matrix $({i-1}[T])_m..$”.

• Page 86, two lines below equation (3.32) should read as

  “...the remaining five variables, $\theta_1, \theta_2, \theta_3, \theta_4$, and $\theta_5$ in ...”

• Page 88, third line from bottom – “manipulator (Example 3.1, the ....” should read as “manipulator (Example 3.3, the ...”

• Figure 3.5, the heading “Joint 2 restricted .....120°” should be deleted. The figure is redrawn in the reprint.

• Page 93, line 7 from top should read as

  “$\pm(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}})$” instead of “$\pm(\frac{1}{2}, \frac{1}{2})$”.

• Page 94, in equation (3.46) $a_0$ and $b_0$, in general, can be a function of $y$. Hence, “$a_0$” and “$b_0$” is to be replaced by “$a_0(y)$” and “$b_0(y)$”, respectively.

• Page 95, equation (3.51) should read as

  $(a_{m-1}b_n - a_m b_{n-1})x^{m-1} + (a_{m-2}b_n - a_m b_{n-2})x^{m-2} + ... + a_0 b_n = 0$

• Page 99, Exercise 3.13 – “....compare with Exercise 3.11.” should read as “....compare with Exercise 3.12.”.

• Page 105, in Fig. 4.1, the symbol “$\theta_2$” is to replaced by “$\phi_2$”.

• Page 106, sixth line from top – the sentence “...can have 12 different loops...” is misleading as there can be more than 12 loops. It is to be replaced by “...can have many different loops – for example, five ....”.

2
Page 109, equation (4.9) – the last equation should read as

\[ \theta_1 + \phi_2 = \phi_1 + \phi_3 + \pi \]

Page 109, equation (4.10) – the superscript T is missing.

Page 111, seventh line from top – “dialectic” should be spelt as “dialytic”.

Page 113, line 7 from top – “from Eqns (4.15) and (4.23)...” should read as “from Eqns (4.21) and (4.23)...”.

Page 114, Example 4.2 – It should be “(see Fig. 2.22).”

Page 114, the last equation in (4.25) should read as

\[ (\text{Base} \mathbf{S}_3 - \text{Base} \mathbf{S}_1) \cdot (\text{Base} \mathbf{S}_3 - \text{Base} \mathbf{S}_1) = k_{31}^2 \]

Page 115, the last three lines should read as

“... constants. The second equation in Eqn (4.26) also yields a quadratic in \( x_2 \) with the coefficients as functions of \( \theta_3, l_2, l_3 \) and constants. Following Sylvester’s dialytic method, we can eliminate \( \theta_2 \) between the quartic and the quadratic....”

Page 116, a bracket ( is missing in first equation in Eqn (4.31). It should read as

\[ q_8 = (p_0 a^4 + p_1 a^3 + p_2 a^2 + p_3 a + p_4)^2 \times (p_0 a^4 - p_1 a^3 + p_2 a^2 - p_3 a + p_4)^2 \]

Page 120, in equation (4.40) the symbol “×” should be replaced by “+”.

Page 126, line after equation (4.54) should read as

“and again using Eqns (4.51) and (4.51),...” should be “and again using Eqns (4.51) and (4.54),...”.

Page 126, line 4 after equation (4.54) – “\( p, p \)” should read as “\( p, q \)”.

Page 128, Equation (4.56) should read as

\[ \phi = \theta_1 + \phi_2 - 2\pi \]

and likewise the term \( \theta_1 + \phi_2 \) in 2 lines below equation (4.58) should read as \( \theta_1 + \phi_2 - 2\pi \). This follows from how the angles are marked in Fig. 4.8.

Page 129, Example 4.6 – “in Fig. 2.22...” should read as “in Fig. 2.23...”.

Page 129, equation (4.60) should be corrected to

\[ \text{Base} \mathbf{S}_1 = \text{Base} \mathbf{S}_1 + \text{Base} \mathbf{p}_\text{Object} \]

The last term was left out.

Page 132, figure 4.10 for exercise 4.2 – The angle \( \phi_3 \) and \( \phi_2 \) are the angles between “Link 2 and Link 3” and between “Link 3 and Link 4” respectively. These are not marked in the figure. In addition, the symbol “\( O_f R \)” should be “\( O_R \)”. 
• Page 134, Fig. 4.13 – “Moving platform” should read as “Moving platform”.

• In Section 5.2, the development of angular velocity matrix is discussed starting from $[R][R]^{-1}$. It is more correct and conventional to use $[R][R]^T$ and then take derivatives etc. Hence, in all equations involving angular velocity in Chapter 5 wherever $[R]^{-1}$ occurs it is to be replaced by $[R]^T$.

• Page 142, equation (5.13), the subscript 0 should be superscript 0. The equation should read as

$$0V_p = \dot{0}i[R]^{-1}0p$$

• Page 144, line below equation (5.25) should read as “Equations (5.21), (5.24) and (5.25) can be used to obtain,...”

• item Page 144, one line below Example 5.1 – “Figure 2.16..” should read as “Figure 2.17...”.

• Page 144, last line – “(5.25), we have” should read “(5.24, we have”.

• Page 145, two lines below equations – “...as shown in Fig. 2.16.” should read as “...as shown in Fig. 2.17”.

• Page 151, equation (5.36) should read as

$$g_{11} = g_{22} \quad \text{and} \quad g_{12} = 0$$

• Page 152, two lines from bottom – “Example 4.1” should read as “Example 4.2”.

• Not to confuse the symbol “$[K^*]$ ” used in Chapter 5 with the symbol used in Chapter 10, all “$[K^*]$ ” in Chapter 5 is replaced with light face symbol “$[K^*]$ ”. See also Exercise problems 5.8, 5.9, 5.13. Likewise in some places the symbol used for the Jacobian matrix is incorrectly bold. It should be uniformly light face $J$

• Page 156, 4 lines below equation (5.53) – “...given in Eqn (4.32).” should read as “...given in Eqn (4.33).”

• Page 159, line below Fig. 5.6 – “From Eqn (5.53)...” should read as “From Eqn (5.55)...”.

• Page 162, 2 lines below equation (5.60) – “...equation in Eqn (4.2)...” should read as “...equation in Eqn (4.3)...”.

• Page 163, the expression for $\cos \theta_1$ above figure 5.8 should be

$$\cos \theta_1 = \frac{l_0^2 + l_1^2 - (l_2 + l_3)^2}{2l_0 l_1}$$

• Page 172, “ = ” symbol is missing between the second and the third term. The equation (5.75) should read as

$$B_0 F_{Tool} \triangleq \begin{pmatrix} B_0 F_{Tool} \\ - - - \\ B_0 M_{Tool} \end{pmatrix} = \begin{pmatrix} \sum_{i=1}^{6} B_0 s_i f_i \\ - - - \\ \sum_{i=1}^{6} (B_0 b_i \times B_0 s_i) f_i \end{pmatrix}$$
• Page 173, in equation (5.78), the second \(B_0s_1\) should be \(B_0s_2\).

• Page 178, equation (5.88) – the superscript 
\(-1\) should be deleted. It should read as 
\[0^0\nabla_{\text{Tool}} = 0^0\nabla_{\text{Tool}}[J(\Theta)]\hat{\Theta} \]

• Page 179, Exercise 5.1 – “...angular velocity would be but to use?” should read s “.....angular velocity would be put to use?”.

• Page 179, 180, Exercise problems 5.9 and 5.14 – “...discussed in Example 5.2” should read as “...discussed in Example 5.3”

• Page 187, Equation (6.5) – The rotation matrix should be \(0_i[R] \) instead of \(i_0[R]\).

• Page 190, Equation (6.19) – The symbol “-” is over \(L\) and not over \(q\). The left-hand side of equation (6.19) should read as \(L(\mathbf{q}, \dot{\mathbf{q}})\)

• Page 192, Equation (6.30) – The mass matrix should have a bold \(M\).

• Page 202, Equation (6.36) – The Jacobian matrix is a light face \(J\). The derivative symbol “.” is over \(J\) and not over \(q\).

• Page 205, Equations (6.37) and (6.38) – The symbol “\(M\)” in the mass matrix should be bold “\(\mathbf{M}\)”.

• Page 211, Equation (6.45) – The last term is \(0_i\omega_i \times (0_i\omega_i \times 0_i[R] \mathbf{p})\)

• Page 211, line below equation (6.45) – The line should read as “If \(\mathbf{p}\) is a constant, then \(i\mathbf{V}_p = i\dot{\mathbf{V}}_p = 0\) and ....”.

• Page 212, first line of the algorithm – “...in Section 5.2...” should read as “...in Section 5.3...”.

• Page 225, line below equation (7.11) – \(\theta_{1u}\) should read as \(\theta_{1}(u)\).

• Page 230, equation (7.17) – The term \((x(t) - x_0)\) should read as \((x(t) - x_f)\). This error is there in the second print also!

• Page 231, equation (7.19) – The third equation should read as 
\[a_2 = \frac{3}{t_f^2}(x_f - x_0) - \frac{2}{t_f}x_0 - \frac{1}{t_f}x_f\]

• Page 232, equations (7.23) should read as
\[
x(t) = a + r \cos(\phi(t)) \\
y(t) = b + r \sin(\phi(t)) \\
z(t) = c
\]
• Page 233, step 2 – 2 should be a superscript as in $C^2$.
• Page 243, Fig. 8.3 – The input to the top right block diagram is $T_d(s)$ and not $V_a(s)$.
• Page 246, Fig. 8.4 – The input should be $\Omega_d(s)$ and not $\Omega_d(t)$.
• Page 247, equation (8.18) – the last term should read as

$$\frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

• Page 256, line 1 – “Eqn (6.14)” should read as “Eqn (6.30)”.
• Page 260, line 4 – “...$\theta_i$ ($i = 1$)...” should read as “...$\theta_i$ ($i = 1, 2$)...”
• Page 268, Equation after equation (8.42) – The second term is $\ddot{\Theta}_d$.
• Page 268, second last line – $\theta_1^*d$ should be replaced by $\theta_i^*d$.
• Page 274, equation (8.52) – The term $\ddot{\phi}$ is to replaced with $\ddot{\phi}_d$.
• Page 278, figure 8.29 – There should be no arrow into the model based block with Coriolis, centripetal and gravity term.
• Page 283, two lines above Section 8.8.2 – “Section 8.7” should be Section “8.6”.
• Page 285, figure 8.32 – At the top, it should be $f_x, f_y, n_z$. $f_x$ is repeated.
• Section 8.9 - In the text $[S]'$ should be replaced by $[S']$ as in figure 8.34.
• Page 299, Exercise 8.7 – In inequality in the third line should read as $\pi/2 \leq \phi \leq \pi$.
• Page 306, last but one block – The denominator is $J_l$ and not $J_1$.
• Page 313, 5 lines below figure 9.5 – $I_t$ should be $l(t)$.
• Page 317, Equation (9.22) – One extra $=$ is to be removed.
• Page 344, third line after equation (9.92) – The symbol $\dot{X}$ should be $\dot{X}_d$.
• Page 345, Equation (9.93) should read as

$$G_r(q_r, q_f) = -[J^r_{q_r}]^T[K_p]_\chi \dot{\chi} + G_r(q_{rd}, q_{fd})$$

• Page 359, The reference “Chandra Shaker, M. ....” is now available as

• Page 370, Figure 10.3 – The plot and the axis numbers are to be shifted up and to the right.
• Page 396 – In equation (10.36) and line below, the symbol $\Psi$ should be bold face as $\Psi$. 6
• Page 406, three lines below figure 10.30, the expression should read as

\[(u_g, v_g, a_0 \cos(\omega_1 u_g) \sin(\omega_2 v_g))\]

I wish to thank the readers who have pointed out many of the mistakes. Pointing out any additional mistakes would be highly appreciated.