FUNDAMENTALS OF ROBOTIC MECHANICAL SYSTEMS

Third Edition

Theory, Methods, and Algorithms

Errata

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Introduction: In order to ease the finding of items in this document, we have kept the page format and the original fonts of the book; we have also typeset with typewriter font---the one used in this Introduction---text that does not belong to the book.

p. 62: Text from eq.(2.98) and up to the paragraph below eq.(2.110) should read:

$$\{\mathbf{T}\}_{\mathcal{A}} \equiv \begin{bmatrix} [\,\mathbf{Q}\,]_{\mathcal{A}} & [\,\mathbf{b}\,]_{\mathcal{A}} \\ \mathbf{0}^T & 1 \end{bmatrix} \tag{2.98}$$

where $\mathbf{0}$ is a three-dimensional array of zeros and, as the real unity, need not be expressed in any particular frame.

Furtheremore[1],

Theorem 2.2.5 *The representations of $\{\mathbf{T}\}$ carrying coordinates in frame $\mathcal{B}$ into coordinates in frame $\mathcal{A}$, in these two frames, are related by a similarity transformation:*

$$\{\mathbf{T}\}_{\mathcal{B}} = \begin{bmatrix} [\,\mathbf{Q}\,]_{\mathcal{A}} & [\,\mathbf{Q}^T\,]_{\mathcal{A}}[\,\mathbf{b}\,]_{\mathcal{A}} \\ \mathbf{0}^T & 1 \end{bmatrix} \equiv \{\mathbf{R}\}_{\mathcal{A}}{}^T\{\mathbf{T}\}_{\mathcal{A}}\{\mathbf{R}\}_{\mathcal{A}} \tag{2.99}$$

where Theorem 2.5.2 has been invoked, while $\{\mathbf{R}\}_{\mathcal{A}}$ is defined as

$$\{\mathbf{R}\}_{\mathcal{A}} \equiv \begin{bmatrix} [\,\mathbf{Q}\,]_{\mathcal{A}} & \mathbf{0} \\ \mathbf{0}^T & 1 \end{bmatrix} \tag{2.100}$$

The inverse transformation of that defined in eq.(2.98) can be derived from eq.(2.94b), thus obtaining

$$\{\,\mathbf{T}^{-1}\,\}_{\mathcal{B}} = \begin{bmatrix} [\,\mathbf{Q}^T\,]_{\mathcal{B}} & -[\,\mathbf{Q}^T\,]_{\mathcal{B}}[\,\mathbf{b}\,]_{\mathcal{A}} \\ \mathbf{0}^T & 1 \end{bmatrix} \equiv \begin{bmatrix} [\,\mathbf{Q}^T\,]_{\mathcal{B}} & -[\,\mathbf{b}\,]_{\mathcal{B}} \\ \mathbf{0}^T & 1 \end{bmatrix} \tag{2.101}$$

Notice that the foregoing inverse appears naturally in $\mathcal{B}$, rather than in $\mathcal{A}$.

Furthermore, homogeneous transformations can be concatenated. Indeed, let $\mathcal{F}_k$, for $k = i-1,\, i,\, i+1$, denote three coordinate frames, with origins at O_k. Moreover, let $\mathbf{Q}_{i-1}$ be the rotation carrying $\mathcal{F}_{i-1}$ into an orientation coinciding with that of $\mathcal{F}_i$. If a similar definition for $\mathbf{Q}_i$ is adopted, then $\mathbf{Q}_i$ denotes the rotation carrying $\mathcal{F}_i$ into an orientation coinciding with that of $\mathcal{F}_{i+1}$. First, the case in which all three origins coincide is considered. Clearly,

$$[\,\mathbf{p}\,]_i = [\,\mathbf{Q}_{i-1}^T\,]_{i-1}[\,\mathbf{p}\,]_{i-1} \tag{2.102}$$

$$[\,\mathbf{p}\,]_{i+1} = [\,\mathbf{Q}_i^T\,]_i[\,\mathbf{p}\,]_i = [\,\mathbf{Q}_i^T\,]_i[\,\mathbf{Q}_{i-1}^T\,]_{i-1}[\,\mathbf{p}\,]_{i-1} \tag{2.103}$$

the inverse relation of that appearing in eq.(2.103) being

$$[\,\mathbf{p}\,]_{i-1} = [\,\mathbf{Q}_{i-1}\,]_{i-1}[\,\mathbf{Q}_i\,]_i[\,\mathbf{p}\,]_{i+1} \tag{2.104}$$

[1] cf. Theorem 2.5.2. The reader is invited to prove this result.

If now the origins do not coincide, let $\mathbf{a}_{i-1}$ and $\mathbf{a}_i$ denote the vectors $\overrightarrow{O_{i-1}O_i}$ and $\overrightarrow{O_iO_{i+1}}$, respectively. The homogeneous-coordinate transformation matrices $\{\mathbf{T}_{i-1}\}_{i-1}$ and $\{\mathbf{T}_i\}_i$ thus arising are, apparently,

$$\{\mathbf{T}_{i-1}\}_{i-1} = \begin{bmatrix} [\,\mathbf{Q}_{i-1}\,]_{i-1} & [\,\mathbf{a}_{i-1}\,]_{i-1} \\ \mathbf{0}^T & 1 \end{bmatrix}, \quad \{\mathbf{T}_i\}_i = \begin{bmatrix} [\,\mathbf{Q}_i\,]_i & [\,\mathbf{a}_i\,]_i \\ \mathbf{0}^T & 1 \end{bmatrix} \tag{2.105}$$

Further, let $\mathbf{p}_i$ denote vector $\overrightarrow{O_iP}$ *in any frame*. The transformations of the position vector of P are, thus,

$$\{\mathbf{p}_{i-1}\}_{i-1} = \{\mathbf{T}_{i-1}\}_{i-1}\{\mathbf{p}_i\}_i \tag{2.106}$$
$$\{\mathbf{p}_{i-1}\}_{i-1} = \{\mathbf{T}_{i-1}\}_{i-1}\{\mathbf{T}_i\}_i\{\mathbf{p}_{i+1}\}_{i+1} \tag{2.107}$$

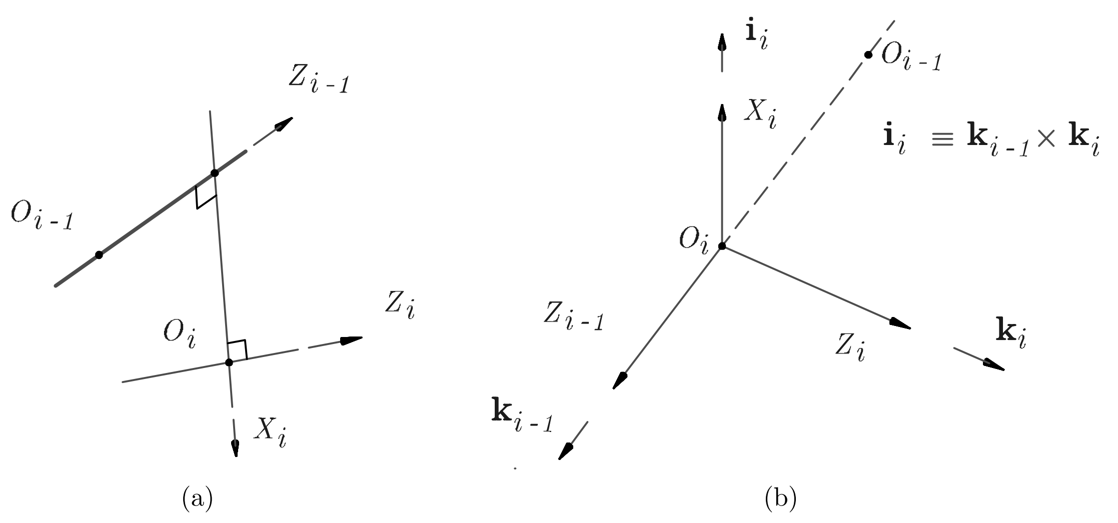
the corresponding inverse transformations being

$$\{\,\mathbf{p}_i\,\}_i = \{\mathbf{T}_{i-1}\}_{i-1}^{-1}\{\,\mathbf{p}_{i-1}\,\}_{i-1} \tag{2.108}$$
$$\{\,\mathbf{p}_{i+1}\,\}_{i+1} = \{\mathbf{T}_i\}_i^{-1}\{\,\mathbf{p}_i\,\}_i = \{\mathbf{T}_i\}_i^{-1}\{\mathbf{T}_{i-1}\}_{i-1}^{-1}\{\,\mathbf{p}_{i-1}\,\}_{i-1} \tag{2.109}$$

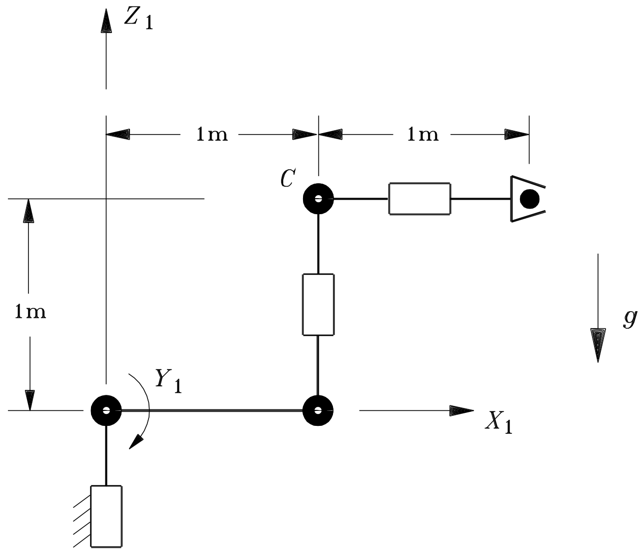
Notice that, in the above relations, we have written $\{\mathbf{T}_i\}_i^{-1}$, rather than $\{\mathbf{T}_i^{-1}\}_i$, which are different. The reader is invited to show, with the aid of relation (2.101), that

$$\{\mathbf{T}_i\}_i^{-1} = \{\mathbf{T}_i^{-1}\}_{i+1} \tag{2.110}$$

p. 132: `Figures 4.2(a) & (b) should be replaced by:`

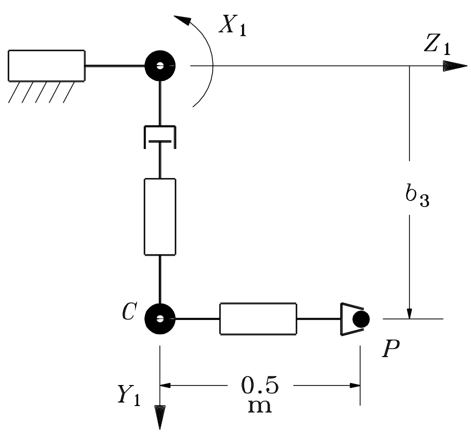


p. 227: `Exercise 5.2 makes reference to a specific posture (configuration in the text) of the robot of Fig. 4.19, but that figure shows an arbitrary posture. The posture in question is that of the figure below:`



p. 298: The caption of Fig. 7.7 makes reference to Fig. 4.19, which should be Fig. 4.15:

p. 229: Exercises 5.2 and 5.8 make reference to a specific posture (configuration in the text) of the robot of Fig. 4.19, but that figure shows an arbitrary posture. The posture in question is shown in the figure below:



p. 316 Exercise 7.3 makes reference to a specific posture of the robot of Fig. 4.19, but that figure shows an arbitrary posture. The posture in question is that displayed in the erratum item of p. 227.