The **rigidnotation** package*

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Abstract

This package provides LaTeX macros to easily and concisely typeset vectors and matrices in a flexible way such as to follow the RIGID notation convention. The package enables the user to define custom commands that can then be used in any math-mode environment to efficiently and rigorously typeset the notational elements commonly used in robotics research (and many other fields) for position vectors, rotation matrices, pose matrices, etc.

1 Introduction

A useful typesetting system should reduce to a minimum the number of keystrokes required by the user while enabling a flexible usage of the system and cater to various needs. This is the philosophy behind this package.

This package makes it easy to typeset vectors and matrices following the RIGID convention, which is compliant with the *ISO 800000 Standard on Quantities and Units*. To do so, this package defines a *command factory* that can be used to concisely generate multiple commands, each one dedicated to a user-defined quantity (e.g. position vector, velocity vector, rotation matrix). The user can then call the generated commands within math-mode environments to typeset a concise representation of the quantity.

For instance, `\Pos[\dot]{s}{b}{w}\Tran` produces

$$
{}^{w}_{b}\dot{\boldsymbol{p}}_{s}^{\top}
$$

which very concisely represents the time-derivative of the transposed position vector of subject s with respect to basis b when expressed in coordinate system w. When typing the keystrokes, the user can think: *position of s with respect to b expressed in w, transposed.* Except for the accent, the order in which the elements are typed respects the order in which they can be spoken, making it easier to remember the order of the arguments.

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*This document corresponds to **rigidnotation** 1.0.0, dated 2024/05/13.

The *subject* of a quantity is the elements to which the quantity pertains (e.g. the orientation of the subject, the velocity of the subject). The *basis* is the element relative to which the quantity is observed/measured/defined (e.g. the velocity of the car/subject relative to the train/basis). A vector quantity is commonly pictured as an arrow pointing from the basis to the subject. To facilitate computations, quantities are *expressed* in a *coordinate system* such that they can be represented as a set of numbers. Sometime it makes sense to specify only a subset of the four elements: quantity, subject, basis, and coordinate system. This package allows the user to specify only the necessary elements. A *concise mode* can also be enabled such that when the basis and coordinate system are the same, only the basis is denoted.

2 Usage

The typical usage of the package involves defining quantities of interest in the preamble, like

```
\usepackage{rigidnotation}
\NewRigidNotation{Vel}{v} % Velocity
\NewRigidNotation{Acc}{a} % Acceleration
% Whether the concise notation is desired
\SetConciseNotation{\BooleanTrue}
```

in which quantities representing velocities and accelerations are defined. Then, in any math-mode environment, variations of the following commands can be used:

```
\begin{equation*}
  1:\Vel \quad
  2:\Vel[\hat] \quad
  3:\Vel[\ddot]{s} \quad
  4:\SetConciseNotation \Vel{s}{b}{b} \quad
  5:\Vel{s}{b}{c} \quad
  6:\UnsetConciseNotation \Vel{s}{b}{b} \quad
  7:\Acc{s}{b}\Tran \quad
  8:\Acc{s}{b}^2 \quad
  9:\Rot{s}{b}\Inv \quad
\end{equation*}
```

to produce

$$1: \boldsymbol{v} \quad 2: \hat{\boldsymbol{v}} \quad 3: \ddot{\boldsymbol{v}}_s \quad 4: {}_b\boldsymbol{v}_s \quad 5: {}_b^c\boldsymbol{v}_s \quad 6: {}_b^b\boldsymbol{v}_s \quad 7: {}_b\boldsymbol{a}_W^\top \quad 8: {}_b\boldsymbol{a}_W^2 \quad 9: {}_b\boldsymbol{R}_W^{-1}$$

where the concise notation was enabled for items 4 and 5 but disabled for element 6 (notice the difference). Also note that command `\Rot` was used even though it was not defined in the preamble. This is because the package comes with a few pre-defined quantities: `\Pos`, `\Rot`, and `\Pose`.

2.1   Commands

In the following, arguments surrounded by square brackets are optional while those surrounded by curly brackets are mandatory like [⟨*optional*⟩] and {⟨*mandatory*⟩} respectively.

\NewRigidNotation **Arguments**:

1. {⟨*name*⟩}: Name of the command to create.

2. {⟨*symbol*⟩}: Symbol used to represent the quantity.

Description:
Define a new command that can be used to typeset a physical or mathematical quantity according to the RIGID convention. For instance, \NewRigidNotation{Pos}{p} can be used to create a new command \Pos for typesetting position vectors, with the p symbol being used to represent the quantity. After it has been defined, the new command can be used with the following arguments:

1. [⟨*accent*⟩]: Command to put an accent over the letter (e.g. \hat).

2. [⟨*subject*⟩]: The symbol of the *subject* (e.g. vector endpoint).

3. [⟨*basis*⟩]: The symbol of the *basis* (e.g. vector origin).

4. [⟨*coord*⟩]: Symbol for the coordinate system potentially used.

Hence, this is a kind of meta-command or command factory: \NewRigidNotation creates a new command that can be used with arguments. For instance, calling \NewRigidNotation{Pos}{p} defines a new command \Pos that can be used with zero or more arguments, as in \Pos[\dot]{a}{b}{c}, in which a is the subject symbol, b is the basis symbol, c is the coordinate system, and a dot ($\cdot$) will be placed above the p in the notation, producing $_b^c\dot{\boldsymbol{p}}_a$.

\SetConciseNotation **Arguments**:

1. [⟨*bool*⟩]: Either \BooleanTrue or \BooleanFalse.

Description:
Sets whether to use the concise notation that omits to state the coordinate system when the basis and coordinate systems are the same. Calling \SetConciseNotation with no argument will enable the concise notation, which is the same as \SetConciseNotation{\BooleanTrue}. Note that, although the argument is optional, curly brackets are used. Also note that the concise notation can be enabled/disabled multiple times throughout the document.

\UnsetConciseNotation **Arguments**: None.
Description:
Informs the package that the concise notation should not be used. This is equivalent to \SetConciseNotation{\BooleanFalse} and is the default behaviour.

\Tran	Macro that typesets a $\cdot^{\mathsf{T}}$ in the right super-script position to denote the transpose as in ${}^{c}_{b}\boldsymbol{p}_{a}^{\mathsf{T}}$.
\Inv	Macro that typesets a $\cdot^{-1}$ in the right super-script position to denote the inverse as in ${}^{c}_{b}\boldsymbol{p}_{a}^{-1}$.
\Herm	Macro that typesets a $\cdot^{\mathsf{H}}$ in the right super-script position to denote the Hermitian as in ${}_{b}\boldsymbol{R}_{a}^{\mathsf{H}}$.
\Conj	Macro that typesets a $\cdot^{*}$ in the right super-script position to denote the complex conjugate as in $\boldsymbol{p}^{*}$.

3 Implementation

\SetConciseNotation Defines whether the concise notation is used or not. When used the concise notation will ommit mentionning the reference frame when the source and reference are the same.

To use the concise notation, either call \SetConciseNotation with no argument or with \SetConciseNotation{\BooleanTrue}.

```
 1 \usepackage{xparse}
 2 \usepackage{mathtools}
 3
 4 %This box is used to measure the width of the post-script
 5 \newsavebox{\RN@postbox}
 6 \newlength{\RN@postboxwd}
 7 \newsavebox{\RN@expbox}
 8 \newlength{\RN@expboxwd}
 9 %Spacing before and after the symbol
10 \def\RN@prespace{0.08em}
11 \def\RN@postspace{0.23em}
12
13 \NewDocumentCommand{\SetConciseNotation}{g}
14 {
15     \newif\IfRN@C
16     \IfNoValueTF{#1}
17     {
18         \RN@Ctrue
19     }
20     {
21         \IfBooleanTF{#1}
22         {
23             \RN@Ctrue
24         }
25         {
26             \RN@Cfalse
27         }
28     }
```

29 }

\UnsetConciseNotation   Disables the concise notation. This is equivalent to `\SetConciseNotation{\BooleanFalse}`.

30 `\def\UnsetConciseNotation{\SetConciseNotation{\BooleanFalse}}`

\RN@makecmd   **Arguments**:

1. [⟨*accent*⟩]: Command to put an accent over the letter (e.g. `\hat`).

2. {⟨*qty*⟩}: Symbol for the quantity to represent.

3. [⟨*subject*⟩]: The symbol of the *subject* (e.g. vector endpoint).

4. [⟨*basis*⟩]: The symbol of the *basis* (e.g. vector origin).

5. [⟨*coord*⟩]: Symbol for the coordinate system potentially used.

Description:
Defines a typesetting command from arguments. Main typesetting routine that should not be needed by the end-user. Instead, the end-user should use `\NewRigidNotation` to define typesetting commands. If the basis and coordinate system are the same, the coordinate system is omitted when the `RN@C` keyword is set.

```
31 \NewDocumentCommand{\RN@makecmd}{omggg}
32 {
33     \IfNoValueTF{#1}{\def\RN@symb{\boldsymbol{#2}}}{\def\RN@symb{#1{\boldsymbol{#2}}}}
34     \IfNoValueTF{#3}
35     {%subject is not specified
36         \IfNoValueTF{#4}
37         {%basis is not specified
38             \IfNoValueTF{#5}
39             {%subject, basis and coordinate system are not specified
40                 \RN@symb
41             }
42             {%subject and basis are not specified, coordinate system is specified
43                 \hspace{\RN@prespace}
44                 \prescript{#5}{}{
45                     \hspace{-\RN@prespace}
46                     \RN@symb
47                 }
48             }
49         }
50         {%basis is specified
51             \IfNoValueTF{#5}%
52             {%basis is specified, subject and coordinate system are not specified
53                 \hspace{\RN@prespace}
54                 \prescript{}{#4}{
55                     \hspace{-\RN@prespace}
56                     \RN@symb
57                 }
```

```
 58                    }
 59                {%basis and coordinate system are specified, subject is not specified
 60                    \IfEq{#4}{#5}
 61                    {
 62                        \IfRN@C
 63                        {%basis and coordinate system are the same and RN@C is set
 64                            \hspace{\RN@prespace}
 65                            \prescript{}{#4}{
 66                                \hspace{-\RN@prespace}
 67                                \RN@symb
 68                            }
 69                        }
 70                        {
 71                            \hspace{\RN@prespace}
 72                            \prescript{#5}{#4}{
 73                                \hspace{-\RN@prespace}
 74                                \RN@symb
 75                            }
 76                        }
 77                    }
 78                    {
 79                        \hspace{\RN@prespace}
 80                        \prescript{#5}{#4}{
 81                            \hspace{-\RN@prespace}
 82                            \RN@symb
 83                        }
 84                    }
 85                }
 86            }
 87            %If there is no subject, no space is needed on the right of the symbol
 88            \setlength{\RN@postboxwd}{0pt}
 89        }
 90        {%subject is specified
 91            \IfNoValueTF{#4}
 92            {%basis is not specified
 93                \IfNoValueTF{#5}
 94                {%subject is specified, basis and coordinate system are not specified
 95                    \RN@symb
 96                    \hspace{-\RN@postspace}
 97                    \prescript{}{#3}{}
 98                }
 99                {%basis is not specified, subject and coordinate system are specified
100                    \hspace{\RN@prespace}
101                    \prescript{#5}{}{
102                        \hspace{-\RN@prespace}
103                        \RN@symb
104                    }
105                    \hspace{-\RN@postspace}
106                    \prescript{}{#3}{}
107                }
```

```
108             }
109         {%basis is specified
110             \IfNoValueTF{#5}
111         {%subject and basis are specified, coordinate system is not specified
112             \hspace{\RN@prespace}
113             \prescript{}{#4}{
114                 \hspace{-\RN@prespace}
115                 \RN@symb
116             }
117             \hspace{-\RN@postspace}
118             \prescript{}{#3}{}
119         }
120         {%subject, basis, and coordinate system are specified
121             \def\RN@argfour{#4}
122             \def\RN@argfive{#5}
123             \ifx\RN@argfour\RN@argfive
124             {
125                 \IfRN@C
126                 {%basis and coordinate system are the same and RN@C is set
127                     \hspace{\RN@prespace}
128                     \prescript{}{#4}{
129                         \hspace{-\RN@prespace}
130                         \RN@symb
131                     }
132                     \hspace{-\RN@postspace}
133                     \prescript{}{#3}{}
134                 }
135                 \else
136                 {
137                     \hspace{\RN@prespace}
138                     \prescript{#5}{#4}{
139                         \hspace{-\RN@prespace}
140                         \RN@symb
141                     }
142                     \hspace{-\RN@postspace}
143                     \prescript{}{#3}{}
144                 }
145                 \fi
146             }
147             \else
148             {
149                 \hspace{\RN@prespace}
150                 \prescript{#5}{#4}{
151                     \hspace{-\RN@prespace}
152                     \RN@symb
153                 }
154                 \hspace{-\RN@postspace}
155                 \prescript{}{#3}{}
156             }
157             \fi
```

```
158            }
159          }
160          %If there is a subject, we need to know the width
161          %of the symbol to bring the exponent closer
162          \sbox{\RN@postbox}{$#3$}
163          \setlength{\RN@postboxwd}{\wd\RN@postbox}
164      }
165      %If the following command is an exponent-type command,
166      %we bring it closer to the symbol.
167      %The next line has to be the last of the macro
168      \@ifnextchar^{\hspace{\RN@postspace}\hspace{-\RN@postboxwd}}{}
169 }
```

\NewRigidNotation **Arguments**:

    1. $\{\langle cmd \rangle\}$: New command name.

    2. $\{\langle sym \rangle\}$: Symbol for the quantity to represent.

Description: Defines a new command that can be used to typeset the given symbol using the RIGID convention. This essentially expands \NewRigidNotation{cmd}{sym} into \NewDocumentCommand{cmd}{oggg}{\RN@makecmd[#1]{sym}{#2}{#3}{#4}} such that \cmd can be used afterward with up to four arguments.

```
170 \NewDocumentCommand{\NewRigidNotation}{mm}%
171 {%
172      \expandafter\NewDocumentCommand\csname #1\endcsname{oggg}%
173      {%
174          \expandafter\csname RN@makecmd\endcsname[##1]{#2}{##2}{##3}{##4}%
175      }%
176 }
```

\Tran Macro that typesets a ⊤ in the right super-script position, closer to the quantity than normal, and with a smaller font size.

```
177 \def\Tran{%
178      \sbox{\RN@expbox}{${\scriptscriptstyle\mathsf{T}}$}%
179      \setlength{\RN@expboxwd}{\wd\RN@expbox}%
180      \ifnum \RN@postboxwd>0%
181          \hspace{\RN@postspace}%
182          \hspace{-\RN@postboxwd}%
183          \ifnum \RN@postboxwd>\RN@expboxwd%
184              \mathmakebox[\RN@postboxwd][l]{%
185                  {}^{\scriptscriptstyle\mathsf{T}}}%
186              }%
187          \else%
188              \mathmakebox[\RN@expboxwd][l]{%
189                  {}^{\scriptscriptstyle\mathsf{T}}}%
190              }%
191          \fi%
192      \else%
193          ^{\scriptscriptstyle\mathsf{T}}%
```

```
194        \fi%
195 }
```

\Inv   Macro that typesets a −1 in the right super-script position, closer to the quantity
        than normal, and with a smaller font size.

```
196 \def\Inv{%
197        \sbox{\RN@expbox}{${\scriptscriptstyle{-1}}$}%
198        \setlength{\RN@expboxwd}{\wd\RN@expbox}%
199        \ifnum \RN@postboxwd>0%
200            \hspace{\RN@postspace}%
201            \hspace{-\RN@postboxwd}%
202            \ifnum \RN@postboxwd>\RN@expboxwd%
203                \mathmakebox[\RN@postboxwd][l]{%
204                    {}^{\scriptscriptstyle{-1}}%
205                }%
206            \else%
207                \mathmakebox[\RN@expboxwd][l]{%
208                    {}^{\scriptscriptstyle{-1}}%
209                }%
210            \fi%
211        \else%
212            ^{\scriptscriptstyle{-1}}%
213        \fi%
214 }
```

\Herm   Macro that typesets a H in the right super-script position, closer to the quantity
        than normal, and with a smaller font size.

```
215 \def\Herm{%
216        \sbox{\RN@expbox}{${\scriptscriptstyle\mathsf{H}}$}%
217        \setlength{\RN@expboxwd}{\wd\RN@expbox}%
218        \ifnum \RN@postboxwd>0%
219            \hspace{\RN@postspace}%
220            \hspace{-\RN@postboxwd}%
221            \ifnum \RN@postboxwd>\RN@expboxwd%
222                \mathmakebox[\RN@postboxwd][l]{%
223                    {}^{\scriptscriptstyle\mathsf{H}}%
224                }%
225            \else%
226                \mathmakebox[\RN@expboxwd][l]{%
227                    {}^{\scriptscriptstyle\mathsf{H}}%
228                }%
229            \fi%
230        \else%
231            ^{\scriptscriptstyle\mathsf{H}}%
232        \fi%
233 }
```

\Conj   Macro that typesets a ∗ in the right super-script position, closer to the quantity
        than normal, and with a smaller font size.

```
234 \def\Conj{%
235     \sbox{\RN@expbox}{${\scriptscriptstyle\ast}$}%
236     \setlength{\RN@expboxwd}{\wd\RN@expbox}%
237     \ifnum \RN@postboxwd>0%
238         \hspace{\RN@postspace}%
239         \hspace{-\RN@postboxwd}%
240         \ifnum \RN@postboxwd>\RN@expboxwd%
241             \mathmakebox[\RN@postboxwd][l]{%
242                 {}^{\scriptscriptstyle\ast}%
243             }%
244         \else%
245             \mathmakebox[\RN@expboxwd][l]{%
246                 {}^{\scriptscriptstyle\ast}%
247             }%
248         \fi%
249     \else%
250         ^{\scriptscriptstyle\ast}%
251     \fi%
252 }
```

Default settings By default, the following commonly used commands are provided. They are used to typeset position vectors, rotation matrices and pose matrices respectively. By default, the concise notation is disabled.

```
253 \NewRigidNotation{Pos}{p}
254 \NewRigidNotation{Rot}{R}
255 \NewRigidNotation{Pose}{T}
256 \UnsetConciseNotation
```