User's Guide to the Rotational Figures (`rotfig.sty`) Style File, Version 1.00

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Contents

1 Introduction

The Rotational Figure style file includes some commands for rapidly generating graphical schemes visualizing in an appealing way the actions of rotations on matrices. Since the number of requests for making this available was increasing the last months, I finally convinced myself to put the effort in making this available for a wide audience.

In this manual, not only the usage of the package but also the original philosophy behind the symbols is given. The fusion, shift-through operator and so forth have a dedicated meaning when working with Givens rotations. The user of this package can decide freely whether he wants to follow these unofficial conventions.

2 Dependencies

The `rotfig` package is depending heavily on three other latex packages `amssymb`, `amsmath` and `graphicx`. It is compulsary to have these installed before the `rotfig` package can run.

3 Basics and structure of the schemes

The design of the rotational figures relies entirely on the latex `array` structure. In fact, each bracket is composed of two parts ⌜ and ⌞, similar for the other types of brackets. Using the correct commands to assign the bottom and top parts to the correct positions in an array creates the desired bracket.

For example the following bracket denotes a rotation and is simply created by assigning `\Rc` (⌜) and `\rc` (⌞) to the correct positions in the array.

```
\begin{array}{c}
  \Rc \\
  \rc
\end{array}
```

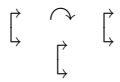
Adding an operation, such as the fusion $\hookrightarrow$, is simply done by invoking the corresponding command `\ca` after the top part of the rotation.

```
\begin{array}{c}
  \Rc\ca \\
  \rc
\end{array}
```



A shift-through $\curvearrowright$ operation acting on three rotations is created by executing `\stb` in an array and needs to be positioned in an empty location within this array.

```
\begin{array}{ccc}
  \Rc & \stb & \Rc \\
  \rc & \Rc  & \rc \\
      & \rc  &
\end{array}
```



3.1 Operation specifiers (rotations, elementary operations)

Initially the convention was that the arrows of the brackets were pointing to the rows affected when executing an operation. Originally two types of operations were created, the rotation and the elementary transformation. A rotation is of the following form, acting towards a matrix on the right.

```
\begin{array}{c}
  \Rc \\
  \rc
\end{array}
```



Besides the right pointing arrow, also a left pointing variant is available.

```
\begin{array}{c}
  \Rcl \\
  \rcl
\end{array}
```



When elementary rotations are involved, such as in Gauss elimination, two rows are used, but not both of them are altered. The row that does not change is identified by `\Gc` or `\gc`, and has now arrow.

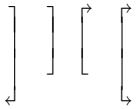
```
\begin{array}{c}
  \Gc \\
  \gc
\end{array}
```


The variant in the other direction.

```
\begin{array}{c}
  \Gcl \\
  \gcl
\end{array}
```


Creating longer brackets is done by adding `\cll` for left pointing transformations and `\clr` for right pointing transforms[1]. Moreover, arrows and non-arrows can be combined in a straightforward way.

```
\begin{array}{ccc}
 \Gcl & \Gcl  & \Rc  & \Rc  \\
 \cll & \cll  & \clr & \clr  \\
 \cll & \gcl  & \gc  & \clr \\
 \rcl &       &      & \rc
\end{array}
```



3.2 Additional actions in the schemes.

Below you find a list of all the possible actions and markers included in the style. Two types of symbols are available, the ones that are placed on top of operation such as the combination arrow $\hookrightarrow$, and the ones that are positioned in an empty spot in an array such as the shift-through operation $\curvearrowright$.

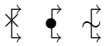
Combination of two transformations, often called the fusion operation.

```
\begin{array}{cc}
  \Rc\ca & \Rc \\
  \rc    & \rc
\end{array}
```



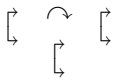
Marking rotations by a bullet, a cross and a similarity sign.

```
\begin{array}{ccc}
  \Rc\ma & \Rc\ba & \Rc\gp \\
  \rc    & \rc    & \rc
\end{array}
```



The shift-through operator.

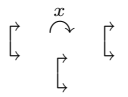
```
\begin{array}{ccc}
  \Rc & \stb & \Rc \\
  \rc & \Rc  & \rc \\
      & \rc  &
\end{array}
```



The shift-through operator with on top a counter of the number of consecutive operations.

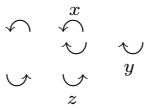
[1] Sometimes the output shows slight shifts between the separate parts of the brackets, this depends on the viewer. In practice, when printing, the difference is not visible.

```
\begin{array}{ccc}
  \Rc & \stbt{x} & \Rc \\
  \rc & \Rc       & \rc \\
      & \rc      &
\end{array}
```



Various directions of shift-through executions, including the additional counter on top or below.

```
\begin{array}{ccc}
  \slb  & \slbt{x} &           \\
        & \slt     & \sltt{y} \\
  \stt  & \sttt{z} &
\end{array}
```



The $\swarrow$ and $\searrow$ symbols denote significant changes in patterns of rotations.

```
\begin{array}{cc}
  \wdl & \wdr
\end{array}
```


3.3 Scheme formats

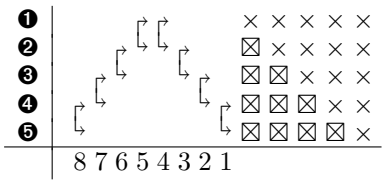
Involving the rotational schemes in latex equations is almost trivial. Examples of possible combinations are shown below.

3.3.1 Single Array

This scheme uses the `dcolumn` package to modify column spacers. Also the vertical spacing between rows is altered to generate a more compact form.

Executing the following code snippet, generates the Equation **??**.

```
\begin{array}{c|c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
c@{\hspace{1mm}}c@{\hspace{1mm}}c@{{\hspace{1mm}}}}
\cone  &&   &   &   &\Rc&\Rc&   &    &
       &\times&\times&\times&\times&\times\\[-0.05cm]
\ctwo  &&   &   &\Rc&\rc&\rc&\Rc&    &
       &\boxtimes&\times&\times&\times&\times\\[-0.05cm]
\cthree&&   &\Rc&\rc&   &   &\rc&\Rc &
       &\boxtimes&\boxtimes&\times&\times&\times\\[-0.05cm]
\cfour &&\Rc&\rc&   &   &   &   &\rc &\Rc
       &\boxtimes&\boxtimes&\boxtimes&\times&\times\\[-0.05cm]
\cfive &&\rc&   &   &   &   &   &    &\rc
       &\boxtimes&\boxtimes&\boxtimes&\boxtimes&\times\\[-0.05cm]
\hline
      && 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1
\end{array}
```



(1)

3.3.2 Involving several arrays

The schemes cooperate well with mathematical formulas. When decomposing the array of rotations and the array depicting the matrix, special attention has to be paid to the number of rows, they should be equal. Otherwise latex vertically centers both arrays, leading to undesired effects.

The next code generates Equation **??**.

```
G_{51}^HA=
\begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}}
  &   \\[-0.05cm]
  &   \\[-0.05cm]
  &   \\[-0.05cm]
  &\Rc\\[-0.05cm]
  &\rc
\end{array}
\left[{\begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}
      c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}}
    \times & \times & \times & \times & \times \\[-0.05cm]
    \times & \times & \times & \times & \times \\[-0.05cm]
    \times & \times & \times & \times & \times \\[-0.05cm]
    \times & \times & \times & \times & \times \\[-0.05cm]
    \times & \times & \times & \times & \times
  \end{array}\right]
\quad=
\quad
\left[{\begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}
      c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}}
    \times & \times & \times & \times & \times \\[-0.05cm]
    \times & \times & \times & \times & \times \\[-0.05cm]
    \times & \times & \times & \times & \times \\[-0.05cm]
    \times & \times & \times & \times & \times \\[-0.05cm]
    0 & \times & \times & \times & \times
  \end{array}\right]
```

$$G_{51}^{H} A = \begin{array}{c} \\ \\ \\ \\ \\ \curvearrowright \end{array} \begin{bmatrix} \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \end{bmatrix} \quad = \quad \begin{bmatrix} \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ 0 & \times & \times & \times & \times \end{bmatrix} \tag{2}$$

The code below generates Equation **??**.

```
  Q^H A =
\begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
```

```
  c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
  c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}}
&   &   &   &   &   &\Rc&   &   &   \\[-0.05cm]
&   &   &   &\Rc&   &\rc&\Rc&   &   \\[-0.05cm]
&   &\Rc&   &\rc&\Rc&   &   &\rc&\Rc&   \\[-0.05cm]
&\Rc&\rc&\Rc&   &\rc&\Rc&   &   &\rc&\Rc\\[-0.05cm]
&\rc&   &\rc&   &   &\rc&   &   &   &\rc
\end{array}
\left[\begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}
                   c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}}
\times & \times & \times & \times & \times \\[-0.05cm]
\times & \times & \times & \times & \times \\[-0.05cm]
\times & \times & \times & \times & \times \\[-0.05cm]
\times & \times & \times & \times & \times \\[-0.05cm]
\times & \times & \times & \times & \times
\end{array}\right]
\quad=
\quad
\left[
\begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}
       c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}}
\times & \times & \times & \times & \times \\[-0.05cm]
0      & \times & \times & \times & \times \\[-0.05cm]
0      & 0      & \times & \times & \times \\[-0.05cm]
0      & 0      & 0      & \times & \times \\[-0.05cm]
0      & 0      & 0      & 0      & \times
\end{array}\right]
```

$$Q^H A = \quad \begin{bmatrix} \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ \times & \times & \times & \times & \times \end{bmatrix} \quad = \quad \begin{bmatrix} \times & \times & \times & \times & \times \\ 0 & \times & \times & \times & \times \\ 0 & 0 & \times & \times & \times \\ 0 & 0 & 0 & \times & \times \\ 0 & 0 & 0 & 0 & \times \end{bmatrix} \tag{3}$$

The code below generates Equation **??**.

```
  H_0 = \quad\quad
\begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}}
   &   &    \\[-0.1cm]
   &   &    \\[-0.1cm]
   &   &\Rc \\[-0.1cm]
   &\Rc&\rc \\[-0.1cm]
\Rc&\rc&    \\[-0.1cm]
\rc&   &
\end{array}
\quad
\left(
\begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
    c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
    c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}}
```

```
   &   &   &   &\Rc&   &   &   &    \\[-0.1cm]
\Rc&   &   &   &\rc&\Rc&   &   &    \\[-0.1cm]
\rc&\Rc&   &   &   &\rc&\Rc&   &    \\[-0.1cm]
   &\rc&\Rc&   &   &   &\rc&\Rc&    \\[-0.1cm]
   &   &\rc&\Rc&   &   &   &\rc&\Rc \\[-0.1cm]
   &   &   &\rc&   &   &   &   &\rc
\end{array}
+
\left[
\begin{array}{c}
\times\\[-0.1cm]
\times\\[-0.1cm]
\times\\[-0.1cm]
0     \\[-0.1cm]
0     \\[-0.1cm]
0
\end{array}\right]
\mathbf{v}_0^H
\quad\right)
```

$$H_0 = \begin{array}{c} \\ \\ \\ \\ \\ \\ \end{array} \left(\begin{array}{c} \\ \\ \\ \\ \\ \\ \end{array} + \begin{bmatrix} \times \\ \times \\ \times \\ 0 \\ 0 \\ 0 \end{bmatrix} \mathbf{v}_0^H \right) \tag{4}$$

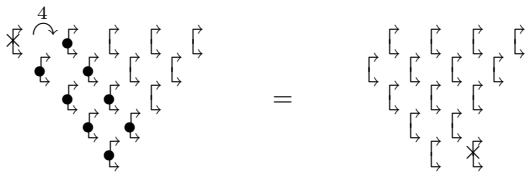
3.3.3 Independent schemes

Schemes do not need to involve matrices.

This code generates Equation **??**.

```
  \begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
  c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
  c@{\hspace{1mm}}c@{\hspace{1mm}}}
   \Rc\ma&\stbt{4}&\Rc\ba&      &\Rc   &      &\Rc&   &\Rc\\[-0.05cm]
   \rc   &\Rc\ba  &\rc   &\Rc\ba&\rc   &\Rc   &\rc&\Rc&\rc\\[-0.05cm]
         &\rc     &\Rc\ba&\rc   &\Rc\ba&\rc   &\Rc&\rc&   \\[-0.05cm]
         &        &\rc   &\Rc\ba&\rc   &\Rc\ba&\rc&   &   \\[-0.05cm]
         &        &      &\rc   &\Rc\ba&\rc   &   &   &   \\[-0.05cm]
         &        &      &      &\rc   &      &   &   &
\end{array}
\quad\quad=\quad\quad
  \begin{array}{c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
  c@{\hspace{1mm}}c@{\hspace{1mm}}c@{\hspace{1mm}}
  c@{\hspace{1mm}}c@{\hspace{1mm}}}
      &\Rc&   &\Rc&   &\Rc   &   &\Rc\\[-0.05cm]
   \Rc&\rc&\Rc&\rc&\Rc&\rc   &\Rc&\rc\\[-0.05cm]
   \rc&\Rc&\rc&\Rc&\rc&\Rc   &\rc&   \\[-0.05cm]
      &\rc&\Rc&\rc&\Rc&\rc   &   &   \\[-0.05cm]
      &   &\rc&\Rc&\rc&\Rc\ma&   &   \\[-0.05cm]
```

```
      &   &   &\rc&   &\rc   &   &
\end{array}
```



(5)

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