(some) LaTeX environments in Jupyter notebook

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Contents

1 (some) LaTeX environments for Jupyter notebook

This extension for IPython 3.x or Jupyter enables to use some LaTeX commands and environments in the notebook's markdown cells.

1. **LaTeX commands and environments**
    - support for some LaTeX commands within markdown cells, *e.g.* `\textit`, `\textbf`, `\underline`
    - support for **theorems-like environments**, support for labels and cross references
    - support for **lists**: *enumerate, itemize*,
    - limited support for a **figure environment**,
    - support for an environment *listing*,
    - additional *textboxa* environment
2. **Citations and bibliography**
    - support for `\cite` with creation of a References section
3. **Document-wide numbering of equations and environments, support for `\label` and `\ref`**
4. **Configuration toolbar**
5. **LaTeX_envs dropdown menu for a quick insertion of environments**
6. **Export to HTML and LaTeX with a customized exporter**
7. Styles can be customized in the `latex_env.css` stylesheet

A simple illustration is as follows: on can type the following in a markdown cell

```
\begin{theorem} \label{theo:dotp}
Let $u$ and $v$ be two vectors of $\mathbb{R}^n$. The dot product can be
    expressed as
\begin{equation}
\label{eq:dotp}
u^Tv = |u||v| \cos \theta,
\end{equation}
where $\theta$ is the angle between $u$ and $v$ ...
\end{theorem}
Then one can reference the equation (\ref{eq:dotp}) in theorem \ref{theo:
    dotp}.
```

and have it rendered as

Theorem 1. *Let u and v be two vectors of $\mathbb{R}^n$. The dot product can be expressed as*

$$u^T v = |u||v| \cos\theta, \tag{1}$$

where θ is the angle between u and v ...

Then one can reference the equation (1) in theorem 1.

1.1 ** What's new **

August 28, 2016 - version 1.2

- **Added support for nested environments of the same type**. Nesting environments of different type was already possible, but there was a limitation for nesting environments of the same kind; eg itemize in itemize in itemize. This was due to to the fact that regular expressions are not suited to recursivity. I have developped a series of functions that enable to extract nested environments and thus cope with such situations.
- Corrected various issues, eg #731, #720 where the content of nested environments was incorrectly converted to markdown.
- Completely reworked the configuration toolbar. Re-added tips.
- Added a toggle-button for the LaTeX_envs menu
- Added system parameters that can be specified using the nbextensions_configurator. Thus reworked the configuration loading/saving.
- Reworked extension loading. It now detects if the notebook is fully loaded before loading itself.

August 03, 2016 - version 1.13

- Added a template to also keep the toc2 features when exporting to html:

  ```
  jupyter nbconvert --to html_toclenvs FILE.ipynb
  ```

- Added a dropdown menu that enables to insert all main LaTeX_envs environments using a simple click. Two keybards shortcuts (Ctrl-E and Ctrl-I) for equations and itemize are also provided. More environments and shortcuts can be added in the file `envsLatex.js`.
- Added a link in the general help menu that points to the documentation.

July 27, 2016 - version 1.1

- In this version I have reworked **equation numbering**. In the previous version, I used a specialized counter and detected equations rendering for updating this counter. Meanwhile, this feature has been introduced in `MathJax` and now we rely on MathJax implementation. rendering is significantly faster. We still have keep the capability of displaying only equation labels (instead of numbers). The numbering is automatically updated and is document-wide.
- I have completely reworked the **notebook conversion** to plain LaTeX and html. We provide specialized exporters, pre and post processors, templates. We also added entry-points to simplify the conversion process. It is now as simple as

  ```
  jupyter nbconvert --to html_with_lenvs FILE.ipynb
  ```

  to convert `FILE.ipynb` into html while keeping all the features of the `latex_envs` notebook extension in the converted version.

2 Main features

2.1 Implementation principle

The main idea is to override the standard Markdown renderer in order to add a *small* parsing of LaTeX expressions and environments. This heavily uses regular expressions. The LaTeX expression are then rendered using an html version. For instance `\underline {something}` is rendered as `<u> something </u>`, that is <u>something</u>. The environments are replaced by an html tag with a class derived from the name of the environment. For example, a `definition` denvronment will be replaced by an html rendering corresponding to the class `latex_definition`. The styles associated with the different classes are specified in `latex_env.css`. These substitutions are implemented in `thsInNb4.js`.

2.2 Support for simple LaTeX commands

We also added some LaTeX commands (e.g. `\textit`, `\textbf`, `\underline`) – this is useful in the case of copy-paste from a LaTeX document. Labels and references are supported, including for equations.

2.3 Available environments

- **theorems-like environments**: *property, theorem, lemma, corollary, proposition, definition,remark, problem, exercise, example*,
- **lists**: *enumerate, itemize*,

- limited support for a *figure* environment,
- an environment *listing*,
- *textboxa*, wich is a `textbox` environment defined as a demonstration (see below).

More environments can be added easily in the javascript source file `thmsInNb4.js`. The rendering is done according to the stylesheet `latex_env.css`, which can be customized.

Remark 1. *When exporting to html, the `latex_env.css` file honored is the file on the Jupyter-notebook-extensions CDN. However, customized css can be added in a `custom.css` file that must reside in the same directory as the notebook itself.*

2.4 Automatic numerotation, labels and references

Counters for numerotation are implemented: one for theorems-like environments, a second for exercises-like environments and a third one for numbering figures.
Mathjax-equations with a label are also numbered document-wide. An anchor is created for any label which enables to links things within the document: `\label` and `\ref` are both supported. A limitation is that numbering is updated (incremented) each time a cell is rendered. A toolbar button is provided to reset the counters and refresh the rendering of the whole document.

A simple example is as follows, featuring automatic numerotation, and the use of labels and references. Also note that standard markdown can be present in the environment and is interpreted. *The rendering is done according to the stylesheet `latex_env.css`, which of course, can be customized to specific uses and tastes.*

```
\begin{definition} \label{def:FT}
Let $x[n]$ be a sequence of length $N$. Then, its **Fourier transform** is
     given by
\begin{equation}
\label{eq:FT}
X[k]= \frac{1}{N} \sum_{n=0}^{N-1} x[n] e^{-j2\pi \frac{kn}{N}}
\end{equation}
\end{definition}
```

Definition 1. *Let $x[n]$ be a sequence of length N. Then, its **Fourier transform** is given by*

$$X[k] = \frac{1}{N} \sum_{n=0}^{N-1} x[n] e^{-j2\pi \frac{kn}{N}} \tag{2}$$

It is now possible to refer to the definition and to the equation by their labels, as in:

```
As an example of Definition \ref{def:FT}, consider the Fourier transform
    (\ref{eq:FT2}) of a pure cosine wave given by
$$
x[n]= \cos(2\pi k_0 n/N),
$$
where $k_0$ is an integer.
```

As an example of Definition 1, consider the Fourier transform (2) of a pure cosine wave given by

$$x[n] = \cos(2\pi k_0 n/N),$$

where k_0 is an integer. Its Fourier transform is given by

$$X[k] = \frac{1}{2}\left(\delta[k-k_0] + \delta[k-k_0]\right),$$

modulo N.

2.5 Bibliography

2.5.1 Usage

It is possible to cite bibliographic references using the standard LaTeX `\cite` mechanism. The extension looks for the references in a bibTeX file, by default `biblio.bib` in the same directory as the notebook. The name of this file can be modified in the configuration toolbar. It is then possible to cite works in the notebook, e.g.

```
The main paper on IPython is definitively \cite{PER-GRA:2007}. Other
    interesting references are certainly \cite{mckinney2012python, rossant
    2013learning}. Interestingly, a presentation of the IPython notebook
    has also be published recently in Nature \cite{shen2014interactive}.
```

The main paper on IPython is definitively [1]. Other interesting references are certainly [2, 3]. Interestingly, a presentation of the IPython notebook has also be published recently in Nature [4].

2.5.2 Implementation

The implemention uses several snippets from the nice icalico-document-tools extension that also considers the rendering of citations in the notebook. We also use a modified version of the bibtex-js parser for reading the references in the bibTeX file. The different functions are implemented

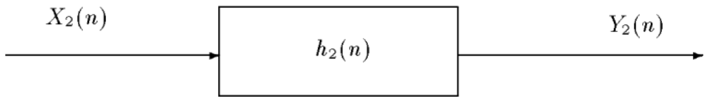


Figure 1: This is an example of figure included using LaTeX commands.

in `bibInNb4.js`. The rendering of citations calls can adopt three styles (Numbered, by key or apa-like) – this can be selected in the configuration toolbar. It is also possible to customize the rendering of references in the reference list. A citation template is provided in the beginning of file `latex_envs.js`:

```
var cit_tpl = {
// feel free to add more types and customize the templates
    'INPROCEEDINGS': '%AUTHOR:InitialsGiven%, ``_%TITLE%_\'\', %BOOKTITLE%, %MONTH% %YEAR%.',
    ... etc
```

The keys are the main types of documents, eg inproceedings, article, inbook, etc. To each key is associated a string where the replaced by the correponding bibtex entry value. The template string can formatted with additional words and effects (markdown or LaTeX are commands are supported)

2.6 Figure environment

Finally, it is sometimes useful to integrate a figure within a markdown cell. The standard markdown markup for that is `![link](image)`, but a limitation is that the image can not be resized, can not be referenced and is not numbered. Furthermore it can be useful for re-using existing code. Threfore we have added a limited support for the `figure` environment. This enables to do something like

```
\begin{figure}
\centerline{\includegraphics[width=10cm]{example.png}}
\caption{\label{fig:example} This is an example of figure included using
   LaTeX commands.}
\end{figure}
```

which renders as

Of course, this Figure can now be referenced:

```
Figure \ref{fig:example} shows a second filter with input $X_2$, output $Y
   _2$ and an impulse response denoted as $h_2(n)$
```

Figure 1 shows a second filter with input X_2, output Y_2 and an impulse response denoted as $h_2(n)$

2.7 figcaption

For Python user, we have added in passing a simple function in the `latex_envs.py` library.

This function can be imported classically, eg `from latex_envs.latex_envs import figcaption` (or `from jupyter_contrib_nbextensions.nbconvert_support.latex_envs import figcaption` if you installed from the jupyter_contrib repo).

Then, this function enables to specify a caption and a label for the next plot. In turn, when exporting to LaTeX, the corresponding plot is converted to a nice figure environement with a label and a caption.

```
%matplotlib inline
import matplotlib.pyplot as plt
from jupyter_contrib_nbextensions.nbconvert_support.latex_envs import
    figcaption
from numpy import pi, sin, arange

plt.plot(sin(2*pi*0.01*arange(100)))
```

```
[<matplotlib.lines.Line2D at 0x7f8a1872ba20>]
```

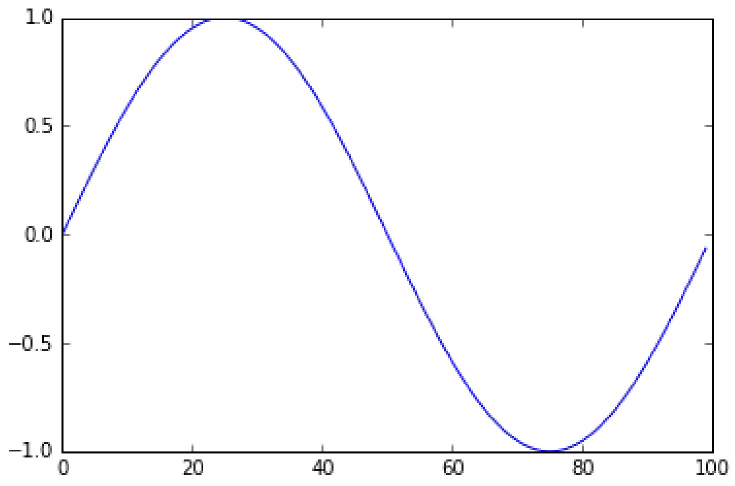


Figure 2: This is a nice sine wave

2.8 Other features

- As shown in the examples, eg 2.4 (or just below), **it is possible to mix LaTeX and markdown markup in environments**
- Support for **line-comments** (within environments): lines beginning with a
- Support for **linebreaks**:

  _, where _ denotes any space, tab, linefeed, cr, is replaced by a linebreak
- Environments can be nested. egg:

```
This is an example of nested environments, with equations inside\\
\begin{proof} Demo
% This is a comment
\begin{enumerate}
\item $$ \left\{ p_1, p_2, p_3 \ldots p_n \right\} $$
\item A **nested enumerate**
\item second item
\begin{enumerate}
\item $ \left\{ p_1, p_2, p_3 \ldots p_n \right\} $
\item And *another one*
\item second item
```

```
\begin{enumerate}
\item $$ \left\{ p_1, p_2, p_3 \ldots p_n \right\} $$
\item second item
\end{enumerate}
\end{enumerate}
\end{enumerate}
\end{proof}
```

which results in

This is an example of nested environments, with equations inside

Proof. Demo

$$\{p_1, p_2, p_3 \ldots p_n\} \tag{3}$$

$$\{p_1, p_2, p_3 \ldots p_n\}$$

A **nested enumerate**

second item

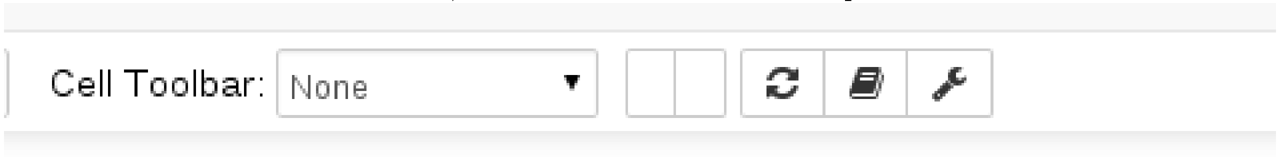
1. $\{p_1, p_2, p_3 \ldots p_n\}$
2. And *another one*
3. second item
   (a) $$\{p_1, p_2, p_3 \ldots p_n\}$$
   (b) second item

□

2.9 User interface

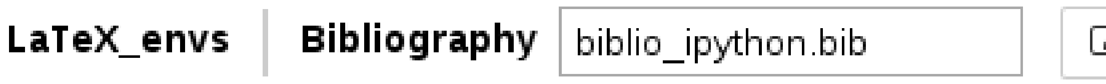
2.9.1 Buttons on main toolbar

On the main toolbar, the extension provides three buttons



The first one can be used to refresh the numerotation of equations and references in all the document. The second one fires the reading of the bibliography bibtex file and creates (or updates) the reference section. Finally the third one is a toogle button that opens or closes the configuration toolbar.

2.9.2 Configuration toolbar



The configuration toolbar enables to enter some configuration options for the extension. First, one can indicate the name of the bibtex file. If this file is not found and the user creates the reference section, then this section will indicate that the file was not found. The references drop-down menu enables to choose the type of reference calls. The Equations input box enable to initiate numbering of equations at the given number (this may be useful for complex documents in several files/parts). Finally the last drop-down menu let the user choose to number equation or to display their label instead. These configuration options are then stored in the notebook's metadata (and restored on reload).

3 Conversion to LaTeX and HTML

The extension works in the live-notebook. Since it relies on a bunch of javascript, the notebook does not render as is in services such as `nbviewer` or `github` viewer. Similarly, `nbconvert` does not know of the LaTeX constructs which are used here and therefore does not fully convert notebooks using this extension.

Therefore, we provide specialized templates and exporters to achieve these conversions.

3.1 Conversion to html

We provide a template `latex_envs.tpl` and an exporter class `LenvsHTMLExporter` (in library `latex_envs.py`). Using that class, conversion simply amounts to

```
jupyter nbconvert --to latex_envs.LenvsHTMLExporter FILE.ipynb
```

A shortcut is also provided

```
jupyter nbconvert --to html_with_lenvs FILE.ipynb
```

It should be noted that the rendering is done exactly in the same way as in the livenotebook. Actually, it is the very same javascript which is run in the html file. The javascript functions are available on the extension github as well as in the `jupyter_notebook_extensions` CDN, which means that the rendering of the html files requires an internet connection (this is also true for the rendering of equations with MathJax).

Another template `latex_envs_toc.tpl` is provided which enables to also keep the toc2 features when exporting to html (*it even works if you do not have the `toc2` extension!*):

```
jupyter nbconvert --to html_with_toclenvs FILE.ipynb
```

If you use the version included in the jupyter_notebook_extensions collection, the entry-points (conversion shortcuts) are a little different: use instead

- `jupyter nbconvert --to html_lenvs FILE.ipynb`
- `jupyter nbconvert --to html_toclenvs FILE.ipynb`

3.2 Conversion to LaTeX

We provide two templates `thmsInNb_article.tplx` and `thmsInNb_report.tplx` for article and report styles respectively. Anyway one can also use the standard article, report, book templates provided with nbconvert. Simply, we have improved some of the internals styles. More importantly, we provide an exporter class `LenvsLatexExporter` (also in library `latex_envs.py`). Using that class, conversion simply amounts to

```
jupyter nbconvert --to latex_envs.LenvsLatexExporter FILE.ipynb
```

A shortcut is also provided

```
jupyter nbconvert --to latex_with_lenvs FILE.ipynb
```

In addition, we provide several further options:

- **removeHeaders**: Remove headers and footers, (default false)
- **figcaptionProcess**: Process figcaptions, (default true)
- **tocrefRemove** Remove tocs and ref sections, + some cleaning, (default true),

These options can be specified on the command line as, eg,

```
jupyter nbconvert --to latex_with_lenvs --LenvsLatexExporter.removeHeaders=True -- LenvsLatexExp
```

If you use the version included in the jupyter_notebook_extensions collection, the entry-points (conversion shortcuts) are a little different: use instead

```
jupyter nbconvert --to latex_lenvs FILE.ipynb
```

Example 1. *As for an example, the present document has been converted using*

```
jupyter nbconvert --to latex_with_lenvs --LenvsLatexExporter.removeHeaders=True latex_env_doc.ip
```

Then the resulting file (without header/footer) has been included in the main file `documentation.tex`, where some LaTeX definitions of environments are done (namely listings, colors, etc) and compiled using

- *`xelatex -interaction=nonstopmode documentation`*
- *`bibTeX documentation`*
- *`xelatex -interaction=nonstopmode documentation`*

The output can be consulted here.

4 Installation

The extension consists in a package that includes a javascript notebook extension. Since Jupyter 4.2, this is the recommended way to distribute nbextensions. The extension can be installed

- from the master version on the github repo (this will be always the most recent version)
- via pip for the version hosted on Pypi
- as part of the great Jupyter-notebook-extensions collection. Follow the instructions there for installing. Once this is done, you can open a tab at `http://localhost:8888/nbextensions` to enable and configure the various extensions.

From the github repo or from Pypi,

- **step 1**: install the package
  - `pip3 install https://github.com/jfbercher/jupyter_latex_envs/archive/master.zip [--user][--upgrade]`
  - or `pip3 install jupyter_latex_envs [--user][--upgrade]`
  - or clone the repo and install `git clone https://github.com/jfbercher/jupyter_latex_envs.git python3 setup.py install`

With Jupyter >= 4.2,

- **step 2**: install the notebook extension

  ```
  jupyter nbextension install --py latex_envs [--user]
  ```

- **step 3**: and enable it

  ```
  jupyter nbextension enable latex_envs [--user] --py
  ```

For Jupyter versions before 4.2, the situation is more tricky since you will have to find the location of the source files (instructions from @jcb91 found here): execute

```
python -c "import os.path as p; from jupyter_highlight_selected_word import __file__ as f, _jupy
```

Then, issue

```
jupyter nbextension install <output source directory>
jupyter nbextension enable latex_envs/latex_envs
```

where `<output source directory>` is the output of the python command.

5 Usage and further examples

5.1 First example (continued)

We continue the first example on fthe Fourier transform definition 1 in order to show that, of course, we can illustrate things using a simple code. Since the Fourier transform is an essential tool in signal processing, We put this in evidence using the `textboxa` environment – which is defined here in the css, and that one should define in the LaTeX counterpart:

```
\begin{textboxa}
The Fourier transform is an extremely useful tool to have in your toolbox!
\end{textboxa}
```

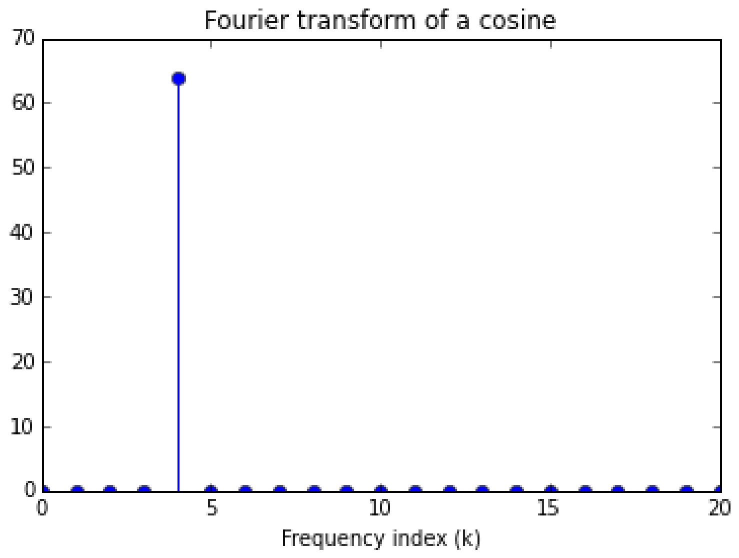
The Fourier transform is an extremely useful tool to have in your toolbox!

The Fourier transform of a pure cosine is given by

$$X[k] = \frac{1}{2}\left(\delta[k - k_0] + \delta[k - k_0]\right),$$

modulo N. This is illustrated in the following simple script:

```
%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
from numpy.fft import fft
k0=4; N=128; n=np.arange(N); k=np.arange(N)
x=np.sin(2*np.pi*k0*n/N)
X=fft(x)
plt.stem(k,np.abs(X))
plt.xlim([0, 20])
plt.title("Fourier transform of a cosine")
_=plt.xlabel("Frequency index (k)")
```



5.2 Second example

This example shows a series of environments, with different facets; **links, references, markdown or/and LaTeX formatting within environments**. The listing of environments below is typed using the environment *listing*...

```
\begin{definition} \label{def:diffeq}
We call \textbf{difference equation} an equation of the form
$$
\label{eq:diffeq}
y[n]= \sum_{k=1}^{p} a_k y[n-k] + \sum_{i=0}^q b_i x[n-i]
$$
\end{definition}

\begin{property}
If all the $a_k$ in equation (\ref{eq:diffeq}) of definition \ref{def:
    diffeq} are zero, then the filter has a **finite impulse response**.
\end{property}

\begin{proof}
Let $\delta[n]$ denote the Dirac impulse. Take $x[n]=\delta[n]$ in (\ref{
    eq:diffeq}). This yields, by definition, the impulse response:
$$
\label{eq:fir}
h[n]= \sum_{i=0}^q b_i \delta[n-i],
$$
which has finite support.
\end{proof}

\begin{theorem}
The poles of a causal stable filter are located within the unit circle in
    the complex plane.
\end{theorem}

\begin{example} \label{ex:IIR1}
Consider $y[n]= a y[n-1] +  x[n]$. The pole of the transfer function is $z
    =a$. The impulse response $h[n]=a^n$ has infinite support.
\end{example}

In the following exercise, you will check that the filter is stable iff $a
    $<1.

\begin{exercise}\label{ex:exofilter}
Consider the filter defined in Example \ref{ex:IIR1}. Using the **function
    ** `lfilter` of scipy, compute and plot the impulse response for
    several values of $a$.
\end{exercise}
```

The lines above are rendered as follows (of course everything can be tailored in the stylesheet):

Definition 2. *We call **difference equation** an equation of the form*

$$y[n] = \sum_{k=1}^{p} a_k y[n-k] + \sum_{i=0}^{q} b_i x[n-i] \tag{4}$$

Properties of the filter are linked to the coefficients of the difference equation. For instance, an immediate property is

Property 1. *If all the a_k in equation (4) of definition 2 are zero, then the filter has a* ***finite impulse response****.*

Proof. Let $\delta[n]$ denote the Dirac impulse. Take $x[n] = \delta[n]$ in (4). This yields, by definition, the impulse response:

$$h[n] = \sum_{i=0}^{q} b_i \delta[n-i], \tag{5}$$

which has finite support. □

Theorem 2. *The poles of a causal stable filter are located within the unit circle in the complex plane.*

Example 2. *Consider $y[n] = ay[n-1] + x[n]$. The pole of the transfer function is $z = a$. The impulse response $h[n] = a^n$ has infinite support.*

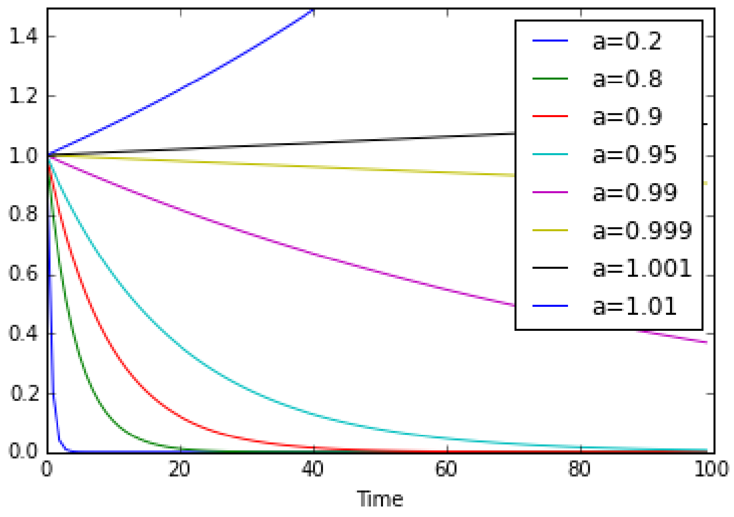
In the following exercise, you will check that the filter is stable iff $a<1$.

Exercise 1. *Consider the filter defined in Example 2. Using the* ***function*** `lfilter` *of scipy, compute and plot the impulse response for several values of a.*

```
The solution of exercise \ref{ex:exofilter}, which uses a difference
    equation as in Definition \ref{def:diffeq}:
```

The solution of exercise 1, which uses a difference equation as in Definition 2:

```
%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
from scipy.signal import lfilter
d=np.zeros(100); d[0]=1 #dirac impulse
alist=[0.2, 0.8, 0.9, 0.95, 0.99, 0.999, 1.001, 1.01]
for a in alist:
    h=lfilter([1], [1, -a],d)
    _=plt.plot(h, label="a={}".format(a))
plt.ylim([0,1.5])
plt.xlabel('Time')
_=plt.legend()
```



5.3 Third example:

This example shows that environments like itemize or enumerate are also available. As already indicated, this is useful for copying text from a TeX file. Following the same idea, text formating commands `\textit`, `\textbf`, `\underline`, etc are also available.

```
The following \textit{environments} are available:
\begin{itemize}
    \item \textbf{Theorems and likes}
    \begin{enumerate}
        \item theorem,
        \item lemma,
        \item corollary
        \item ...
    \end{enumerate}
    \item \textbf{exercises}
    \begin{enumerate}
        \item problem,
        \item example,
        \item exercise
    \end{enumerate}
\end{itemize}
```

which gives...
The following *environments* are available:

- **Theorems and likes**
  1. theorem,
  2. lemma,
  3. corollary
  4. ...
- **exercises**
  1. problem,
  2. example,
  3. exercise

6 Disclaimer, sources and thanks

Originally, I used a piece of code from the nice online markdown editor `stackedit` https://github.com/benweet/stackedit/issues/187, where the authors also considered the problem of incorporating LaTeX markup in their markdown.

I also studied and used examples and code from https://github.com/ipython-contrib/IPython-notebook-extensions.

- This is done in the hope it can be useful. However there are many impovements possible, in the code and in the documentation. **Contributions will be welcome and deeply appreciated.**

- If you have issues, please post an issue at `https://github.com/jfbercher/jupyter_latex_envs/issues` here.

Self-Promotion – Like `latex_envs`? Please star and follow the repository on GitHub.

References

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