# Combining LaTeX with Python

Uwe Ziegenhagen

## Abstract

Even older than Java, Python has achieved a lot of popularity in recent years. It is an easy-to-learn general purpose programming language, with strong abilities not only in state-of-the-art topics such as machine learning and artificial intelligence. In this article we want to present scenarios where LaTeX and Python can work jointly. We will show examples where LaTeX documents are automatically generated by Python or receive content from Python scripts.

## 1 Introducing Python

Python has steadily grown to be one of the big players in terms of programming languages. Invented 1991 by Guido van Rossum at the Centrum Wiskunde & Informatica in the Netherlands, Version 1.0 appeared in 1994. The current versions are 2.7 and 3.x, for people who wish to start with Python, Python 3 is strongly recommended.

Python has a strong emphasis on code readability by using significant amounts of whitespace. In contrast to other programming languages which use brackets, Python uses whitespace and indentation, see Listing 3 for an example.

```
print('Hello' + ' ' + 'World')
```

Listing 1: The unavoidable "Hello World" example

```
def addTwo(a, b):
    return a+b

print(addTwo(5,3)) # gives 8
print(addTwo('U','S')) # gives 'US'
```

Listing 2: A function definition example

Python supports various programming paradigms, as it allows procedural, object-oriented and functional programming. Listing 3 shows an example for the functional programming paradigm, using a lambda function to filter those integers from a list that are divisible by 2.

```
my_list = [1, 2, 3, 4, 5, 6, 7, 8]
result = filter(lambda x: x % 2 == 0, my_list)
print(list(result))
```

Listing 3: Using functional programming to filter a list

Listing 4 shows an example for the OO-programming paradigm. Here we define a class with two properties that is then instantiated.

```
class Person:

    def __init__(self, name, age):
        self.name = name
        self.age = age

    def print_age(self):
        print(self.name + ', ' + str(self.age))

john = Person('John', 50)
john.print_age()
```

Listing 4: Using object-oriented programming

There is excellent literature available for Python learners on- and offline, as a book we can recommend for example [1].

## 2 Writing LaTeX files with Python

After this brief introduction we will focus now on the creation of LaTeX files using Python. The recommended approach is to use a so-called "context managers", as they handle the management of the file references as well as errors in case the file is not accessible or writeable.

Listing 5 shows an example on how to write a simple LaTeX-file. Backslashes need to be escaped, the line endings need to be added. Depending on the platform the code is executed, they will be replaced by the system's line ending. The resulting file is then UTF8-encoded and can easily be processed further.

```
with open('sometexfile.tex','w') as file:
    file.write('\\documentclass{article}\n')
    file.write('\\begin{document}\n')
    file.write('Hello Palo Alto!\n')
    file.write('\\end{document}\n')
```

Listing 5: Writing a TeX-file

The processing, e. g. the compilation by pdfLaTeX and display by the system's PDF viewer can of course also be triggered from Python as Listing 5 shows. Here we create the LaTeX-file and use Python's subprocess module to call pdfLaTeX. Only when this process generates a non-error exit code the platform's PDF-viewer is launched.

```
import subprocess, os

with open('sometexfile.tex','w') as file:
    file.write('\\documentclass{article}\n')
    file.write('\\begin{document}\n')
    file.write('Hello Palo Alto!\n')
    file.write('\\end{document}\n')

x = subprocess.call('pdflatex sometexfile.tex')
if x != 0:
    print('Exit-code not 0, check result!')
else:
    os.system('start sometexfile.pdf')
```

Listing 6: Writing & Processing TEX-files

When LATEX files are created programmatically the goal is often to create serial letters or other dynamically adjusted documents. Python offers various ways to assist in this process. The most intuitive way is probably to use search & replace to fill some place holders with text, Listing 7 shows an example for this approach. The example should be self-explaining, note the nested context managers to read respectively write the LATEX file.

```
place = 'Palo Alto'

with open('place.tex','r') as myfile:
    text = myfile.read()
    text_new = text.replace('$MyPlace$', place)

    with open('place_new.tex', 'w') as output:
        output.write(text_new)
```

Listing 7: Replacing text

While this approach works of course, it is not a recommended when more complicated typesetting results need to be created. Fortunately Python offers a variety of template engines – either built-in or easily installable with the help of Python's package manager – that improve the workflow and prevent "re-inventing the wheel". Among the different template engines we have successfully worked with Jinja2. It offers full Unicode support, sandboxed execution, template inheritance and many more useful features. Listing 8 shows a non-LATEX example for Jinja2, which tells us the following:

1. Syntax is (easily) understandable
2. Jinja2 brings its own notation for looping, etc.
3. Extensive use of "{", "%", "}"

```
from jinja2 import Template

mytemplate = Template("Hello {{place}}!")
print(mytemplate.render(place="Palo Alto"))

mytemplate = Template("Some numbers: {% for n
    in range(1,10) %}{{n}}{% endfor %}")
print(mytemplate.render())
```

Listing 8: A non-LATEX Jinja2 example

So to make Jinja2 work with LATEX we need to modify the way a template is defined. Listing 2 shows[1] how this reconfiguration can be made. Instead of using brackets we use two LATEX-commands \BLOCK and \VAR Both commands will later be defined as empty LATEX-commands in the LATEX file to have the file compile without errors.

```
import os
import jinja2 as j

latex_env = j.Environment(
    block_start_string = '\BLOCK{',
    block_end_string = '}',
    variable_start_string = '\VAR{',
    variable_end_string = '}',
    comment_start_string = '\#{',
    comment_end_string = '}',
    line_statement_prefix = '%-',
    line_comment_prefix = '%#',
    trim_blocks = True,
    autoescape = False,
    loader = j.FileSystemLoader(os.path.abspath('.'))
    )
```

The following Listing 9 shows an excerpt from the final code, that loads the template, fills the placeholders and writes the final document to the disk. One advantage of this approach is that it allows the template to be separated from the program logic that fills it, it more complex situations the built-in scripting comes very handy.

```
template = latex_env.get_template('jinja-01.tex')
document = template.render(place='Palo Alto')
with open('final-02.tex','w') as output:
    output.write(document)
```

Listing 9: Rendering the document

## 3 Running Python from LATEX

In this section we want to address not the creation of LATEX code but the execution of Python code from within LATEX. There are various packages or tools available which allow this, in this article we want to demonstrate two of them. One derived from code posted to tex.stackexchange.com, the other – pythontex – is a well-maintained LATEX package.

The idea for the code given below came from the fact, that LATEXis a) able to write the content of environments to external files and b) is able to run external commands when `--shell-escape` is enabled. One just needs need to combine both to write and run external files. Based on our question on TSX, a easily implementable solution was given[2], it is shown in Listing 10. When Python code in placed in the `pycode` environment inside a document, LATEX writes its code to the filename specified in the parameter of the environment, runs Python on this file and pipes its output to a `.plog` file. This `.plog`

[1] Source: https://web.archive.org/web/20121024021221/http://e6h.de/post/11/

[2] https://tex.stackexchange.com/questions/116583

file is then read by LaTeX and typeset with syntax highlighting provided by the minted package (which also uses Python internally).

The advantage of this approach is that it can be adjusted easily to different external programs as long as they are able to run in batch mode. One can easily adjust the way the code is included, we have worked successfully with a two-column setup in Beamer, where the left column shows the source code and the right colum the result of the sourcecode's execution. One disadvantage is that the programs are executed each time the LaTeX code is compiled.

```
\usepackage{minted}
\setminted[python]{frame=lines, framesep=2mm,
     baselinestretch=1.2, bgcolor=colBack,fontsize=\
     footnotesize,linenos}
\setminted[text]{frame=lines, framesep=2mm,
     baselinestretch=1.2, bgcolor=colBack,fontsize=\
     footnotesize,linenos}

\usepackage{fancyvrb}
\makeatletter
\newenvironment{pycode}[1]%
  {\xdef\d@tn@me{#1}\xdef\r@ncmd{python #1.py > #1.
       plog}%
  \typeout{Writing file #1}\VerbatimOut{#1.py}%
  }
  {\endVerbatimOut %
 \toks0{\immediate\write18}%
 \expandafter\toks\expandafter1\expandafter{\r@ncmd}%
 \edef\d@r@ncmd{\the\toks0{\the\toks1}}\d@r@ncmd %
 \noindent Input
 \inputminted{python}{\d@tn@me.py}%
 \noindent Output
 \inputminted{text}{\d@tn@me.plog}%
}
\makeatother
```

Listing 10: The pycode environment

The pythontex package [2] uses a more advanced approach as it is able to detect if the Python code has been edited or not. Only if an edit took place the Python code is rerun thus saving time especially with more complicated Python code. The workflow is the following: first the LaTeX engine of your choce is run, followed by the pythontex executable. After this the last step, another latex run is executed. The package offers various LaTeX commands as well as corresponding environments, see the package documentation.

Let us show with an example, see Listing 11, how the package can be applied. After loading the pythontex package we use the \pyc command – which only executes code and does not typeset it – for the first line of Python code. Here we instruct Python to load a function from the yahoo_fin library which allows us to retrieve stock information from Yahoo given that an internet connection is available.

In the following table we then use \py commands to specifiy which stock quote shall be retrieved. This command requires the executed Python code to return a single expression.

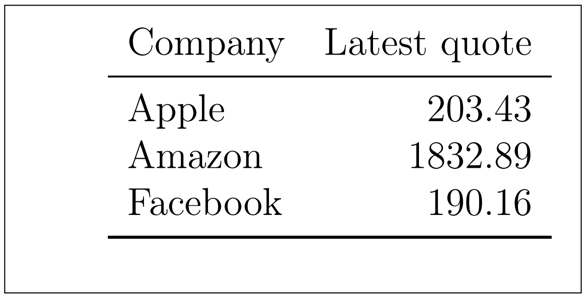
```
\documentclass[12pt]{article}
\usepackage[utf8]{inputenc}
\usepackage[T1]{fontenc}
\usepackage{pythontex}
\usepackage{booktabs}
\begin{document}

\pyc{from yahoo_fin import stock_info as si}

\begin{tabular}{lr}
\toprule
Company & Latest quote \\
\midrule
Apple & \py{round(si.get_live_price("aapl"),2)} \\
Amazon & \py{round(si.get_live_price("amzn"),2)} \\
Facebook & \py{round(si.get_live_price("fb"),2)} \\
\bottomrule
\end{tabular}

\end{document}
```

Listing 11: A pythontex example to retrieve stock prices



| Company | Latest quote |
|---|---|
| Apple | 203.43 |
| Amazon | 1832.89 |
| Facebook | 190.16 |

**Figure 1**: Resulting PDF from Listing 11

The pythontex package provides many more features among them even symbolic computation, it can thus be highly recommended.

## 4 Summary

We have shown how easy LaTeX documents can be enriched by Python, a scripting language that is easy to learn and fun to work with. Accompanying to this article is the more extensive presentation held at TUG 2019 for which the interested reader can find the slides at www.uweziegenhagen.de

## References

[1] M. Lutz. *Learning Python.* O'Reilly, 2013.

[2] G. M. Poore. Pythontex: reproducible documents with latex,python, and more. *Comput. Sci. Disc.* 8(1), 2015.

◇ Uwe Ziegenhagen
Escher Str. 221
50739 Cologne
Germany
`ziegenhagen@gmail.com`
`https://www.uweziegenhagen.de`