The package piton*

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Abstract

The package piton provides tools to typeset computer listings in Python, OCaml, C and SQL with syntactic highlighting by using the Lua library LPEG. It requires LuaLaTeX.

1 Presentation

The package piton uses the Lua library LPEG[1] for parsing Python, OCaml, C or SQL listings and typesets them with syntactic highlighting. Since it uses the Lua of LuaLaTeX, it works with `lualatex` only (and won't work with the other engines: `latex`, `pdflatex` and `xelatex`). It does not use external program and the compilation does not require `--shell-escape`. The compilation is very fast since all the parsing is done by the library LPEG, written in C.

Here is an example of code typeset by piton, with the environment `{Piton}`.

```
from math import pi

def arctan(x,n=10):
    """Compute the mathematical value of arctan(x)

    n is the number of terms in the sum
    """
    if x < 0:
        return -arctan(-x) # recursive call
    elif x > 1:
        return pi/2 - arctan(1/x)
        (we have used that arctan(x) + arctan(1/x) = π/2 for x > 0)[2]
    else:
        s = 0
        for k in range(n):
            s += (-1)**k/(2*k+1)*x**(2*k+1)
        return s
```

2 Installation

The package piton is contained in two files: `piton.sty` and `piton.lua` (the LaTeX file `piton.sty` loaded by `\usepackage` will load the Lua file `piton.lua`). Both files must be in a repertory where LaTeX will be able to find them, for instance in a `texmf` tree. However, the best is to install piton with a TeX distribution such as MiKTeX, TeX Live or MacTeX.

[*] This document corresponds to the version 2.4 of piton, at the date of 2024/01/15.

[1] LPEG is a pattern-matching library for Lua, written in C, based on *parsing expression grammars*: http://www.inf.puc-rio.br/~roberto/lpeg/

[2] This LaTeX escape has been done by beginning the comment by `#>`.

3 Use of the package

3.1 Loading the package

The package piton should be loaded with the classical command `\usepackage`: `\usepackage{piton}`.

Nevertheless, we have two remarks:

- the package piton uses the package xcolor (but piton does *not* load xcolor: if xcolor is not loaded before the `\begin{document}`, a fatal error will be raised).
- the package piton must be used with LuaLaTeX exclusively: if another LaTeX engine (`latex`, `pdflatex`, `xelatex`,...) is used, a fatal error will be raised.

3.2 Choice of the computer language

In current version, the package piton supports four computer languages: Python, OCaml, SQL and C (in fact C++). It supports also a special language called "`minimal`": cf. 27.

By default, the language used is Python.

It's possible to change the current language with the command `\PitonOptions` and its key `language`: `\PitonOptions{language = C}`.

New 2.4 The name of the L3 variable corresponding to that key is `\l_piton_language_str`.

In what follows, we will speak of Python, but the features described also apply to the other languages.

3.3 The tools provided to the user

The package piton provides several tools to typeset Python code: the command `\piton`, the environment `{Piton}` and the command `\PitonInputFile`.

- The command `\piton` should be used to typeset small pieces of code inside a paragraph. For example:

  ```
  \piton{def square(x): return x*x}    def square(x): return x*x
  ```

  The syntax and particularities of the command `\piton` are detailed below.

- The environment `{Piton}` should be used to typeset multi-lines code. Since it takes its argument in a verbatim mode, it can't be used within the argument of a LaTeX command. For sake of customization, it's possible to define new environments similar to the environment `{Piton}` with the command `\NewPitonEnvironment`: cf. 4.3 p. 8.

- The command `\PitonInputFile` is used to insert and typeset a external file.

  It's possible to insert only a part of the file: cf. part 5.2, p. 9.

  New 2.2 The key `path` of the command `\PitonOptions` specifies a path where the files included by `\PitonInputFile` will be searched.

3.4 The syntax of the command \piton

In fact, the command `\piton` is provided with a double syntax. It may be used as a standard command of LaTeX taking its argument between curly braces (`\piton{...}`) but it may also be used with a syntax similar to the syntax of the command `\verb`, that is to say with the argument delimited by two identical characters (e.g.: `\piton|...|`).

- Syntax `\piton{...}`

  When its argument is given between curly braces, the command `\piton` does not take its argument in verbatim mode. In particular:

  - several consecutive spaces will be replaced by only one space (and the also the character of end on line),

    but the command `\␣` is provided to force the insertion of a space;

- it's not possible to use `%` inside the argument,
  but the command `\%` is provided to insert a `%`;
- the braces must be appear by pairs correctly nested
  but the commands `\{` and `\}` are also provided for individual braces;
- the LaTeX commands[3] are fully expanded and not executed,
  so it's possible to use `\\` to insert a backslash.

The other characters (including `#`, `^`, `_`, `&`, `$` and `@`) must be inserted without backslash.

Examples :

```
\piton{MyString = '\\n'}
\piton{def even(n): return n\%2==0}
\piton{c="#"     # an affectation }
\piton{c="#" \ \ \ # an affectation }
\piton{MyDict = {'a': 3, 'b': 4 }}
```

```
MyString = '\n'
def even(n): return n%2==0
c="#" # an affectation
c="#"    # an affectation
MyDict = {'a': 3, 'b': 4 }
```

It's possible to use the command `\piton` in the arguments of a LaTeX command.[4]

- Syntaxe `\piton|...|`

  When the argument of the command `\piton` is provided between two identical characters, that argument is taken in a *verbatim mode*. Therefore, with that syntax, the command `\piton` can't be used within the argument of another command.

  Examples :

```
\piton|MyString = '\n'|
\piton!def even(n): return n%2==0!
\piton+c="#"     # an affectation +
\piton?MyDict = {'a': 3, 'b': 4}?
```

```
MyString = '\n'
def even(n): return n%2==0
c="#"     # an affectation
MyDict = {'a': 3, 'b': 4}
```

4 Customization

With regard to the font used by piton in its listings, it's only the current monospaced font. The package piton merely uses internally the standard LaTeX command `\texttt`.

4.1 The keys of the command \PitonOptions

The command `\PitonOptions` takes in as argument a comma-separated list of *key=value* pairs. The scope of the settings done by that command is the current TeX group.[5]
These keys may also be applied to an individual environment `{Piton}` (between square brackets).

- The key `language` speficies which computer language is considered (that key is case-insensitive). Five values are allowed : `Python`, `OCaml`, `C`, `SQL` and `minimal`. The initial value is `Python`.
- The key `path` specifies a path where the files included by `\PitonInputFile` will be searched.
- The key `gobble` takes in as value a positive integer n: the first n characters are discarded (before the process of highlightning of the code) for each line of the environment `{Piton}`. These characters are not necessarily spaces.
- When the key `auto-gobble` is in force, the extension piton computes the minimal value n of the number of consecutive spaces beginning each (non empty) line of the environment `{Piton}` and applies `gobble` with that value of n.

[3] That concerns the commands beginning with a backslash but also the active characters (with catcode equal to 13).
[4] For example, it's possible to use the command `\piton` in a footnote. Example : `s = 'A string'`.
[5] We remind that a LaTeX environment is, in particular, a TeX group.

- When the key `env-gobble` is in force, `piton` analyzes the last line of the environment `{Piton}`, that is to say the line which contains `\end{Piton}` and determines whether that line contains only spaces followed by the `\end{Piton}`. If we are in that situation, `piton` computes the number n of spaces on that line and applies `gobble` with that value of n. The name of that key comes from *environment gobble*: the effect of gobble is set by the position of the commands `\begin{Piton}` and `\end{Piton}` which delimit the current environment.

- **New 2.3** The key `write` takes in as argument a name of file (with its extension) and write the content of the current environment in that file. At the first use of a file by `piton`, it is erased.

- The key `line-numbers` activates the line numbering in the environments `{Piton}` and in the listings resulting from the use of `\PitonInputFile`.

  In fact, the key `line-numbers` has several subkeys.

  - With the key `line-numbers/skip-empty-lines`, the empty lines are considered as non existent for the line numbering (if the key `/absolute` is in force, the key `/skip-empty-lines` is no-op in `\PitonInputFile`). The initial value of that key is `true` (and not `false`).[6]
  - With the key `line-numbers/label-empty-lines`, the labels (that is to say the numbers) of the empty lines are displayed. If the key `/skip-empty-line` is in force, the clé `/label-empty-lines` is no-op. The initial value of that key is `true`.
  - With the key `line-numbers/absolute`, in the listings generated in `\PitonInputFile`, the numbers of the lines displayed are *absolute* (that is to say: they are the numbers of the lines in the file). That key may be useful when `\PitonInputFile` is used to insert only a part of the file (cf. part 5.2, p. 9). The key `/absolute` is no-op in the environments `{Piton}`.
  - The key `line-numbers/start` requires that the line numbering begins to the value of the key.
  - With the key `line-numbers/resume`, the counter of lines is not set to zero at the beginning of each environment `{Piton}` or use of `\PitonInputFile` as it is otherwise. That allows a numbering of the lines across several environments.
  - The key `line-numbers/sep` is the horizontal distance between the numbers of lines (inserted by `line-numbers`) and the beginning of the lines of code. The initial value is 0.7 em.

  For convenience, a mechanism of factorisation of the prefix `line-numbers` is provided. That means that it is possible, for instance, to write:

  ```
  \PitonOptions
    {
      line-numbers =
        {
          skip-empty-lines = false ,
          label-empty-lines = false ,
          sep = 1 em
        }
    }
  ```

- The key `left-margin` corresponds to a margin on the left. That key may be useful in conjonction with the key `line-numbers` if one does not want the numbers in an overlapping position on the left.

  It's possible to use the key `left-margin` with the value `auto`. With that value, if the key `line-numbers` is in force, a margin will be automatically inserted to fit the numbers of lines. See an example part 6.1 on page 18.

[6] For the language Python, the empty lines in the docstrings are taken into account (by design).

- The key `background-color` sets the background color of the environments `{Piton}` and the listings produced by `\PitonInputFile` (it's possible to fix the width of that background with the key `width` described below).

  The key `background-color` supports also as value a *list* of colors. In this case, the successive rows are colored by using the colors of the list in a cyclic way.

  Example : `\PitonOptions{background-color = {gray!5,white}}`

  The key `background-color` accepts a color defined «on the fly». For example, it's possible to write `background-color = [cmyk]{0.1,0.05,0,0}`.

- With the key `prompt-background-color`, piton adds a color background to the lines beginning with the prompt "`>>>`" (and its continuation "`...`") characteristic of the Python consoles with REPL (*read-eval-print loop*).

- The key `width` will fix the width of the listing. That width applies to the colored backgrounds specified by `background-color` and `prompt-background-color` but also for the automatic breaking of the lines (when required by `break-lines`: cf. 5.1.2, p. 9).

  That key may take in as value a numeric value but also the special value `min`. With that value, the width will be computed from the maximal width of the lines of code. Caution: the special value `min` requires two compilations with LuaLaTeX[7].

  For an example of use of `width=min`, see the section 6.2, p. 18.

- When the key `show-spaces-in-strings` is activated, the spaces in the strings of characters[8] are replaced by the character ␣ (U+2423 : OPEN BOX). Of course, that character U+2423 must be present in the monospaced font which is used.[9]

  Example : `my_string = 'Very␣good␣answer'`

  With the key `show-spaces`, all the spaces are replaced by U+2423 (and no line break can occur on those "visible spaces", even when the key `break-lines`[10] is in force).

```
\begin{Piton}[language=C,line-numbers,auto-gobble,background-color = gray!15]
    void bubbleSort(int arr[], int n) {
        int temp;
        int swapped;
        for (int i = 0; i < n-1; i++) {
            swapped = 0;
            for (int j = 0; j < n - i - 1; j++) {
                if (arr[j] > arr[j + 1]) {
                    temp = arr[j];
                    arr[j] = arr[j + 1];
                    arr[j + 1] = temp;
                    swapped = 1;
                }
            }
            if (!swapped) break;
        }
    }
\end{Piton}
```

```
void bubbleSort(int arr[], int n) {
    int temp;
    int swapped;
    for (int i = 0; i < n-1; i++) {
```

[7] The maximal width is computed during the first compilation, written on the `aux` file and re-used during the second compilation. Several tools such as `latexmk` (used by Overleaf) do automatically a sufficient number of compilations.

[8] With the language Python that feature applies only to the short strings (delimited by `'` or `"`). In OCaml, that feature does not apply to the *quoted strings*.

[9] The package piton simply uses the current monospaced font. The best way to change that font is to use the command `\setmonofont` of the package fontspec.

[10] cf. 5.1.2 p. 9

```
        swapped = 0;
        for (int j = 0; j < n - i - 1; j++) {
            if (arr[j] > arr[j + 1]) {
                temp = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = temp;
                swapped = 1;
            }
        }
        if (!swapped) break;
    }
}
```

The command `\PitonOptions` provides in fact several other keys which will be described further (see in particular the “Pages breaks and line breaks” p. 8).

4.2 The styles

4.2.1 Notion of style

The package piton provides the command `\SetPitonStyle` to customize the different styles used to format the syntactic elements of the Python listings. The customizations done by that command are limited to the current TeX group.[11]

The command `\SetPitonStyle` takes in as argument a comma-separated list of *key=value* pairs. The keys are names of styles and the value are LaTeX formatting instructions.

These LaTeX instructions must be formatting instructions such as `\color{...}`, `\bfseries`, `\slshape`, etc. (the commands of this kind are sometimes called *semi-global* commands). It’s also possible to put, *at the end of the list of instructions*, a LaTeX command taking exactly one argument.

Here an example which changes the style used to highlight, in the definition of a Python function, the name of the function which is defined. That code uses the command `\highLight` of lua-ul (that package requires also the package luacolor).

```
\SetPitonStyle{ Name.Function = \bfseries \highLight[red!50] }
```

In that example, `\highLight[red!50]` must be considered as the name of a LaTeX command which takes in exactly one argument, since, usually, it is used with `\highLight[red!50]{...}`.

With that setting, we will have : `def cube(x) : return x * x * x`

The different styles, and their use by piton in the different languages which it supports (Python, OCaml, C, SQL and “`minimal`”), are described in the part 7, starting at the page 23.

The command `\PitonStyle` takes in as argument the name of a style and allows to retrieve the value (as a list of LaTeX instructions) of that style.

For example, it’s possible to write `{\PitonStyle{Keyword}{function}}` and we will have the word **function** formatted as a keyword.

The syntax `{\PitonStyle{`*`style`*`}{...}}` is mandatory in order to be able to deal both with the semi-global commands and the commands with arguments which may be present in the definition of the style *`style`*.

[11] We remind that a LaTeX environment is, in particular, a TeX group.

4.2.2 Global styles and local styles

A style may be defined globally with the command `\SetPitonStyle`. That means that it will apply to all the informatic languages that use that style.

For example, with the command

```
\SetPitonStyle{Comment = \color{gray}}
```

all the comments will be composed in gray in all the listings, whatever informatic language they use (Python, C, OCaml, etc.).

New 2.2 But it's also possible to define a style locally for a given informatic langage by providing the name of that language as optional argument (between square brackets) to the command `\SetPitonStyle`.[12]

For example, with the command

```
\SetPitonStyle[SQL]{Keywords = \color[HTML]{006699} \bfseries \MakeUppercase}
```

the keywords in the SQL listings will be composed in capital letters, even if they appear in lower case in the LaTeX source (we recall that, in SQL, the keywords are case-insensitive).

As expected, if an informatic language uses a given style and if that style has no local definition for that language, the global version is used. That notion of "global style" has no link with the notion of global definition in TeX (the notion of *group* in TeX).[13]

The package piton itself (that is to say the file `piton.sty`) defines all the styles globally.

4.2.3 The style UserFunction

The extension piton provides a special style called `UserFunction`. That style applies to the names of the functions previously defined by the user (for example, in Python, these names are those following the keyword `def` in a previous Python listing). The initial value of that style is empty, and, therefore, the names of the functions are formatted as standard text (in black). However, it's possible to change the value of that style, as any other style, with the command `\SetPitonStyle`.

In the following example, we fix as value for that style `UserFunction` the initial value of the style `Name.Function` (which applies to the name of the functions, *at the moment of their definition*).

```
\SetPitonStyle{UserFunction = \color[HTML]{CC00FF}}
```

```
def transpose(v,i,j):
    x = v[i]
    v[i] = v[j]
    v[j] = x

def passe(v):
    for in in range(0,len(v)-1):
        if v[i] > v[i+1]:
            transpose(v,i,i+1)
```

As one see, the name `transpose` has been highlighted because it's the name of a Python function previously defined by the user (hence the name `UserFunction` for that style).

Of course, the list of the names of Python functions previously défined is kept in the memory of LuaLaTeX (in a global way, that is to say independently of the TeX groups). The extension piton provides a command to clear that list : it's the command `\PitonClearUserFunctions`. When it is used without argument, that command is applied to all the informatic languages used by the user but it's also possible to use it with an optional argument (between square brackets) which is a list of informatic languages to which the command will be applied.[14]

[12] We recall, that, in the package piton, the names of the informatic languages are case-insensitive.

[13] As regards the TeX groups, the definitions done by `\SetPitonStyle` are always local.

[14] We remind that, in piton, the name of the informatic languages are case-insensitive.

4.3 Creation of new environments

Since the environment `{Piton}` has to catch its body in a special way (more or less as verbatim text), it's not possible to construct new environments directly over the environment `{Piton}` with the classical commands `\newenvironment` (of standard LaTeX) or `\NewDocumentEnvironment` (of LaTeX3).
That's why piton provides a command `\NewPitonEnvironment`. That command takes in three mandatory arguments.
That command has the same syntax as the classical environment `\NewDocumentEnvironment`.

With the following instruction, a new environment `{Python}` will be constructed with the same behaviour as `{Piton}`:

```
\NewPitonEnvironment{Python}{O{}}{\PitonOptions{#1}}{}
```

If one wishes to format Python code in a box of tcolorbox, it's possible to define an environment `{Python}` with the following code (of course, the package tcolorbox must be loaded).

```
\NewPitonEnvironment{Python}{}
  {\begin{tcolorbox}}
  {\end{tcolorbox}}
```

With this new environment `{Python}`, it's possible to write:

```
\begin{Python}
def square(x):
    """Compute the square of a number"""
    return x*x
\end{Python}
```

```
def square(x):
    """Compute the square of a number"""
    return x*x
```

5 Advanced features

5.1 Page breaks and line breaks

5.1.1 Page breaks

By default, the listings produced by the environment `{Piton}` and the command `\PitonInputFile` are not breakable.
However, the command `\PitonOptions` provides the key `splittable` to allow such breaks.

- If the key `splittable` is used without any value, the listings are breakable everywhere.
- If the key `splittable` is used with a numeric value n (which must be a non-negative integer number), the listings are breakable but no break will occur within the first n lines and within the last n lines. Therefore, `splittable=1` is equivalent to `splittable`.

Even with a background color (set by the key `background-color`), the pages breaks are allowed, as soon as the key `splittable` is in force.[15]

[15] With the key `splittable`, the environments `{Piton}` are breakable, even within a (breakable) environment of tcolorbox. Remind that an environment of tcolorbox included in another environment of tcolorbox is *not* breakable, even when both environments use the key `breakable` of tcolorbox.

5.1.2 Line breaks

By default, the elements produced by piton can't be broken by an end on line. However, there are keys to allow such breaks (the possible breaking points are the spaces, even the spaces in the Python strings).

- With the key `break-lines-in-piton`, the line breaks are allowed in the command `\piton{...}` (but not in the command `\piton|...|`, that is to say the command `\piton` in verbatim mode).
- With the key `break-lines-in-Piton`, the line breaks are allowed in the environment `{Piton}` (hence the capital letter `P` in the name) and in the listings produced by `\PitonInputFile`.
- The key `break-lines` is a conjonction of the two previous keys.

The package piton provides also several keys to control the appearance on the line breaks allowed by `break-lines-in-Piton`.

- With the key `indent-broken-lines`, the indentation of a broken line is respected at carriage return.
- The key `end-of-broken-line` corresponds to the symbol placed at the end of a broken line. The initial value is: `\hspace*{0.5em}\textbackslash`.
- The key `continuation-symbol` corresponds to the symbol placed at each carriage return. The initial value is: `+\;` (the command `\;` inserts a small horizontal space).
- The key `continuation-symbol-on-indentation` corresponds to the symbol placed at each carriage return, on the position of the indentation (only when the key `indent-broken-line` is in force). The initial value is: `$\hookrightarrow\;$`.

The following code has been composed with the following tuning:

```
\PitonOptions{width=12cm,break-lines,indent-broken-lines,background-color=gray!15}
```

```
    def dict_of_list(l):
        """Converts a list of subrs and descriptions of glyphs in \
+       ↪ a dictionary"""
        our_dict = {}
        for list_letter in l:
            if (list_letter[0][0:3] == 'dup'): # if it's a subr
                name = list_letter[0][4:-3]
                print("We treat the subr of number " + name)
            else:
                name = list_letter[0][1:-3] # if it's a glyph
                print("We treat the glyph of number " + name)
            our_dict[name] = [treat_Postscript_line(k) for k in \
+           ↪ list_letter[1:-1]]
        return dict
```

5.2 Insertion of a part of a file

The command `\PitonInputFile` inserts (with formating) the content of a file. In fact, it's possible to insert only *a part* of that file. Two mechanisms are provided in this aim.

- It's possible to specify the part that we want to insert by the numbers of the lines (in the original file).
- It's also possible to specify the part to insert with textual markers.

In both cases, if we want to number the lines with the numbers of the lines in the file, we have to use the key `line-numbers/absolute`.

5.2.1 With line numbers

The command \PitonInputFile supports the keys first-line and last-line in order to insert only the part of file between the corresponding lines. Not to be confused with the key line-numbers/start which fixes the first line number for the line numbering. In a sens, line-numbers/start deals with the output whereas first-line and last-line deal with the input.

5.2.2 With textual markers

In order to use that feature, we first have to specify the format of the markers (for the beginning and the end of the part to include) with the keys marker-beginning and marker-end (usually with the command \PitonOptions).

Let us take a practical example.

We assume that the file to include contains solutions to exercises of programmation on the following model.

```
#[Exercise 1] Iterative version
def fibo(n):
    if n==0: return 0
    else:
        u=0
        v=1
        for i in range(n-1):
            w = u+v
            u = v
            v = w
        return v
#<Exercise 1>
```

The markers of the beginning and the end are the strings #[Exercise 1] and #<Exercise 1>. The string “Exercise 1” will be called the *label* of the exercise (or of the part of the file to be included). In order to specify such markers in piton, we will use the keys marker/beginning and marker/end with the following instruction (the character # of the comments of Python must be inserted with the protected form \#).

```
\PitonOptions{ marker/beginning = \#[#1] , marker/end = \#<#1> }
```

As one can see, marker/beginning is an expression corresponding to the mathematical function which transforms the label (here Exercise 1) into the the beginning marker (in the example #[Exercise 1]). The string #1 corresponds to the occurrences of the argument of that function, which the classical syntax in TeX. Idem for marker/end.

Now, you only have to use the key range of \PitonInputFile to insert a marked content of the file.

```
\PitonInputFile[range = Exercise 1]{file_name}
```

```
def fibo(n):
    if n==0: return 0
    else:
        u=0
        v=1
        for i in range(n-1):
            w = u+v
            u = v
            v = w
        return v
```

The key marker/include-line requires the insertion of the lines containing the markers.

```
\PitonInputFile[marker/include-lines,range = Exercise 1]{file_name}
```

```
#[Exercise 1] Iterative version
def fibo(n):
    if n==0: return 0
    else:
        u=0
        v=1
        for i in range(n-1):
            w = u+v
            u = v
            v = w
        return v
#<Exercise 1>
```

In fact, there exist also the keys `begin-range` and `end-range` to insert several marked contents at the same time.
For example, in order to insert the solutions of the exercises 3 to 5, we will write (if the file has the correct structure!):

```
\PitonInputFile[begin-range = Exercise 3, end-range = Exercise 5]{file_name}
```

5.3 Highlighting some identifiers

Modification 2.4

The command `\SetPitonIdentifier` allows to change the formatting of some identifiers.

That command takes in three arguments: one

- The optionnal argument (within square brackets) specifies the informatic langage. If this argument is not present, the tunings done by `\SetPitonIdentifier` will apply to all the informatic langages of piton.[16]
- The first mandatory argument is a comma-separated list of names of identifiers.
- The second mandatory argument is a list of LaTeX instructions of the same type as piton "styles" previously presented (cf 4.2 p. 6).

Caution: Only the identifiers may be concerned by that key. The keywords and the built-in functions won't be affected, even if their name appear in the first argument of the command `\SetPitonIdentifier`.

```
\SetPitonIdentifier{l1,l2}{\color{red}}
\begin{Piton}
def tri(l):
    """Segmentation sort"""
    if len(l) <= 1:
        return l
    else:
        a = l[0]
        l1 = [ x for x in l[1:] if x < a  ]
        l2 = [ x for x in l[1:] if x >= a ]
        return tri(l1) + [a] + tri(l2)
\end{Piton}
```

[16] We recall, that, in the package piton, the names of the informatic languages are case-insensitive.

```
def tri(l):
    """Segmentation sort"""
    if len(l) <= 1:
        return l
    else:
        a = l[0]
        l1 = [ x for x in l[1:] if x < a  ]
        l2 = [ x for x in l[1:] if x >= a ]
        return tri(l1) + [a] + tri(l2)
```

By using the command `\SetPitonIdentifier`, it's possible to add other built-in functions (or other new keywords, etc.) that will be detected by piton.

```
\SetPitonIdentifier[Python]
  {cos, sin, tan, floor, ceil, trunc, pow, exp, ln, factorial}
  {\PitonStyle{Name.Builtin}}

\begin{Piton}
from math import *
cos(pi/2)
factorial(5)
ceil(-2.3)
floor(5.4)
\end{Piton}
```

```
from math import *
cos(pi/2)
factorial(5)
ceil(-2.3)
floor(5.4)
```

5.4 Mechanisms to escape to LaTeX

The package piton provides several mechanisms for escaping to LaTeX:

- It's possible to compose comments entirely in LaTeX.
- It's possible to have the elements between `$` in the comments composed in LateX mathematical mode.
- It's possible to ask piton to detect automatically some LaTeX commands, thanks to the key `detected-commands`.
- It's also possible to insert LaTeX code almost everywhere in a Python listing.

One should aslo remark that, when the extension piton is used with the class beamer, piton detects in `{Piton}` many commands and environments of Beamer: cf. 5.5 p. 15.

5.4.1 The "LaTeX comments"

In this document, we call "LaTeX comments" the comments which begins by `#>`. The code following those characters, until the end of the line, will be composed as standard LaTeX code. There is two tools to customize those comments.

- It's possible to change the syntatic mark (which, by default, is `#>`). For this purpose, there is a key `comment-latex` available only in the preamble of the document, allows to choice the characters which, preceded by `#`, will be the syntatic marker.

  For example, if the preamble contains the following instruction:

  ```
  \PitonOptions{comment-latex = LaTeX}
  ```

  the LaTeX comments will begin by `#LaTeX`.

  If the key `comment-latex` is used with the empty value, all the Python comments (which begins by `#`) will, in fact, be "LaTeX comments".

- It's possible to change the formatting of the LaTeX comment itself by changing the piton style `Comment.LaTeX`.

  For example, with `\SetPitonStyle{Comment.LaTeX = \normalfont\color{blue}}`, the LaTeX comments will be composed in blue.

  If you want to have a character `#` at the beginning of the LaTeX comment in the PDF, you can use set `Comment.LaTeX` as follows:

  ```
  \SetPitonStyle{Comment.LaTeX = \color{gray}\#\normalfont\space }
  ```

  For other examples of customization of the LaTeX comments, see the part 6.2 p. 18

If the user has required line numbers (with the key `line-numbers`), it's possible to refer to a number of line with the command `\label` used in a LaTeX comment.[17]

5.4.2 The key "math-comments"

It's possible to request that, in the standard Python comments (that is to say those beginning by `#` and not `#>`), the elements between `$` be composed in LaTeX mathematical mode (the other elements of the comment being composed verbatim).
That feature is activated by the key `math-comments`, *which is available only in the preamble of the document.*

Here is a example, where we have assumed that the preamble of the document contains the instruction `\PitonOptions{math-comment}`:

```
\begin{Piton}
def square(x):
    return x*x # compute $x^2$
\end{Piton}
```

```
def square(x):
    return x*x # compute x^2
```

5.4.3 The key "detected-commands"

New 2.4

The key `detected-commands` of `\PitonOptions` allow to specify a (comma-separated) list of names of LaTeX commands that will be detected directly by piton.

- The key `detected-commands` must be used in the preamble of the LaTeX document.
- The names of the LaTeX commands must appear without the leading backslash (eg. `detected-commands = { emph, bfseries }`).
- These commands must be LaTeX commands with only one (mandatory) argument between braces (and these braces must be explicit).

We assume that the preamble of the LaTeX document contains the following line.

```
\PitonOptions{detected-commands = highLight}
```

Then, it's possible to write directly:

[17] That feature is implemented by using a redefinition of the standard command `\label` in the environments `{Piton}`. Therefore, incompatibilities may occur with extensions which redefine (globally) that command `\label` (for example: varioref, refcheck, showlabels, etc.)

```
\begin{Piton}
def fact(n):
    if n==0:
        return 1
    else:
        \highLight{return n*fact(n-1)}
\end{Piton}
```

```
def fact(n):
    if n==0:
        return 1
    else:
        return n*fact(n-1)
```

5.4.4 The mechanism "escape"

It's also possible to overwrite the Python listings to insert LaTeX code almost everywhere (but between lexical units, of course). By default, piton does not fix any delimiters for that kind of escape. In order to use this mechanism, it's necessary to specify the delimiters which will delimit the escape (one for the beginning and one for the end) by using the keys `begin-escape` and `end-escape`, *available only in the preamble of the document.*

We consider once again the previous example of a recursive programmation of the factorial. We want to highlight in pink the instruction containing the recursive call. With the package lua-el, we can use the syntax `\highLight[LightPink]{...}`. Because of the optional argument between square brackets, it's not possible to use the key `detected-commands` but it's possible to acheive our goal with the more general mechanism "escape".

We assume that the preamble of the document contains the following instruction:

```
\PitonOptions{begin-escape=!,end-escape=!}
```

Then, it's possible to write:

```
\begin{Piton}
def fact(n):
    if n==0:
        return 1
    else:
        !\highLight[LightPink]{!return n*fact(n-1)!}!
\end{Piton}
```

```
def fact(n):
    if n==0:
        return 1
    else:
        return n*fact(n-1)
```

Caution : The escape to LaTeX allowed by the `begin-escape` and `end-escape` is not active in the strings nor in the Python comments (however, it's possible to have a whole Python comment composed in LaTeX by beginning it with `#>`; such comments are merely called "LaTeX comments" in this document).

5.4.5 The mechanism "escape-math"

The mechanism "`escape-math`" is very similar to the mechanism "`escape`" since the only difference is that the elements sent to LaTeX are composed in the math mode of LaTeX.
This mechanism is activated with the keys `begin-escape-math` and `end-escape-math` (*which are available only in the preamble of the document*).
Despite the technical similarity, the use of the the mechanism "`escape-math`" is in fact rather different from that of the mechanism "`escape`". Indeed, since the elements are composed in a mathématical

mode of LaTeX, they are, in particular, composed within a TeX group and therefore, they can't be used to change the formatting of other lexical units.
In the langages where the character `$` does not play a important role, it's possible to activate that mechanism "`escape-math`" with the character `$`:

```
\PitonOptions{begin-escape-math=$,end-escape-math=$}
```

Remark that the character `$` must *not* be protected by a backslash.

However, it's probably more prudent to use `\(` et `\)`.

```
\PitonOptions{begin-escape-math=\(,end-escape-math=\)}
```

Here is an example of utilisation.

```
\begin{Piton}[line-numbers]
def arctan(x,n=10):
    if \(x < 0\) :
        return \(-\arctan(-x)\)
    elif \(x > 1\) :
        return \(\pi/2 - \arctan(1/x)\)
    else:
        s = \(0\)
        for \(k\) in range(\(n\)): s += \(\smash{\frac{(-1)^k}{2k+1} x^{2k+1}}\)
        return s
\end{Piton}
```

```
def arctan(x,n=10):
    if $x < 0$ :
        return $-\arctan(-x)$
    elif $x > 1$ :
        return $\pi/2 - \arctan(1/x)$
    else:
        s = $0$
        for $k$ in range($n$): s += $\frac{(-1)^k}{2k+1} x^{2k+1}$
        return s
```

5.5 Behaviour in the class Beamer

First remark
Since the environment `{Piton}` catches its body with a verbatim mode, it's necessary to use the environments `{Piton}` within environments `{frame}` of Beamer protected by the key `fragile`, i.e. beginning with `\begin{frame}[fragile]`.[18]

When the package piton is used within the class beamer[19], the behaviour of piton is slightly modified, as described now.

[18] Remind that for an environment `{frame}` of Beamer using the key `fragile`, the instruction `\end{frame}` must be alone on a single line (except for any leading whitespace).

[19] The extension piton detects the class beamer and the package beamerarticle if it is loaded previously but, if needed, it's also possible to activate that mechanism with the key `beamer` provided by piton at load-time: `\usepackage[beamer]{piton}`

5.5.1 {Piton} et \PitonInputFile are “overlay-aware”

When piton is used in the class beamer, the environment `{Piton}` and the command `\PitonInputFile` accept the optional argument `<...>` of Beamer for the overlays which are involved.
For example, it’s possible to write:

```
\begin{Piton}<2-5>
...
\end{Piton}
```

and

```
\PitonInputFile<2-5>{my_file.py}
```

5.5.2 Commands of Beamer allowed in {Piton} and \PitonInputFile

When piton is used in the class beamer , the following commands of beamer (classified upon their number of arguments) are automatically detected in the environments `{Piton}` (and in the listings processed by `\PitonInputFile`):

- no mandatory argument : `\pause`[20]. ;
- one mandatory argument : `\action`, `\alert`, `\invisible`, `\only`, `\uncover` and `\visible` ;
- two mandatory arguments : `\alt` ;
- three mandatory arguments : `\temporal`.

In the mandatory arguments of these commands, the braces must be balanced. However, the braces included in short strings[21] of Python are not considered.

Regarding the fonctions `\alt` and `\temporal` there should be no carriage returns in the mandatory arguments of these functions.

Here is a complete example of file:

```
\documentclass{beamer}
\usepackage{piton}
\begin{document}
\begin{frame}[fragile]
\begin{Piton}
def string_of_list(l):
    """Convert a list of numbers in string"""
    \only<2->{s = "{" + str(l[0])}
    \only<3->{for x in l[1:]: s = s + "," + str(x)}
    \only<4->{s = s + "}"}
    return s
\end{Piton}
\end{frame}
\end{document}
```

In the previous example, the braces in the Python strings `"{"` and `"}"` are correctly interpreted (without any escape character).

[20] One should remark that it’s also possible to use the command `\pause` in a “LaTeX comment”, that is to say by writing `#> \pause`. By this way, if the Python code is copied, it’s still executable by Python

[21] The short strings of Python are the strings delimited by characters `'` or the characters `"` and not `'''` nor `"""`. In Python, the short strings can’t extend on several lines.

5.5.3 Environments of Beamer allowed in {Piton} and \PitonInputFile

When piton is used in the class beamer, the following environments of Beamer are directly detected in the environments `{Piton}` (and in the listings processed by `\PitonInputFile`): `{actionenv}`, `{alertenv}`, `{invisibleenv}`, `{onlyenv}`, `{uncoverenv}` and `{visibleenv}`.
However, there is a restriction: these environments must contain only *whole lines of Python code* in their body.

Here is an example:

```
\documentclass{beamer}
\usepackage{piton}
\begin{document}
\begin{frame}[fragile]
\begin{Piton}
def square(x):
    """Compure the square of its argument"""
    \begin{uncoverenv}<2>
    return x*x
    \end{uncoverenv}
\end{Piton}
\end{frame}
\end{document}
```

Remark concerning the command \alert and the environment {alertenv} of Beamer

Beamer provides an easy way to change the color used by the environment `{alertenv}` (and by the command `\alert` which relies upon it) to highlight its argument. Here is an example:

```
\setbeamercolor{alerted text}{fg=blue}
```

However, when used inside an environment `{Piton}`, such tuning will probably not be the best choice because piton will, by design, change (most of the time) the color the different elements of text. One may prefer an environment `{alertenv}` that will change the background color for the elements to be hightlighted.

Here is a code that will do that job and add a yellow background. That code uses the command `\@highLight` of lua-ul (that extension requires also the package luacolor).

```
\setbeamercolor{alerted text}{bg=yellow!50}
\makeatletter
\AddToHook{env/Piton/begin}
  {\renewenvironment<>{alertenv}{\only#1{\@highLight[alerted text.bg]}}{}}
\makeatother
```

That code redefines locally the environment `{alertenv}` within the environments `{Piton}` (we recall that the command `\alert` relies upon that environment `{alertenv}`).

5.6 Footnotes in the environments of piton

If you want to put footnotes in an environment `{Piton}` or (or, more unlikely, in a listing produced by `\PitonInputFile`), you can use a pair `\footnotemark`–`\footnotetext`.

However, it's also possible to extract the footnotes with the help of the package footnote or the package footnotehyper.

If piton is loaded with the option `footnote` (with `\usepackage[footnote]{piton}` or with `\PassOptionsToPackage`), the package footnote is loaded (if it is not yet loaded) and it is used to extract the footnotes.

If piton is loaded with the option `footnotehyper`, the package footnotehyper is loaded (if it is not yet loaded) ant it is used to extract footnotes.

Caution: The packages footnote and footnotehyper are incompatible. The package footnotehyper is the successor of the package footnote and should be used preferently. The package footnote has some drawbacks, in particular: it must be loaded after the package xcolor and it is not perfectly compatible with hyperref.

In this document, the package piton has been loaded with the option `footnotehyper`. For examples of notes, cf. 6.3, p. 19.

5.7 Tabulations

Even though it's recommended to indent the Python listings with spaces (see PEP 8), piton accepts the characters of tabulation (that is to say the characters U+0009) at the beginning of the lines. Each character U+0009 is replaced by n spaces. The initial value of n is 4 but it's possible to change it with the key `tab-size` of `\PitonOptions`.

There exists also a key `tabs-auto-gobble` which computes the minimal value n of the number of consecutive characters U+0009 beginning each (non empty) line of the environment `{Piton}` and applies `gobble` with that value of n (before replacement of the tabulations by spaces, of course). Hence, that key is similar to the key `auto-gobble` but acts on U+0009 instead of U+0020 (spaces).

6 Examples

6.1 Line numbering

We remind that it's possible to have an automatic numbering of the lines in the Python listings by using the key `line-numbers`.
By default, the numbers of the lines are composed by piton in an overlapping position on the left (by using internally the command `\llap` of LaTeX).
In order to avoid that overlapping, it's possible to use the option `left-margin=auto` which will insert automatically a margin adapted to the numbers of lines that will be written (that margin is larger when the numbers are greater than 10).

```
\PitonOptions{background-color=gray!10, left-margin = auto, line-numbers}
\begin{Piton}
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x)        #> (recursive call)
    elif x > 1:
        return pi/2 - arctan(1/x) #> (other recursive call)
    else:
        return sum( (-1)**k/(2*k+1)*x**(2*k+1) for k in range(n) )
\end{Piton}
```

```
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x)        (recursive call)
    elif x > 1:
        return pi/2 - arctan(1/x) (other recursive call)
    else:
        return sum( (-1)**k/(2*k+1)*x**(2*k+1) for k in range(n) )
```

6.2 Formatting of the LaTeX comments

It's possible to modify the style `Comment.LaTeX` (with `\SetPitonStyle`) in order to display the LaTeX comments (which begin with `#>`) aligned on the right margin.

```
\PitonOptions{background-color=gray!10}
\SetPitonStyle{Comment.LaTeX = \hfill \normalfont\color{gray}}
\begin{Piton}
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x)        #> recursive call
    elif x > 1:
        return pi/2 - arctan(1/x) #> other recursive call
    else:
        return sum( (-1)**k/(2*k+1)*x**(2*k+1) for k in range(n) )
\end{Piton}
```

```
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x)                                          recursive call
    elif x > 1:
        return pi/2 - arctan(1/x)                           another recursive call
    else:
        return sum( (-1)**k/(2*k+1)*x**(2*k+1) for k in range(n) )
```

It's also possible to display these LaTeX comments in a kind of second column by limiting the width of the Python code with the key `width`. In the following example, we use the key `width` with the special value `min`.

```
\PitonOptions{background-color=gray!10, width=min}
\NewDocumentCommand{\MyLaTeXCommand}{m}{\hfill \normalfont\itshape\rlap{\quad #1}}
\SetPitonStyle{Comment.LaTeX = \MyLaTeXCommand}
\begin{Piton}
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x) #> recursive call
    elif x > 1:
        return pi/2 - arctan(1/x) #> another recursive call
    else:
        s = 0
        for k in range(n):
             s += (-1)**k/(2*k+1)*x**(2*k+1)
        return s
\end{Piton}
```

```
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x)                     recursive call
    elif x > 1:
        return pi/2 - arctan(1/x)              another recursive call
    else:
        s = 0
        for k in range(n):
             s += (-1)**k/(2*k+1)*x**(2*k+1)
        return s
```

6.3 Notes in the listings

In order to be able to extract the notes (which are typeset with the command `\footnote`), the extension piton must be loaded with the key `footnote` or the key `footenotehyper` as explained in the section 5.6 p. 17. In this document, the extension piton has been loaded with the key `footnotehyper`. Of course, in an environment `{Piton}`, a command `\footnote` may appear only within a LaTeX comment (which begins with `#>`). It's possible to have comments which contain only that command `\footnote`. That's the case in the following example.

```
\PitonOptions{background-color=gray!10}
\begin{Piton}
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x)#>\footnote{First recursive call.}]
    elif x > 1:
        return pi/2 - arctan(1/x)#>\footnote{Second recursive call.}
    else:
        return sum( (-1)**k/(2*k+1)*x**(2*k+1) for k in range(n) )
\end{Piton}
```

```
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x)[22]
    elif x > 1:
        return pi/2 - arctan(1/x)[23]
    else:
        return sum( (-1)**k/(2*k+1)*x**(2*k+1) for k in range(n) )
```

If an environment `{Piton}` is used in an environment `{minipage}` of LaTeX, the notes are composed, of course, at the foot of the environment `{minipage}`. Recall that such `{minipage}` can't be broken by a page break.

```
\PitonOptions{background-color=gray!10}
\emphase\begin{minipage}{\linewidth}
\begin{Piton}
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x)#>\footnote{First recursive call.}
    elif x > 1:
        return pi/2 - arctan(1/x)#>\footnote{Second recursive call.}
    else:
        return sum( (-1)**k/(2*k+1)*x**(2*k+1) for k in range(n) )
\end{Piton}
\end{minipage}
```

```
def arctan(x,n=10):
    if x < 0:
        return -arctan(-x)[a]
    elif x > 1:
        return pi/2 - arctan(1/x)[b]
    else:
        return sum( (-1)**k/(2*k+1)*x**(2*k+1) for k in range(n) )
```

[a] First recursive call.
[b] Second recursive call.

6.4 An example of tuning of the styles

The graphical styles have been presented in the section 4.2, p. 6.

We present now an example of tuning of these styles adapted to the documents in black and white. We use the font *DejaVu Sans Mono*[24] specified by the command `\setmonofont` of fontspec.
That tuning uses the command `\highLight` of lua-ul (that package requires itself the package luacolor).

```
\setmonofont[Scale=0.85]{DejaVu Sans Mono}

\SetPitonStyle
```

[22] First recursive call.
[23] Second recursive call.
[24] See: https://dejavu-fonts.github.io

```
  {
    Number = ,
    String = \itshape ,
    String.Doc = \color{gray} \slshape ,
    Operator = ,
    Operator.Word = \bfseries ,
    Name.Builtin = ,
    Name.Function = \bfseries \highLight[gray!20] ,
    Comment = \color{gray} ,
    Comment.LaTeX = \normalfont \color{gray},
    Keyword = \bfseries ,
    Name.Namespace = ,
    Name.Class = ,
    Name.Type = ,
    InitialValues = \color{gray}
  }
```

In that tuning, many values given to the keys are empty: that means that the corresponding style won't insert any formating instruction (the element will be composed in the standard color, usually in black, etc.). Nevertheless, those entries are mandatory because the initial value of those keys in piton is *not* empty.

```
from math import pi

def arctan(x,n=10):
    """Compute the mathematical value of arctan(x)

    n is the number of terms in the sum
    """
    if x < 0:
        return -arctan(-x) # recursive call
    elif x > 1:
        return pi/2 - arctan(1/x)
        (we have used that arctan(x) + arctan(1/x) = π/2 for x > 0)
    else:
        s = 0
        for k in range(n):
            s += (-1)**k/(2*k+1)*x**(2*k+1)
        return s
```

6.5 Use with pyluatex

The package pyluatex is an extension which allows the execution of some Python code from `lualatex` (provided that Python is installed on the machine and that the compilation is done with `lualatex` and `--shell-escape`).
Here is, for example, an environment `{PitonExecute}` which formats a Python listing (with piton) but display also the output of the execution of the code with Python (for technical reasons, the `!` is mandatory in the signature of the environment).

```
\ExplSyntaxOn
\NewDocumentEnvironment { PitonExecute } { ! O { } } % the ! is mandatory
  {
    \PyLTVerbatimEnv
    \begin{pythonq}
  }
  {
    \end{pythonq}
    \directlua
      {
        tex.print("\\PitonOptions{#1}")
        tex.print("\\begin{Piton}")
        tex.print(pyluatex.get_last_code())
        tex.print("\\end{Piton}")
        tex.print("")
      }
    \begin{center}
      \directlua{tex.print(pyluatex.get_last_output())}
    \end{center}
  }
\ExplSyntaxOff
```

This environment `{PitonExecute}` takes in as optional argument (between square brackets) the options of the command `\PitonOptions`.

7 The styles for the different computer languages

7.1 The language Python

In piton, the default language is Python. If necessary, it's possible to come back to the language Python with \PitonOptions{language=Python}.

The initial settings done by piton in piton.sty are inspired by the style manni de Pygments, as applied by Pygments to the language Python.[25]

Style	Use
Number	the numbers
String.Short	the short strings (entre ' ou ")
String.Long	the long strings (entre ''' ou """) excepted the doc-strings (governed by String.Doc)
String	that key fixes both String.Short et String.Long
String.Doc	the doc-strings (only with """ following PEP 257)
String.Interpol	the syntactic elements of the fields of the f-strings (that is to say the characters { et }); that style inherits for the styles String.Short and String.Long (according the kind of string where the interpolation appears)
Interpol.Inside	the content of the interpolations in the f-strings (that is to say the elements between { and }); if the final user has not set that key, those elements will be formatted by piton as done for any Python code.
Operator	the following operators: != == << >> - ~ + / * % = < > & . | @
Operator.Word	the following operators: in, is, and, or et not
Name.Builtin	almost all the functions predefined by Python
Name.Decorator	the decorators (instructions beginning by @)
Name.Namespace	the name of the modules
Name.Class	the name of the Python classes defined by the user *at their point of definition* (with the keyword class)
Name.Function	the name of the Python functions defined by the user *at their point of definition* (with the keyword def)
UserFunction	the name of the Python functions previously defined by the user (the initial value of that parameter is empty and, hence, these elements are drawn, by default, in the current color, usually black)
Exception	les exceptions prédéfinies (ex.: SyntaxError)
InitialValues	the initial values (and the preceding symbol =) of the optional arguments in the definitions of functions; if the final user has not set that key, those elements will be formatted by piton as done for any Python code.
Comment	the comments beginning with #
Comment.LaTeX	the comments beginning with #>, which are composed by piton as LaTeX code (merely named "LaTeX comments" in this document)
Keyword.Constant	True, False et None
Keyword	the following keywords: assert, break, case, continue, del, elif, else, except, exec, finally, for, from, global, if, import, lambda, non local, pass, raise, return, try, while, with, yield et yield from.

[25] See: https://pygments.org/styles/. Remark that, by default, Pygments provides for its style manni a colored background whose color is the HTML color #F0F3F3. It's possible to have the same color in {Piton} with the instruction \PitonOptions{background-color = [HTML]{F0F3F3}}.

7.2 The language OCaml

It's possible to switch to the language OCaml with \PitonOptions{language = OCaml}.

It's also possible to set the language OCaml for an individual environment {Piton}.

```
\begin{Piton}[language=OCaml]
...
\end{Piton}
```

The option exists also for \PitonInputFile : \PitonInputFile[language=OCaml]{...}

Style	Use
Number	the numbers
String.Short	the characters (between ')
String.Long	the strings, between " but also the *quoted-strings*
String	that key fixes both String.Short and String.Long
Operator	les opérateurs, en particulier +, -, /, *, @, !=, ==, &&
Operator.Word	les opérateurs suivants : and, asr, land, lor, lsl, lxor, mod et or
Name.Builtin	les fonctions not, incr, decr, fst et snd
Name.Type	the name of a type of OCaml
Name.Field	the name of a field of a module
Name.Constructor	the name of the constructors of types (which begins by a capital)
Name.Module	the name of the modules
Name.Function	the name of the Python functions defined by the user *at their point of definition* (with the keyword let)
UserFunction	the name of the OCaml functions previously defined by the user (the initial value of that parameter is empty and these elements are drawn in the current color, usually black)
Exception	the predefined exceptions (eg : End_of_File)
TypeParameter	the parameters of the types
Comment	the comments, between (* et *); these comments may be nested
Keyword.Constant	true et false
Keyword	the following keywords: assert, as, begin, class, constraint, done, downto, do, else, end, exception, external, for, function, functor, fun , if include, inherit, initializer, in , lazy, let, match, method, module, mutable, new, object, of, open, private, raise, rec, sig, struct, then, to, try, type, value, val, virtual, when, while and with

7.3 The language C (and C++)

It’s possible to switch to the language C with \PitonOptions{language = C}.

It’s also possible to set the language C for an individual environment {Piton}.

```
\begin{Piton}[language=C]
...
\end{Piton}
```

The option exists also for \PitonInputFile : \PitonInputFile[language=C]{...}

Style	Use
Number	the numbers
String.Long	the strings (between ")
String.Interpol	the elements %d, %i, %f, %c, etc. in the strings; that style inherits from the style String.Long
Operator	the following operators : != == << >> - ~ + / * % = < > & . | @
Name.Type	the following predefined types: bool, char, char16_t, char32_t, double, float, int, int8_t, int16_t, int32_t, int64_t, long, short, signed, unsigned, void et wchar_t
Name.Builtin	the following predefined functions: printf, scanf, malloc, sizeof and alignof
Name.Class	le nom des classes au moment de leur définition, c’est-à-dire après le mot-clé class
Name.Function	the name of the Python functions defined by the user *at their point of definition* (with the keyword let)
UserFunction	the name of the Python functions previously defined by the user (the initial value of that parameter is empty and these elements are drawn in the current color, usually black)
Preproc	the instructions of the preprocessor (beginning par #)
Comment	the comments (beginning by // or between /* and */)
Comment.LaTeX	the comments beginning by //> which are composed by piton as LaTeX code (merely named “LaTeX comments” in this document)
Keyword.Constant	default, false, NULL, nullptr and true
Keyword	the following keywords: alignas, asm, auto, break, case, catch, class, constexpr, const, continue, decltype, do, else, enum, extern, for, goto, if, nexcept, private, public, register, restricted, try, return, static, static_assert, struct, switch, thread_local, throw, typedef, union, using, virtual, volatile and while

7.4 The language SQL

It's possible to switch to the language SQL with \PitonOptions{language = SQL}.

It's also possible to set the language SQL for an individual environment {Piton}.

```
\begin{Piton}[language=SQL]
...
\end{Piton}
```

The option exists also for \PitonInputFile : \PitonInputFile[language=SQL]{...}

Style	Use
Number	the numbers
String.Long	the strings (between ' and not " because the elements between " are names of fields and formatted with Name.Field)
Operator	the following operators : = != <> >= > < <= * + /
Name.Table	the names of the tables
Name.Field	the names of the fields of the tables
Name.Builtin	the following built-in functions (their names are *not* case-sensitive): avg, count, char_lenght, concat, curdate, current_date, date_format, day, lower, ltrim, max, min, month, now, rank, round, rtrim, substring, sum, upper and year.
Comment	the comments (beginning by -- or between /* and */)
Comment.LaTeX	the comments beginning by --> which are composed by piton as LaTeX code (merely named "LaTeX comments" in this document)
Keyword	the following keywords (their names are *not* case-sensitive): add, after, all, alter, and, as, asc, between, by, change, column, create, cross join, delete, desc, distinct, drop, from, group, having, in, inner, insert, into, is, join, left, like, limit, merge, not, null, on, or, order, over, right, select, set, table, then, truncate, union, update, values, when, where and with.

It's possible to automatically capitalize the keywords by modifiying locally for the language SQL the style Keywords.

```
\SetPitonStyle[SQL]{Keywords = \bfseries \MakeUppercase}
```

7.5 The language “minimal”

New 2.4

It’s possible to switch to the language “`minimal`” with `\PitonOptions{language = minimal}`.

It’s also possible to set the language “`minimal`” for an individual environment `{Piton}`.

```
\begin{Piton}[language=minimal]
...
\end{Piton}
```

The option exists also for `\PitonInputFile` : `\PitonInputFile[language=minimal]{...}`

Style	Usage
`Number`	the numbers
`String`	the strings (between `"`)
`Comment`	les comments (which begins with `#`)
`Comment.LaTeX`	the comments beginning with `#>`, which are composed by piton as LaTeX code (merely named “LaTeX comments” in this document)

That language is provided for the final user who might wish to add keywords in that language (with the command `\SetPitonIdentifier`: cf. 5.3, p. 11) in order to create, for example, a language for pseudo-code.

8 Implementation

The development of the extension piton is done on the following GitHub depot:
https://github.com/fpantigny/piton

8.1 Introduction

The main job of the package piton is to take in as input a Python listing and to send back to LaTeX as output that code *with interlaced LaTeX instructions of formatting*.
In fact, all that job is done by a LPEG called python. That LPEG, when matched against the string of a Python listing, returns as capture a Lua table containing data to send to LaTeX. The only thing to do after will be to apply tex.tprint to each element of that table.[26]

Consider, for example, the following Python code:

```
def parity(x):
    return x%2
```

The capture returned by the lpeg python against that code is the Lua table containing the following elements :

```
{ "\\__piton_begin_line:" }[a]
{ "{\PitonStyle{Keyword}{" }[b]
{ luatexbase.catcodetables.CatcodeTableOther[c], "def" }
{ "}}" }
{ luatexbase.catcodetables.CatcodeTableOther, " " }
{ "{\PitonStyle{Name.Function}{" }
{ luatexbase.catcodetables.CatcodeTableOther, "parity" }
{ "}}" }
{ luatexbase.catcodetables.CatcodeTableOther, "(" }
{ luatexbase.catcodetables.CatcodeTableOther, "x" }
{ luatexbase.catcodetables.CatcodeTableOther, ")" }
{ luatexbase.catcodetables.CatcodeTableOther, ":" }
{ "\\__piton_end_line: \\__piton_newline: \\__piton_begin_line:" }
{ luatexbase.catcodetables.CatcodeTableOther, "    " }
{ "{\PitonStyle{Keyword}{" }
{ luatexbase.catcodetables.CatcodeTableOther, "return" }
{ "}}" }
{ luatexbase.catcodetables.CatcodeTableOther, " " }
{ luatexbase.catcodetables.CatcodeTableOther, "x" }
{ "{\PitonStyle{Operator}{" }
{ luatexbase.catcodetables.CatcodeTableOther, "&" }
{ "}}" }
{ "{\PitonStyle{Number}{" }
{ luatexbase.catcodetables.CatcodeTableOther, "2" }
{ "}}" }
{ "\\__piton_end_line:" }
```

[a] Each line of the Python listings will be encapsulated in a pair: _@@_begin_line: – \@@_end_line:. The token \@@_end_line: must be explicit because it will be used as marker in order to delimit the argument of the command \@@_begin_line:. Both tokens _@@_begin_line: and \@@_end_line: will be nullified in the command \piton (since there can't be lines breaks in the argument of a command \piton).

[b] The lexical elements of Python for which we have a piton style will be formatted via the use of the command \PitonStyle. Such an element is typeset in LaTeX via the syntax {\PitonStyle{*style*}{...}} because the instructions inside an \PitonStyle may be both semi-global declarations like \bfseries and commands with one argument like \fbox.

[c] luatexbase.catcodetables.CatcodeTableOther is a mere number which corresponds to the "catcode table" whose all characters have the catcode "other" (which means that they will be typeset by LaTeX verbatim).

[26] Recall that tex.tprint takes in as argument a Lua table whose first component is a "catcode table" and the second element a string. The string will be sent to LaTeX with the regime of catcodes specified by the catcode table. If no catcode table is provided, the standard catcodes of LaTeX will be used.

We give now the LaTeX code which is sent back by Lua to TeX (we have written on several lines for legibility but no character `\r` will be sent to LaTeX). The characters which are greyed-out are sent to LaTeX with the catcode “other” (=12). All the others characters are sent with the regime of catcodes of L3 (as set by `\ExplSyntaxOn`)

```
\__piton_begin_line:{\PitonStyle{Keyword}{def}}
␣{\PitonStyle{Name.Function}{parity}}(x):\__piton_end_line:\__piton_newline:
\__piton_begin_line:␣␣␣␣{\PitonStyle{Keyword}{return}}
␣x{\PitonStyle{Operator}{%}}{\PitonStyle{Number}{2}}\__piton_end_line:
```

8.2 The L3 part of the implementation

8.2.1 Declaration of the package

```
⟨*STY⟩
\NeedsTeXFormat{LaTeX2e}
\RequirePackage{l3keys2e}
\ProvidesExplPackage
  {piton}
  {\PitonFileDate}
  {\PitonFileVersion}
  {Highlight Python codes with LPEG on LuaLaTeX}
```

```
\cs_new_protected:Npn \@@_error:n { \msg_error:nn { piton } }
\cs_new_protected:Npn \@@_warning:n { \msg_warning:nn { piton } }
\cs_new_protected:Npn \@@_error:nn { \msg_error:nnn { piton } }
\cs_new_protected:Npn \@@_error:nnn { \msg_error:nnnn { piton } }
\cs_new_protected:Npn \@@_fatal:n { \msg_fatal:nn { piton } }
\cs_new_protected:Npn \@@_fatal:nn { \msg_fatal:nnn { piton } }
\cs_new_protected:Npn \@@_msg_new:nn { \msg_new:nnn { piton } }
\cs_new_protected:Npn \@@_msg_new:nnn { \msg_new:nnnn { piton } }
\cs_new_protected:Npn \@@_gredirect_none:n #1
  {
    \group_begin:
    \globaldefs = 1
    \msg_redirect_name:nnn { piton } { #1 } { none }
    \group_end:
  }
```

```
\@@_msg_new:nn { LuaLaTeX~mandatory }
  {
    LuaLaTeX~is~mandatory.\\
    The~package~'piton'~requires~the~engine~LuaLaTeX.\\
    \str_if_eq:onT \c_sys_jobname_str { output }
      { If~you~use~Overleaf,~you~can~switch~to~LuaLaTeX~in~the~"Menu". \\}
    If~you~go~on,~the~package~'piton'~won't~be~loaded.
  }
\sys_if_engine_luatex:F { \msg_critical:nn { piton } { LuaLaTeX~mandatory } }
```

```
\RequirePackage { luatexbase }
```

```
\@@_msg_new:nnn { piton.lua~not~found }
  {
    The~file~'piton.lua'~can't~be~found.\\
    The~package~'piton'~won't~be~loaded.\\
    If~you~want~to~know~how~to~retrieve~the~file~'piton.lua',~type~H~<return>.
  }
  {
    On~the~site~CTAN,~go~to~the~page~of~'piton':~https://ctan.org/pkg/piton.~
    The~file~'README.md'~explains~how~to~retrieve~the~files~'piton.sty'~and~
    'piton.lua'.
  }
```

```
\file_if_exist:nF { piton.lua }
  { \msg_critical:nn { piton } { piton.lua~not~found } }
```

The boolean `\g_@@_footnotehyper_bool` will indicate if the option `footnotehyper` is used.

```
\bool_new:N \g_@@_footnotehyper_bool
```

The boolean `\g_@@_footnote_bool` will indicate if the option `footnote` is used, but quicky, it will also be set to `true` if the option `footnotehyper` is used.

```
\bool_new:N \g_@@_footnote_bool
```

The following boolean corresponds to the key `math-comments` (only at load-time).

```
\bool_new:N \g_@@_math_comments_bool
```

```
\bool_new:N \g_@@_beamer_bool
\tl_new:N \g_@@_escape_inside_tl
```

We define a set of keys for the options at load-time.

```
\keys_define:nn { piton / package }
  {
    footnote .bool_gset:N = \g_@@_footnote_bool ,
    footnotehyper .bool_gset:N = \g_@@_footnotehyper_bool ,

    beamer .bool_gset:N = \g_@@_beamer_bool ,
    beamer .default:n = true ,

    math-comments .code:n = \@@_error:n { moved~to~preamble } ,
    comment-latex .code:n = \@@_error:n { moved~to~preamble } ,

    unknown .code:n = \@@_error:n { Unknown~key~for~package }
  }
```

```
\@@_msg_new:nn { moved~to~preamble }
  {
    The~key~'\l_keys_key_str'~*must*~now~be~used~with~
    \token_to_str:N \PitonOptions`in~the~preamble~of~your~
    document.\\
    That~key~will~be~ignored.
  }
\@@_msg_new:nn { Unknown~key~for~package }
  {
    Unknown~key.\\
    You~have~used~the~key~'\l_keys_key_str'~but~the~only~keys~available~here~
    are~'beamer',~'footnote',~'footnotehyper'.~Other~keys~are~available~in~
    \token_to_str:N \PitonOptions.\\
    That~key~will~be~ignored.
  }
```

We process the options provided by the user at load-time.

```
\ProcessKeysOptions { piton / package }
```

```
\@ifclassloaded { beamer } { \bool_gset_true:N \g_@@_beamer_bool } { }
\@ifpackageloaded { beamerarticle } { \bool_gset_true:N \g_@@_beamer_bool } { }
\bool_if:NT \g_@@_beamer_bool { \lua_now:n { piton_beamer = true } }
```

```
\hook_gput_code:nnn { begindocument } { . }
  {
    \@ifpackageloaded { xcolor }
      { }
      { \msg_fatal:nn { piton } { xcolor~not~loaded } }
  }
\@@_msg_new:nn { xcolor~not~loaded }
  {
    xcolor~not~loaded \\
    The~package~'xcolor'~is~required~by~'piton'.\\
    This~error~is~fatal.
  }
\@@_msg_new:nn { footnote~with~footnotehyper~package }
  {
    Footnote~forbidden.\\
    You~can't~use~the~option~'footnote'~because~the~package~
    footnotehyper~has~already~been~loaded.~
    If~you~want,~you~can~use~the~option~'footnotehyper'~and~the~footnotes~
    within~the~environments~of~piton~will~be~extracted~with~the~tools~
    of~the~package~footnotehyper.\\
    If~you~go~on,~the~package~footnote~won't~be~loaded.
  }
\@@_msg_new:nn { footnotehyper~with~footnote~package }
  {
    You~can't~use~the~option~'footnotehyper'~because~the~package~
    footnote~has~already~been~loaded.~
    If~you~want,~you~can~use~the~option~'footnote'~and~the~footnotes~
    within~the~environments~of~piton~will~be~extracted~with~the~tools~
    of~the~package~footnote.\\
    If~you~go~on,~the~package~footnotehyper~won't~be~loaded.
  }
```

```
\bool_if:NT \g_@@_footnote_bool
  {
```

The class beamer has its own system to extract footnotes and that's why we have nothing to do if beamer is used.

```
    \@ifclassloaded { beamer }
      { \bool_gset_false:N \g_@@_footnote_bool }
      {
        \@ifpackageloaded { footnotehyper }
          { \@@_error:n { footnote~with~footnotehyper~package } }
          { \usepackage { footnote } }
      }
  }
\bool_if:NT \g_@@_footnotehyper_bool
  {
```

The class beamer has its own system to extract footnotes and that's why we have nothing to do if beamer is used.

```
    \@ifclassloaded { beamer }
      { \bool_gset_false:N \g_@@_footnote_bool }
      {
        \@ifpackageloaded { footnote }
          { \@@_error:n { footnotehyper~with~footnote~package } }
          { \usepackage { footnotehyper } }
        \bool_gset_true:N \g_@@_footnote_bool
      }
  }
```

The flag `\g_@@_footnote_bool` is raised and so, we will only have to test `\g_@@_footnote_bool` in order to know if we have to insert an environment {savenotes}.

```
\lua_now:n
  {
    piton = piton~or { }
    piton.ListCommands = lpeg.P ( false )
  }
```

8.2.2 Parameters and technical definitions

The following string will contain the name of the informatic language considered (the initial value is `python`).

```
\str_new:N \l_piton_language_str
\str_set:Nn \l_piton_language_str { python }
```

```
\str_new:N \l_@@_path_str
```

In order to have a better control over the keys.

```
\bool_new:N \l_@@_in_PitonOptions_bool
\bool_new:N \l_@@_in_PitonInputFile_bool
```

We will compute (with Lua) the numbers of lines of the Python code and store it in the following counter.

```
\int_new:N \l_@@_nb_lines_int
```

The same for the number of non-empty lines of the Python codes.

```
\int_new:N \l_@@_nb_non_empty_lines_int
```

The following counter will be used to count the lines during the composition. It will count all the lines, empty or not empty. It won't be used to print the numbers of the lines.

```
\int_new:N \g_@@_line_int
```

The following token list will contain the (potential) informations to write on the `aux` (to be used in the next compilation).

```
\tl_new:N \g_@@_aux_tl
```

The following counter corresponds to the key `splittable` of `\PitonOptions`. If the value of `\l_@@_splittable_int` is equal to n, then no line break can occur within the first n lines or the last n lines of the listings.

```
\int_new:N \l_@@_splittable_int
```

An initial value of `splittable` equal to 100 is equivalent to say that the environments `{Piton}` are unbreakable.

```
\int_set:Nn \l_@@_splittable_int { 100 }
```

The following string corresponds to the key `background-color` of `\PitonOptions`.

```
\clist_new:N \l_@@_bg_color_clist
```

The package `piton` will also detect the lines of code which correspond to the user input in a Python console, that is to say the lines of code beginning with `>>>` and `...`. It's possible, with the key `prompt-background-color`, to require a background for these lines of code (and the other lines of code will have the standard background color specified by `background-color`).

```
\tl_new:N \l_@@_prompt_bg_color_tl
```

The following parameters correspond to the keys `begin-range` and `end-range` of the command `\PitonInputFile`.

```
\str_new:N \l_@@_begin_range_str
\str_new:N \l_@@_end_range_str
```

The argument of `\PitonInputFile`.

```
\str_new:N \l_@@_file_name_str
```

We will count the environments `{Piton}` (and, in fact, also the commands `\PitonInputFile`, despite the name `\g_@@_env_int`).

```
\int_new:N \g_@@_env_int
```

The parameter \l_@@_writer_str corresponds to the key write. We will store the list of the files already used in \g_@@_write_seq (we must not erase a file which has been still been used).

```
\str_new:N \l_@@_write_str
\seq_new:N \g_@@_write_seq
```

The following boolean corresponds to the key show-spaces.

```
\bool_new:N \l_@@_show_spaces_bool
```

The following booleans correspond to the keys break-lines and indent-broken-lines.

```
\bool_new:N \l_@@_break_lines_in_Piton_bool
\bool_new:N \l_@@_indent_broken_lines_bool
```

The following token list corresponds to the key continuation-symbol.

```
\tl_new:N \l_@@_continuation_symbol_tl
\tl_set:Nn \l_@@_continuation_symbol_tl { + }
```

The following token list corresponds to the key continuation-symbol-on-indentation. The name has been shorten to csoi.

```
\tl_new:N \l_@@_csoi_tl
\tl_set:Nn \l_@@_csoi_tl { $ \hookrightarrow \; $  }
```

The following token list corresponds to the key end-of-broken-line.

```
\tl_new:N \l_@@_end_of_broken_line_tl
\tl_set:Nn \l_@@_end_of_broken_line_tl { \hspace*{0.5em} \textbackslash }
```

The following boolean corresponds to the key break-lines-in-piton.

```
\bool_new:N \l_@@_break_lines_in_piton_bool
```

The following dimension will be the width of the listing constructed by {Piton} or \PitonInputFile.

- If the user uses the key width of \PitonOptions with a numerical value, that value will be stored in \l_@@_width_dim.
- If the user uses the key width with the special value min, the dimension \l_@@_width_dim will, *in the second run*, be computed from the value of \l_@@_line_width_dim stored in the aux file (computed during the first run the maximal width of the lines of the listing). During the first run, \l_@@_width_line_dim will be set equal to \linewidth.
- Elsewhere, \l_@@_width_dim will be set at the beginning of the listing (in \@@_pre_env:) equal to the current value of \linewidth.

```
\dim_new:N \l_@@_width_dim
```

We will also use another dimension called \l_@@_line_width_dim. That will the width of the actual lines of code. That dimension may be lower than the whole \l_@@_width_dim because we have to take into account the value of \l_@@_left_margin_dim (for the numbers of lines when line-numbers is in force) and another small margin when a background color is used (with the key background-color).

```
\dim_new:N \l_@@_line_width_dim
```

The following flag will be raised with the key width is used with the special value min.

```
\bool_new:N \l_@@_width_min_bool
```

If the key width is used with the special value min, we will compute the maximal width of the lines of an environment {Piton} in \g_@@_tmp_width_dim because we need it for the case of the key width is used with the spacial value min. We need a global variable because, when the key footnote is in force, each line when be composed in an environment {savenotes} and we need to exit our \g_@@_tmp_width_dim from that environment.

```
\dim_new:N \g_@@_tmp_width_dim
```

The following dimension corresponds to the key left-margin of \PitonOptions.

```
\dim_new:N \l_@@_left_margin_dim
```

The following boolean will be set when the key `left-margin=auto` is used.

```
\bool_new:N \l_@@_left_margin_auto_bool
```

The following dimension corresponds to the key `numbers-sep` of `\PitonOptions`.

```
\dim_new:N \l_@@_numbers_sep_dim
\dim_set:Nn \l_@@_numbers_sep_dim { 0.7 em }
```

The tabulators will be replaced by the content of the following token list.

```
\tl_new:N \l_@@_tab_tl
```

Be careful. The following sequence `\g_@@_languages_seq` is not the list of the languages supported by `piton`. It's the list of the languages for which at least a user function has been defined. We need that sequence only for the command `\PitonClearUserFunctions` when it is used without its optional argument: it must clear all the list of languages for which at least a user function has been defined.

```
\seq_new:N \g_@@_languages_seq
```

```
\cs_new_protected:Npn \@@_set_tab_tl:n #1
  {
    \tl_clear:N \l_@@_tab_tl
    \prg_replicate:nn { #1 }
      { \tl_put_right:Nn \l_@@_tab_tl { ~ } }
  }
\@@_set_tab_tl:n { 4 }
```

The following integer corresponds to the key `gobble`.

```
\int_new:N \l_@@_gobble_int
```

```
\tl_new:N \l_@@_space_tl
\tl_set:Nn \l_@@_space_tl { ~ }
```

At each line, the following counter will count the spaces at the beginning.

```
\int_new:N \g_@@_indentation_int
```

```
\cs_new_protected:Npn \@@_an_indentation_space:
  { \int_gincr:N \g_@@_indentation_int }
```

The following command `\@@_beamer_command:n` executes the argument corresponding to its argument but also stores it in `\l_@@_beamer_command_str`. That string is used only in the error message "`cr~not~allowed`" raised when there is a carriage return in the mandatory argument of that command.

```
\cs_new_protected:Npn \@@_beamer_command:n #1
  {
    \str_set:Nn \l_@@_beamer_command_str { #1 }
    \use:c { #1 }
  }
```

In the environment `{Piton}`, the command `\label` will be linked to the following command.

```
\cs_new_protected:Npn \@@_label:n #1
  {
    \bool_if:NTF \l_@@_line_numbers_bool
      {
        \@bsphack
        \protected@write \@auxout { }
          {
            \string \newlabel { #1 }
            {
```

Remember that the content of a line is typeset in a box *before* the composition of the potential number of line.

```
              { \int_eval:n { \g_@@_visual_line_int + 1 } }
              { \thepage }
            }
          }
        \@esphack
     }
     { \@@_error:n { label~with~lines~numbers } }
  }
```

The following commands corresponds to the keys `marker/beginning` and `marker/end`. The values of that keys are functions that will be applied to the "*range*" specified by the final user in an individual `\PitonInputFile`. They will construct the markers used to find textually in the external file loaded by `piton` the part which must be included (and formatted).

```
\cs_new_protected:Npn \@@_marker_beginning:n #1 { }
\cs_new_protected:Npn \@@_marker_end:n #1 { }
```

The following commands are a easy way to insert safely braces (`{` and `}`) in the TeX flow.

```
\cs_new_protected:Npn \@@_open_brace: { \directlua { piton.open_brace() } }
\cs_new_protected:Npn \@@_close_brace: { \directlua { piton.close_brace() } }
```

The following token list will be evaluated at the beginning of `\@@_begin_line:`... `\@@_end_line:` and cleared at the end. It will be used by LPEG acting between the lines of the Python code in order to add instructions to be executed at the beginning of the line.

```
\tl_new:N \g_@@_begin_line_hook_tl
```

For example, the LPEG `Prompt` will trigger the following command which will insert an instruction in the hook `\g_@@_begin_line_hook` to specify that a background must be inserted to the current line of code.

```
\cs_new_protected:Npn \@@_prompt:
  {
    \tl_gset:Nn \g_@@_begin_line_hook_tl
      {
        \tl_if_empty:NF \l_@@_prompt_bg_color_tl % added 2023-04-24
          { \clist_set:NV \l_@@_bg_color_clist \l_@@_prompt_bg_color_tl }
      }
  }
```

8.2.3 Treatment of a line of code

```
\cs_new_protected:Npn \@@_replace_spaces:n #1
  {
    \tl_set:Nn \l_tmpa_tl { #1 }
    \bool_if:NTF \l_@@_show_spaces_bool
      {
        \tl_set:Nn \l_@@_space_tl { ␣ }
        \regex_replace_all:nnN { \x20 } { ␣ } \l_tmpa_tl % U+2423
      }
      {
```

If the key `break-lines-in-Piton` is in force, we replace all the characters U+0020 (that is to say the spaces) by `\@@_breakable_space:`. Remark that, except the spaces inserted in the LaTeX comments (and maybe in the math comments), all these spaces are of catcode "other" (=12) and are unbreakable.

```
        \bool_if:NT \l_@@_break_lines_in_Piton_bool
          {
            \regex_replace_all:nnN
              { \x20 }
              { \c { @@_breakable_space: } }
```

```
       \l_tmpa_tl
     }
   }
  \l_tmpa_tl
 }
```

In the contents provided by Lua, each line of the Python code will be surrounded by `\@@_begin_line:` and `\@@_end_line:`. `\@@_begin_line:` is a LaTeX command that we will define now but `\@@_end_line:` is only a syntactic marker that has no definition.

```
\cs_set_protected:Npn \@@_begin_line: #1 \@@_end_line:
 {
  \group_begin:
  \g_@@_begin_line_hook_tl
  \int_gzero:N \g_@@_indentation_int
```

First, we will put in the coffin `\l_tmpa_coffin` the actual content of a line of the code (without the potential number of line).

Be careful: There is curryfication in the following code.

```
  \bool_if:NTF \l_@@_width_min_bool
   \@@_put_in_coffin_ii:n
   \@@_put_in_coffin_i:n
   {
    \language = -1
    \raggedright
    \strut
    \@@_replace_spaces:n { #1 }
    \strut \hfil
   }
```

Now, we add the potential number of line, the potential left margin and the potential background.

```
  \hbox_set:Nn \l_tmpa_box
   {
    \skip_horizontal:N \l_@@_left_margin_dim
    \bool_if:NT \l_@@_line_numbers_bool
     {
      \bool_if:nF
       {
        \str_if_eq_p:nn { #1 } { \PitonStyle {Prompt}{} }
        &&
        \l_@@_skip_empty_lines_bool
       }
       { \int_gincr:N \g_@@_visual_line_int}

      \bool_if:nT
       {
        ! \str_if_eq_p:nn { #1 } { \PitonStyle {Prompt}{} }
        ||
        ( ! \l_@@_skip_empty_lines_bool && \l_@@_label_empty_lines_bool )
       }
       \@@_print_number:

     }
```

If there is a background, we must remind that there is a left margin of 0.5 em for the background...

```
    \clist_if_empty:NF \l_@@_bg_color_clist
     {
```

... but if only if the key `left-margin` is not used !

```
      \dim_compare:nNnT \l_@@_left_margin_dim = \c_zero_dim
        { \skip_horizontal:n { 0.5 em } }
     }
    \coffin_typeset:Nnnnn \l_tmpa_coffin T l \c_zero_dim \c_zero_dim
   }
  \box_set_dp:Nn \l_tmpa_box { \box_dp:N \l_tmpa_box + 1.25 pt }
  \box_set_ht:Nn \l_tmpa_box { \box_ht:N \l_tmpa_box + 1.25 pt }
```

```
    \clist_if_empty:NTF \l_@@_bg_color_clist
      { \box_use_drop:N \l_tmpa_box }
      {
        \vtop
          {
            \hbox:n
              {
                \@@_color:N \l_@@_bg_color_clist
                \vrule height \box_ht:N \l_tmpa_box
                       depth \box_dp:N \l_tmpa_box
                       width \l_@@_width_dim
              }
            \skip_vertical:n { - \box_ht_plus_dp:N \l_tmpa_box }
            \box_use_drop:N \l_tmpa_box
          }
      }
    \vspace { - 2.5 pt }
    \group_end:
    \tl_gclear:N \g_@@_begin_line_hook_tl
  }
```

In the general case (which is also the simpler), the key `width` is not used, or (if used) it is not used with the special value `min`. In that case, the content of a line of code is composed in a vertical coffin with a width equal to `\l_@@_line_width_dim`. That coffin may, eventually, contains several lines when the key `broken-lines-in-Piton` (or `broken-lines`) is used.
That commands takes in its argument by curryfication.

```
\cs_set_protected:Npn \@@_put_in_coffin_i:n
  { \vcoffin_set:Nnn \l_tmpa_coffin \l_@@_line_width_dim }
```

The second case is the case when the key `width` is used with the special value `min`.

```
\cs_set_protected:Npn \@@_put_in_coffin_ii:n #1
  {
```

First, we compute the natural width of the line of code because we have to compute the natural width of the whole listing (and it will be written on the `aux` file in the variable `\l_@@_width_dim`).

```
    \hbox_set:Nn \l_tmpa_box { #1 }
```

Now, you can actualize the value of `\g_@@_tmp_width_dim` (it will be used to write on the `aux` file the natural width of the environment).

```
    \dim_compare:nNnT { \box_wd:N \l_tmpa_box } > \g_@@_tmp_width_dim
      { \dim_gset:Nn \g_@@_tmp_width_dim { \box_wd:N \l_tmpa_box } }
    \hcoffin_set:Nn \l_tmpa_coffin
      {
        \hbox_to_wd:nn \l_@@_line_width_dim
```

We unpack the block in order to free the potential `\hfill` springs present in the LaTeX comments (cf. section 6.2, p. 18).

```
          { \hbox_unpack:N \l_tmpa_box \hfil }
      }
  }
```

The command `\@@_color:N` will take in as argument a reference to a comma-separated list of colors. A color will be picked by using the value of `\g_@@_line_int` (modulo the number of colors in the list).

```
\cs_set_protected:Npn \@@_color:N #1
  {
    \int_set:Nn \l_tmpa_int { \clist_count:N #1 }
    \int_set:Nn \l_tmpb_int { \int_mod:nn \g_@@_line_int \l_tmpa_int + 1 }
    \tl_set:Nx \l_tmpa_tl { \clist_item:Nn #1 \l_tmpb_int }
    \tl_if_eq:NnTF \l_tmpa_tl { none }
```

By setting `\l_@@_width_dim` to zero, the colored rectangle will be drawn with zero width and, thus, it will be a mere strut (and we need that strut).

```
      { \dim_zero:N \l_@@_width_dim }
      { \exp_args:NV \@@_color_i:n \l_tmpa_tl }
  }
```

The following command `\@@_color:n` will accept both the instruction `\@@_color:n { red!15 }` and the instruction `\@@_color:n { [rgb]{0.9,0.9,0} }`.

```
\cs_set_protected:Npn \@@_color_i:n #1
  {
    \tl_if_head_eq_meaning:nNTF { #1 } [
      {
        \tl_set:Nn \l_tmpa_tl { #1 }
        \tl_set_rescan:Nno \l_tmpa_tl { } \l_tmpa_tl
        \exp_last_unbraced:No \color \l_tmpa_tl
      }
      { \color { #1 } }
  }
```

```
\cs_new_protected:Npn \@@_newline:
  {
    \int_gincr:N \g_@@_line_int
    \int_compare:nNnT \g_@@_line_int > { \l_@@_splittable_int - 1 }
      {
        \int_compare:nNnT
          { \l_@@_nb_lines_int - \g_@@_line_int } > \l_@@_splittable_int
          {
            \egroup
            \bool_if:NT \g_@@_footnote_bool { \end { savenotes } }
            \par \mode_leave_vertical:
            \bool_if:NT \g_@@_footnote_bool { \begin { savenotes } }
            \vtop \bgroup
          }
     }
  }
```

```
\cs_set_protected:Npn \@@_breakable_space:
  {
    \discretionary
      { \hbox:n { \color { gray } \l_@@_end_of_broken_line_tl } }
      {
        \hbox_overlap_left:n
          {
            {
              \normalfont \footnotesize \color { gray }
              \l_@@_continuation_symbol_tl
            }
            \skip_horizontal:n { 0.3 em }
            \clist_if_empty:NF \l_@@_bg_color_clist
              { \skip_horizontal:n { 0.5 em } }
          }
        \bool_if:NT \l_@@_indent_broken_lines_bool
          {
            \hbox:n
              {
                \prg_replicate:nn { \g_@@_indentation_int } { ~ }
                { \color { gray } \l_@@_csoi_tl }
              }
          }
      }
      { \hbox { ~ } }
  }
```

8.2.4 PitonOptions

```
\bool_new:N \l_@@_line_numbers_bool
```

```
\bool_new:N \l_@@_skip_empty_lines_bool
\bool_set_true:N \l_@@_skip_empty_lines_bool
\bool_new:N \l_@@_line_numbers_absolute_bool
\bool_new:N \l_@@_label_empty_lines_bool
\bool_set_true:N \l_@@_label_empty_lines_bool
\int_new:N \l_@@_number_lines_start_int
\bool_new:N \l_@@_resume_bool
```

```
\keys_define:nn { PitonOptions / marker }
  {
    beginning .code:n = \cs_set:Nn \@@_marker_beginning:n { #1 } ,
    beginning .value_required:n = true ,
    end .code:n = \cs_set:Nn \@@_marker_end:n { #1 } ,
    end .value_required:n = true ,
    include-lines .bool_set:N = \l_@@_marker_include_lines_bool ,
    include-lines .default:n = true ,
    unknown .code:n = \@@_error:n { Unknown~key~for~marker }
  }
```

```
\keys_define:nn { PitonOptions / line-numbers }
  {
    true .code:n = \bool_set_true:N \l_@@_line_numbers_bool ,
    false .code:n = \bool_set_false:N \l_@@_line_numbers_bool ,

    start .code:n =
      \bool_if:NTF \l_@@_in_PitonOptions_bool
        { Invalid~key }
        {
          \bool_set_true:N \l_@@_line_numbers_bool
          \int_set:Nn \l_@@_number_lines_start_int { #1 }
        } ,
    start .value_required:n = true ,

    skip-empty-lines .code:n =
      \bool_if:NF \l_@@_in_PitonOptions_bool
        { \bool_set_true:N \l_@@_line_numbers_bool }
      \str_if_eq:nnTF { #1 } { false }
        { \bool_set_false:N \l_@@_skip_empty_lines_bool }
        { \bool_set_true:N \l_@@_skip_empty_lines_bool } ,
    skip-empty-lines .default:n = true ,

    label-empty-lines .code:n =
      \bool_if:NF \l_@@_in_PitonOptions_bool
        { \bool_set_true:N \l_@@_line_numbers_bool }
      \str_if_eq:nnTF { #1 } { false }
        { \bool_set_false:N \l_@@_label_empty_lines_bool }
        { \bool_set_true:N \l_@@_label_empty_lines_bool } ,
    label-empty-lines .default:n = true ,

    absolute .code:n =
      \bool_if:NTF \l_@@_in_PitonOptions_bool
        { \bool_set_true:N \l_@@_line_numbers_absolute_bool }
        { \bool_set_true:N \l_@@_line_numbers_bool }
      \bool_if:NT \l_@@_in_PitonInputFile_bool
        {
          \bool_set_true:N \l_@@_line_numbers_absolute_bool
          \bool_set_false:N \l_@@_skip_empty_lines_bool
        }
      \bool_lazy_or:nnF
        \l_@@_in_PitonInputFile_bool
        \l_@@_in_PitonOptions_bool
        { \@@_error:n { Invalid~key } } ,
    absolute .value_forbidden:n = true ,
    resume .code:n =
      \bool_set_true:N \l_@@_resume_bool
      \bool_if:NF \l_@@_in_PitonOptions_bool
        { \bool_set_true:N \l_@@_line_numbers_bool } ,
    resume .value_forbidden:n = true ,

    sep .dim_set:N = \l_@@_numbers_sep_dim ,
    sep .value_required:n = true ,

    unknown .code:n = \@@_error:n { Unknown~key~for~line-numbers }
  }
```

Be careful! The name of the following set of keys must be considered as public! Hence, it should *not* be changed.

```
\keys_define:nn { PitonOptions }
  {
    detected-commands .code:n =  \@@_detected_commands:n { #1 } ,
    detected-commands .value_required:n = true ,
    detected-commands .usage:n = preamble ,
```

First, we put keys that should be avalaible only in the preamble.

```
    begin-escape .code:n =
      \lua_now:e { piton.begin_escape = "\lua_escape:n{#1}" } ,
    begin-escape .value_required:n = true ,
    begin-escape .usage:n = preamble ,

    end-escape   .code:n =
      \lua_now:e { piton.end_escape = "\lua_escape:n{#1}" } ,
    end-escape   .value_required:n = true ,
    end-escape .usage:n = preamble ,

    begin-escape-math .code:n =
      \lua_now:e { piton.begin_escape_math = "\lua_escape:n{#1}" } ,
    begin-escape-math .value_required:n = true ,
    begin-escape-math .usage:n = preamble ,

    end-escape-math .code:n =
      \lua_now:e { piton.end_escape_math = "\lua_escape:n{#1}" } ,
    end-escape-math .value_required:n = true ,
    end-escape-math .usage:n = preamble ,

    comment-latex .code:n = \lua_now:n { comment_latex = "#1" } ,
    comment-latex .value_required:n = true ,
    comment-latex .usage:n = preamble ,

    math-comments .bool_set:N = \g_@@_math_comments_bool ,
    math-comments .default:n  = true ,
    math-comments .usage:n = preamble ,
```

Now, general keys.

```
    language         .code:n =
      \str_set:Nx \l_piton_language_str { \str_lowercase:n { #1 } } ,
    language         .value_required:n  = true ,
    path             .str_set:N         = \l_@@_path_str ,
    path             .value_required:n  = true ,
    gobble           .int_set:N         = \l_@@_gobble_int ,
    gobble           .value_required:n  = true ,
    auto-gobble      .code:n            = \int_set:Nn \l_@@_gobble_int { -1 } ,
    auto-gobble      .value_forbidden:n = true ,
    env-gobble       .code:n            = \int_set:Nn \l_@@_gobble_int { -2 } ,
    env-gobble       .value_forbidden:n = true ,
    tabs-auto-gobble .code:n            = \int_set:Nn \l_@@_gobble_int { -3 } ,
    tabs-auto-gobble .value_forbidden:n = true ,

    marker .code:n =
      \bool_lazy_or:nnTF
        \l_@@_in_PitonInputFile_bool
        \l_@@_in_PitonOptions_bool
        { \keys_set:nn { PitonOptions / marker } { #1 } }
        { \@@_error:n { Invalid~key } } ,
    marker .value_required:n = true ,

    line-numbers .code:n =
      \keys_set:nn { PitonOptions / line-numbers } { #1 } ,
    line-numbers .default:n = true ,

    splittable       .int_set:N         = \l_@@_splittable_int ,
    splittable       .default:n         = 1 ,
    background-color .clist_set:N       = \l_@@_bg_color_clist ,
    background-color .value_required:n  = true ,
    prompt-background-color .tl_set:N         = \l_@@_prompt_bg_color_tl ,
    prompt-background-color .value_required:n = true ,

    width .code:n =
      \str_if_eq:nnTF  { #1 } { min }
        {
          \bool_set_true:N \l_@@_width_min_bool
          \dim_zero:N \l_@@_width_dim
        }
        {
          \bool_set_false:N \l_@@_width_min_bool
          \dim_set:Nn \l_@@_width_dim { #1 }
        } ,
    width .value_required:n  = true ,

    write .str_set:N = \l_@@_write_str ,
    write .value_required:n = true ,

    left-margin      .code:n =
      \str_if_eq:nnTF { #1 } { auto }
        {
          \dim_zero:N \l_@@_left_margin_dim
          \bool_set_true:N \l_@@_left_margin_auto_bool
        }
        {
          \dim_set:Nn \l_@@_left_margin_dim { #1 }
          \bool_set_false:N \l_@@_left_margin_auto_bool
        } ,
    left-margin      .value_required:n  = true ,

    tab-size         .code:n            = \@@_set_tab_tl:n { #1 } ,
    tab-size         .value_required:n  = true ,
    show-spaces      .bool_set:N        = \l_@@_show_spaces_bool ,
    show-spaces      .default:n         = true ,
    show-spaces-in-strings .code:n      = \tl_set:Nn \l_@@_space_tl { ␣ } , % U+2423
    show-spaces-in-strings .value_forbidden:n = true ,
    break-lines-in-Piton .bool_set:N    = \l_@@_break_lines_in_Piton_bool ,
    break-lines-in-Piton .default:n     = true ,
    break-lines-in-piton .bool_set:N    = \l_@@_break_lines_in_piton_bool ,
    break-lines-in-piton .default:n     = true ,
    break-lines .meta:n = { break-lines-in-piton , break-lines-in-Piton } ,
    break-lines .value_forbidden:n      = true ,
    indent-broken-lines .bool_set:N     = \l_@@_indent_broken_lines_bool ,
    indent-broken-lines .default:n      = true ,
    end-of-broken-line  .tl_set:N       = \l_@@_end_of_broken_line_tl ,
    end-of-broken-line  .value_required:n = true ,
    continuation-symbol .tl_set:N       = \l_@@_continuation_symbol_tl ,
    continuation-symbol .value_required:n = true ,
    continuation-symbol-on-indentation .tl_set:N = \l_@@_csoi_tl ,
    continuation-symbol-on-indentation .value_required:n = true ,

    first-line .code:n = \@@_in_PitonInputFile:n
      { \int_set:Nn \l_@@_first_line_int { #1 } } ,
    first-line .value_required:n = true ,

    last-line .code:n = \@@_in_PitonInputFile:n
      { \int_set:Nn \l_@@_last_line_int { #1 } } ,
    last-line .value_required:n = true ,

    begin-range .code:n = \@@_in_PitonInputFile:n
      { \str_set:Nn \l_@@_begin_range_str { #1 } } ,
    begin-range .value_required:n = true ,

    end-range .code:n = \@@_in_PitonInputFile:n
      { \str_set:Nn \l_@@_end_range_str { #1 } } ,
    end-range .value_required:n = true ,

    range .code:n = \@@_in_PitonInputFile:n
      {
        \str_set:Nn \l_@@_begin_range_str { #1 }
        \str_set:Nn \l_@@_end_range_str { #1 }
      } ,
    range .value_required:n = true ,

    resume .meta:n = line-numbers/resume ,

    unknown .code:n = \@@_error:n { Unknown~key~for~PitonOptions } ,

    % deprecated
    all-line-numbers .code:n =
      \bool_set_true:N \l_@@_line_numbers_bool
      \bool_set_false:N \l_@@_skip_empty_lines_bool ,
    all-line-numbers .value_forbidden:n = true ,

    % deprecated
    numbers-sep .dim_set:N = \l_@@_numbers_sep_dim ,
    numbers-sep .value_required:n = true
  }
```

```
\cs_new_protected:Npn \@@_in_PitonInputFile:n #1
  {
    \bool_if:NTF \l_@@_in_PitonInputFile_bool
      { #1 }
      { \@@_error:n { Invalid~key } }
  }
```

```
\NewDocumentCommand \PitonOptions { m }
  {
    \bool_set_true:N \l_@@_in_PitonOptions_bool
    \keys_set:nn { PitonOptions } { #1 }
    \bool_set_false:N \l_@@_in_PitonOptions_bool
  }
```

When using `\NewPitonEnvironment` a user may use `\PitonOptions` inside. However, the set of keys available should be different that in standard `\PitonOptions`. That's why we define a version of `\PitonOptions` with no restriction on the set of available keys and we will link that version to `\PitonOptions` in such environment.

```
\NewDocumentCommand \@@_fake_PitonOptions { }
  { \keys_set:nn { PitonOptions } }
```

8.2.5 The numbers of the lines

The following counter will be used to count the lines in the code when the user requires the numbers of the lines to be printed (with `line-numbers`).

```
\int_new:N \g_@@_visual_line_int
```

```
\cs_new_protected:Npn \@@_print_number:
  {
    \hbox_overlap_left:n
      {
        {
          \color { gray }
          \footnotesize
          \int_to_arabic:n \g_@@_visual_line_int
        }
        \skip_horizontal:N \l_@@_numbers_sep_dim
      }
  }
```

8.2.6 The command to write on the aux file

```
\cs_new_protected:Npn \@@_write_aux:
  {
    \tl_if_empty:NF \g_@@_aux_tl
      {
        \iow_now:Nn \@mainaux { \ExplSyntaxOn }
        \iow_now:Nx \@mainaux
          {
            \tl_gset:cn { c_@@_ \int_use:N \g_@@_env_int _ tl }
              { \exp_not:o \g_@@_aux_tl }
          }
        \iow_now:Nn \@mainaux { \ExplSyntaxOff }
      }
    \tl_gclear:N \g_@@_aux_tl
  }
```

The following macro with be used only when the key `width` is used with the special value `min`.

```
\cs_new_protected:Npn \@@_width_to_aux:
  {
    \tl_gput_right:Nx \g_@@_aux_tl
      {
        \dim_set:Nn \l_@@_line_width_dim
          { \dim_eval:n { \g_@@_tmp_width_dim } }
      }
  }
```

8.2.7 The main commands and environments for the final user

```
\NewDocumentCommand { \piton } { }
  { \peek_meaning:NTF \bgroup \@@_piton_standard \@@_piton_verbatim }
```

```
\NewDocumentCommand { \@@_piton_standard } { m }
  {
    \group_begin:
    \ttfamily
```

The following tuning of LuaTeX in order to avoid all break of lines on the hyphens.

```
    \automatichyphenmode = 1
    \cs_set_eq:NN \\ \c_backslash_str
    \cs_set_eq:NN \% \c_percent_str
    \cs_set_eq:NN \{ \c_left_brace_str
    \cs_set_eq:NN \} \c_right_brace_str
    \cs_set_eq:NN \$ \c_dollar_str
    \cs_set_eq:cN { ~ } \space
    \cs_set_protected:Npn \@@_begin_line: { }
    \cs_set_protected:Npn \@@_end_line: { }
    \tl_set:Nx \l_tmpa_tl
      {
        \lua_now:e
          { piton.ParseBis('\l_piton_language_str',token.scan_string()) }
          { #1 }
      }
    \bool_if:NTF \l_@@_show_spaces_bool
      { \regex_replace_all:nnN { \x20 } { ␣ } \l_tmpa_tl } % U+2423
```

The following code replaces the characters U+0020 (spaces) by characters U+0020 of catcode 10: thus, they become breakable by an end of line.

```
      {
        \bool_if:NT \l_@@_break_lines_in_piton_bool
          { \regex_replace_all:nnN { \x20 } { \x20 } \l_tmpa_tl }
      }
    \l_tmpa_tl
    \group_end:
  }
```

```
\NewDocumentCommand { \@@_piton_verbatim } { v }
  {
    \group_begin:
    \ttfamily
    \automatichyphenmode = 1
    \cs_set_protected:Npn \@@_begin_line: { }
    \cs_set_protected:Npn \@@_end_line: { }
    \tl_set:Nx \l_tmpa_tl
      {
        \lua_now:e
          { piton.Parse('\l_piton_language_str',token.scan_string()) }
          { #1 }
      }
    \bool_if:NT \l_@@_show_spaces_bool
      { \regex_replace_all:nnN { \x20 } { ␣ } \l_tmpa_tl } % U+2423
    \l_tmpa_tl
    \group_end:
  }
```

The following command is not a user command. It will be used when we will have to “rescan” some chunks of Python code. For example, it will be the initial value of the Piton style `InitialValues` (the default values of the arguments of a Python function).

```
\cs_new_protected:Npn \@@_piton:n #1
  {
    \group_begin:
    \cs_set_protected:Npn \@@_begin_line: { }
    \cs_set_protected:Npn \@@_end_line: { }
    \bool_lazy_or:nnTF
      \l_@@_break_lines_in_piton_bool
      \l_@@_break_lines_in_Piton_bool
      {
        \tl_set:Nx \l_tmpa_tl
          {
            \lua_now:e
              { piton.ParseTer('\l_piton_language_str',token.scan_string()) }
              { #1 }
```

```
     }
   }
   {
    \tl_set:Nx \l_tmpa_tl
     {
      \lua_now:e
       { piton.Parse('\l_piton_language_str',token.scan_string()) }
       { #1 }
     }
   }
  \bool_if:NT \l_@@_show_spaces_bool
   { \regex_replace_all:nnN { \x20 } { ␣ } \l_tmpa_tl } % U+2423
  \l_tmpa_tl
  \group_end:
 }
```

The following command is similar to the previous one but raise a fatal error if its argument contains a carriage return.

```
\cs_new_protected:Npn \@@_piton_no_cr:n #1
 {
  \group_begin:
  \cs_set_protected:Npn \@@_begin_line: { }
  \cs_set_protected:Npn \@@_end_line: { }
  \cs_set_protected:Npn \@@_newline:
   { \msg_fatal:nn { piton } { cr~not~allowed } }
  \bool_lazy_or:nnTF
   \l_@@_break_lines_in_piton_bool
   \l_@@_break_lines_in_Piton_bool
   {
    \tl_set:Nx \l_tmpa_tl
     {
      \lua_now:e
       { piton.ParseTer('\l_piton_language_str',token.scan_string()) }
       { #1 }
     }
   }
   {
    \tl_set:Nx \l_tmpa_tl
     {
      \lua_now:e
       { piton.Parse('\l_piton_language_str',token.scan_string()) }
       { #1 }
     }
   }
  \bool_if:NT \l_@@_show_spaces_bool
   { \regex_replace_all:nnN { \x20 } { ␣ } \l_tmpa_tl } % U+2423
  \l_tmpa_tl
  \group_end:
 }
```

Despite its name, `\@@_pre_env:` will be used both in `\PitonInputFile` and in the environments such as `{Piton}`.

```
\cs_new:Npn \@@_pre_env:
 {
  \automatichyphenmode = 1
  \int_gincr:N \g_@@_env_int
  \tl_gclear:N \g_@@_aux_tl
  \dim_compare:nNnT \l_@@_width_dim = \c_zero_dim
   { \dim_set_eq:NN \l_@@_width_dim \linewidth }
```

We read the information written on the `aux` file by a previous run (when the key `width` is used with the special value `min`). At this time, the only potential information written on the `aux` file is the value of `\l_@@_line_width_dim` when the key `width` has been used with the special value `min`).

```
    \cs_if_exist_use:c { c_@@ _ \int_use:N \g_@@_env_int _ tl }
    \bool_if:NF \l_@@_resume_bool { \int_gzero:N \g_@@_visual_line_int }
    \dim_gzero:N \g_@@_tmp_width_dim
    \int_gzero:N \g_@@_line_int
    \dim_zero:N \parindent
    \dim_zero:N \lineskip
    \cs_set_eq:NN \label \@@_label:n
  }
```

If the final user has used both `left-margin=auto` and `line-numbers`, we have to compute the width of the maximal number of lines at the end of the environment to fix the correct value to `left-margin`. The first argument of the following function is the name of the Lua function that will be applied to the second argument in order to count the number of lines.

```
\cs_new_protected:Npn \@@_compute_left_margin:nn #1 #2
  {
    \bool_lazy_and:nnT \l_@@_left_margin_auto_bool \l_@@_line_numbers_bool
       {
        \hbox_set:Nn \l_tmpa_box
          {
            \footnotesize
            \bool_if:NTF \l_@@_skip_empty_lines_bool
              {
                \lua_now:n
                  { piton.#1(token.scan_argument()) }
                  { #2 }
                \int_to_arabic:n
                  { \g_@@_visual_line_int + \l_@@_nb_non_empty_lines_int }
               }
              {
                \int_to_arabic:n
                  { \g_@@_visual_line_int + \l_@@_nb_lines_int }
              }
           }
         \dim_set:Nn \l_@@_left_margin_dim
           { \box_wd:N \l_tmpa_box + \l_@@_numbers_sep_dim + 0.1 em }
       }
  }
\cs_generate_variant:Nn \@@_compute_left_margin:nn { n o }
```

Whereas `\l_@@_with_dim` is the width of the environment, `\l_@@_line_width_dim` is the width of the lines of code without the potential margins for the numbers of lines and the background. Depending on the case, you have to compute `\l_@@_line_width_dim` from `\l_@@_width_dim` or we have to do the opposite.

```
\cs_new_protected:Npn \@@_compute_width:
  {
    \dim_compare:nNnTF \l_@@_line_width_dim = \c_zero_dim
      {
        \dim_set_eq:NN \l_@@_line_width_dim \l_@@_width_dim
        \clist_if_empty:NTF \l_@@_bg_color_clist
```

If there is no background, we only subtract the left margin.

```
          { \dim_sub:Nn \l_@@_line_width_dim \l_@@_left_margin_dim }
```

If there is a background, we subtract 0.5 em for the margin on the right.

```
          {
            \dim_sub:Nn \l_@@_line_width_dim { 0.5 em }
```

And we subtract also for the left margin. If the key `left-margin` has been used (with a numerical value or with the special value `min`), `\l_@@_left_margin_dim` has a non-zero value[27] and we use that value. Elsewhere, we use a value of 0.5 em.

[27] If the key `left-margin` has been used with the special value `min`, the actual value of `\l__left_margin_dim` has yet been computed when we use the current command.

```
            \dim_compare:nNnTF \l_@@_left_margin_dim = \c_zero_dim
              { \dim_sub:Nn \l_@@_line_width_dim { 0.5 em } }
              { \dim_sub:Nn \l_@@_line_width_dim \l_@@_left_margin_dim }
          }
      }
```

If `\l_@@_line_width_dim` has yet a non-zero value, that means that it has been read in the `aux` file: it has been written by a previous run because the key `width` is used with the special value `min`). We compute now the width of the environment by computations opposite to the preceding ones.

```
      {
        \dim_set_eq:NN \l_@@_width_dim \l_@@_line_width_dim
        \clist_if_empty:NTF \l_@@_bg_color_clist
          { \dim_add:Nn \l_@@_width_dim \l_@@_left_margin_dim }
          {
            \dim_add:Nn \l_@@_width_dim { 0.5 em }
            \dim_compare:nNnTF \l_@@_left_margin_dim = \c_zero_dim
              { \dim_add:Nn \l_@@_width_dim { 0.5 em } }
              { \dim_add:Nn \l_@@_width_dim \l_@@_left_margin_dim }
          }
      }
  }
```

```
\NewDocumentCommand { \NewPitonEnvironment } { m m m m }
  {
```

We construct a TeX macro which will catch as argument all the tokens until `\end{name_env}` with, in that `\end{name_env}`, the catcodes of `\`, `{` and `}` equal to 12 ("`other`"). The latter explains why the definition of that function is a bit complicated.

```
    \use:x
      {
        \cs_set_protected:Npn
          \use:c { _@@_collect_ #1 :w }
          ####1
          \c_backslash_str end \c_left_brace_str #1 \c_right_brace_str
      }
         {
            \group_end:
            \mode_if_vertical:TF \mode_leave_vertical: \newline
```

We count with Lua the number of lines of the argument. The result will be stored by Lua in `\l_@@_nb_lines_int`. That information will be used to allow or disallow page breaks.

```
            \lua_now:n { piton.CountLines(token.scan_argument()) } { ##1 }
```

The first argument of the following function is the name of the Lua function that will be applied to the second argument in order to count the number of lines.

```
            \@@_compute_left_margin:nn { CountNonEmptyLines } { ##1 }
            \@@_compute_width:
            \ttfamily
            \dim_zero:N \parskip
```

`\g_@@_footnote_bool` is raised when the package piton has been loaded with the key `footnote` *or* the key `footnotehyper`.

```
            \bool_if:NT \g_@@_footnote_bool { \begin { savenotes } }
```

Now, the key `write`.

```
            \lua_now:e { piton.write = "\l_@@_write_str" }
            \str_if_empty:NF \l_@@_write_str
              {
                \seq_if_in:NVTF \g_@@_write_seq \l_@@_write_str
                  { \lua_now:n { piton.write_mode = "a" } }
                  {
                    \lua_now:n { piton.write_mode = "w" }
                    \seq_gput_left:NV \g_@@_write_seq \l_@@_write_str
                  }
              }
            \vtop \bgroup
            \lua_now:e
              {
                piton.GobbleParse
                  (
                    '\l_piton_language_str' ,
                    \int_use:N \l_@@_gobble_int ,
                    token.scan_argument()
                  )
              }
              { ##1 }
            \vspace { 2.5 pt }
            \egroup
            \bool_if:NT \g_@@_footnote_bool { \end { savenotes } }
```

If the user has used the key `width` with the special value `min`, we write on the `aux` file the value of `\l_@@_line_width_dim` (largest width of the lines of code of the environment).

```
            \bool_if:NT \l_@@_width_min_bool \@@_width_to_aux:
```

The following `\end{#1}` is only for the stack of environments of LaTeX.

```
            \end { #1 }
            \@@_write_aux:
          }
```

We can now define the new environment.
We are still in the definition of the command `\NewPitonEnvironment`...

```
    \NewDocumentEnvironment { #1 } { #2 }
      {
        \cs_set_eq:NN \PitonOptions \@@_fake_PitonOptions
        #3
        \@@_pre_env:
        \int_compare:nNnT \l_@@_number_lines_start_int > \c_zero_int
          { \int_gset:Nn \g_@@_visual_line_int { \l_@@_number_lines_start_int - 1 } }
        \group_begin:
        \tl_map_function:nN
          { \ \\ \{ \} \$ \& \# \^ \_ \% \~ \^^I }
          \char_set_catcode_other:N
        \use:c { _@@_collect_ #1 :w }
      }
      { #4 }
```

The following code is for technical reasons. We want to change the catcode of `^^M` before catching the arguments of the new environment we are defining. Indeed, if not, we will have problems if there is a final optional argument in our environment (if that final argument is not used by the user in an instance of the environment, a spurious space is inserted, probably because the `^^M` is converted to space).

```
    \AddToHook { env / #1 / begin } { \char_set_catcode_other:N \^^M }
  }
```

This is the end of the definition of the command `\NewPitonEnvironment`.

Now, we define the environment `{Piton}`, which is the main environment provided by the package piton. Of course, you use `\NewPitonEnvironment`.

```
\bool_if:NTF \g_@@_beamer_bool
  {
    \NewPitonEnvironment { Piton } { d < > O { } }
      {
        \keys_set:nn { PitonOptions } { #2 }
        \IfValueTF { #1 }
          { \begin { uncoverenv } < #1 > }
          { \begin { uncoverenv } }
      }
      { \end { uncoverenv } }
  }
  {
    \NewPitonEnvironment { Piton } { O { } }
      { \keys_set:nn { PitonOptions } { #1 } }
      { }
  }
```

The code of the command `\PitonInputFile` is somewhat similar to the code of the environment `{Piton}`. In fact, it's simpler because there isn't the problem of catching the content of the environment in a verbatim mode.

```
\NewDocumentCommand { \PitonInputFile } { d < > O { } m }
  {
    \group_begin:
    \tl_if_empty:NTF \l_@@_path_str
      { \str_set:Nn \l_@@_file_name_str { #3 } }
      {
        \str_set_eq:NN \l_@@_file_name_str \l_@@_path_str
        \str_put_right:Nn \l_@@_file_name_str { / #3 }
      }
    \file_if_exist:nTF { \l_@@_file_name_str }
      { \@@_input_file:nn { #1 } { #2 } }
      { \msg_error:nnn { piton } { Unknown~file } { #3 } }
    \group_end:
  }
```

The following command uses as implicit argument the name of the file in `\l_@@_file_name_str`.

```
\cs_new_protected:Npn \@@_input_file:nn #1 #2
  {
```

We recall that, if we are in Beamer, the command `\PitonInputFile` is "overlay-aware" and that's why there is an optional argument between angular brackets (`<` and `>`).

```
    \tl_if_novalue:nF { #1 }
      {
        \bool_if:NTF \g_@@_beamer_bool
          { \begin { uncoverenv } < #1 > }
          { \@@_error:n { overlay~without~beamer } }
      }
    \group_begin:
      \int_zero_new:N \l_@@_first_line_int
      \int_zero_new:N \l_@@_last_line_int
      \int_set_eq:NN \l_@@_last_line_int \c_max_int
      \bool_set_true:N \l_@@_in_PitonInputFile_bool
      \keys_set:nn { PitonOptions } { #2 }
      \bool_if:NT \l_@@_line_numbers_absolute_bool
        { \bool_set_false:N \l_@@_skip_empty_lines_bool }
      \bool_if:nTF
        {
          (
            \int_compare_p:nNn \l_@@_first_line_int > \c_zero_int
            || \int_compare_p:nNn \l_@@_last_line_int < \c_max_int
          )
          && ! \str_if_empty_p:N \l_@@_begin_range_str
        }
        {
          \@@_error:n { bad~range~specification }
          \int_zero:N \l_@@_first_line_int
          \int_set_eq:NN \l_@@_last_line_int \c_max_int
        }
        {
          \str_if_empty:NF \l_@@_begin_range_str
            {
              \@@_compute_range:
              \bool_lazy_or:nnT
                \l_@@_marker_include_lines_bool
                { ! \str_if_eq_p:NN \l_@@_begin_range_str \l_@@_end_range_str }
                {
                  \int_decr:N \l_@@_first_line_int
                  \int_incr:N \l_@@_last_line_int
                }
            }
        }
      \@@_pre_env:
      \bool_if:NT \l_@@_line_numbers_absolute_bool
        { \int_gset:Nn \g_@@_visual_line_int { \l_@@_first_line_int - 1 } }
      \int_compare:nNnT \l_@@_number_lines_start_int > \c_zero_int
        {
          \int_gset:Nn \g_@@_visual_line_int
            { \l_@@_number_lines_start_int - 1 }
        }
```

The following case arise when the code `line-numbers/absolute` is in force without the use of a marked range.

```
      \int_compare:nNnT \g_@@_visual_line_int < \c_zero_int
        { \int_gzero:N \g_@@_visual_line_int }
      \mode_if_vertical:TF \mode_leave_vertical: \newline
```

We count with Lua the number of lines of the argument. The result will be stored by Lua in `\l_@@_nb_lines_int`. That information will be used to allow or disallow page breaks.

```
      \lua_now:e { piton.CountLinesFile('\l_@@_file_name_str') }
```

The first argument of the following function is the name of the Lua function that will be applied to the second argument in order to count the number of lines.

```
      \@@_compute_left_margin:no { CountNonEmptyLinesFile } \l_@@_file_name_str
      \@@_compute_width:
      \ttfamily
      \bool_if:NT \g_@@_footnote_bool { \begin { savenotes } }
      \vtop \bgroup
      \lua_now:e
        {
          piton.ParseFile(
           '\l_piton_language_str' ,
           '\l_@@_file_name_str' ,
           \int_use:N \l_@@_first_line_int ,
           \int_use:N \l_@@_last_line_int )
        }
      \egroup
      \bool_if:NT \g_@@_footnote_bool { \end { savenotes } }
      \bool_if:NT \l_@@_width_min_bool \@@_width_to_aux:
    \group_end:
```

We recall that, if we are in Beamer, the command `\PitonInputFile` is “overlay-aware” and that’s why we close now an environment `{uncoverenv}` that we have opened at the beginning of the command.

```
    \tl_if_novalue:nF { #1 }
      { \bool_if:NT \g_@@_beamer_bool { \end { uncoverenv } } }
    \@@_write_aux:
  }
```

The following command computes the values of `\l_@@_first_line_int` and `\l_@@_last_line_int` when `\PitonInputFile` is used with textual markers.

```
\cs_new_protected:Npn \@@_compute_range:
  {
```

We store the markers in L3 strings (`str`) in order to do safely the following replacement of `\#`.

```
    \str_set:Nx \l_tmpa_str { \@@_marker_beginning:n \l_@@_begin_range_str }
    \str_set:Nx \l_tmpb_str { \@@_marker_end:n \l_@@_end_range_str }
```

We replace the sequences `\#` which may be present in the prefixes (and, more unlikely, suffixes) added to the markers by the functions `\@@_marker_beginning:n` and `\@@_marker_end:n`

```
    \exp_args:NnV \regex_replace_all:nnN { \\\# } \c_hash_str \l_tmpa_str
    \exp_args:NnV \regex_replace_all:nnN { \\\# } \c_hash_str \l_tmpb_str
    \lua_now:e
      {
        piton.ComputeRange
          ( '\l_tmpa_str' , '\l_tmpb_str' , '\l_@@_file_name_str' )
      }
  }
```

8.2.8 The styles

The following command is fundamental: it will be used by the Lua code.

```
\NewDocumentCommand { \PitonStyle } { m }
  {
    \cs_if_exist_use:cF { pitonStyle _ \l_piton_language_str  _ #1 }
      { \use:c { pitonStyle _ #1 } }
  }

\NewDocumentCommand { \SetPitonStyle } { O { } m }
  {
    \str_set:Nx \l_@@_SetPitonStyle_option_str { \str_lowercase:n { #1 } }
    \str_if_eq:onT \l_@@_SetPitonStyle_option_str { current-language }
      { \str_set_eq:NN \l_@@_SetPitonStyle_option_str \l_piton_language_str }
    \keys_set:nn { piton / Styles } { #2 }
    \str_clear:N \l_@@_SetPitonStyle_option_str
  }

\cs_new_protected:Npn \@@_math_scantokens:n #1
  { \normalfont \scantextokens { $#1$ } }

\clist_new:N \g_@@_style_clist
\clist_set:Nn \g_@@_styles_clist
  {
    Comment ,
    Comment.LaTeX ,
    Exception ,
    FormattingType ,
    Identifier ,
    InitialValues ,
    Interpol.Inside ,
    Keyword ,
    Keyword.Constant ,
    Name.Builtin ,
    Name.Class ,
    Name.Constructor ,
    Name.Decorator ,
    Name.Field ,
    Name.Function ,
    Name.Module ,
    Name.Namespace ,
    Name.Table ,
    Name.Type ,
    Number ,
    Operator ,
    Operator.Word ,
    Preproc ,
    Prompt ,
    String.Doc ,
    String.Interpol ,
    String.Long ,
    String.Short ,
    TypeParameter ,
    UserFunction
  }

\clist_map_inline:Nn \g_@@_styles_clist
```

```
  {
    \keys_define:nn { piton / Styles }
      {
        #1 .value_required:n = true ,
        #1 .code:n =
         \tl_set:cn
           {
             pitonStyle _
             \str_if_empty:NF \l_@@_SetPitonStyle_option_str
               { \l_@@_SetPitonStyle_option_str _ }
             #1
           }
           { ##1 }
      }
  }

\keys_define:nn { piton / Styles }
  {
    String          .meta:n = { String.Long = #1 , String.Short = #1 } ,
    Comment.Math    .tl_set:c = pitonStyle Comment.Math ,
    Comment.Math    .default:n = \@@_math_scantokens:n ,
    Comment.Math    .initial:n = ,
    ParseAgain      .tl_set:c = pitonStyle ParseAgain ,
    ParseAgain      .value_required:n = true ,
    ParseAgain.noCR .tl_set:c = pitonStyle ParseAgain.noCR ,
    ParseAgain.noCR .value_required:n = true ,
    unknown         .code:n =
      \@@_error:n { Unknown~key~for~SetPitonStyle }
  }
```

We add the word String to the list of the styles because we will use that list in the error message for an unknown key in \SetPitonStyle.

```
\clist_gput_left:Nn \g_@@_styles_clist { String }
```

Of course, we sort that clist.

```
\clist_gsort:Nn \g_@@_styles_clist
  {
    \str_compare:nNnTF { #1 } < { #2 }
      \sort_return_same:
      \sort_return_swapped:
  }
```

8.2.9 The initial styles

The initial styles are inspired by the style “manni” of Pygments.

```
\SetPitonStyle
  {
    Comment             = \color[HTML]{0099FF} \itshape ,
    Exception           = \color[HTML]{CC0000} ,
    Keyword             = \color[HTML]{006699} \bfseries ,
    Keyword.Constant    = \color[HTML]{006699} \bfseries ,
    Name.Builtin        = \color[HTML]{336666} ,
    Name.Decorator      = \color[HTML]{9999FF},
    Name.Class          = \color[HTML]{00AA88} \bfseries ,
    Name.Function       = \color[HTML]{CC00FF} ,
    Name.Namespace      = \color[HTML]{00CCFF} ,
    Name.Constructor    = \color[HTML]{006000} \bfseries ,
    Name.Field          = \color[HTML]{AA6600} ,
    Name.Module         = \color[HTML]{0060A0} \bfseries ,
    Name.Table         = \color[HTML]{309030} ,
    Number             = \color[HTML]{FF6600} ,
    Operator           = \color[HTML]{555555} ,
    Operator.Word      = \bfseries ,
    String             = \color[HTML]{CC3300} ,
    String.Doc         = \color[HTML]{CC3300} \itshape ,
    String.Interpol    = \color[HTML]{AA0000} ,
    Comment.LaTeX      = \normalfont \color[rgb]{.468,.532,.6} ,
    Name.Type          = \color[HTML]{336666} ,
    InitialValues      = \@@_piton:n ,
    Interpol.Inside    = \color{black}\@@_piton:n ,
    TypeParameter      = \color[HTML]{336666} \itshape ,
    Preproc            = \color[HTML]{AA6600} \slshape ,
    Identifier         = \@@_identifier:n ,
    UserFunction       = ,
    Prompt             = ,
    ParseAgain.noCR    = \@@_piton_no_cr:n ,
    ParseAgain         = \@@_piton:n ,
  }
```

The last styles `ParseAgain.noCR` and `ParseAgain` should be considered as "internal style" (not available for the final user). However, maybe we will change that and document these styles for the final user (why not?).

If the key `math-comments` has been used at load-time, we change the style `Comment.Math` which should be considered only at an "internal style". However, maybe we will document in a future version the possibility to write change the style *locally* in a document)].

```
\bool_if:NT \g_@@_math_comments_bool { \SetPitonStyle { Comment.Math } }
```

8.2.10 Highlighting some identifiers

```
\NewDocumentCommand { \SetPitonIdentifier } { o m m }
  {
    \clist_set:Nn \l_tmpa_clist { #2 }
    \IfNoValueTF { #1 }
      {
        \clist_map_inline:Nn \l_tmpa_clist
          { \cs_set:cpn { pitonIdentifier _ ##1 } { #3 } }
      }
      {
        \str_set:Nx \l_tmpa_str { \str_lowercase:n { #1 } }
        \str_if_eq:onT \l_tmpa_str { current-language }
          { \str_set_eq:NN \l_tmpa_str \l_piton_language_str }
        \clist_map_inline:Nn \l_tmpa_clist
          { \cs_set:cpn { pitonIdentifier _ \l_tmpa_str _ ##1 } { #3 } }
      }
  }
```

```
\cs_new_protected:Npn \@@_identifier:n #1
  {
    \cs_if_exist_use:cF { pitonIdentifier _ \l_piton_language_str _ #1 }
      { \cs_if_exist_use:c { pitonIdentifier_ #1 } }
    { #1 }
  }
```

```
\keys_define:nn { PitonOptions }
  { identifiers .code:n = \@@_set_identifiers:n { #1 } }
```

```
\keys_define:nn { Piton / identifiers }
  {
    names .clist_set:N = \l_@@_identifiers_names_tl ,
    style .tl_set:N    = \l_@@_style_tl ,
  }
```

```
\cs_new_protected:Npn \@@_set_identifiers:n #1
  {
    \@@_error:n { key~identifiers~deprecated }
    \@@_gredirect_none:n { key~identifiers~deprecated }
    \clist_clear_new:N \l_@@_identifiers_names_tl
    \tl_clear_new:N \l_@@_style_tl
    \keys_set:nn { Piton / identifiers } { #1 }
    \clist_map_inline:Nn \l_@@_identifiers_names_tl
      {
        \tl_set_eq:cN
          { PitonIdentifier _ \l_piton_language_str _ ##1 }
          \l_@@_style_tl
      }
  }
```

In particular, we have an highlighting of the indentifiers which are the names of Python functions previously defined by the user. Indeed, when a Python function is defined, the style `Name.Function.Internal` is applied to that name. We define now that style (you define it directly and you short-cut the function `\SetPitonStyle`).

```
\cs_new_protected:cpn { pitonStyle _ Name.Function.Internal } #1
  {
```

First, the element is composed in the TeX flow with the style `Name.Function` which is provided to the final user.

```
    { \PitonStyle { Name.Function } { #1 } }
```

Now, we specify that the name of the new Python function is a known identifier that will be formated with the Piton style `UserFunction`. Of course, here the affectation is global because we have to exit many groups and even the environments `{Piton}`).

```
    \cs_gset_protected:cpn { PitonIdentifier _ \l_piton_language_str _ #1 }
      { \PitonStyle { UserFunction } }
```

Now, we put the name of that new user function in the dedicated sequence (specific of the current language). **That sequence will be used only by `\PitonClearUserFunctions`.**

```
    \seq_if_exist:cF { g_@@_functions _ \l_piton_language_str _ seq }
      { \seq_new:c { g_@@_functions _ \l_piton_language_str _ seq } }
    \seq_gput_right:cn { g_@@_functions _ \l_piton_language_str _ seq } { #1 }
```

We update `\g_@@_languages_seq` which is used only by the command `\PitonClearUserFunctions` when it's used without its optional argument.

```
    \seq_if_in:NVF \g_@@_languages_seq \l_piton_language_str
      { \seq_gput_left:NV \g_@@_languages_seq \l_piton_language_str }
  }
```

```
\NewDocumentCommand \PitonClearUserFunctions { ! o }
  {
    \tl_if_novalue:nTF { #1 }
```

If the command is used without its optional argument, we will deleted the user language for all the informatic languages.

```
      { \@@_clear_all_functions: }
      { \@@_clear_list_functions:n { #1 } }
  }
```

```
\cs_new_protected:Npn \@@_clear_list_functions:n #1
  {
    \clist_set:Nn \l_tmpa_clist { #1 }
    \clist_map_function:NN \l_tmpa_clist \@@_clear_functions_i:n
    \clist_map_inline:nn { #1 }
      { \seq_gremove_all:Nn \g_@@_languages_seq { ##1 } }
  }
```

```
\cs_new_protected:Npn \@@_clear_functions_i:n #1
  { \exp_args:Ne \@@_clear_functions_ii:n { \str_lowercase:n { #1 } } }
```

The following command clears the list of the user-defined functions for the language provided in argument (mandatory in lower case).

```
\cs_new_protected:Npn \@@_clear_functions_ii:n #1
  {
    \seq_if_exist:cT { g_@@_functions _ #1 _ seq }
      {
        \seq_map_inline:cn { g_@@_functions _ #1 _ seq }
          { \cs_undefine:c { PitonIdentifier _ #1 _ ##1} }
        \seq_gclear:c { g_@@_functions _ #1 _ seq }
      }
  }

\cs_new_protected:Npn \@@_clear_functions:n #1
  {
    \@@_clear_functions_i:n { #1 }
    \seq_gremove_all:Nn \g_@@_languages_seq { #1 }
  }
```

The following command clears all the user-defined functions for all the informatic languages.

```
\cs_new_protected:Npn \@@_clear_all_functions:
  {
    \seq_map_function:NN \g_@@_languages_seq \@@_clear_functions_i:n
    \seq_gclear:N \g_@@_languages_seq
  }
```

8.2.11 Security

```
\AddToHook { env / piton / begin }
  { \msg_fatal:nn { piton } { No~environment~piton } }

\msg_new:nnn { piton } { No~environment~piton }
  {
    There~is~no~environment~piton!\\
    There~is~an~environment~{Piton}~and~a~command~
    \token_to_str:N \piton\ but~there~is~no~environment~
    {piton}.~This~error~is~fatal.
  }
```

8.2.12 The error messages of the package

```
\@@_msg_new:nn { key~identifiers~deprecated }
  {
    The~key~'identifiers'~in~the~command~\token_to_str:N PitonOptions\
    is~now~deprecated:~you~should~use~the~command~
    \token_to_str:N \SetPitonIdentifier\ instead.\\
    However,~you~can~go~on.
  }
\@@_msg_new:nn { Unknown~key~for~SetPitonStyle }
  {
    The~style~'\l_keys_key_str'~is~unknown.\\
    This~key~will~be~ignored.\\
    The~available~styles~are~(in~alphabetic~order):~
    \clist_use:Nnnn \g_@@_styles_clist { ~and~ } { ,~ } { ~and~ }.
  }
\@@_msg_new:nn { Invalid~key }
  {
    Wrong~use~of~key.\\
    You~can't~use~the~key~'\l_keys_key_str'~here.\\
    That~key~will~be~ignored.
  }
\@@_msg_new:nn { Unknown~key~for~line-numbers }
  {
    Unknown~key. \\
    The~key~'line-numbers / \l_keys_key_str'~is~unknown.\\
    The~available~keys~of~the~family~'line-numbers'~are~(in~
    alphabetic~order):~
    absolute,~false,~label-empty-lines,~resume,~skip-empty-lines,~
    sep,~start~and~true.\\
    That~key~will~be~ignored.
  }
\@@_msg_new:nn { Unknown~key~for~marker }
  {
    Unknown~key. \\
    The~key~'marker / \l_keys_key_str'~is~unknown.\\
    The~available~keys~of~the~family~'marker'~are~(in~
    alphabetic~order):~ beginning,~end~and~include-lines.\\
    That~key~will~be~ignored.
  }
\@@_msg_new:nn { bad~range~specification }
  {
    Incompatible~keys.\\
    You~can't~specify~the~range~of~lines~to~include~by~using~both~
    markers~and~explicit~number~of~lines.\\
    Your~whole~file~'\l_@@_file_name_str'~will~be~included.
  }
\@@_msg_new:nn { syntax~error }
  {
    Your~code~\l_piton_language_str\ is~not~syntactically~correct.\\
    It~won't~be~printed~in~the~PDF~file.
  }
\NewDocumentCommand \PitonSyntaxError { }
  { \@@_error:n { syntax~error } }
\@@_msg_new:nn { begin~marker~not~found }
  {
    Marker~not~found.\\
    The~range~'\l_@@_begin_range_str'~provided~to~the~
    command~\token_to_str:N \PitonInputFile\ has~not~been~found.~
    The~whole~file~'\l_@@_file_name_str'~will~be~inserted.
  }
\@@_msg_new:nn { end~marker~not~found }
  {
    Marker~not~found.\\
    The~marker~of~end~of~the~range~'\l_@@_end_range_str'~
    provided~to~the~command~\token_to_str:N \PitonInputFile\
    has~not~been~found.~The~file~'\l_@@_file_name_str'~will~
    be~inserted~till~the~end.
  }
\NewDocumentCommand \PitonBeginMarkerNotFound { }
  { \@@_error:n { begin~marker~not~found } }
\NewDocumentCommand \PitonEndMarkerNotFound { }
  { \@@_error:n { end~marker~not~found } }
\@@_msg_new:nn { Unknown~file }
  {
    Unknown~file. \\
    The~file~'#1'~is~unknown.\\
    Your~command~\token_to_str:N \PitonInputFile\ will~be~discarded.
  }
\msg_new:nnnn { piton } { Unknown~key~for~PitonOptions }
```

```
  {
    Unknown~key. \\
    The~key~'\l_keys_key_str'~is~unknown~for~\token_to_str:N \PitonOptions.~
    It~will~be~ignored.\\
    For~a~list~of~the~available~keys,~type~H~<return>.
  }
  {
    The~available~keys~are~(in~alphabetic~order):~
    auto-gobble,~
    background-color,~
    break-lines,~
    break-lines-in-piton,~
    break-lines-in-Piton,~
    continuation-symbol,~
    continuation-symbol-on-indentation,~
    detected-commands,~
    end-of-broken-line,~
    end-range,~
    env-gobble,~
    gobble,~
    indent-broken-lines,~
    language,~
    left-margin,~
    line-numbers/,~
    marker/,~
    path,~
    prompt-background-color,~
    resume,~
    show-spaces,~
    show-spaces-in-strings,~
    splittable,~
    tabs-auto-gobble,~
    tab-size,~width~
    and~write.
  }

\@@_msg_new:nn { label~with~lines~numbers }
  {
    You~can't~use~the~command~\token_to_str:N \label\
    because~the~key~'line-numbers'~is~not~active.\\
    If~you~go~on,~that~command~will~ignored.
  }

\@@_msg_new:nn { cr~not~allowed }
  {
    You~can't~put~any~carriage~return~in~the~argument~
    of~a~command~\c_backslash_str
    \l_@@_beamer_command_str\ within~an~
    environment~of~'piton'.~You~should~consider~using~the~
    corresponding~environment.\\
    That~error~is~fatal.
  }

\@@_msg_new:nn { overlay~without~beamer }
  {
    You~can't~use~an~argument~<...>~for~your~command~
    \token_to_str:N \PitonInputFile\ because~you~are~not~
    in~Beamer.\\
    If~you~go~on,~that~argument~will~be~ignored.
  }
```

8.2.13 We load piton.lua

```
\hook_gput_code:nnn { begindocument } { . }
  { \lua_now:e { require("piton.lua") } }
```

8.2.14 Detected commands

```
\cs_new_protected:Npn \@@_detected_commands:n #1
  { \lua_now:n { piton.addListCommands('#1') } }
```

```
\ExplSyntaxOff
\directlua
  {
    lpeg.locale(lpeg)
    local P , alpha , C , Cf, space = lpeg.P , lpeg.alpha , lpeg.C , lpeg.Cf , lpeg.space
    local One_P = space ^ 0
                  * C ( alpha ^ 1 ) / ( function (s) return P ( string.char(92) .. s ) end )
                  * space ^ 0
    function piton.addListCommands( key_value )
       piton.ListCommands =
         piton.ListCommands +
           Cf ( One_P * ( P "," * One_P ) ^ 0  ,
                ( function (s,t) return s + t end ) ) : match ( key_value )
    end
  }
⟨/STY⟩
```

8.3 The Lua part of the implementation

The Lua code will be loaded via a {luacode*} environment. The environment is by itself a Lua block and the local declarations will be local to that block. All the global functions (used by the L3 parts of the implementation) will be put in a Lua table piton.

```
⟨*LUA⟩
if piton.comment_latex == nil then piton.comment_latex = ">" end
piton.comment_latex = "#" .. piton.comment_latex
```

The following functions are an easy way to safely insert braces ({ and }) in the TeX flow.

```
function piton.open_brace ()
   tex.sprint("{")
end
function piton.close_brace ()
   tex.sprint("}")
end
```

8.3.1 Special functions dealing with LPEG

We will use the Lua library lpeg which is built in LuaTeX. That's why we define first aliases for several functions of that library.

```
local P, S, V, C, Ct, Cc = lpeg.P, lpeg.S, lpeg.V, lpeg.C, lpeg.Ct, lpeg.Cc
local Cf, Cs , Cg , Cmt , Cb = lpeg.Cf, lpeg.Cs, lpeg.Cg , lpeg.Cmt , lpeg.Cb
local R = lpeg.R
```

The function Q takes in as argument a pattern and returns a LPEG *which does a capture* of the pattern. That capture will be sent to LaTeX with the catcode "other" for all the characters: it's suitable for elements of the Python listings that piton will typeset verbatim (thanks to the catcode "other").

```
local function Q(pattern)
  return Ct ( Cc ( luatexbase.catcodetables.CatcodeTableOther ) * C ( pattern ) )
end
```

The function `L` takes in as argument a pattern and returns a LPEG *which does a capture* of the pattern. That capture will be sent to LaTeX with standard LaTeX catcodes for all the characters: the elements captured will be formatted as normal LaTeX codes. It's suitable for the "LaTeX comments" in the environments `{Piton}` and the elements beetween `begin-escape` and `end-escape`. That function won't be much used.

```
local function L(pattern)
  return Ct ( C ( pattern ) )
end
```

The function `Lc` (the c is for *constant*) takes in as argument a string and returns a LPEG *with does a constant capture* which returns that string. The elements captured will be formatted as L3 code. It will be used to send to LaTeX all the formatting LaTeX instructions we have to insert in order to do the syntactic highlighting (that's the main job of piton). That function will be widely used.

```
local function Lc(string)
  return Cc ( { luatexbase.catcodetables.expl , string } )
end
```

The function `K` creates a LPEG which will return as capture the whole LaTeX code corresponding to a Python chunk (that is to say with the LaTeX formatting instructions corresponding to the syntactic nature of that Python chunk). The first argument is a Lua string corresponding to the name of a piton style and the second element is a pattern (that is to say a LPEG without capture)

```
local function K(style, pattern)
  return
     Lc ( "{\\PitonStyle{" .. style .. "}{" )
     * Q ( pattern )
     * Lc ( "}}" )
end
```

The formatting commands in a given piton style (eg. the style `Keyword`) may be semi-global declarations (such as `\bfseries` or `\slshape`) or LaTeX macros with an argument (such as `\fbox` or `\colorbox{yellow}`). In order to deal with both syntaxes, we have used two pairs of braces: `{\PitonStyle{Keyword}{`*`text to format`*`}}`.

The following function `WithStyle` is similar to the function `K` but should be used for multi-lines elements.

```
local function WithStyle(style,pattern)
  return
       Ct ( Cc "Open" * Cc ( "{\\PitonStyle{" .. style .. "}{" ) * Cc "}}" )
     * pattern
     * Ct ( Cc "Close" )
end
```

The following LPEG catches the Python chunks which are in LaTeX escapes (and that chunks will be considered as normal LaTeX constructions). Since the elements that will be catched must be sent to LaTeX with standard LaTeX catcodes, we put the capture (done by the function `C`) in a table (by using `Ct`, which is an alias for `lpeg.Ct`) without number of catcode table at the first component of the table.

```
Escape = P ( false )
if piton.begin_escape ~= nil
then
  Escape =
    P(piton.begin_escape)
    * L ( ( 1 - P(piton.end_escape) ) ^ 1 )
    * P(piton.end_escape)
end
```

```
EscapeMath = P ( false )
if piton.begin_escape_math ~= nil
then
  EscapeMath =
    P(piton.begin_escape_math)
    * Lc ( "\\ensuremath{" )
    * L ( ( 1 - P(piton.end_escape_math) ) ^ 1 )
    * Lc ( "}" )
    * P(piton.end_escape_math)
end
```

The following line is mandatory.

```
lpeg.locale(lpeg)
```

The basic syntactic LPEG

```
local alpha, digit = lpeg.alpha, lpeg.digit
local space = P " "
```

Remember that, for LPEG, the Unicode characters such as à, â, ç, etc. are in fact strings of length 2 (2 bytes) because lpeg is not Unicode-aware.

```
local letter = alpha + P "_"
  + P "â" + P "à" + P "ç" + P "é" + P "è" + P "ê" + P "ë" + P "ï" + P "î"
  + P "ô" + P "û" + P "ü" + P "Â" + P "À" + P "Ç" + P "É" + P "È" + P "Ê"
  + P "Ë" + P "Ï" + P "Î" + P "Ô" + P "Û" + P "Ü"

local alphanum = letter + digit
```

The following LPEG `identifier` is a mere pattern (that is to say more or less a regular expression) which matches the Python identifiers (hence the name).

```
local identifier = letter * alphanum ^ 0
```

On the other hand, the LPEG `Identifier` (with a capital) also returns a *capture*.

```
local Identifier = K ( 'Identifier' , identifier )
```

By convention, we will use names with an initial capital for LPEG which return captures.

Here is the first use of our function `K`. That function will be used to construct LPEG which capture Python chunks for which we have a dedicated piton style. For example, for the numbers, piton provides a style which is called `Number`. The name of the style is provided as a Lua string in the second argument of the function `K`. By convention, we use single quotes for delimiting the Lua strings which are names of piton styles (but this is only a convention).

```
local Number =
  K ( 'Number' ,
      ( digit^1 * P "." * digit^0 + digit^0 * P "." * digit^1 + digit^1 )
      * ( S "eE" * S "+-" ^ -1 * digit^1 ) ^ -1
      + digit^1
    )
```

We recall that `piton.begin_espace` and `piton_end_escape` are Lua strings corresponding to the keys `begin-escape` and `end-escape`.

```
local Word
if piton.begin_escape ~= nil -- before : ''
then Word = Q ( ( ( 1 - space - P(piton.begin_escape) - P(piton.end_escape) )
                   - S "'\"\r[()]" - digit ) ^ 1 )
else Word = Q ( ( ( 1 - space ) - S "'\"\r[()]" - digit ) ^ 1 )
end
```

```
local Space = ( Q " " ) ^ 1

local SkipSpace = ( Q " " ) ^ 0

local Punct = Q ( S ".,:;!" )

local Tab = P "\t" * Lc ( '\\l_@@_tab_tl' )
```

```
local SpaceIndentation = Lc ( '\\@@_an_indentation_space:' ) * ( Q " " )
```

```
local Delim = Q ( S "[()]" )
```

The following LPEG catches a space (U+0020) and replace it by `\l_@@_space_tl`. It will be used in the strings. Usually, `\l_@@_space_tl` will contain a space and therefore there won't be difference. However, when the key `show-spaces-in-strings` is in force, `\\l_@@_space_tl` will contain ␣ (U+2423) in order to visualize the spaces.

```
local VisualSpace = space * Lc "\\l_@@_space_tl"
```

If the classe Beamer is used, some environemnts and commands of Beamer are automatically detected in the listings of piton.

```
local Beamer = P ( false )
local BeamerBeginEnvironments = P ( true )
local BeamerEndEnvironments = P ( true )
if piton_beamer
then
% \bigskip
% The following function will return a \textsc{lpeg} which will catch an
% environment of Beamer (supported by \pkg{piton}), that is to say |{uncover}|,
% |{only}|, etc.
%    \begin{macrocode}
  local BeamerNamesEnvironments =
    P "uncoverenv" + P "onlyenv" + P "visibleenv" + P "invisibleenv"
    + P "alertenv" + P "actionenv"
  BeamerBeginEnvironments =
      ( space ^ 0 *
        L
          (
            P "\\begin{" * BeamerNamesEnvironments * "}"
            * ( P "<" * ( 1 - P ">" ) ^ 0 * P ">" ) ^ -1
          )
        * P "\r"
      ) ^ 0
  BeamerEndEnvironments =
      ( space ^ 0 *
        L ( P "\\end{" * BeamerNamesEnvironments * P "}" )
        * P "\r"
      ) ^ 0
```

The following function will return a LPEG which will catch an environment of Beamer (supported by piton), that is to say `{uncoverenv}`, etc. The argument `lpeg` should be `MainLoopPython`, `MainLoopC`, etc.

```
  function OneBeamerEnvironment(name,lpeg)
    return
        Ct ( Cc "Open"
              * C (
                    P ( "\\begin{" .. name ..   "}" )
                    * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  )
             * Cc ( "\\end{" .. name ..  "}" )
```

```
            )
       * (
           C ( ( 1 - P ( "\\end{" .. name .. "}" ) ) ^ 0 )
           / ( function (s) return lpeg : match(s) end )
         )
       * P ( "\\end{" .. name ..  "}" ) * Ct ( Cc "Close" )
  end
end
```

```
local languages = { }
```

8.3.2 The LPEG python

Some strings of length 2 are explicit because we want the corresponding ligatures available in some fonts such as *Fira Code* to be active.

```
local Operator =
  K ( 'Operator' ,
      P "!=" + P "<>" + P "==" + P "<<" + P ">>" + P "<=" + P ">=" + P ":="
      + P "//" + P "**" + S "-~+/*%=<>&.@|"
    )

local OperatorWord =
  K ( 'Operator.Word' , P "in" + P "is" + P "and" + P "or" + P "not" )

local Keyword =
  K ( 'Keyword' ,
      P "as" + P "assert" + P "break" + P "case" + P "class" + P "continue"
      + P "def" + P "del" + P "elif" + P "else" + P "except" + P "exec"
      + P "finally" + P "for" + P "from" + P "global" + P "if" + P "import"
      + P "lambda" + P "non local" + P "pass" + P "return" + P "try"
      + P "while" + P "with" + P "yield" + P "yield from" )
  + K ( 'Keyword.Constant' ,P "True" + P "False" + P "None" )

local Builtin =
  K ( 'Name.Builtin' ,
      P "__import__" + P "abs" + P "all" + P "any" + P "bin" + P "bool"
    + P "bytearray" + P "bytes" + P "chr" + P "classmethod" + P "compile"
    + P "complex" + P "delattr" + P "dict" + P "dir" + P "divmod"
    + P "enumerate" + P "eval" + P "filter" + P "float" + P "format"
    + P "frozenset" + P "getattr" + P "globals" + P "hasattr" + P "hash"
    + P "hex" + P "id" + P "input" + P "int" + P "isinstance" + P "issubclass"
    + P "iter" + P "len" + P "list" + P "locals" + P "map" + P "max"
    + P "memoryview" + P "min" + P "next" + P "object" + P "oct" + P "open"
    + P "ord" + P "pow" + P "print" + P "property" + P "range" + P "repr"
    + P "reversed" + P "round" + P "set" + P "setattr" + P "slice" + P "sorted"
    + P "staticmethod" + P "str" + P "sum" + P "super" + P "tuple" + P "type"
    + P "vars" + P "zip" )


local Exception =
  K ( 'Exception' ,
      P "ArithmeticError" + P "AssertionError" + P "AttributeError"
   + P "BaseException" + P "BufferError" + P "BytesWarning" + P "DeprecationWarning"
   + P "EOFError" + P "EnvironmentError" + P "Exception" + P "FloatingPointError"
   + P "FutureWarning" + P "GeneratorExit" + P "IOError" + P "ImportError"
   + P "ImportWarning" + P "IndentationError" + P "IndexError" + P "KeyError"
   + P "KeyboardInterrupt" + P "LookupError" + P "MemoryError" + P "NameError"
   + P "NotImplementedError" + P "OSError" + P "OverflowError"
   + P "PendingDeprecationWarning" + P "ReferenceError" + P "ResourceWarning"
   + P "RuntimeError" + P "RuntimeWarning" + P "StopIteration"
   + P "SyntaxError" + P "SyntaxWarning" + P "SystemError" + P "SystemExit"
   + P "TabError" + P "TypeError" + P "UnboundLocalError" + P "UnicodeDecodeError"
   + P "UnicodeEncodeError" + P "UnicodeError" + P "UnicodeTranslateError"
   + P "UnicodeWarning" + P "UserWarning" + P "ValueError" + P "VMSError"
   + P "Warning" + P "WindowsError" + P "ZeroDivisionError"
   + P "BlockingIOError" + P "ChildProcessError" + P "ConnectionError"
   + P "BrokenPipeError" + P "ConnectionAbortedError" + P "ConnectionRefusedError"
   + P "ConnectionResetError" + P "FileExistsError" + P "FileNotFoundError"
   + P "InterruptedError" + P "IsADirectoryError" + P "NotADirectoryError"
   + P "PermissionError" + P "ProcessLookupError" + P "TimeoutError"
   + P "StopAsyncIteration" + P "ModuleNotFoundError" + P "RecursionError" )


local RaiseException = K ( 'Keyword' , P "raise" ) * SkipSpace * Exception * Q ( P "(" )

```

In Python, a “decorator” is a statement whose begins by @ which patches the function defined in the following statement.

```
local Decorator = K ( 'Name.Decorator' , P "@" * letter^1  )
```

The following LPEG DefClass will be used to detect the definition of a new class (the name of that new class will be formatted with the piton style Name.Class).

Example: class myclass:

```
local DefClass =
  K ( 'Keyword' , P "class" ) * Space * K ( 'Name.Class' , identifier )
```

If the word class is not followed by a identifier, it will be catched as keyword by the LPEG Keyword (useful if we want to type a list of keywords).

The following LPEG ImportAs is used for the lines beginning by import. We have to detect the potential keyword as because both the name of the module and its alias must be formatted with the piton style Name.Namespace.

Example: import numpy as np

Moreover, after the keyword import, it’s possible to have a comma-separated list of modules (if the keyword as is not used).

Example: import math, numpy

```
local ImportAs =
  K ( 'Keyword' , P "import" )
   * Space
   * K ( 'Name.Namespace' ,
         identifier * ( P "." * identifier ) ^ 0 )
   * (
       ( Space * K ( 'Keyword' , P "as" ) * Space
          * K ( 'Name.Namespace' , identifier ) )
       +
       ( SkipSpace * Q ( P "," ) * SkipSpace
          * K ( 'Name.Namespace' , identifier ) ) ^ 0
     )
```

Be careful: there is no commutativity of + in the previous expression.

The LPEG FromImport is used for the lines beginning by from. We need a special treatment because the identifier following the keyword from must be formatted with the piton style Name.Namespace and the following keyword import must be formatted with the piton style Keyword and must *not* be catched by the LPEG ImportAs.

Example: from math import pi

```
local FromImport =
  K ( 'Keyword' , P "from" )
    * Space * K ( 'Name.Namespace' , identifier )
    * Space * K ( 'Keyword' , P "import" )
```

The strings of Python For the strings in Python, there are four categories of delimiters (without counting the prefixes for f-strings and raw strings). We will use, in the names of our LPEG, prefixes to distinguish the LPEG dealing with that categories of strings, as presented in the following tabular.

	`Single`	`Double`
`Short`	`'text'`	`"text"`
`Long`	`'''test'''`	`"""text"""`

We have also to deal with the interpolations in the f-strings. Here is an example of a f-string with an interpolation and a format instruction[28] in that interpolation:
`f'Total price: {total+1:.2f} €'`

The interpolations beginning by `%` (even though there is more modern technics now in Python).

```
local PercentInterpol =
  K ( 'String.Interpol' ,
      P "%"
      * ( P "(" * alphanum ^ 1 * P ")" ) ^ -1
      * ( S "-#0 +" ) ^ 0
      * ( digit ^ 1 + P "*" ) ^ -1
      * ( P "." * ( digit ^ 1 + P "*" ) ) ^ -1
      * ( S "HlL" ) ^ -1
      * S "sdfFeExXorgiGauc%"
    )
```

We can now define the LPEG for the four kinds of strings. It's not possible to use our function `K` because of the interpolations which must be formatted with another piton style that the rest of the string.[29]

```
local SingleShortString =
  WithStyle ( 'String.Short' ,
```

First, we deal with the f-strings of Python, which are prefixed by `f` or `F`.

```
         Q ( P "f'" + P "F'" )
         * (
             K ( 'String.Interpol' , P "{" )
              * K ( 'Interpol.Inside' , ( 1 - S "}':" ) ^ 0  )
              * Q ( P ":" * (1 - S "}:'") ^ 0 ) ^ -1
              * K ( 'String.Interpol' , P "}" )
             +
             VisualSpace
             +
             Q ( ( P "\\'" + P "{{" + P "}}" + 1 - S " {}'" ) ^ 1 )
           ) ^ 0
         * Q ( P "'" )
       +
```

Now, we deal with the standard strings of Python, but also the "raw strings".

```
         Q ( P "'" + P "r'" + P "R'" )
         * ( Q ( ( P "\\'" + 1 - S " '\r%" ) ^ 1 )
             + VisualSpace
             + PercentInterpol
             + Q ( P "%" )
           ) ^ 0
         * Q ( P "'" ) )


```

[28] There is no special piton style for the formatting instruction (after the colon): the style which will be applied will be the style of the encompassing string, that is to say `String.Short` or `String.Long`.

[29] The interpolations are formatted with the piton style `Interpol.Inside`. The initial value of that style is `\@@_piton:n` wich means that the interpolations are parsed once again by piton.

```
local DoubleShortString =
  WithStyle ( 'String.Short' ,
         Q ( P "f\"" + P "F\"" )
         * (
             K ( 'String.Interpol' , P "{" )
               * Q ( ( 1 - S "}\":" ) ^ 0 , 'Interpol.Inside' )
               * ( K ( 'String.Interpol' , P ":" ) * Q ( (1 - S "}:\"") ^ 0 ) ) ^ -1
               * K ( 'String.Interpol' , P "}" )
             +
             VisualSpace
             +
             Q ( ( P "\\\"" + P "{{" + P "}}" + 1 - S " {}\"" ) ^ 1 )
            ) ^ 0
         * Q ( P "\"" )
       +
         Q ( P "\"" + P "r\"" + P "R\"" )
         * ( Q ( ( P "\\\"" + 1 - S " \"\r%" ) ^ 1 )
             + VisualSpace
             + PercentInterpol
             + Q ( P "%" )
           ) ^ 0
         * Q ( P "\"" ) )

local ShortString = SingleShortString + DoubleShortString
```

Beamer The following pattern `balanced_braces` will be used for the (mandatory) argument of the commands `\only` and *al.* of Beamer. It's necessary to use a *grammar* because that pattern mainly checks the correct nesting of the delimiters (and it's known in the theory of formal languages that this can't be done with regular expressions *stricto sensu* only).

```
local balanced_braces =
  P { "E" ,
       E =
           (
             P "{" * V "E" * P "}"
             +
             ShortString
             +
             ( 1 - S "{}" )
           ) ^ 0
    }
```

```
if piton_beamer
then
  Beamer =
      L ( P "\\pause" * ( P "[" * ( 1 - P "]" ) ^ 0 * P "]" ) ^ -1 )
    +
      Ct ( Cc "Open"
            * C (
                  (
                    P "\\uncover" + P "\\only" + P "\\alert" + P "\\visible"
                    + P "\\invisible" + P "\\action"
                  )
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopPython:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )
    + OneBeamerEnvironment ( "uncoverenv" , MainLoopPython )
    + OneBeamerEnvironment ( "onlyenv" , MainLoopPython )
    + OneBeamerEnvironment ( "visibleenv" , MainLoopPython )
    + OneBeamerEnvironment ( "invisibleenv" , MainLoopPython )
    + OneBeamerEnvironment ( "alertenv" , MainLoopPython )
    + OneBeamerEnvironment ( "actionenv" , MainLoopPython )
    +
      L (
```

For `\\alt`, the specification of the overlays (between angular brackets) is mandatory.

```
          ( P "\\alt" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
    +
      L (
```

For `\\temporal`, the specification of the overlays (between angular brackets) is mandatory.

```
          ( P "\\temporal" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
end
```

Detected commands

```
DetectedCommands =
      Ct ( Cc "Open"
            * C (
                  piton.ListCommands
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopPython:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )
```

EOL The following LPEG will detect the Python prompts when the user is typesetting an interactive session of Python (directly or through `{pyconsole}` of `pyluatex`). We have to detect that prompt twice. The first detection (called *hasty detection*) will be before the `\@@_begin_line:` because you want to trigger a special background color for that row (and, after the `\@@_begin_line:`, it's too late to change de background).

```
local PromptHastyDetection = ( # ( P ">>>" + P "..." ) * Lc ( '\\@@_prompt:' ) ) ^ -1
```

We remind that the marker `#` of LPEG specifies that the pattern will be detected but won't consume any character.

With the following LPEG, a style will actually be applied to the prompt (for instance, it's possible to decide to discard these prompts).

```
local Prompt = K ( 'Prompt' , ( ( P ">>>" + P "..." ) * P " " ^ -1 ) ^ -1  )
```

The following LPEG `EOL` is for the end of lines.

```
local EOL =
  P "\r"
  *
  (
    ( space^0 * -1 )
    +
```

We recall that each line in the Python code we have to parse will be sent back to LaTeX between a pair `\@@_begin_line:` – `\@@_end_line:`[30].

```
    Ct (
         Cc "EOL"
         *
         Ct (
              Lc "\\@@_end_line:"
              * BeamerEndEnvironments
              * BeamerBeginEnvironments
              * PromptHastyDetection
              * Lc "\\@@_newline: \\@@_begin_line:"
              * Prompt
            )
       )
  )
  *
  SpaceIndentation ^ 0
```

The long strings

```
local SingleLongString =
  WithStyle ( 'String.Long' ,
     ( Q ( S "fF" * P "'''" )
         * (
             K ( 'String.Interpol' , P "{"  )
               * K ( 'Interpol.Inside' , ( 1 - S "}:\r" - P "'''" ) ^ 0  )
               * Q ( P ":" * (1 - S "}:\r" - P "'''" ) ^ 0 ) ^ -1
               * K ( 'String.Interpol' , P "}"  )
             +
             Q ( ( 1 - P "'''" - S "{}'\r" ) ^ 1 )
             +
             EOL
           ) ^ 0
       +
         Q ( ( S "rR" ) ^ -1  * P "'''" )
         * (
             Q ( ( 1 - P "'''" - S "\r%" ) ^ 1 )
             +
             PercentInterpol
             +
             P "%"
             +
             EOL
           ) ^ 0
      )
      * Q ( P "'''" ) )


local DoubleLongString =
  WithStyle ( 'String.Long' ,
     (
```

[30] Remember that the `\@@_end_line:` must be explicit because it will be used as marker in order to delimit the argument of the command `\@@_begin_line:`

```
        Q ( S "fF" * P "\"\"\"" )
        * (
            K ( 'String.Interpol', P "{"  )
              * K ( 'Interpol.Inside' , ( 1 - S "}:\r" - P "\"\"\"" ) ^ 0 )
              * Q ( P ":" * (1 - S "}:\r" - P "\"\"\"" ) ^ 0 ) ^ -1
              * K ( 'String.Interpol' , P "}"  )
            +
            Q ( ( 1 - P "\"\"\"" - S "{}\"\r" ) ^ 1 )
            +
            EOL
          ) ^ 0
      +
        Q ( ( S "rR" ) ^ -1  * P "\"\"\"" )
        * (
            Q ( ( 1 - P "\"\"\"" - S "%\r" ) ^ 1 )
            +
            PercentInterpol
            +
            P "%"
            +
            EOL
          ) ^ 0
     )
     * Q ( P "\"\"\"" )
  )
local LongString = SingleLongString + DoubleLongString
```

We have a LPEG for the Python docstrings. That LPEG will be used in the LPEG `DefFunction` which deals with the whole preamble of a function definition (which begins with `def`).

```
local StringDoc =
    K ( 'String.Doc' , P "\"\"\"" )
      * ( K ( 'String.Doc' , (1 - P "\"\"\"" - P "\r" ) ^ 0  ) * EOL
          * Tab ^ 0
        ) ^ 0
      * K ( 'String.Doc' , ( 1 - P "\"\"\"" - P "\r" ) ^ 0 * P "\"\"\"" )
```

The comments in the Python listings We define different LPEG dealing with comments in the Python listings.

```
local CommentMath =
  P "$" * K ( 'Comment.Math' , ( 1 - S "$\r" ) ^ 1  ) * P "$"

local Comment =
  WithStyle ( 'Comment' ,
     Q ( P "#" )
     * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0 )
  * ( EOL + -1 )
```

The following LPEG `CommentLaTeX` is for what is called in that document the “LaTeX comments”. Since the elements that will be catched must be sent to LaTeX with standard LaTeX catcodes, we put the capture (done by the function `C`) in a table (by using `Ct`, which is an alias for `lpeg.Ct`).

```
local CommentLaTeX =
  P(piton.comment_latex)
  * Lc "{\\PitonStyle{Comment.LaTeX}{\\ignorespaces"
  * L ( ( 1 - P "\r" ) ^ 0 )
  * Lc "}}"
  * ( EOL + -1 )
```

DefFunction The following LPEG `expression` will be used for the parameters in the *argspec* of a Python function. It's necessary to use a *grammar* because that pattern mainly checks the correct nesting of the delimiters (and it's known in the theory of formal languages that this can't be done with regular expressions *stricto sensu* only).

```
local expression =
  P { "E" ,
       E = ( P "'" * ( P "\\'" + 1 - S "'\r" ) ^ 0 * P "'"
             + P "\"" * (P "\\\"" + 1 - S "\"\r" ) ^ 0 * P "\""
             + P "{" * V "F" * P "}"
             + P "(" * V "F" * P ")"
             + P "[" * V "F" * P "]"
             + ( 1 - S "{}()[]\r," ) ) ^ 0 ,
       F = ( P "{" * V "F" * P "}"
             + P "(" * V "F" * P ")"
             + P "[" * V "F" * P "]"
             + ( 1 - S "{}()[]\r\"'" ) ) ^ 0
    }
```

We will now define a LPEG `Params` that will catch the list of parameters (that is to say the *argspec*) in the definition of a Python function. For example, in the line of code

```
def MyFunction(a,b,x=10,n:int): return n
```

the LPEG `Params` will be used to catch the chunk `a,b,x=10,n:int`.
Or course, a `Params` is simply a comma-separated list of `Param`, and that's why we define first the LPEG `Param`.

```
local Param =
  SkipSpace * Identifier * SkipSpace
   * (
         K ( 'InitialValues' , P "=" * expression )
       + Q ( P ":" ) * SkipSpace * K ( 'Name.Type' , letter ^ 1  )
     ) ^ -1
```

```
local Params = ( Param * ( Q "," * Param ) ^ 0 ) ^ -1
```

The following LPEG `DefFunction` catches a keyword `def` and the following name of function *but also everything else until a potential docstring*. That's why this definition of LPEG must occur (in the file `piton.sty`) after the definition of several other LPEG such as `Comment`, `CommentLaTeX`, `Params`, `StringDoc`...

```
local DefFunction =
  K ( 'Keyword' , P "def" )
  * Space
  * K ( 'Name.Function.Internal' , identifier )
  * SkipSpace
  * Q ( P "(" ) * Params * Q ( P ")" )
  * SkipSpace
  * ( Q ( P "->" ) * SkipSpace * K ( 'Name.Type' , identifier  ) ) ^ -1
```

Here, we need a piton style `ParseAgain` which will be linked to `\@@_piton:n` (that means that the capture will be parsed once again by piton). We could avoid that kind of trick by using a non-terminal of a grammar but we have probably here a better legibility.

```
  * K ( 'ParseAgain' , ( 1 - S ":\r" )^0  )
  * Q ( P ":" )
  * ( SkipSpace
      * ( EOL + CommentLaTeX + Comment ) -- in all cases, that contains an EOL
      * Tab ^ 0
      * SkipSpace
      * StringDoc ^ 0 -- there may be additionnal docstrings
    ) ^ -1
```

Remark that, in the previous code, CommentLaTeX *must* appear before Comment: there is no commutativity of the addition for the *parsing expression grammars* (PEG).

If the word def is not followed by an identifier and parenthesis, it will be catched as keyword by the LPEG Keyword (useful if, for example, the final user wants to speak of the keyword def).

Miscellaneous

```
local ExceptionInConsole = Exception *  Q ( ( 1 - P "\r" ) ^ 0 ) * EOL
```

The main LPEG for the language Python First, the main loop :

```
local MainPython =
       EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + CommentLaTeX
     + Beamer
     + DetectedCommands
     + LongString
     + Comment
     + ExceptionInConsole
     + Delim
     + Operator
     + OperatorWord * ( Space + Punct + Delim + EOL + -1 )
     + ShortString
     + Punct
     + FromImport
     + RaiseException
     + DefFunction
     + DefClass
     + Keyword * ( Space + Punct + Delim + EOL + -1 )
     + Decorator
     + Builtin * ( Space + Punct + Delim + EOL + -1 )
     + Identifier
     + Number
     + Word
```

Here, we must not put local!

```
MainLoopPython =
  (  ( space^1 * -1 )
     + MainPython
  ) ^ 0
```

We recall that each line in the Python code to parse will be sent back to LaTeX between a pair \@@_begin_line: – \@@_end_line:[31].

```
local python = P ( true )

python =
  Ct (
       ( ( space - P "\r" ) ^0 * P "\r" ) ^ -1
       * BeamerBeginEnvironments
       * PromptHastyDetection
       * Lc '\\@@_begin_line:'
       * Prompt
       * SpaceIndentation ^ 0
       * MainLoopPython
       * -1
```

[31] Remember that the \@@_end_line: must be explicit because it will be used as marker in order to delimit the argument of the command \@@_begin_line:

```
       * Lc '\\@@_end_line:'
     )
languages['python'] = python
```

8.3.3 The LPEG ocaml

```
local Delim = Q ( P "[|" + P "|]" + S "[()]" )
local Punct = Q ( S ",:;!" )
```

The identifiers catched by `cap_identifier` begin with a cap. In OCaml, it's used for the constructors of types and for the modules.

```
local cap_identifier = R "AZ" * ( R "az" + R "AZ" + S "_'" + digit ) ^ 0
local Constructor = K ( 'Name.Constructor' , cap_identifier )
local ModuleType = K ( 'Name.Type' , cap_identifier )
```

The identifiers which begin with a lower case letter or an underscore are used elsewhere in OCaml.

```
local identifier =
  ( R "az" + P "_") * ( R "az" + R "AZ" + S "_'" + digit ) ^ 0
local Identifier = K ( 'Identifier' , identifier )
```

Now, we deal with the records because we want to catch the names of the fields of those records in all circunstancies.

```
local expression_for_fields =
  P { "E" ,
       E = ( P "{" * V "F" * P "}"
             + P "(" * V "F" * P ")"
             + P "[" * V "F" * P "]"
             + P "\"" * (P "\\\"" + 1 - S "\"\r" )^0 * P "\""
             + P "'" * ( P "\\'" + 1 - S "'\r" )^0 * P "'"
             + ( 1 - S "{}()[]\r;" ) ) ^ 0 ,
       F = ( P "{" * V "F" * P "}"
             + P "(" * V "F" * P ")"
             + P "[" * V "F" * P "]"
             + ( 1 - S "{}()[]\r\"'" ) ) ^ 0
    }
local OneFieldDefinition =
    ( K ( 'KeyWord' , P "mutable" ) * SkipSpace ) ^ -1
  * K ( 'Name.Field' , identifier ) * SkipSpace
  * Q ":" * SkipSpace
  * K ( 'Name.Type' , expression_for_fields )
  * SkipSpace

local OneField =
    K ( 'Name.Field' , identifier ) * SkipSpace
  * Q "=" * SkipSpace
  * ( C ( expression_for_fields ) / ( function (s) return LoopOCaml:match(s) end ) )
  * SkipSpace

local Record =
  Q "{" * SkipSpace
  *
    (
      OneFieldDefinition * ( Q ";" * SkipSpace * OneFieldDefinition ) ^ 0
      +
      OneField * ( Q ";" * SkipSpace * OneField ) ^ 0
    )
  *
  Q "}"
```

Now, we deal with the notations with points (eg: `List.length`). In OCaml, such notation is used for the fields of the records and for the modules.

```
local DotNotation =
  (
      K ( 'Name.Module' , cap_identifier )
        * Q "."
        * ( Identifier + Constructor + Q "(" + Q "[" + Q "{" )

      +
      Identifier
        * Q "."
        * K ( 'Name.Field' , identifier )
  )
  * ( Q "." * K ( 'Name.Field' , identifier ) ) ^ 0
local Operator =
  K ( 'Operator' ,
      P "!=" + P "<>" + P "==" + P "<<" + P ">>" + P "<=" + P ">=" + P ":="
      + P "||" + P "&&" + P "//" + P "**" + P ";;" + P "::" + P "->"
      + P "+." + P "-." + P "*." + P "/."
      + S "-~+/*%=<>&@|"
    )

local OperatorWord =
  K ( 'Operator.Word' ,
      P "and" + P "asr" + P "land" + P "lor" + P "lsl" + P "lxor"
      + P "mod" + P "or" )

local Keyword =
  K ( 'Keyword' ,
      P "assert" + P "as" + P "begin" + P "class" + P "constraint" + P "done"
  + P "downto" + P "do" + P "else" + P "end" + P "exception" + P "external"
  + P "for" + P "function" + P "functor" + P "fun"  + P "if"
  + P "include" + P "inherit" + P "initializer" + P "in"  + P "lazy" + P "let"
  + P "match" + P "method" + P "module" + P "mutable" + P "new" + P "object"
  + P "of" + P "open" + P "private" + P "raise" + P "rec" + P "sig"
  + P "struct" + P "then" + P "to" + P "try" + P "type"
  + P "value" + P "val" + P "virtual" + P "when" + P "while" + P "with" )
  + K ( 'Keyword.Constant' , P "true" + P "false" )


local Builtin =
  K ( 'Name.Builtin' , P "not" + P "incr" + P "decr" + P "fst" + P "snd" )
```

The following exceptions are exceptions in the standard library of OCaml (Stdlib).

```
local Exception =
  K (   'Exception' ,
       P "Division_by_zero" + P "End_of_File" + P "Failure"
     + P "Invalid_argument" + P "Match_failure" + P "Not_found"
     + P "Out_of_memory" + P "Stack_overflow" + P "Sys_blocked_io"
     + P "Sys_error" + P "Undefined_recursive_module" )
```

The characters in OCaml

```
local Char =
  K ( 'String.Short' , P "'" * ( ( 1 - P "'" ) ^ 0 + P "\\'" ) * P "'" )
```

Beamer

```
local balanced_braces =
  P { "E" ,
       E =
           (
             P "{" * V "E" * P "}"
             +
             P "\"" * ( 1 - S "\"" ) ^ 0 * P "\""  -- OCaml strings
             +
             ( 1 - S "{}" )
           ) ^ 0
    }
```

```
if piton_beamer
then
  Beamer =
      L ( P "\\pause" * ( P "[" * ( 1 - P "]" ) ^ 0 * P "]" ) ^ -1 )
    +
      Ct ( Cc "Open"
            * C (
                  (
                    P "\\uncover" + P "\\only" + P "\\alert" + P "\\visible"
                    + P "\\invisible" + P "\\action"
                  )
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopOCaml:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )
    + OneBeamerEnvironment ( "uncoverenv" , MainLoopOCaml )
    + OneBeamerEnvironment ( "onlyenv" , MainLoopOCaml )
    + OneBeamerEnvironment ( "visibleenv" , MainLoopOCaml )
    + OneBeamerEnvironment ( "invisibleenv" , MainLoopOCaml )
    + OneBeamerEnvironment ( "alertenv" , MainLoopOCaml )
    + OneBeamerEnvironment ( "actionenv" , MainLoopOCaml )
    +
      L (
```

For `\\alt`, the specification of the overlays (between angular brackets) is mandatory.

```
          ( P "\\alt" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
    +
      L (
```

For `\\temporal`, the specification of the overlays (between angular brackets) is mandatory.

```
          ( P "\\temporal" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
end
```

```
DetectedCommands =
      Ct ( Cc "Open"
            * C (
                  piton.ListCommands
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopOCaml:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )
```

EOL

```
local EOL =
  P "\r"
  *
  (
    ( space^0 * -1 )
    +
    Ct (
         Cc "EOL"
         *
         Ct (
              Lc "\\@@_end_line:"
              * BeamerEndEnvironments
              * BeamerBeginEnvironments
              * PromptHastyDetection
              * Lc "\\@@_newline: \\@@_begin_line:"
              * Prompt
            )
       )
  )
  *
  SpaceIndentation ^ 0
```

The strings en OCaml We need a pattern `ocaml_string` without captures because it will be used within the comments of OCaml.

```
local ocaml_string =
       Q ( P "\"" )
     * (
         VisualSpace
         +
         Q ( ( 1 - S " \"\r" ) ^ 1 )
         +
         EOL
       ) ^ 0
     * Q ( P "\"" )
```

```
local String = WithStyle ( 'String.Long' , ocaml_string )
```

Now, the “quoted strings” of OCaml (for example `{ext|Essai|ext}`).
For those strings, we will do two consecutive analysis. First an analysis to determine the whole string and, then, an analysis for the potential visual spaces and the EOL in the string.
The first analysis require a match-time capture. For explanations about that programmation, see the paragraphe *Lua’s long strings* in `www.inf.puc-rio.br/~roberto/lpeg`.

```
local ext = ( R "az" + P "_" ) ^ 0
local open = "{" * Cg(ext, 'init') * "|"
local close = "|" * C(ext) * "}"
local closeeq =
  Cmt ( close * Cb('init'),
        function (s, i, a, b) return a==b end )
```

The LPEG `QuotedStringBis` will do the second analysis.

```
local QuotedStringBis =
  WithStyle ( 'String.Long' ,
      (
        Space
        +
        Q ( ( 1 - S " \r" ) ^ 1 )
        +
        EOL
      ) ^ 0  )

```

We use a "function capture" (as called in the official documentation of the LPEG) in order to do the second analysis on the result of the first one.

```
local QuotedString =
   C ( open * ( 1 - closeeq ) ^ 0  * close ) /
  ( function (s) return QuotedStringBis : match(s) end )
```

The comments in the OCaml listings In OCaml, the delimiters for the comments are `(*` and `*)`. There are unsymmetrical and OCaml allow those comments to be nested. That's why we need a grammar.

In these comments, we embed the math comments (between `$` and `$`) and we embed also a treatment for the end of lines (since the comments may be multi-lines).

```
local Comment =
  WithStyle ( 'Comment' ,
     P {
         "A" ,
         A = Q "(*"
             * ( V "A"
                 + Q ( ( 1 - P "(*" - P "*)" - S "\r$\"" ) ^ 1 ) -- $
                 + ocaml_string
                 + P "$" * K ( 'Comment.Math' , ( 1 - S "$\r" ) ^ 1 ) * P "$" -- $
                 + EOL
               ) ^ 0
             * Q "*)"
       }   )
```

The DefFunction

```
local balanced_parens =
  P { "E" ,
       E =
           (
             P "(" * V "E" * P ")"
             +
             ( 1 - S "()" )
           ) ^ 0
    }
local Argument =
  K ( 'Identifier' , identifier )
  + Q "(" * SkipSpace
    * K ( 'Identifier' , identifier ) * SkipSpace
    * Q ":" * SkipSpace
    * K ( 'Name.Type' , balanced_parens ) * SkipSpace
    * Q ")"
```

Despite its name, then LPEG `DefFunction` deals also with `let open` which opens locally a module.

```
local DefFunction =
  K ( 'Keyword' , P "let open" )
   * Space
   * K ( 'Name.Module' , cap_identifier )
  +
  K ( 'Keyword' , P "let rec" + P "let" + P "and" )
    * Space
    * K ( 'Name.Function.Internal' , identifier )
    * Space
    * (
        Q "=" * SkipSpace * K ( 'Keyword' , P "function" )
        +
        Argument
         * ( SkipSpace * Argument ) ^ 0
         * (
             SkipSpace
             * Q ":"
             * K ( 'Name.Type' , ( 1 - P "=" ) ^ 0 )
           ) ^ -1
      )
```

The DefModule The following LPEG will be used in the definitions of modules but also in the definitions of *types* of modules.

```
local DefModule =
  K ( 'Keyword' , P "module" ) * Space
  *
    (
          K ( 'Keyword' , P "type" ) * Space
        * K ( 'Name.Type' , cap_identifier )
      +
        K ( 'Name.Module' , cap_identifier ) * SkipSpace
        *
          (
            Q "(" * SkipSpace
              * K ( 'Name.Module' , cap_identifier ) * SkipSpace
              * Q ":" * SkipSpace
              * K ( 'Name.Type' , cap_identifier ) * SkipSpace
              *
                (
                  Q "," * SkipSpace
                    * K ( 'Name.Module' , cap_identifier ) * SkipSpace
                    * Q ":" * SkipSpace
                    * K ( 'Name.Type' , cap_identifier ) * SkipSpace
                ) ^ 0
              * Q ")"
          ) ^ -1
        *
          (
            Q "=" * SkipSpace
            * K ( 'Name.Module' , cap_identifier )  * SkipSpace
            * Q "("
            * K ( 'Name.Module' , cap_identifier ) * SkipSpace
              *
              (
                Q ","
                *
                K ( 'Name.Module' , cap_identifier ) * SkipSpace
              ) ^ 0
            * Q ")"
          ) ^ -1
    )
  +
  K ( 'Keyword' , P "include" + P "open" )
  * Space * K ( 'Name.Module' , cap_identifier )
```

The parameters of the types

```
local TypeParameter = K ( 'TypeParameter' , P "'" * alpha * # ( 1 - P "'" ) )
```

The main LPEG for the language OCaml First, the main loop :

```
MainOCaml =
       EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + Beamer
     + DetectedCommands
     + TypeParameter
     + String + QuotedString + Char
     + Comment
     + Delim
     + Operator
     + Punct
     + FromImport
     + Exception
     + DefFunction
     + DefModule
     + Record
     + Keyword * ( Space + Punct + Delim + EOL + -1 )
     + OperatorWord * ( Space + Punct + Delim + EOL + -1 )
     + Builtin * ( Space + Punct + Delim + EOL + -1 )
     + DotNotation
     + Constructor
     + Identifier
     + Number
     + Word

LoopOCaml = MainOCaml ^ 0

MainLoopOCaml =
  (  ( space^1 * -1 )
     + MainOCaml
  ) ^ 0
```

We recall that each line in the Python code to parse will be sent back to LaTeX between a pair \@@_begin_line: – \@@_end_line:[32].

```
local ocaml = P ( true )

ocaml =
  Ct (
       ( ( space - P "\r" ) ^0 * P "\r" ) ^ -1
       * BeamerBeginEnvironments
       * Lc ( '\\@@_begin_line:' )
       * SpaceIndentation ^ 0
       * MainLoopOCaml
       * -1
       * Lc ( '\\@@_end_line:' )
     )
languages['ocaml'] = ocaml
```

8.3.4 The LPEG for the language C

```
local Delim = Q ( S "{[()]}" )
```

```
local Punct = Q ( S ",:;!" )
```

[32] Remember that the \@@_end_line: must be explicit because it will be used as marker in order to delimit the argument of the command \@@_begin_line:

Some strings of length 2 are explicit because we want the corresponding ligatures available in some fonts such as *Fira Code* to be active.

```
local identifier = letter * alphanum ^ 0

local Operator =
  K ( 'Operator' ,
      P "!=" + P "==" + P "<<" + P ">>" + P "<=" + P ">="
      + P "||" + P "&&" + S "-~+/*%=<>&.@|!"
    )

local Keyword =
  K ( 'Keyword' ,
      P "alignas" + P "asm" + P "auto" + P "break" + P "case" + P "catch"
      + P "class" + P "const" + P "constexpr" + P "continue"
      + P "decltype" + P "do" + P "else" + P "enum" + P "extern"
      + P "for" + P "goto" + P "if" + P "nexcept" + P "private" + P "public"
      + P "register" + P "restricted" + P "return" + P "static" + P "static_assert"
      + P "struct" + P "switch" + P "thread_local" + P "throw" + P "try"
      + P "typedef" + P "union" + P "using" + P "virtual" + P "volatile"
      + P "while"
    )
  + K ( 'Keyword.Constant' ,
        P "default" + P "false" + P "NULL" + P "nullptr" + P "true"
      )

local Builtin =
  K ( 'Name.Builtin' ,
      P "alignof" + P "malloc" + P "printf" + P "scanf" + P "sizeof"
    )

local Type =
  K ( 'Name.Type' ,
      P "bool" + P "char" + P "char16_t" + P "char32_t" + P "double"
      + P "float" + P "int" + P "int8_t" + P "int16_t" + P "int32_t"
      + P "int64_t" + P "long" + P "short" + P "signed" + P "unsigned"
      + P "void" + P "wchar_t"
    )

local DefFunction =
  Type
  * Space
  * Q ( "*" ) ^ -1
  * K ( 'Name.Function.Internal' , identifier )
  * SkipSpace
  * # P "("
```

We remind that the marker # of LPEG specifies that the pattern will be detected but won't consume any character.

The following LPEG DefClass will be used to detect the definition of a new class (the name of that new class will be formatted with the piton style Name.Class).

Example: class myclass:

```
local DefClass =
  K ( 'Keyword' , P "class" ) * Space * K ( 'Name.Class' , identifier )
```

If the word class is not followed by a identifier, it will be catched as keyword by the LPEG Keyword (useful if we want to type a list of keywords).

The strings of C

```
local String =
  WithStyle ( 'String.Long' ,
      Q "\""
      * ( VisualSpace
          + K ( 'String.Interpol' ,
                P "%" * ( S "difcspxXou" + P "ld" + P "li" + P "hd" + P "hi" )
              )
          + Q ( ( P "\\\"" + 1 - S " \"" ) ^ 1 )
        ) ^ 0
      * Q "\""
    )
```

Beamer The following LPEG `balanced_braces` will be used for the (mandatory) argument of the commands `\only` and *al.* of Beamer. It's necessary to use a *grammar* because that pattern mainly checks the correct nesting of the delimiters (and it's known in the theory of formal languages that this can't be done with regular expressions *stricto sensu* only).

```
local balanced_braces =
  P { "E" ,
       E =
           (
             P "{" * V "E" * P "}"
             +
             String
             +
             ( 1 - S "{}" )
           ) ^ 0
    }
```

```
if piton_beamer
then
  Beamer =
      L ( P "\\pause" * ( P "[" * ( 1 - P "]" ) ^ 0 * P "]" ) ^ -1 )
    +
      Ct ( Cc "Open"
            * C (
                  (
                    P "\\uncover" + P "\\only" + P "\\alert" + P "\\visible"
                    + P "\\invisible" + P "\\action"
                  )
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopC:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )
    + OneBeamerEnvironment ( "uncoverenv" , MainLoopC )
    + OneBeamerEnvironment ( "onlyenv" , MainLoopC )
    + OneBeamerEnvironment ( "visibleenv" , MainLoopC )
    + OneBeamerEnvironment ( "invisibleenv" , MainLoopC )
    + OneBeamerEnvironment ( "alertenv" , MainLoopC )
    + OneBeamerEnvironment ( "actionenv" , MainLoopC )
    +
      L (
```

For `\\alt`, the specification of the overlays (between angular brackets) is mandatory.

```
          ( P "\\alt" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
    +
      L (
```

For \\temporal, the specification of the overlays (between angular brackets) is mandatory.

```
          ( P "\\temporal" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
end
```

```
DetectedCommands =
      Ct ( Cc "Open"
            * C (
                  piton.ListCommands
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopC:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )
```

EOL The following LPEG EOL is for the end of lines.

```
local EOL =
  P "\r"
  *
  (
    ( space^0 * -1 )
    +
```

We recall that each line in the Python code we have to parse will be sent back to LaTeX between a pair \@@_begin_line: – \@@_end_line:[33].

```
    Ct (
         Cc "EOL"
         *
         Ct (
              Lc "\\@@_end_line:"
              * BeamerEndEnvironments
              * BeamerBeginEnvironments
              * PromptHastyDetection
              * Lc "\\@@_newline: \\@@_begin_line:"
              * Prompt
            )
       )
  )
  *
  SpaceIndentation ^ 0
```

The directives of the preprocessor

```
local Preproc =
  K ( 'Preproc' , P "#" * (1 - P "\r" ) ^ 0  ) * ( EOL + -1 )
```

[33] Remember that the \@@_end_line: must be explicit because it will be used as marker in order to delimit the argument of the command \@@_begin_line:

The comments in the C listings We define different LPEG dealing with comments in the C listings.

```
local CommentMath =
  P "$" * K ( 'Comment.Math' , ( 1 - S "$\r" ) ^ 1  ) * P "$"

local Comment =
  WithStyle ( 'Comment' ,
     Q ( P "//" )
     * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0 )
  * ( EOL + -1 )

local LongComment =
  WithStyle ( 'Comment' ,
               Q ( P "/*" )
               * ( CommentMath + Q ( ( 1 - P "*/" - S "$\r" ) ^ 1 ) + EOL ) ^ 0
               * Q ( P "*/" )
            ) -- $
```

The following LPEG `CommentLaTeX` is for what is called in that document the “LaTeX comments”. Since the elements that will be catched must be sent to LaTeX with standard LaTeX catcodes, we put the capture (done by the function `C`) in a table (by using `Ct`, which is an alias for `lpeg.Ct`).

```
local CommentLaTeX =
  P(piton.comment_latex)
  * Lc "{\\PitonStyle{Comment.LaTeX}{\\ignorespaces"
  * L ( ( 1 - P "\r" ) ^ 0 )
  * Lc "}}"
  * ( EOL + -1 )
```

The main LPEG for the language C First, the main loop :

```
local MainC =
       EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + CommentLaTeX
     + Beamer
     + DetectedCommands
     + Preproc
     + Comment + LongComment
     + Delim
     + Operator
     + String
     + Punct
     + DefFunction
     + DefClass
     + Type * ( Q ( "*" ) ^ -1 + Space + Punct + Delim + EOL + -1 )
     + Keyword * ( Space + Punct + Delim + EOL + -1 )
     + Builtin * ( Space + Punct + Delim + EOL + -1 )
     + Identifier
     + Number
     + Word
```

Here, we must not put `local`!

```
MainLoopC =
  (  ( space^1 * -1 )
     + MainC
  ) ^ 0
```

We recall that each line in the C code to parse will be sent back to LaTeX between a pair `\@@_begin_line:` – `\@@_end_line:`[34].

```
languageC =
  Ct (
       ( ( space - P "\r" ) ^0 * P "\r" ) ^ -1
       * BeamerBeginEnvironments
       * Lc '\\@@_begin_line:'
       * SpaceIndentation ^ 0
       * MainLoopC
       * -1
       * Lc '\\@@_end_line:'
     )
```

```
languages['c'] = languageC
```

8.3.5 The LPEG language SQL

In the identifiers, we will be able to catch those contening spaces, that is to say like `"last name"`.

```
local identifier =
  letter * ( alphanum + P "-" ) ^ 0
  + P '"' * ( ( alphanum + space - P '"' ) ^ 1 ) * P '"'


local Operator =
  K ( 'Operator' ,
      P "=" + P "!=" + P "<>" + P ">=" + P ">" + P "<=" + P "<"  + S "*+/"
    )
```

In SQL, the keywords are case-insensitive. That's why we have a little complication. We will catch the keywords with the identifiers and, then, distinguish the keywords with a Lua function. However, some keywords will be catched in special LPEG because we want to detect the names of the SQL tables.

```
local function Set (list)
  local set = {}
  for _, l in ipairs(list) do set[l] = true end
  return set
end

local set_keywords = Set
 {
   "ADD" , "AFTER" , "ALL" , "ALTER" , "AND" , "AS" , "ASC" , "BETWEEN" , "BY" ,
   "CHANGE" , "COLUMN" , "CREATE" , "CROSS JOIN" , "DELETE" , "DESC" , "DISTINCT" ,
   "DROP" , "FROM" , "GROUP" , "HAVING" , "IN" , "INNER" , "INSERT" , "INTO" , "IS" ,
   "JOIN" , "LEFT" , "LIKE" , "LIMIT" , "MERGE" , "NOT" , "NULL" , "ON" , "OR" ,
   "ORDER" , "OVER" , "RIGHT" , "SELECT" , "SET" , "TABLE" , "THEN" , "TRUNCATE" ,
   "UNION" , "UPDATE" , "VALUES" , "WHEN" , "WHERE" , "WITH"
 }

local set_builtins = Set
 {
   "AVG" , "COUNT" , "CHAR_LENGHT" , "CONCAT" , "CURDATE" , "CURRENT_DATE" ,
   "DATE_FORMAT" , "DAY" , "LOWER" , "LTRIM" , "MAX" , "MIN" , "MONTH" , "NOW" ,
   "RANK" , "ROUND" , "RTRIM" , "SUBSTRING" , "SUM" , "UPPER" , "YEAR"
 }
```

The LPEG `Identifer` will catch the identifiers of the fields but also the keywords and the built-in functions of SQL. If will *not* catch the names of the SQL tables.

[34] Remember that the `\@@_end_line:` must be explicit because it will be used as marker in order to delimit the argument of the command `\@@_begin_line:`

```
local Identifier =
  C ( identifier ) /
  (
    function (s)
        if set_keywords[string.upper(s)] -- the keywords are case-insensitive in SQL
```

Remind that, in Lua, it's possible to return *several* values.

```
        then return { "{\\PitonStyle{Keyword}{" } ,
                    { luatexbase.catcodetables.other , s } ,
                    { "}}" }
        else if set_builtins[string.upper(s)]
             then return { "{\\PitonStyle{Name.Builtin}{" } ,
                         { luatexbase.catcodetables.other , s } ,
                         { "}}" }
             else return { "{\\PitonStyle{Name.Field}{" } ,
                         { luatexbase.catcodetables.other , s } ,
                         { "}}" }
             end
        end
    end
  )
```

The strings of SQL

```
local String =
  K ( 'String.Long' , P "'" * ( 1 - P "'" ) ^ 1 * P "'" )
```

Beamer The following LPEG `balanced_braces` will be used for the (mandatory) argument of the commands `\only` and *al.* of Beamer. It's necessary to use a *grammar* because that pattern mainly checks the correct nesting of the delimiters (and it's known in the theory of formal languages that this can't be done with regular expressions *stricto sensu* only).

```
local balanced_braces =
  P { "E" ,
       E =
           (
             P "{" * V "E" * P "}"
             +
             String
             +
             ( 1 - S "{}" )
           ) ^ 0
    }
```

```
if piton_beamer
then
  Beamer =
      L ( P "\\pause" * ( P "[" * ( 1 - P "]" ) ^ 0 * P "]" ) ^ -1 )
    +
      Ct ( Cc "Open"
            * C (
                  (
                    P "\\uncover" + P "\\only" + P "\\alert" + P "\\visible"
                    + P "\\invisible" + P "\\action"
                  )
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopSQL:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )
    + OneBeamerEnvironment ( "uncoverenv" , MainLoopSQL )
    + OneBeamerEnvironment ( "onlyenv" , MainLoopSQL )
    + OneBeamerEnvironment ( "visibleenv" , MainLoopSQL )
    + OneBeamerEnvironment ( "invisibleenv" , MainLoopSQL )
    + OneBeamerEnvironment ( "alertenv" , MainLoopSQL )
    + OneBeamerEnvironment ( "actionenv" , MainLoopSQL )
    +
      L (
```

For `\\alt`, the specification of the overlays (between angular brackets) is mandatory.

```
          ( P "\\alt" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
    +
      L (
```

For `\\temporal`, the specification of the overlays (between angular brackets) is mandatory.

```
          ( P "\\temporal" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
end
```

```
DetectedCommands =
      Ct ( Cc "Open"
            * C (
                  piton.ListCommands
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopSQL:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )
```

EOL The following LPEG `EOL` is for the end of lines.

```
local EOL =
  P "\r"
  *
  (
    ( space^0 * -1 )
    +
```

We recall that each line in the SQL code we have to parse will be sent back to LaTeX between a pair `\@@_begin_line:` – `\@@_end_line:`[35].

```
    Ct (
```

[35] Remember that the `\@@_end_line:` must be explicit because it will be used as marker in order to delimit the argument of the command `\@@_begin_line:`

```
         Cc "EOL"
         *
         Ct (
              Lc "\\@@_end_line:"
              * BeamerEndEnvironments
              * BeamerBeginEnvironments
              * Lc "\\@@_newline: \\@@_begin_line:"
            )
       )
  )
  *
  SpaceIndentation ^ 0
```

The comments in the SQL listings We define different LPEG dealing with comments in the SQL listings.

```
local CommentMath =
  P "$" * K ( 'Comment.Math' , ( 1 - S "$\r" ) ^ 1  ) * P "$"

local Comment =
  WithStyle ( 'Comment' ,
     Q ( P "--" )  -- syntax of SQL92
     * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0 )
  * ( EOL + -1 )

local LongComment =
  WithStyle ( 'Comment' ,
               Q ( P "/*" )
               * ( CommentMath + Q ( ( 1 - P "*/" - S "$\r" ) ^ 1 ) + EOL ) ^ 0
               * Q ( P "*/" )
            ) -- $
```

The following LPEG `CommentLaTeX` is for what is called in that document the “LaTeX comments”. Since the elements that will be catched must be sent to LaTeX with standard LaTeX catcodes, we put the capture (done by the function `C`) in a table (by using `Ct`, which is an alias for `lpeg.Ct`).

```
local CommentLaTeX =
  P(piton.comment_latex)
  * Lc "{\\PitonStyle{Comment.LaTeX}{\\ignorespaces"
  * L ( ( 1 - P "\r" ) ^ 0 )
  * Lc "}}"
  * ( EOL + -1 )
```

The main LPEG for the language SQL

```
local function LuaKeyword ( name )
return
   Lc ( "{\\PitonStyle{Keyword}{" )
   * Q ( Cmt (
               C ( identifier ) ,
               function(s,i,a) return string.upper(a) == name end
             )
       )
   * Lc ( "}}" )
end
```

```
local TableField =
     K ( 'Name.Table' , identifier )
     * Q ( P "." )
     * K ( 'Name.Field' , identifier )

local OneField =
  (
    Q ( P "(" * ( 1 - P ")" ) ^ 0 * P ")" )
    +
    K ( 'Name.Table' , identifier )
      * Q ( P "." )
      * K ( 'Name.Field' , identifier )
    +
    K ( 'Name.Field' , identifier )
  )
  * (
      Space * LuaKeyword ( "AS" ) * Space * K ( 'Name.Field' , identifier )
    ) ^ -1
  * ( Space * ( LuaKeyword ( "ASC" ) + LuaKeyword ( "DESC" ) ) ) ^ -1

local OneTable =
     K ( 'Name.Table' , identifier )
   * (
       Space
       * LuaKeyword ( "AS" )
       * Space
       * K ( 'Name.Table' , identifier )
     ) ^ -1

local WeCatchTableNames =
     LuaKeyword ( "FROM" )
   * ( Space + EOL )
   * OneTable * ( SkipSpace * Q ( P "," ) * SkipSpace * OneTable ) ^ 0
  + (
      LuaKeyword ( "JOIN" ) + LuaKeyword ( "INTO" ) + LuaKeyword ( "UPDATE" )
      + LuaKeyword ( "TABLE" )
    )
    * ( Space + EOL ) * OneTable
```

First, the main loop :

```
local MainSQL =
       EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + CommentLaTeX
     + Beamer
     + DetectedCommands
     + Comment + LongComment
     + Delim
     + Operator
     + String
     + Punct
     + WeCatchTableNames
     + ( TableField + Identifier ) * ( Space + Operator + Punct + Delim + EOL + -1 )
     + Number
     + Word
```

Here, we must not put `local`!

```
MainLoopSQL =
  (  ( space^1 * -1 )
     + MainSQL
  ) ^ 0
```

We recall that each line in the C code to parse will be sent back to LaTeX between a pair `\@@_begin_line:` – `\@@_end_line:`[36].

[36] Remember that the `\@@_end_line:` must be explicit because it will be used as marker in order to delimit the argument of the command `\@@_begin_line:`

```
languageSQL =
  Ct (
       ( ( space - P "\r" ) ^ 0 * P "\r" ) ^ -1
       * BeamerBeginEnvironments
       * Lc '\\@@_begin_line:'
       * SpaceIndentation ^ 0
       * MainLoopSQL
       * -1
       * Lc '\\@@_end_line:'
     )
languages['sql'] = languageSQL
```

8.3.6 The LPEG language Minimal

```
local CommentMath =
  P "$" * K ( 'Comment.Math' , ( 1 - S "$\r" ) ^ 1  ) * P "$"

local Comment =
  WithStyle ( 'Comment' ,
     Q ( P "#" )
     * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0 )
  * ( EOL + -1 )


local String =
  WithStyle ( 'String.Short' ,
      Q "\""
      * ( VisualSpace
          + Q ( ( P "\\\"" + 1 - S " \"" ) ^ 1 )
        ) ^ 0
      * Q "\""
    )


local balanced_braces =
  P { "E" ,
       E =
           (
             P "{" * V "E" * P "}"
             +
             String
             +
             ( 1 - S "{}" )
           ) ^ 0
    }

if piton_beamer
then
  Beamer =
      L ( P "\\pause" * ( P "[" * ( 1 - P "]" ) ^ 0 * P "]" ) ^ -1 )
    +
      Ct ( Cc "Open"
            * C (
                  (
                    P "\\uncover" + P "\\only" + P "\\alert" + P "\\visible"
                    + P "\\invisible" + P "\\action"
                  )
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopMinimal:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )
    + OneBeamerEnvironment ( "uncoverenv" , MainLoopMinimal )
    + OneBeamerEnvironment ( "onlyenv" , MainLoopMinimal )
    + OneBeamerEnvironment ( "visibleenv" , MainLoopMinimal )
    + OneBeamerEnvironment ( "invisibleenv" , MainLoopMinimal )
    + OneBeamerEnvironment ( "alertenv" , MainLoopMinimal )
    + OneBeamerEnvironment ( "actionenv" , MainLoopMinimal )
    +
      L (
          ( P "\\alt" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
    +
      L (
          ( P "\\temporal" )
          * P "<" * (1 - P ">") ^ 0 * P ">"
          * P "{"
        )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}{" )
      * K ( 'ParseAgain.noCR' , balanced_braces )
      * L ( P "}" )
end

DetectedCommands =
      Ct ( Cc "Open"
            * C (
                  piton.ListCommands
                  * ( P "<" * (1 - P ">") ^ 0 * P ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
         )
       * ( C ( balanced_braces ) / (function (s) return MainLoopMinimal:match(s) end ) )
       * P "}" * Ct ( Cc "Close" )

local EOL =
  P "\r"
  *
  (
    ( space^0 * -1 )
    +
    Ct (
         Cc "EOL"
         *
         Ct (
              Lc "\\@@_end_line:"
              * BeamerEndEnvironments
              * BeamerBeginEnvironments
              * Lc "\\@@_newline: \\@@_begin_line:"
            )
       )
  )
  *
  SpaceIndentation ^ 0

```

```
local CommentMath =
  P "$" * K ( 'Comment.Math' , ( 1 - S "$\r" ) ^ 1  ) * P "$" -- $

local CommentLaTeX =
  P(piton.comment_latex)
  * Lc "{\\PitonStyle{Comment.LaTeX}{\\ignorespaces"
  * L ( ( 1 - P "\r" ) ^ 0 )
  * Lc "}}"
  * ( EOL + -1 )

local identifier = letter * alphanum ^ 0

local Identifier = K ( 'Identifier' , identifier )

local MainMinimal =
       EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + CommentLaTeX
     + Beamer
     + DetectedCommands
     + Comment
     + Delim
     + String
     + Punct
     + Identifier
     + Number
     + Word

MainLoopMinimal =
  (  ( space^1 * -1 )
     + MainMinimal
  ) ^ 0

languageMinimal =
  Ct (
       ( ( space - P "\r" ) ^ 0 * P "\r" ) ^ -1
       * BeamerBeginEnvironments
       * Lc '\\@@_begin_line:'
       * SpaceIndentation ^ 0
       * MainLoopMinimal
       * -1
       * Lc '\\@@_end_line:'
     )
languages['minimal'] = languageMinimal

% \bigskip
% \subsubsection{The function Parse}
%
%
% The function |Parse| is the main function of the package \pkg{piton}. It
% parses its argument and sends back to LaTeX the code with interlaced
% formatting LaTeX instructions. In fact, everything is done by the
% \textsc{lpeg} corresponding to the considered language (|languages[language]|)
% which returns as capture a Lua table containing data to send to LaTeX.
%
% \bigskip
%    \begin{macrocode}
function piton.Parse(language,code)
  local t = languages[language] : match ( code )
  if t == nil
  then
```

```
    tex.sprint("\\PitonSyntaxError")
    return -- to exit in force the function
  end
  local left_stack = {}
  local right_stack = {}
  for _ , one_item in ipairs(t)
  do
     if one_item[1] == "EOL"
     then
          for _ , s in ipairs(right_stack)
            do tex.sprint(s)
            end
          for _ , s in ipairs(one_item[2])
            do tex.tprint(s)
            end
          for _ , s in ipairs(left_stack)
            do tex.sprint(s)
            end
     else
```

Here is an example of an item beginning with "Open".

```
{ "Open" , "\begin{uncover}<2>" , "\end{cover}" }
```

In order to deal with the ends of lines, we have to close the environment ({cover} in this example) at the end of each line and reopen it at the beginning of the new line. That's why we use two Lua stacks, called left_stack and right_stack. left_stack will be for the elements like \begin{uncover}<2> and right_stack will be for the elements like \end{cover}.

```
          if one_item[1] == "Open"
          then
               tex.sprint( one_item[2] )
               table.insert(left_stack,one_item[2])
               table.insert(right_stack,one_item[3])
          else
               if one_item[1] == "Close"
               then
                    tex.sprint( right_stack[#right_stack] )
                    left_stack[#left_stack] = nil
                    right_stack[#right_stack] = nil
               else
                    tex.tprint(one_item)
               end
          end
     end
  end
end
```

The function ParseFile will be used by the LaTeX command \PitonInputFile. That function merely reads the whole file (that is to say all its lines) and then apply the function Parse to the resulting Lua string.

```
function piton.ParseFile(language,name,first_line,last_line)
  local s = ''
  local i = 0
  for line in io.lines(name)
  do i = i + 1
     if i >= first_line
     then s = s .. '\r' .. line
     end
     if i >= last_line then break end
  end
```

We extract the BOM of utf-8, if present.

```
  if string.byte(s,1) == 13
  then if string.byte(s,2) == 239
       then if string.byte(s,3) == 187
            then if string.byte(s,4) == 191
```

```
                 then s = string.sub(s,5,-1)
                 end
            end
       end
  end
  piton.Parse(language,s)
end
```

8.3.7 Two variants of the function Parse with integrated preprocessors

The following command will be used by the user command `\piton`. For that command, we have to undo the duplication of the symbols `#`.

```
function piton.ParseBis(language,code)
  local s = ( Cs ( ( P '##' / '#' + 1 ) ^ 0 ) ) : match ( code )
  return piton.Parse(language,s)
end
```

The following command will be used when we have to parse some small chunks of code that have yet been parsed. They are re-scanned by LaTeX because it has been required by `\@@_piton:n` in the `piton` style of the syntaxic element. In that case, you have to remove the potential `\@@_breakable_space:` that have been inserted when the key `break-lines` is in force.

```
function piton.ParseTer(language,code)
  local s = ( Cs ( ( P '\\@@_breakable_space:' / ' ' + 1 ) ^ 0 ) )
            : match ( code )
  return piton.Parse(language,s)
end
```

8.3.8 Preprocessors of the function Parse for gobble

We deal now with preprocessors of the function `Parse` which are needed when the “gobble mechanism” is used.

The function `gobble` gobbles *n* characters on the left of the code. It uses a LPEG that we have to compute dynamically because if depends on the value of *n*.

```
local function gobble(n,code)
  function concat(acc,new_value)
    return acc .. new_value
  end
  if n==0
  then return code
  else
       return Cf (
                   Cc ( "" ) *
                   ( 1 - P "\r" ) ^ (-n)  * C ( ( 1 - P "\r" ) ^ 0 )
                     * ( C ( P "\r" )
                     * ( 1 - P "\r" ) ^ (-n)
                     * C ( ( 1 - P "\r" ) ^ 0 )
                    ) ^ 0 ,
                    concat
                 ) : match ( code )
  end
end
```

The following function `add` will be used in the following LPEG `AutoGobbleLPEG`, `TabsAutoGobbleLPEG` and `EnvGobbleLPEG`.

```
local function add(acc,new_value)
  return acc + new_value
end
```

The following LPEG returns as capture the minimal number of spaces at the beginning of the lines of code. The main work is done by two *fold captures* (`lpeg.Cf`), one using `add` and the other (encompassing the previous one) using `math.min` as folding operator.

```
local AutoGobbleLPEG =
    ( space ^ 0 * P "\r" ) ^ -1
    * Cf (
           (
```

We don't take into account the empty lines (with only spaces).

```
             ( P " " ) ^ 0 * P "\r"
             +
             Cf ( Cc(0) * ( P " " * Cc(1) ) ^ 0 , add )
             * ( 1 - P " " ) * ( 1 - P "\r" ) ^ 0 * P "\r"
           ) ^ 0
```

Now for the last line of the Python code...

```
           *
           ( Cf ( Cc(0) * ( P " " * Cc(1) ) ^ 0 , add )
           * ( 1 - P " " ) * ( 1 - P "\r" ) ^ 0 ) ^ -1 ,
           math.min
         )
```

The following LPEG is similar but works with the indentations.

```
local TabsAutoGobbleLPEG =
    ( space ^ 0 * P "\r" ) ^ -1
    * Cf (
           (
             ( P "\t" ) ^ 0 * P "\r"
             +
             Cf ( Cc(0) * ( P "\t" * Cc(1) ) ^ 0 , add )
             * ( 1 - P "\t" ) * ( 1 - P "\r" ) ^ 0 * P "\r"
           ) ^ 0
           *
           ( Cf ( Cc(0) * ( P "\t" * Cc(1) ) ^ 0 , add )
           * ( 1 - P "\t" ) * ( 1 - P "\r" ) ^ 0 ) ^ -1 ,
           math.min
         )
```

The following LPEG returns as capture the number of spaces at the last line, that is to say before the `\end{Piton}` (and usually it's also the number of spaces before the corresponding `\begin{Piton}` because that's the traditionnal way to indent in LaTeX). The main work is done by a *fold capture* (`lpeg.Cf`) using the function `add` as folding operator.

```
local EnvGobbleLPEG =
  ( ( 1 - P "\r" ) ^ 0 * P "\r" ) ^ 0
    * Cf ( Cc(0) * ( P " " * Cc(1) ) ^ 0 , add ) * -1
```

```
function piton.GobbleParse(language,n,code)
  if n==-1
  then n = AutoGobbleLPEG : match(code)
  else if n==-2
       then n = EnvGobbleLPEG : match(code)
       else if n==-3
            then n = TabsAutoGobbleLPEG : match(code)
            end
       end
  end
  piton.Parse(language,gobble(n,code))
  if piton.write ~= ''
  then local file = assert(io.open(piton.write,piton.write_mode))
       file:write(code)
       file:close()
  end
end
```

8.3.9 To count the number of lines

```
function piton.CountLines(code)
  local count = 0
  for i in code : gmatch ( "\r" ) do count = count + 1 end
  tex.sprint(
      luatexbase.catcodetables.expl ,
      '\\int_set:Nn \\l_@@_nb_lines_int {' .. count .. '}' )
end
```

```
function piton.CountNonEmptyLines(code)
  local count = 0
  count =
  ( Cf (  Cc(0) *
          (
            ( P " " ) ^ 0 * P "\r"
            + ( 1 - P "\r" ) ^ 0 * P "\r" * Cc(1)
          ) ^ 0
          * (1 - P "\r" ) ^ 0 ,
         add
       ) * -1 ) : match (code)
  tex.sprint(
      luatexbase.catcodetables.expl ,
      '\\int_set:Nn \\l_@@_nb_non_empty_lines_int {' .. count .. '}' )
end
```

```
function piton.CountLinesFile(name)
  local count = 0
  io.open(name) -- added
  for line in io.lines(name) do count = count + 1 end
  tex.sprint(
      luatexbase.catcodetables.expl ,
      '\\int_set:Nn \\l_@@_nb_lines_int {' .. count .. '}' )
end
```

```
function piton.CountNonEmptyLinesFile(name)
  local count = 0
  for line in io.lines(name)
  do if not ( ( ( P " " ) ^ 0 * -1 ) : match ( line ) )
     then count = count + 1
     end
  end
  tex.sprint(
      luatexbase.catcodetables.expl ,
      '\\int_set:Nn \\l_@@_nb_non_empty_lines_int {' .. count .. '}' )
end
```

The following function stores in `\l_@@_first_line_int` and `\l_@@_last_line_int` the numbers of lines of the file `file_name` corresponding to the strings `marker_beginning` and `marker_end`.

```
function piton.ComputeRange(marker_beginning,marker_end,file_name)
  local s = ( Cs ( ( P '##' / '#' + 1 ) ^ 0 ) ) : match ( marker_beginning )
  local t = ( Cs ( ( P '##' / '#' + 1 ) ^ 0 ) ) : match ( marker_end )
  local first_line = -1
  local count = 0
  local last_found = false
  for line in io.lines(file_name)
  do if first_line == -1
     then if string.sub(line,1,#s) == s
          then first_line = count
          end
     else if string.sub(line,1,#t) == t
          then last_found = true
```

```
               break
          end
     end
     count = count + 1
  end
  if first_line == -1
  then tex.sprint("\\PitonBeginMarkerNotFound")
  else if last_found == false
       then tex.sprint("\\PitonEndMarkerNotFound")
       end
  end
  tex.sprint(
      luatexbase.catcodetables.expl ,
      '\\int_set:Nn \\l_@@_first_line_int {' .. first_line .. ' + 2 }'
      .. '\\int_set:Nn \\l_@@_last_line_int {' .. count .. ' }' )
end
⟨/LUA⟩
```

9 History

The successive versions of the file `piton.sty` provided by TeXLive are available on the SVN server of TeXLive:

`https://tug.org/svn/texlive/trunk/Master/texmf-dist/tex/lualatex/piton/piton.sty`

The development of the extension piton is done on the following GitHub repository:
`https://github.com/fpantigny/piton`

Changes between versions 2.3 and 2.4

The key `identifiers` of the command `\PitonOptions` is now deprecated and replaced by the new command `\SetPitonIdentifier`.
A new special language called “minimal” has been added.
New key `detected-commands`.

Changes between versions 2.2 and 2.3

New key `detected-commands`
The variable `\l_piton_language_str` is now public.

Changes between versions 2.2 and 2.3

New key `write`.

Changes between versions 2.1 and 2.2

New key `path` for `\PitonOptions`.
New language SQL.
It’s now possible to define styles locally to a given language (with the optional argument of `\SetPitonStyle`).

Changes between versions 2.0 and 2.1

The key `line-numbers` has now subkeys `line-numbers/skip-empty-lines`, `line-numbers/label-empty-lines`, etc.
The key `all-line-numbers` is deprecated: use `line-numbers/skip-empty-lines=false`.
New system to import, with `\PitonInputFile`, only a part (of the file) delimited by textual markers.
New keys `begin-escape`, `end-escape`, `begin-escape-math` and `end-escape-math`.
The key `escape-inside` is deprecated: use `begin-escape` and `end-escape`.

Changes between versions 1.6 and 2.0

The extension `piton` nows supports the computer languages OCaml and C (and, of course, Python).

Changes between versions 1.5 and 1.6

New key `width` (for the total width of the listing).
New style `UserFunction` to format the names of the Python functions previously defined by the user.
Command `\PitonClearUserFunctions` to clear the list of such functions names.

Changes between versions 1.4 and 1.5

New key `numbers-sep`.

Changes between versions 1.3 and 1.4

New key `identifiers` in `\PitonOptions`.
New command `\PitonStyle`.
`background-color` now accepts as value a *list* of colors.

Changes between versions 1.2 and 1.3

When the class Beamer is used, the environment `{Piton}` and the command `\PitonInputFile` are "overlay-aware" (that is to say, they accept a specification of overlays between angular brackets).
New key `prompt-background-color`
It's now possible to use the command `\label` to reference a line of code in an environment `{Piton}`.
A new command `\␣` is available in the argument of the command `\piton{...}` to insert a space (otherwise, several spaces are replaced by a single space).

Changes between versions 1.1 and 1.2

New keys `break-lines-in-piton` and `break-lines-in-Piton`.
New key `show-spaces-in-string` and modification of the key `show-spaces`.
When the class `beamer` is used, the environements `{uncoverenv}`, `{onlyenv}`, `{visibleenv}` and `{invisibleenv}`

Changes between versions 1.0 and 1.1

The extension `piton` detects the class `beamer` and activates the commands `\action`, `\alert`, `\invisible`, `\only`, `\uncover` and `\visible` in the environments `{Piton}` when the class `beamer` is used.

Changes between versions 0.99 and 1.0

New key `tabs-auto-gobble`.

Changes between versions 0.95 and 0.99

New key `break-lines` to allow breaks of the lines of code (and other keys to customize the appearance).

Changes between versions 0.9 and 0.95

New key `show-spaces`.
The key `left-margin` now accepts the special value `auto`.
New key `latex-comment` at load-time and replacement of `##` by `#>`
New key `math-comments` at load-time.
New keys `first-line` and `last-line` for the command `\InputPitonFile`.

Changes between versions 0.8 and 0.9

New key `tab-size`.
Integer value for the key `splittable`.

Changes between versions 0.7 and 0.8

New keys `footnote` and `footnotehyper` at load-time.
New key `left-margin`.

Changes between versions 0.6 and 0.7

New keys `resume`, `splittable` and `background-color` in `\PitonOptions`.
The file `piton.lua` has been embedded in the file `piton.sty`. That means that the extension `piton` is now entirely contained in the file `piton.sty`.

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