
tabel Documentation

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Contents:

1	About Tabel	3
1.1	Design objectives	3
2	Install	5
3	Quickstart	7
3.1	init	7
3.2	slice	7
3.3	set	8
3.4	append Tabel and row	9
3.5	instance properties	9
3.6	pandas	10
4	Resources & getting help	11
5	Stable releases	13
6	Dependencies	15
6.1	Tested on:	15
7	Contributing to Tabel	17
8	Contributors	19
9	What's in the name?	21
10	ToDo	23
11	Performance	25
11.1	slicing tables	26
11.2	appending rows	26
11.3	grouping tables	27
11.4	joining tables	28
12	Cookbook	29
12.1	Initialization	29
12.2	Slicing	30
12.3	Setting	32

12.4	Referencing	32
12.5	Appending	33
12.5.1	Appending Tabel	33
12.5.2	Appending row	34
12.5.3	Appending column	34
12.6	Changing column names	35
12.7	Transposing	35
12.8	Group By	36
12.9	Sorting	36
12.10	Joining	37
12.11	Saving	37
12.12	Reading	38
13	API Reference	39
13.1	tabel module	39
13.1.1	transpose	39
13.1.2	read_tabel	39
13.1.3	first	40
13.2	class Tabel	40
13.2.1	getter	41
13.2.2	setter	42
13.2.3	repr	43
13.2.4	append	43
13.2.5	row_append	44
13.2.6	join	44
13.2.7	group_by	45
13.2.8	sort	45
13.2.9	astype	46
13.2.10	save	46
13.2.11	properties	47
13.2.11.1	dict	47
13.2.11.2	shape	47
13.2.11.3	len	47
13.2.11.4	dtype	47
13.2.11.5	valid	47
13.2.12	class attributes	47
14	license	49
15	Indices and tables	51
	Python Module Index	53
	Index	55

Tabel provides a lightweight and intuitive object for data tables, two dimensional tables with rows and columns. Based on Numpy, therefore fast and seamless integration with all the popular data tools.

Lightweight, intuitive and fast data-tables.

Tabel data-tables are tables with columns and column names, rows and row numbers. Indexing and slicing your data is analogous to numpy array's. The only real difference is that each column can have its own data type.

1.1 Design objectives

I got frustrated with pandas: it's complicated slicing syntax (.loc, .x, .iloc, .. etc), it's enforced index column and the Series objects I get when I want a numpy array. With Tabel I created the simplified pandas I need for many of my data-jobs. Just focussing on simple slicing of multi-datatype tables and basic table tools.

- Intuitive simple slicing.
- Using numpy machinery, for best performance, integration with other tools and future support.
- Store data by column numpy arrays (column store).
- No particular index column, all columns can be used as the index, the choice is up to the user.
- Fundamental necessities for sorting, grouping, joining and appending tables.

CHAPTER 2

Install

`pip install tabel`

3.1 init

To setup a Tabel:

```
>>> from tabel import Tabel
>>> tbl = Tabel([ ["John", "Joe", "Jane"],
...               [1.82, 1.65, 2.15],
...               [False, False, True]], columns = ["Name", "Height", "Married"])
>>> tbl
```

Name	Height	Married
John	1.82	0
Joe	1.65	0
Jane	2.15	1

```
3 rows ['<U4', '<f8', '|b1']
```

Alternatively, Tabels can be setup from dictionaries, numpy arrays, pandas DataFrames, or no data at all. Database connectors usually return data as a list of records, the module provides a convenience function to transpose this into a list of columns.

3.2 slice

Slicing can be done the numpy way, always returning Tabel objects:

```
>>> tbl[1:3, [0, 2]]
```

Name	Married
Joe	0
Jane	1

```
2 rows ['<U4', '|b1']
```

Slices will always return a Table except in three distinct cases, when:

1. explicitly one column is requested, a numpy array is returned:

```
>>> tbl[1:3, 'Name']          # doctest: +SKIP
array(['Joe', 'Jane'],
      dtype='<U4')
```

2. explicitly one row is requested, a tuple is returned:

```
>>> tbl[0, :]
('John', 1.82, False)
```

3. explicitly one element is requested:

```
>>> tbl[0, 'Name']
'John'
```

In general, slicing is intuitive and does not deviate from what would expect from numpy. With the one addition that columns can be referred to by names as well as numbers.

3.3 set

Setting elements works the same as slicing:

```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15],
↳ 'Married': [False,False,True]})
>>> tbl[0, "Name"] = "Jos"
>>> tbl
```

Name	Height	Married
Jos	1.82	0
Joe	1.65	0
Jane	2.15	1

```
3 rows ['<U4', '<f8', '|b1']
```

The datatype that the value is expected to have, is the same as the datatype a slice would result into.

Adding columns, works the same as setting elements, just give it a new name:

```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15],
↳ 'Married': [False,False,True]})
>>> tbl['new'] = [1,2,3]
>>> tbl
```

Name	Height	Married	new
John	1.82	0	1
Joe	1.65	0	2
Jane	2.15	1	3

```
3 rows ['<U4', '<f8', '|b1', '<i8']
```

Or set the whole column to the same value:

```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15],
↳ 'Married': [False,False,True]})
>>> tbl['new'] = 13
```

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```
>>> tbl
Name | Height | Married | new
-----+-----+-----+-----
John | 1.82 | 0 | 13
Joe | 1.65 | 0 | 13
Jane | 2.15 | 1 | 13
3 rows ['<U4', '<f8', '|b1', '<i8']
```

Just like numpy, slices are not actual copies of the data, rather they are references.

3.4 append Tabel and row

Tables can be appended with other Tables:

```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15],
↳ 'Married': [False,False,True]})
>>> tbl += tbl
>>> tbl
Name | Height | Married
-----+-----+-----
John | 1.82 | 0
Joe | 1.65 | 0
Jane | 2.15 | 1
John | 1.82 | 0
Joe | 1.65 | 0
Jane | 2.15 | 1
6 rows ['<U4', '<f8', '|b1']
```

Or append rows as dictionary:

```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15],
↳ 'Married': [False,False,True]})
>>> tbl.row_append({'Height':1.81, 'Name':"Jack", 'Married':True})
>>> tbl
Name | Height | Married
-----+-----+-----
John | 1.82 | 0
Joe | 1.65 | 0
Jane | 2.15 | 1
Jack | 1.81 | 1
4 rows ['<U4', '<f8', '|b1']
```

3.5 instance properties

Your data is simply stored as a list of numpy arrays and can be accessed or manipulated like that (just don't make a mess):

```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15],
↳ 'Married': [False,False,True]})
>>> tbl.columns
['Name', 'Height', 'Married']
>>> tbl.data # doctest: +SKIP
```

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```
[array(['John', 'Joe', 'Jane'],
      dtype='<U4'), array([ 1.82,  1.65,  2.15]), array([False, False,  True],
      dtype=bool)]
```

Further the basic means to asses the size of your data:

```
>>> tbl.shape
(3, 3)
>>> len(tbl)
3
```

3.6 pandas

For for interfacing with the popular datatable framework, going back and forth is easy:

```
>>> import pandas as pd
>>> df = pd.DataFrame({'a':range(3), 'b':range(10,13)})
>>> df
   a  b
0  0 10
1  1 11
2  2 12
```

To make a Tabel from a DataFrame, just supply it to the initialize:

```
>>> tbl = Tabel(df)
>>> tbl
   a |  b
-----+-----
  0 | 10
  1 | 11
  2 | 12
3 rows ['<i8', '<i8']
```

The dict property of Tabel provides a way to make a DataFrame from a Tabel:

```
>>> df = pd.DataFrame(tbl.dict)
>>> df
   a  b
0  0 10
1  1 11
2  2 12
```

CHAPTER 4

Resources & getting help

- See for the full API and more examples the documentation on [RTD](#).
- The repository on [Github](#).
- Installables on [pip](#).
- Questions and answers on [StackOverflow](#), I will try to monitor for it.

CHAPTER 5

Stable releases

- tabel 1.2.2
 - Added argument to save and read methods for csv and gz formats to specify whether or not to write/read a header with the column names. For reading header can be left to None for automatic sniffing of the header. Default is True for both read and save methods.
- tabel 1.2.1
 - Removed unicode characters from description to fix pip install *issue* <<https://github.com/BastiaanBergman/tabel/issues/6#issue-440282452>>.
- tabel 1.2.0
 - Fix for numpy 1.15.5 “warnings”
 - Fix for outerjoin to raise an error in case of unsupported datatypes
- tabel 1.1
 - Added join and group_by methods
 - September 27, 2018
- tabel 1.0
 - First release
 - September 8, 2018

Dependencies

- numpy
- tabulate (optional, recommended)
- pandas (optional, for converting back and forth to DataFrames)

6.1 Tested on:

- Python 3.6.4; numpy 1.15.4
- Python 3.6.4; numpy 1.14.3
- Python 2.7.14; numpy 1.14.0

Contributing to Tabel

Tabel is perfect already, no more contributions needed. Just kidding!

See the repository for filing issues and proposing enhancements.

I'm using pytest, pylint, doctest, sphinx and setuptools.

- **pytest**

```
cd tabel/test
conda activate py3_6
pytest
conda activate py2_7
pytest
```

- **pylint**

```
cd tabel/
./pylint.sh
```

- **doctest**

```
cd tabel/docs
make doctest
```

- **sphinx**

```
cd tabel/docs
make html
```

- **setuptools/pypi**

```
python setup.py sdist bdist_wheel
twine upload dist/tabel-1.1.0.*
```


CHAPTER 8

Contributors

Just me, Bastiaan Bergman [Bastiaan.Bergman@gmail.com].

CHAPTER 9

What's in the name?

Tabel is Dutch for table (two-dimensional enlisting), [wiktionary](#). The english word table, as in “dinner table”, translates in Dutch to *tafel*. The Dutch word *tafel* is an old fashioned word for data-table, mostly used for calculation tables which itself is old fashioned as well.

CHAPTER 10

ToDo

- polish error messages and validity checking and add testing for it.
- cache buffers for faster appending: store temp in list and concatenate to array only once we use another method
- allow for (sparse) numpy arrays as an element
- adjust & limit `__repr__` width for very wide Tabela in jupyter cell
- `items()` and `row_items()` and `keys()` and `values()` method
- `pop_column` method
- tox - environment testing
- set subsets of Tabela with (subsets) of other Tabela, seems logic as `__setitem__` is allowed to provide the datatype that should have come from a `__getitem__`
- datetime column support
- add disk datalogger

Performance

Tabel is designed for those cases where you have data of multiple types, like records in a database, where the volume is small enough to fit it all in memory and high freedom of data manipulation is needed. Use Tabel when the following conditions are met:

- Multiple columns with different datatypes each
- Fields in a row have a shared relation (e.g. records in a database)
- All data fits in memory
- Only few and relatively simple SQL queries are needed
- A large proportion of the data is numeric and would need column-wise arithmetic
- Data manipulation requires complex (computed) slicing across both dimensions (rows and columns)

If the above conditions are not met, consider these alternatives:

- numpy - if your data is purely numerical or when fields in a row have no relation.
- HDF5 - if your data does not fit in memory
- SQLite or MySQL - if you need complex DB queries (e.g. transactional)

That said, good general performance is paramount. Here below are some tests to give an rough overview of where Tabel stands relative to pandas.

To do the tests, a few tools are needed:

```
>>> import numpy as np
>>> import pandas as pd
>>> from tabel import Tabel
>>> from timeit import default_timer
```

11.1 slicing tables

As Tabel is based on numpy, this is where it is good at. I think slicing syntax is both clean and fast (about 15x faster than pandas in the below tests).

First slicing test is to get a whole row from a large table. The return value should be a tuple from Tabel, pandas produces an object array which I believe is not very efficient as columns usually have different datatypes. Tabel is about 43x faster in this particular case:

```
>>> n = 1000000
>>> data_dict = {'a':[1,2,3,4] * n, 'b':['a1','a2']*2*n, 'c':np.arange(4*n)}
>>> df = pd.DataFrame(data_dict)
>>> tbl = Tabel(data_dict)
>>> def test_pandas_slice(n):
...     t0 = default_timer()
...     for i in range(n):
...         _ = df.iloc[100].values
...     return (default_timer() - t0)/n*1e6, "micro-sec"
>>> test_pandas_slice(100000) # doctest: +SKIP
(130.62096348032355, 'micro-sec')
>>> def test_tabel_slice(n):
...     t0 = default_timer()
...     for i in range(n):
...         _ = tbl[100]
...     return (default_timer() - t0)/n*1e6, "micro-sec"
>>> test_tabel_slice(100000) # doctest: +SKIP
(3.045091559179127, 'micro-sec')
```

Second slicing test is to get a number of rows from one particular column, the return value should be an array. Tabel is about 15x faster in this case:

```
>>> def test_pandas_slice(n):
...     t0 = default_timer()
...     for i in range(n):
...         _ = df['a'][1:10].values
...     return (default_timer() - t0)/n*1e6, "micro-sec"
>>> test_pandas_slice(100000) # doctest: +SKIP
(63.41531826881692, 'micro-sec')
>>> def test_tabel_slice(n):
...     t0 = default_timer()
...     for i in range(n):
...         _ = tbl[1:10, 'a']
...     return (default_timer() - t0)/n*1e6, "micro-sec"
>>> test_tabel_slice(100000) # doctest: +SKIP
(4.007692479062825, 'micro-sec')
```

11.2 appending rows

I find myself often doing something similar to the following procedure:

```
>>> for i in large_number: # doctest: +SKIP
...     row = calculate_something()
...     tbl.append(row)
```

where “do something” could be reading some tricky formatted ascii file or calculating the position of the stars, it

doesn't matter. The point is, appending data is never a very efficient thing to do, memory needs to be reserved, all values need to be re-evaluated for type setting and then all data gets copied over to the new location. Still I prefer this over more efficient methods as it keeps my code clean and simple.

I expect bad performance for both Tabel and pandas, but a simple test shows that pandas is doing a bit worse. If we repeatedly add a simple row of two integers to a pandas DataFrame we'll use about 300 micro-second per row:

```
>>> import pandas as pd
>>> from tabel import Tabel
>>> from timeit import default_timer
>>> df = pd.DataFrame({'1':[], '2':[]})
>>> row = pd.DataFrame({'1':[1], '2':[2]})
>>> def test_pandas(n):
...     t0 = default_timer()
...     for i in range(n):
...         df.append(row, ignore_index=True)
...     return (default_timer() - t0)/n*1e6, "micro-sec"
>>> test_pandas(100000)                                     # doctest: +SKIP
(299.0699630905874, 'micro-sec')
```

The same exercise with Tabel's `tabel.Tabel.row_append` method takes only a quarter of that time:

```
>>> tbl = Tabel()
>>> row = (1, 2)
>>> def test_tabel(n):
...     t0 = default_timer()
...     for i in range(n):
...         tbl.row_append(row)
...     return (default_timer() - t0)/n*1e6, "micro-sec"
>>> test_tabel(100000)                                       # doctest: +SKIP
(79.83603572938591, 'micro-sec')
```

Granted, there are very many different scenarios thinkable and there probably are scenarios where pandas would outperform Tabel. If you come across one of those please let me know and I happily add it here.

11.3 grouping tables

A big Tabel with a million rows can be grouped by multiple columns. Both pandas and Tabel take a good amount of time on this, but then this is typically done once on a an individual Tabel or DataFrame. pandas is about 10x faster than Tabel on this simple test. The good news is that this is independent of n, meaning they're both equally scalable.

```
>>> n = 100000
>>> data_dict = {'a':[1,2,3,4] * n, 'b':['a1','a2']*2*n, 'c':np.arange(4*n)}
>>> df = pd.DataFrame(data_dict)
>>> def test_pandas_groupby(n):
...     t0 = default_timer()
...     for i in range(n):
...         _ = df.groupby(('a', 'b')).sum()
...     return (default_timer() - t0)/n*1e3, "mili-sec"
>>> test_pandas_groupby(10)                                   # doctest: +SKIP
(34.32465291116387, 'mili-sec')
>>> tbl = Tabel(data_dict)
>>> def test_tabel_groupby(n):
...     t0 = default_timer()
...     for i in range(n):
...         _ = tbl.group_by(('b', 'a'), [(np.sum, 'c')])
```

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```
...     return (default_timer() - t0)/n*1e3, "mili-sec"
>>> test_tabel_groupby(10)                                # doctest: +SKIP
(322.54316059406847, 'mili-sec')
```

11.4 joining tables

Two Tabela can be joined together by some common key present in both Tabela. Two table with a million rows takes about 2.5 second to be joined with pandas and 5 times that with Tabela, this ratio reduces somewhat with n. See the codeblock below for the specific case tested here.

```
>>> n = 1000000
>>> data_dict = {'a':[1,2,3,4] * n, 'b':['a1','a2']*2*n, 'c':np.arange(4*n)}
>>> df_1 = pd.DataFrame(data_dict)
>>> df_2 = pd.DataFrame(data_dict)
>>> def test_pandas_join():
...     t0 = default_timer()
...     _ = df_1.join(df_2, on='c', how='inner', lsuffix='l', rsuffix='r')
...     return (default_timer() - t0)*1e3, "mili-sec"
>>> test_pandas_join()                                    # doctest: +SKIP
(2462.8482228145003, 'mili-sec')
>>> tbl_1 = Tabela(data_dict)
>>> tbl_2 = Tabela(data_dict)
>>> def test_tabel_join():
...     t0 = default_timer()
...     _ = tbl_1.join(tbl_2, key='c', jointype='inner')
...     return (default_timer() - t0)*1e3, "mili-sec"
>>> test_tabel_join()                                    # doctest: +SKIP
(10393.40596087277, 'mili-sec')
```


12.1 Initialization

API documentation: `tabel.Tabel`.

From a list of lists and a separate list of column names:

```
>>> from tabel import Tabel
>>> tbl = Tabel([ ["John", "Joe", "Jane"],
...               [1.82, 1.65, 2.15],
...               [False, False, True]], columns = ["Name", "Height", "Married"])
>>> tbl
```

Name	Height	Married
John	1.82	0
Joe	1.65	0
Jane	2.15	1

```
3 rows ['<U4', '<f8', '|b1']
```

From a dictionary:

```
>>> data = {'Name' : ["John", "Joe", "Jane"],
...         'Height' : [1.82, 1.65, 2.15],
...         'Married': [False, False, True]}
>>> tbl = Tabel(data)
>>> tbl
```

Name	Height	Married
John	1.82	0
Joe	1.65	0
Jane	2.15	1

```
3 rows ['<U4', '<f8', '|b1']
```

From numpy arrays:

```
>>> Tabel([np.array(["John", "Joe", "Jane"]),
...         np.array([1.82, 1.65, 2.15]),
...         np.array([False, False, True])])
0      |      1      |      2
-----+-----+-----
John   |  1.82   |      0
Joe    |  1.65   |      0
Jane   |  2.15   |      1
3 rows ['<U4', '<f8', '|b1']
```

Or initialize an empty Tabel:

```
>>> tbl = Tabel()
>>> tbl
<BLANKLINE>
0 rows []
>>> len(tbl), tbl.shape
(0, (0, 0))
```

12.2 Slicing

API documentation: [tabel.Tabel.__getitem__](#).

See the API reference for a detailed description: [Tabel.__getitem__](#).

Some common examples:

```
>>> tbl = Tabel([ ["John", "Joe", "Jane"],
...               [1.82, 1.65, 2.15],
...               [False, False, True]], columns = ["Name", "Height", "Married"])
>>> tbl
Name    |      Height |      Married
-----+-----+-----
John    |      1.82   |              0
Joe     |      1.65   |              0
Jane    |      2.15   |              1
3 rows ['<U4', '<f8', '|b1']
```

Slicing works on both rows and columns:

```
>>> tbl[:, 1:3]
      Height |      Married
-----+-----
      1.82 |              0
      1.65 |              0
      2.15 |              1
3 rows ['<f8', '|b1']
```

Indexing:

```
>>> tbl[[1, 2], [0, 2]]
Name    |      Married
-----+-----
Joe     |              0
Jane    |              1
2 rows ['<U4', '|b1']
```

Using named columns:

```
>>> tbl[:, ['Name', 'Married']]
Name | Married
-----+-----
John |      0
Joe  |      0
Jane |      1
3 rows ['<U4', '|b1']
```

the “:” can be left out, if you’re addressing columns by their names:

```
>>> tbl[:, ['Name', 'Married']]
Name | Married
-----+-----
John |      0
Joe  |      0
Jane |      1
3 rows ['<U4', '|b1']
```

Indexing using boolean array’s:

```
>>> index = ~tbl[:, 'Married']
>>> tbl[index, :]
Name | Height | Married
-----+-----+-----
John |    1.82 |      0
Joe  |    1.65 |      0
2 rows ['<U4', '<f8', '|b1']
```

(The “:” can be omitted for columns as well)

If a single index is given for the row or column position, the returned datatype is a row (tuple) or column (array) instead of Tabel:

```
>>> tbl['Married']
array([False, False,  True])
>>> tbl[1:2, 'Married']
array([False])
```

In all other cases the returned datatype is Tabel, including lists of length one:

```
>>> tbl[:, ['Married']]
Married
-----
      0
      0
      1
3 rows ['|b1']
```

Equally so for rows:

```
>>> tbl[2]
('Jane', 2.15, True)
>>> tbl[2, 1:3]
(2.15, True)
```

Finally, single elements are obtained by individually addressing them:

```
>>> tbl[0, "Name"]
'John'
```

12.3 Setting

API documentation: `label.Tabel.__setitem__`.

There is an detailed description in the API documentation: `label.Tabel.__setitem__`. Generally, one just provides the datatype and shape that would have come from the equivalent get call:

Set a single element:

```
>>> tbl[0, "Name"] = "Jos"
>>> tbl
  Name | Height | Married
-----+-----+-----
  Jos  |    1.82 |         0
  Joe  |    1.65 |         0
  Jane |    2.15 |         1
3 rows ['<U4', '<f8', '|b1']
```

Set (part of) a column:

```
>>> tbl[0:2, 1] = np.array([2, 3])
>>> tbl
  Name | Height | Married
-----+-----+-----
  Jos  |      2 |         0
  Joe  |      3 |         0
  Jane |    2.15 |         1
3 rows ['<U4', '<f8', '|b1']
```

Set (part of) a single row:

```
>>> tbl[0] = ["John", 1.333, 0]
>>> tbl
  Name | Height | Married
-----+-----+-----
  John |    1.333 |         0
  Joe  |      3 |         0
  Jane |    2.15 |         1
3 rows ['<U4', '<f8', '|b1']
```

12.4 Referencing

Slices are references, Slices return new table objects, but their data always refers back to the original one as long as that remains in existence. Exceptions are:

- New initialization of Tabel objects copy the data
- Boolean or integer indexing of *rows* returns a Tabel object with copied data

To show, take a slice from *tbl*, modify its first columns, check out the original *tbl*:

```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15],
↳'Married': [False,False,True]})
>>> tbl_b = tbl[:,[1,2]]
>>> tbl_b[:,0] = [1.3,1.4,1.5]
>>> tbl
  Name |      Height |      Married
-----+-----+-----
  John |         1.3 |           0
   Joe |         1.4 |           0
   Jane |         1.5 |           1
3 rows ['<U4', '<f8', '|b1']
```

Column arrays are references too, with the same exceptions as slices. Therefore the standard numpy arithmetic can be used:

```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15],
↳'Married': [False,False,True]})
>>> tbl["Height"] *= 2
>>> tbl
  Name |      Height |      Married
-----+-----+-----
  John |         3.64 |           0
   Joe |         3.3 |           0
   Jane |         4.3 |           1
3 rows ['<U4', '<f8', '|b1']
```

12.5 Appending

12.5.1 Appending Tabel

API documentation: [tabel.Tabel.append](#).

Tables can be appended with their append method:

```
>>> tbl = Tabel([ ["John", "Joe", "Jane"],
...               [1.82,1.65,2.15],
...               [False,False,True]], columns = ["Name", "Height", "Married"])
>>> tblb = Tabel([["Bas"],[2.01],[True]], columns=["Name", "Height", "Married"])
>>> tbl.append(tblb)
>>> tbl
  Name |      Height |      Married
-----+-----+-----
  John |         1.82 |           0
   Joe |         1.65 |           0
   Jane |         2.15 |           1
   Bas |         2.01 |           1
4 rows ['<U4', '<f8', '|b1']
```

or using the “+=” syntax:

```
>>> tblb = Tabel([["Bas"],[2.01],[True]], columns=["Name", "Height", "Married"])
>>> tbl = Tabel([ ["John", "Joe", "Jane"],
...               [1.82,1.65,2.15],
...               [False,False,True]], columns = ["Name", "Height", "Married"])
```

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```
>>> tbl += tblb
>>> tbl
  Name |   Height |   Married
-----+-----+-----
  John |     1.82 |         0
   Joe |     1.65 |         0
   Jane |     2.15 |         1
    Bas |     2.01 |         1
4 rows ['<U4', '<f8', '|b1']
```

12.5.2 Appending row

API documentation: `label.Table.row_append`.

You can also append a row (dict, list or tuple) at the end of the Table, for example:

```
>>> tbl.row_append({'Name': "Jack", 'Height': 1.82, 'Married': 1})
>>> tbl
  Name |   Height |   Married
-----+-----+-----
  John |     1.82 |         0
   Joe |     1.65 |         0
   Jane |     2.15 |         1
    Bas |     2.01 |         1
   Jack |     1.82 |         1
5 rows ['<U4', '<f8', '<i8']
```

12.5.3 Appending column

API documentation: `label.Table.__setitem__`.

To add a new column to the Table, just provide a new column name:

```
>>> tbl = Table({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82, 1.65, 2.15], 'Married': [False, False, True]})
>>> tbl["New"] = "Foo"
>>> tbl["Newer"] = list(range(3))
>>> tbl
  Name |   Height |   Married | New |   Newer
-----+-----+-----+---+-----
  John |     1.82 |         0 | Foo |         0
   Joe |     1.65 |         0 | Foo |         1
   Jane |     2.15 |         1 | Foo |         2
3 rows ['<U4', '<f8', '|b1', '<U3', '<i8']
```

Notes: When changing a column two syntaxes give approximately the same result, with, however, a notable difference. Using a slice object “:” will change all elements of the column with the new element(s) provided. If just the column name is provided, with no indication for row, than the whole column is replaced with the column provided.

```
>>> tbl = Table( [ ["John", "Joe", "Jane"],
...               [1.82, 1.65, 2.15],
...               [False, False, True] ],
...               columns = ["Name", "Height", "Married"])
```

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```
>>> tbl[:, "Name"] = [1, 2, 3]
>>> tbl
  Name |   Height |   Married
-----+-----+-----
    1 |     1.82 |         0
    2 |     1.65 |         0
    3 |     2.15 |         1
3 rows ['<U4', '<f8', '|b1']
>>> tbl["Name"] = [1, 2, 3]
>>> tbl
  Name |   Height |   Married
-----+-----+-----
    1 |     1.82 |         0
    2 |     1.65 |         0
    3 |     2.15 |         1
3 rows ['<i8', '<f8', '|b1']
```

Note how in the first case the type of the name column stays “<U8” while second case the type of the Name column changes to <i8.

12.6 Changing column names

API documentation: `tabel.Tabel.columns`.

Just manipulate the columns property directly:

```
>>> data = [ ["John", "Joe", "Jane"],
...          [1.82, 1.65, 2.15],
...          [False, False, True]]
>>> tbl = Tabel(data, columns=["Name", "Height", "Married"])
>>> tbl
  Name |   Height |   Married
-----+-----+-----
 John |     1.82 |         0
  Joe |     1.65 |         0
 Jane |     2.15 |         1
3 rows ['<U4', '<f8', '|b1']
>>> tbl.columns = ["First Name", "BMI", "Overweight"]
>>> tbl
  First Name |   BMI |   Overweight
-----+-----+-----
   John     |  1.82 |         0
    Joe     |  1.65 |         0
   Jane     |  2.15 |         1
3 rows ['<U4', '<f8', '|b1']
```

12.7 Transposing

API documentation: `tabel.T`.

Data from database connectors often comes in list of records, a convenience function is available to make the transpose:

```
>>> from tabel import T
>>> data = [['John', 1.82, False], ['Joe', 1.65, False], ['Jane', 2.15, True]]
>>> tbl = Tabel(T(data))
>>> tbl
0 | 1 | 2
-----+-----+-----
John | 1.82 | 0
Joe | 1.65 | 0
Jane | 2.15 | 1
3 rows ['<U4', '<f8', '|b1']
```

12.8 Group By

API documentation: `tabel.Tabel.group_by`.

To group by unique elements in a column or unique combinations of elements in columns provide the column(s) as a list as the first argument. The second argument is a list of tuples for the aggregate functions and their columns:

```
>>> from tabel import first
>>> tbl = Tabel({'a':[10,20,30, 40]*3, 'b':["100","200"]*6, 'c':[100,200]*6})
>>> tbl
a | b | c
-----+-----+-----
10 | 100 | 100
20 | 200 | 200
30 | 100 | 100
40 | 200 | 200
10 | 100 | 100
20 | 200 | 200
30 | 100 | 100
40 | 200 | 200
10 | 100 | 100
20 | 200 | 200
30 | 100 | 100
40 | 200 | 200
12 rows ['<i8', '<U3', '<i8']
>>> tbl.group_by(['b','a'], [(np.sum, 'a'), (first, 'c')])
b | a | a_sum | c_first
-----+-----+-----+-----
100 | 10 | 30 | 100
200 | 20 | 60 | 200
100 | 30 | 90 | 100
200 | 40 | 120 | 200
4 rows ['<U3', '<i8', '<i8', '<i8']
```

`first` is a convenience function, for when aggregation should just take the first element.

12.9 Sorting

API documentation: `tabel.Tabel.sort`.


```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15], 'Married': [False,False,True]})
>>> tbl.sort("Name")
>>> tbl
  Name | Height | Married
-----+-----+-----
  Jane |    2.15 |         1
   Joe |    1.65 |         0
  John |    1.82 |         0
3 rows ['<U4', '<f8', '|b1']
```

Note that one can use indexing to reorder in any order:

```
>>> tbl[[2,1,0],[2,1,0]]
  Married | Height | Name
-----+-----+-----
         0 |    1.82 | John
         0 |    1.65 | Joe
         1 |    2.15 | Jane
3 rows ['|b1', '<f8', '<U4']
```

12.10 Joining

API documentation: `tabel.Tabel.join`.

To join another Tabel, provide the Table and the column or columns to use as a key for joining:

```
>>> tbl = Tabel({'a':list(range(4)), "b": ['a','b'] *2})
>>> tbl_b = Tabel({'a':list(range(4)), "c": ['d','e'] *2})
>>> tbl.join(tbl_b, "a")
  a | b_l | c_r
-----+-----+-----
  0 | a   | d
  1 | b   | e
  2 | a   | d
  3 | b   | e
4 rows ['<i8', '<U1', '<U1']
```

12.11 Saving

API documentation: `tabel.Tabel.save`.

Data can be saved to disk in various formats:

```
>>> tbl = Tabel({'Name' : ["John", "Joe", "Jane"], 'Height' : [1.82,1.65,2.15],
↳ 'Married': [False,False,True]})
>>> tbl.save("test.csv", fmt="csv")
```

I recommend the numpy native ‘npz’ format:

```
>>> tbl.save("test.npz", fmt="npz")
```

12.12 Reading

API documentation: `tabel.read_tabel`.

Read from disk:

```
>>> from tabel import read_tabel
>>> t = read_tabel("test.csv", fmt="csv")
>>> t
```

Name	Height	Married
John	1.82	False
Joe	1.65	False
Jane	2.15	True

```
3 rows ['<U4', '<f8', '<U5']
```

13.1 `tabel` module

13.1.1 `transpose`

`tabel.transpose(datastruct)`
Transpose rows and columns.

Convenience function. Usually DB connectors return data as a list of records, Tabel takes and internally stores data as a list of columns (column store). This function will transpose the list of records into a list of columns without a priori assuming anything about the datatype of each individual element.

Parameters `datastruct` (*list*) – list or tuple containing lists or tuples with the data for each row.

Returns transposed `datastruct`, list containing lists with the data for each column.

`tabel.T(datastruct)`
Convenience alias for `tabel.transpose`.

13.1.2 `read_tabel`

`tabel.read_tabel(filename, fmt=u'auto', header=True)`
Read data from disk

Read data from disk and return a Tabel object.

Parameters

- **filename** (*str*) – filename string, including path and extension.
- **fmt** (*str*) – format specifier, supports: 'csv', 'npz', 'gz'.
- **header** (*bool*) – whether to expect a header (True) or not (False) or try to sniff (None), only used for csv and gz

Returns Tabel object containing the data.

13.1.3 first

`tabel.first(array)`

Get the first element when doing a `tabel.Tabel.group_by`.

Arguments :

array (numpy ndarray) : numpy 1D array containing the subset of elements

Returns : The first element of ar

Examples : See `Tabel.group_by` for examples

13.2 class Tabel

class `tabel.Tabel` (*datastruct=None, columns=None, copy=True*)

Tabel datastructure

Data table with rows and columns, rows are numbered columns are named. Each column has its own datatype. Data is stored by columns (column store), fixed datatype per column, varyiable datatypes from column to column.

Parameters

- **datastruct** (*object*) – list, tuple, ndarray or dict of lists, tuples, ndarrays or elements; or a *pandas.DataFrame*. List of columns of data. See `tabel.T` for a convenience function to transpose a list of records.
- **columns** (*list of strings*) – Column names, ignored when keys are part of the datastruct (dict and *pandas.DataFrame*). Automatic names are generated, if omitted, as strings of column number.
- **copy** (*boolean*) – Wether to make a copy of the data or to reference to the current memory location (when possible), default: True

Notes

1. It is possible to create an empty Tabel instance and later add data using the `tabel.Tabel.append` and/or `tabel.Tabel.__setitem__` methods.
 2. It is possible to add or manipulate data directly through the instance attributes `tabel.Tabel.columns` and `tabel.Tabel.data`. One could use the `tabel.Tabel.valid` method to check wether the manipulated structure is still valid.
 4. If one or more (but not all) of the columns contain a single element this element is repeated to match the length of the other columns.
-

Examples

To initialize a Tabel, call the constructor with the data in column lists:

```
>>> from label import Tabel
>>> Tabel( [ ["John", "Joe", "Jane"],
...         [1.82, 1.65, 2.15],
...         [False, False, True] ],
...        columns = ["Name", "Height", "Married"])
Name | Height | Married
-----+-----+-----
John | 1.82 | 0
Joe | 1.65 | 0
Jane | 2.15 | 1
3 rows ['<U4', '<f8', '|b1']
```

13.2.1 getter

Tabel.__getitem__(key)

Indexing and slicing parts of a Tabel.

Slicing and indexing mostly follows Numpy array and Python list conventions.

Arguments:

key (r, c): r can be a single integer, a boolean array, an integer itereable or a slice object. c can be a single integer or string, a boolean array, an integer or string itereable or a slice object.

key (int, string) : When only a single int or string is supplied it is considered to point to a whole single column or a whole single row (in that order).

Returns:

Depending on key, four different types can be returned.

element (): If both the row place and the column place are a single integer (or string for the column place), addressing a single element in the Tabel, wich could be of any datatype supported by Numpy.ndarray.

column (ndarray): If the column place is a single string or integer, adresssing a single column and the row place is either abscent or not an integer.

row (tuple) : If the row place is a single integer, adresssing a single row and the counmn place is either abscent or not a single integer/string.

Tabel (Tabel) : If a tuple key (r, c) is provided with anything other than an integer for the row place and anything other than a single integer/string type for the column place.

Notes

Returned Tabel objects from slicing are referenced to the original Tabel object unless row indexing was with a boolean list/array or the returned type was not a Tabel or np.ndarray object. Changes made to the slice will be reflected in the original Tabel. Appending or joining Tabels or adding/renaming columns will never be reflected in the original Tabel object. Use the *py:copy* function to make a full copy of the object.

Raises `KeyError` – When a key is referencing an invallid or not existing part of the data.

Examples

```
>>> tbl[:, 1:3]
Height | Married
-----+-----
      1.82 |      0
      1.65 |      0
      2.15 |      1
3 rows ['<f8', '|b1']
```

```
>>> tbl[0, 0]
'John'
>>> tbl["Name"]
array(['John', 'Joe', 'Jane'], dtype='<U4')
>>> tbl[0]
('John', 1.82, False)
```

13.2.2 setter

`Tabel.__setitem__(key, value)`

Setting a slice of a Tabel

Setting, like getting, slices mostly follows numpy conventions. Specifically the rules for the key are the same as for `tabel.Tabel.__getitem__` with the same relation between key and expected type for the value. In addition this method can also be used to add new columns.

Parameters

- **key** (*int*, *string*) – *r* can be a single integer, a boolean array, an integer iterable or a slice object.

c can be a single integer or string, a boolean array, an integer or string iterable or a slice object.

To address a single element in the Tabel object the key should be a tuple of (*r*, *c*) with *r* a single integer addressing the row and *c* a single integer or string addressing the column of the element to be changed.

- **key** – When only a single int or string is supplied it is considered to point to a whole single column or a whole single row (in that order).
- **value** (*object*) – The type the value needs to have depends on the key provided.

element: A single element of the same type, or a type convertible to the same, as the column targeted as a destination. See `tabel.Tabel.dtype` to get the type of the columns.

column : An array or list of elements, each element of of the same type, or a type convertible to the same, as the column targeted as a destination. If a new column is targeted a single element could be provided, in which case it will be replicated along all rows.

row : A tuple of elements, each of the same type or a type convertible to the same, as the column targeted as a destination. Length of the tuple should match the number of columns addressed.

Tabel : Not currently implemented.

Returns nothing, change in-place.

Notes

When changing a column two syntaxes give approximately the same result, with, however, a notable difference. Using a slice object “:” will change all elements of the column with the new element(s) provided. If just the column name is provided, with no indication for row, then the whole column is replaced with the column provided.

```
>>> tbl = Tabel( [ ["John", "Joe", "Jane"], [1.82, 1.65, 2.15],
...               [False, False, True] ], columns = ["Name", "Height", "Married"])
>>> tbl[:, "Name"] = [1, 2, 3]
>>> tbl
  Name |   Height |   Married
-----+-----+-----
    1 |     1.82 |         0
    2 |     1.65 |         0
    3 |     2.15 |         1
3 rows ['<U4', '<f8', '|b1']
>>> tbl["Name"] = [1, 2, 3]
>>> tbl
  Name |   Height |   Married
-----+-----+-----
    1 |     1.82 |         0
    2 |     1.65 |         0
    3 |     2.15 |         1
3 rows ['<i8', '<f8', '|b1']
```

Note how in the first case the type of the name column stays “<U8” while second case the type of the Name column changes to “<i8”.

13.2.3 repr

Tabel. **__repr__** ()

Pretty print using tabulate.

Examples

```
>>> tbl = Tabel( [ ["John", "Joe", "Jane"], [1.82, 1.65, 2.15],
...               [False, False, True] ], columns = ["Name", "Height", "Married"])
>>> tbl
  Name |   Height |   Married
-----+-----+-----
  John |     1.82 |         0
   Joe |     1.65 |         0
  Jane |     2.15 |         1
3 rows ['<U4', '<f8', '|b1']
```

13.2.4 append

Tabel. **append** (tbl)

Append new Tabel to the current Tabel.

Append a Tabel or pandas.DataFrame to the end of this Tabel. Each column is appended to each column of the instance invoking the method.

Parameters `tbl` (`Tabel`) – Tabel with the same columns as the current Tabel, order of columns does not need to match. Columns do not need to match if the current Tabel has zero length. Besides Tabel objects pandas.DataFrame objects are also allowed.

Returns Nothing, change in-place.

13.2.5 row_append

`Tabel.row_append(row)`

Append a row record at the end of the Tabel.

Appending a single row at the end of the Tabel.

Parameters `row` (`dict`, `list`, `tuple`) – The row to be appended to the Tabel. If a dict is provided the keys should match the column names of the Tabel. If a list or tuple is provided the length and order should match the columns of the Tabel. columns do not need to match if the current Tabel has zero length.

Returns Nothing. Change in-place.

13.2.6 join

`Tabel.join(tbl_r, key, key_r=None, jointype=u'inner', suffixes=(u'_l', u'_r'))`

dbase join tables with ind column(s) as the keys.

Performs a database style joins on the two tables, the current instance and the provided tabel 'tbl_r' on the columns listed in 'key'.

Parameters

- **tbl_r** (`Tabel`) – The right tabel to be joined.
- **key** (`string` or `list`) – Name of the column(s) to be used as the key(s).
- **key_r** (`list`) – A list of columnnames of the right tabel matching the left tabel. Defaults to the list provided in `ind`.
- **jointype** (`str`) – One of: *inner*, *left*, *right*, *outer*. If *inner*, returns the elements common to both tabels. If *outer*, returns the common elements as well as the elements of the left tabel not in the right tabel and the elements of the right tabel not in the left tabel. If *left*, returns the common elements and the elements of the left tabel not in the right tabel. If *right*, returns the common elements and the elements of the right tabel not in the left tabel.
- **suffixes** (`tuple`) – Strings to be added to the left and right tabel column names.

Returns The joined tabel

Notes

The order and suffixes of the returned Tabel depend on the jointype. For all types, all but the key columns are suffixed with the left and the right suffix respectively. The left Tabel columns come first followed by the right Tabel columns, with the key column placed first of its Tabel columns. For *inner* and *left* jointypes the right key column is left out. for *right* jointype the left key column is left out. For the *outer* jointype both keys are present and suffixed.

Examples

Join a Tabel into the current Tabel matching on column 'a':

```
>>> tbl = Tabel({"a":list(range(4)), "b": ['a', 'b'] *2})
>>> tbl_b = Tabel({"a":list(range(4)), "c": ['d', 'e'] *2})
>>> tbl.join(tbl_b, "a")
  a | b_l | c_r
-----+-----+-----
  0 | a   | d
  1 | b   | e
  2 | a   | d
  3 | b   | e
4 rows ['<i8', '<U1', '<U1']
```

13.2.7 group_by

`Tabel.group_by(key, aggregate_fie_col=None)`

Groups and aggregates Tabel.

Parameters

- **key** (*str or list*) – name or list of names of the columns to be grouped by.
- **aggregate_fie_col** (*list*) – list of tuples (*function, column*) where *function* is the function to be applied to aggregate and *column* is the string name of the column. *function* should take an 1D array as an input and the returned value is treated as a single element. Only the grouped columns of *key* are returned if omitted.

Returns Tabel object with requested columns

Examples

grouping by 'a' and then by 'b', agregating with taking the sum of 'a' elements and taking the first 'c' element of each group:

```
>>> tbl = Tabel({'a':[10, 20, 30, 40]*3, 'b':["100", "200"]*6, 'c':[100, 200]*6})
>>> from tabel import first
>>> tbl.group_by(['b', 'a'], [ (np.sum, 'a'), (first, 'c')])
  b | a | a_sum | c_first
-----+-----+-----+-----
  100 | 10 | 30 | 100
  200 | 20 | 60 | 200
  100 | 30 | 90 | 100
  200 | 40 | 120 | 200
4 rows ['<U3', '<i8', '<i8', '<i8']
```

13.2.8 sort

`Tabel.sort(columns)`

Sort the Tabel.

Sorting in-place the Tabel according to columns provided. Rows always stay together, just the order of rows is affected.

Parameters **columns** (*string or list*) – column name or column names to be sorted, listed in-order.

Returns Nothing. Sorting in-place.

Examples

```
>>> tbl = Tabel({'a':['b', 'g', 'd'], 'b':list(range(3))})
>>> tbl.sort('a')
>>> tbl
a  |  b
----+----
b  |  0
d  |  2
g  |  1
3 rows ['<U1', '<i8']
```

13.2.9 astype

`Tabel.astype` (*dtypes*)

Returns a type-converted tabel.

Converts the tabel according to the provided list of dtypes and returns a new Tabel instance.

Parameters **dtypes** (*list*) – list of valid numpy dtypes in the order of the columns. List should have same length as number of columns present (see *Tabel.shape*) See *Tabel.dtype* for the current types of the Tabel.

Returns Tabel object with the columns converted to the new dtype.

Examples:

13.2.10 save

`Tabel.save` (*filename, fmt=u'auto', header=True*)

Save to file

Saves the Tabel data including a header with the column names to a file of the specified name in the current directory or the directory specified.

Parameters

- **filename** (*str*) – filename, should include path
- **fmt** (*str*) – formatting, valid values are: 'auto', 'csv', 'npz', 'gz'
 - auto** : Determine the filetype from the file extension.
 - csv** : Write to csv file using python's *csv* module.
 - gz** : Write to csv using python's *csv* module and zip using standard *gzip* module.
 - npz** : Write to compressed *numpy* native binary format.
- **header** (*bool*) – whether to write a header line with the column names, only used for csv and gz

Returns Nothing.

13.2.11 properties

13.2.11.1 dict

`Tabel.dict`

Dump all data as a dict of columns.

Keywords are the column names and values are the column Numpy.ndarrays. Usefull when transferring to a pandas DataFrame.

13.2.11.2 shape

`Tabel.shape`

Tabel shape.

Returns tuple (r, c) with r the number of rows and c the number of columns.

13.2.11.3 len

`Tabel.__len__ = <unbound method Tabel.__len__>`

13.2.11.4 dtype

`Tabel.dtype`

List of dtypes of the data columns.

13.2.11.5 valid

`Tabel.valid`

Check wether the current datastructure is legit.

Returns (bool) True if the Tabel internal structure is valid.

Notes

This is currently checking for the length of the columns to be the same and the number of the columns to be the same as the number of column names.

13.2.12 class attributes

`Tabel.repr_layout = u'presto'`

The layout used with *tabulate* in the `__repr__()` method.

Type string

`Tabel.max_repr_rows = 20`

Maximum number of rows to show when `__repr__()` is invoked.

Type int

`Tabel.join_fill_value = {u'float': nan, u'integer': 999999, u'string': u''}`

Fill vallues to be used when doing outer joins

Type dict

CHAPTER 14

license

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CHAPTER 15

Indices and tables

- `genindex`
- `modindex`
- `search`

t

tabel, [39](#)

Symbols

`__getitem__()` (*tabel.Tabel method*), 41
`__len__` (*tabel.Tabel attribute*), 47
`__repr__()` (*tabel.Tabel method*), 43
`__setitem__()` (*tabel.Tabel method*), 42

A

`append()` (*tabel.Tabel method*), 43
`astype()` (*tabel.Tabel method*), 46

D

`dict` (*tabel.Tabel attribute*), 47
`dtype` (*tabel.Tabel attribute*), 47

F

`first()` (*in module tabel*), 40

G

`group_by()` (*tabel.Tabel method*), 45

J

`join()` (*tabel.Tabel method*), 44
`join_fill_value` (*tabel.Tabel attribute*), 47

M

`max_repr_rows` (*tabel.Tabel attribute*), 47

R

`read_tabel()` (*in module tabel*), 39
`repr_layout` (*tabel.Tabel attribute*), 47
`row_append()` (*tabel.Tabel method*), 44

S

`save()` (*tabel.Tabel method*), 46
`shape` (*tabel.Tabel attribute*), 47
`sort()` (*tabel.Tabel method*), 45

T

`T()` (*in module tabel*), 39

`Tabel` (*class in tabel*), 40
`tabel` (*module*), 39
`transpose()` (*in module tabel*), 39

V

`valid` (*tabel.Tabel attribute*), 47